1 GOVERNMENT OF RAJASTHAN	1.1 Urban Development Department
Rajasthan Urban Infrastructure Development Project (RUIDP) (ADB Loan No. 1647-IND)	**Ajmer, Bikaner, Jaipur, Jodhpur, Kota and Udaipur**
1.1.1.1.1 STANDARD SPECIFICATIONS (CIVIL WORKS)	
Project Management Unit - RUIDP Avs Building, Jawahar Circle Malviya Nagar, Jaipur 302017	1.1.1.1.1.1
	1.1.1.2 December, 2001

2 GENERAL

2.1 Preamble

2.1.1 These Specifications cover the items of work in structural and non structural parts of the Works coming under purview of this document. All work shall be carried out in conformation with this. In general, provisions of Indian Standards, Indian Roads Congress Codes, MoST Specifications for Roads and Bridge Works (IV Revision) and other national standards have been followed. These Specifications are not intended to cover the minute details. The work shall be executed in accordance with best modern practices. All codes and standards referred to in these Specifications shall be the latest revision thereof.

2.2 Inclusive Documents

2.2.1 The provisions of special conditions of contract, those specified on the tender as well as execution Drawings and notes or other Specifications issued in writing by the Engineer shall form part of these Specifications.

2.3 Order of Precedence, Clarifications and Interpretation

2.3.1 When the various Specifications and codes referred to in preceding portion are at variance with these Specifications and with each other, the following order of precedence will generally be accepted.

1. Written instructions of the Engineer.
2. Special Conditions of Contract, Item wise Technical Specifications, if provided, and Execution Drawings.
3. Provisions of General Specifications.
4. I.S. Codes.
5. IRC Codes, M.O.S.T., Specifications, etc.

2.3.2 The attention of the Contractor is drawn to those Clauses of IS codes which require either Specification by Engineer or the mutual agreement between the supplier and purchaser. In such cases it is the responsibility of the Contractor to seek clarification on any uncertainty and obtain prior approval of the Engineer before taking up the supply/construction.

2.4 Measurement and Payments

2.4.1 The methods of measurement and payment shall be as described under various items and in the bill of quantity. Where specific definitions are not given, the methods described in IS Codes will be followed. Should there be any detail of construction or materials which has not been referred to in these Specification or in the bill of quantities and Drawings but the necessity for which may be implied or inferred wherefrom, or which are usual or essential to the completion of the work in the trades, the same shall be deemed to be included in the rates and prices quoted by the Contractor in the bill of quantities.

2.5 Unacceptable Work

2.5.1 All defective Works are liable to be demolished, rebuilt and defective materials replaced by the Contractor at his own cost. In the event of such Works being accepted by carrying out repairs etc. as specified by the Engineer, the cost of repairs will be borne by the Contractor.

2.5.2 In the event of the work being accepted by giving ‘Design Concession’, arising out of but not limited to under sizing, under strength, shift in location and alignment, etc. and accepting design stresses in members which are higher than those provided for in the original design or by accepting materials not fully meeting the Specifications, etc. the Contractor will be paid for the Works actually carried out by him at the suitable reduced rate of the tendered rates for the portion of the work thus accepted.

2.6 Water Supply and Sanitary Works

2.6.1 All items covered under the above head shall conform to the detailed Specifications given for each of the items in addition to the by-laws of the local bodies within whose jurisdiction the Works are executed. The Works shall be carried out as per the relevant IS Codes and as per the instructions of the Engineer.

2.7 Floor and Levels

2.7.1 Building

2.7.1.1 Floor I is the lowest floor above the ground level in the building unless otherwise specified in a particular case. The floors above Floor I shall be numbered in sequence as Floor 2, Floor 3 and so on. The number shall increase upwards.

2.7.1.2 Floor level: For floor 1, top level of finished floor shall be the floor level and for all other floors above floor 1, top level of the structural slabs shall be the floor level.

2.7.1.3 Plinth level: Floor 1 level or 1.2 m above the ground level whichever is lower shall be the plinth level.

2.7.2 Special Structures

2.7.2.1 For structures like retaining walls, wing walls, chimneys, over head reservoirs/tanks and other elevated structures, where elevations/heights above a defined datum level have not been specified and identification of floors cannot be done as in case of buildings, levels at 1.2 m above the ground level shall be the floor level as well as plinth level. Level at a height of 3.5 m above floor 1 level will be reckoned as floor 2 levels and level at a height of 3.5 m above the floor 2 level will be floor 3 levels and so on. Where the total height above floor 1 level is not a whole number multiple of 3.5 m, top most floor level shall be the next in sequence to the floor level below even if the difference in height between the two upper most floor levels is less than 3.5 m.

2.8 Foundation and Plinth

2.8.1 The work in foundation and plinth shall include:

1. For buildings: All Works up to 1.2 m above ground level or up to floor 1 level whichever is lower;
2. For abutments, piers and well steining: All Works up to 1.2 m above the bed level;
3. For retaining walls, wing walls, compound walls, chimneys, overhead reservoirs/tanks and other elevated structures: All Works up to 1.2 m above the ground level;
4. For reservoirs/tanks (other than overhead reservoirs/tanks): All Works up to 1.2 m above the ground level
5. For basements: All Works up to 1.2 m above ground level or up to floor 1 level whichever is lower.

Note: Specific provisions shall be made in the estimate for such situations where the foundation level is more than 3 m depth from the plinth for all types of structures mentioned above.

2.9 Maintaining Utility Service and Traffic

2.9.1 Public Utilities

2.9.1.1 Drawings scheduling the affected services like water pipes, sewers, oil pipelines, cables, gas ducts etc. owned by various authorities including Public Undertakings and Local Authorities included in the Contract Documents shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

2.9.1.2 Notwithstanding the fact that the information on affected services may not be exhaustive, the final position of these services within the Works shall be supposed to have been indicated based on the information furnished by different bodies and to the extent the bodies are familiar with the final proposals. The intermediate stages of the Works are, however, unknown at the design stage, these being dictated by the Contractor's methods of working. Accordingly, the Contractor's programme must take into account the period of notice and duration of diversionary Works of each body as given on the Drawings and the Contractor must also allow for any effect of these services and alterations upon the Works and for arranging regular meetings with the various bodies at the commencement of the Contract and throughout the period of the Works in order to maintain the required co-ordination. During the period of Works, the Contractor shall have no objection if the public utility bodies vary their decisions in the execution of their proposals in terms of programme and construction, provided that, in the opinion of the Engineer, the Contractor has received reasonable notice thereof before the relevant alterations are put in hand.

2.9.1.3 No clearance or alterations to the utility shall be carried out unless specially ordered by the Engineer.

2.9.1.4 Any services affected by the Works must be temporarily supported by the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the Works.

2.9.1.5 The Contractor may be required to carry out certain Works for and on behalf of the various bodies and he shall also provide, with the prior approval of the Engineer, such assistance to the various bodies as may be authorised by the Engineer.

2.9.1.6 The work of temporarily supporting and protecting the public utility services during execution of the Works shall be deemed to be part of the Contract and no extra payment shall be made for the same.

2.9.1.7 The Contractor may be required to carry out the removal or shifting of certain services/utilities on specific orders from the Engineer for which payment shall be made to him. Such workers shall be taken up by the Contractor only after obtaining clearance from the Engineer and ensuring adequate safety measures.

2.9.2 Arrangement for Traffic during Construction

2.9.2.1 General

The Contractor shall at all times carry out work on the roads in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of the same. For all Works involving improvements to the existing roads, the Contractor shall, in accordance with the directives of the Engineer, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement, or along a temporary diversion constructed close to the road. The Contractor shall take prior approval of the Engineer regarding traffic arrangements during construction.

2.9.2.2 Passage of Traffic along a part of the Existing Carriageway under Improvement

1. For widening/strengthening existing carriageway where part width of the existing carriageway is proposed to be used for passage of traffic, treated shoulders shall be provided on the side on which work is not in progress. The treatment to the shoulder shall consists of providing at least 150 mm thick granular base course covered with bituminous surface dressing in a width of at least 1.5 m and the surface shall be maintained throughout the period during which traffic uses the same to the satisfaction of the Engineer. The continuous length in which such a work shall be carried out, would be limited normally to 500 m at a place. However, where work is allowed by the Engineer in longer stretches passing places at least 20 m long with additional paved width of 2.5 m shall be provided at every 0.5 km interval.

2. In case of widening existing two-lane to four-lane, the additional two lanes would be constructed first and the traffic diverted to it and only thereafter the required treatment to the existing carriageway would be carried out. However, in case where on the request of the Contractor, work on existing two-lane carriageway is allowed by the Engineer with traffic using part of the existing carriageway, stipulations as in para above shall apply.

3. After obtaining, permission of the Engineer, the treated shoulder shall be dismantled, the debris disposed off and the area cleared as per the direction of the Engineer.

2.9.2.3 Passage of Traffic along a Temporary Diversion

1. In stretches where it is not possible to pass the traffic on part width of the carriageway, a temporary diversion shall be constructed with 7 m carriageway and 2.5 m earthen shoulders on each side (total width of roadway 12 m) with the following provision for road crust in the 7 m width:

   - 200 mm (compacted) granular sub base;
   - 225 mm (compacted) granular base course; and
   - Premix carpet with Seal Coat/Mix Seal Surfacing.

2. The alignment and longitudinal section of diversion including junctions and temporary cross drainage provision shall be as approved by the Engineer.

2.9.2.4 Traffic Safety and Control

1. The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required by the Engineer for the information and protection of traffic approaching or passing through the section of the highway under improvement. Before taking up any construction, an agreed phased programme for the diversion of traffic on the highway shall be drawn up in consultation with the Engineer.

2. The barricades erected on either side of the carriageway/portion of the carriageway closed to traffic, shall be of strong design to resist violation, and painted with alternate black and white stripes. Red lanterns or warning lights of similar type shall be mounted on the barricades at night and kept lit throughout from sunset to sunrise.

3. At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriage way) the channel for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar device as per the directions of the Engineer. At night, the passage shall be delineated with lanterns or other suitable light source.

4. One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for two-lane traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

5. On both sides, suitable regulatory/warning signs as approved by the Engineer shall be installed for the guidance of road users. On each approach, at least two signs shall be put up, one close to the point where transition of carriageway begins and the other 120 m away. The signs shall be of approved design and of reflectory type, if so directed by the Engineer.

2.9.2.5 Maintenance of Diversions and Traffic Control Devices

Signs, lights, barriers and other traffic control devices, as well as the riding surface of diversions shall be maintained in a satisfactory condition till such time they are required as directed by Engineer. The temporary traveled way shall be kept free of dust by frequent applications of water, as directed by the Engineer.

2.9.2.6 Measurements for Payment and Rate

1. All arrangements for traffic during construction including provision of temporary cross drainage structures, if required, and treated shoulder as described in Clause 1.9.2.2 including their maintenance, dismantling and clearing debris, where necessary, shall be considered as incidental to the Works and shall be the Contractor's responsibility.

2. The construction of temporary diversion including temporary cross drainage structures as described structures as described in Clause 1.9.2.3, shall be measured in linear m and the unit contract rate shall be inclusive of full compensation for construction (including supply of material, labour, tools, etc.) maintenance, final dismantling, and disposal.

2.10 Setting Out

The Contractor shall establish working Bench Marks tied with the Reference Bench Mark in the area soon after taking possession of the site. The Reference Bench Mark for the area shall be as indicated in the Contract Documents and the values of the same shall be obtained by the Contractor from the Engineer. The working Bench Marks shall be at the rate of four per km and also at or near all drainage structures, over-bridges and underpasses. The working Bench Marks/levels shall be approved by the Engineer. Checks must be made on these Bench Marks once every months and adjustments, if any, agreed with the Engineer and recorded. An up-to-date record of all Bench marks including approved adjustments, if any, shall be maintained by the Contractor and also a copy supplied to the Engineer for his record.

2.10.1 The lines and levels of formation, side slopes, drainage Works, carriage ways and shoulders shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross-sections are obtained everywhere.

2.10.2 In order to facilitate the setting out of the Works, the centre line of the carriageway or highway must be accurately established by the Contractor and approved by the Engineer. It must then be accurately referenced in a manner satisfactory to the Engineer, every 50 m intervals in plain and rolling terrain and 20 m intervals in hilly terrain and at all curve points as directed by the Engineer, with marker pegs and chainage boards set in or near the fence line, and a schedule of reference dimensions shall be prepared and supplied by the Contractor to the Engineer. These markers shall be maintained until the Works reach finished formation level and are accepted by the Engineer.

2.10.3 On construction reaching the formation level stage, the centre line shall again be set out by the Contractor and when approved by the Engineer, shall be accurately referenced in a manner satisfactory to the Engineer by marker pegs set at the outer limits of the formation.

2.10.4 No reference peg or marker shall be moved or withdrawn without the approval of the Engineer and no earthwork or structural work shall be commenced until the centre line has been referenced.

2.10.5 The Contractor will be the sole responsible party for safeguarding all survey monuments, bench marks, beacons, etc. The Engineer will provide the Contractor with the data necessary for setting out of the centre line. All dimensions and levels shown on the Drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Engineer of any apparent errors or discrepancies in such dimensions or levels. The Contractor shall, in connection with the staking out of the centre line, survey the terrain along the road and shall submit to the

Engineer for his approval, a profile along the road centre line and cross-sections at intervals as required by the Engineer.

2.10.6 After obtaining approval of the Engineer, work on earthwork can commence and the profile and cross sections shall form the basis for measurements and payment. The Contractor shall be responsible for ensuring that all the basic traverse points are in placed at the commencement of the contract and if any are missing, or appear to have been disturbed, the Contractor shall make arrangements to re-establish these points. A “Survey File” containing the necessary data will be made available for this purpose. If in the opinion of the Engineer, design modifications of the centre line or grade are advisable, the Engineer will issue detailed instructions to the Contractor and the Contractor shall perform the modifications in the field, as required, and modify the ground levels on the cross-sections accordingly as many times as required. There will be no separate payment for any survey work performed by the Contractor. The cost of these services shall be considered as being included in the cost of the items of work in the Bill of Quantities.

2.10.7 The work of setting out shall be deemed to be a part of general Works preparatory to the execution of work and no separate payment shall be made for the same.

2.10.8 Precision automatic levels, having a standard deviation of $\pm$ 2 mm per km, and fitted with micrometer attachment shall be used for all double run leveling work. Setting out of the road alignment and measurement of angles shall be done by using theodolite with traversing target, having an accuracy of one second. Measurement of distances shall be done using precision instruments like Distomat or equivalent.

2.11 Methodology and Sequence of Work

2.11.1 Prior to start of the construction activities at site, the Contractor shall, within 30 days after the date of the Letter of Acceptance, submit to the Engineer for approval, the detailed construction methodology including mechanical equipment proposed to be used, sequence of various activities and schedule from start to end of the project. Programme relating to pavement and shoulder construction shall be an integrated activity to be done simultaneously in a coordinated manner. The methodology and the sequence shall be so planned as to provide proper safety, drainage and free flow of traffic.

2.12 Approval of Materials

2.12.1 Approval of all sources of material for Works shall be obtained in writing from the Engineer before their use on the project.

2.12.2 Where the terms crushed gravel/shingle, crushed stone, broken stone or stone aggregate appear in any part of the Tender Documents or Drawings issued for work, they refer to crushed gravel / crushed shingle / crushed stone aggregate obtained from an integrated crushing plant having appropriate primary crusher, secondary crusher and vibratory screen.

2.12.3 Raw and processed samples of the mineral aggregates from the approved quarry shall be submitted by the Contractor at no extra cost.

2.13 Access to Abutting Properties

2.13.1 For the duration of the Works the Contractor shall at all times provide convenient access to paths, steps, bridges or drives for all entrances to property abutting the site and maintain them clear, tidy, and free from mud and objectionable matter.

2.13.2 In addition to the above, in order to ensure uninterrupted traffic flow in the cross roads, the Contractor has to provide and maintain suitable crossing arrangement for the existing traffic to move across the construction work for all categories of roads crossing the roads under construction/improvement during the entire period of construction or till such time that alternative arrangement for the traffic is made.

2.14 Use of Equipment on Works

2.14.1 The following conditions regarding use of equipment's on works shall be followed:

1. The Contractor shall be required to give a trial run of the equipment(s) or establishing their capability to achieve the required Specifications and tolerance to the satisfaction of the Engineer before commencement of the work.

2. All equipment's provided shall be proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Engineer.

3. No equipment or personnel will be removed from site without permission of Engineer.

2.15 Quality Control on Works and Materials

2.15.1 The Contractor shall be responsible for the quality of the work in the entire construction work within the contract. He shall, therefore, have his own independent and adequate set-up for ensuring the same.

2.15.2 The Engineer shall inspect the work from time to time during and after construction and ascertain the quality of the work tested (by himself, by his Testing and Quality Control Units or by any other agency deemed fit by him) generally as per the requirements of the Handbook of Quality Control for construction of roads and runways (IRC Special Publication No. 11 and MoST Specifications for Roads and Bridge Works III Revision). Additional tests may also be conducted where, in the opinion of the Engineer, need for such test exists. In the absence of clear indications and frequency of tests for any item in the above mentioned publication, procedures and tests as directed by the Engineer shall be followed.

2.15.2.1 The Contractor shall provide necessary cooperation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from tome to time. This may include provision of labour, attendance, assistance in packing and dispatching and any other assistance considered necessary in connection with the tests.

2.15.3 For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall be done after obtaining permission from the Engineer.

2.15.4 Similar permission from the Engineer shall be obtained in respect of other items of work prior to proceeding with the next stage of construction.

2.15.5 The Contractor shall carry out modification in procedure of work, if any, as directed by the Engineer during inspection.

2.15.6 Works falling short of quality as per tests indicated in **Clause 1.15.2** above shall be rectified by the Contractor as directed by the Engineer at his own cost.

2.15.7 For testing of samples of soil, soil mix, granular material and mix, bituminous mix, aggregates, cores etc. Samples in the required quantity and form shall be supplied to the Engineer by the Contractor at his own cost

2.15.8 For cement, bitumen and similar other materials where essential tests are to be carried out at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor. He shall also furnish the test certificates to the Engineer.

2.15.9 For testing of cement concrete at site during construction arrangement for supply of samples, sampling, testing and supply of test results shall be made by the Contractor as per the frequency and number of tests specified in the Handbook of Quality Control for Construction of roads and runways, IRC Special Publication No. 11, and relevant IS codes or relevant

Clauses (1702, 1704, 1707, 1717 etc.,) as specified for in most Specifications for Roads and Bridge Works (IV Revision).

2.15.10 The method of sampling and testing of materials shall be as required by the Handbook of Quality Control for construction of roads and runways (IRC Special Publication No. 11), and the Ministry of Shipping and Transport Specifications and where the same are silent, as per the relevant IRC Standards, Specifications, guidelines, Special publications and IS Standards. In the absence of relevant Indian Standards, the sampling and testing procedure to be used shall be as approved by the Engineer.

2.15.11 Where the Engineer considers that in the interest of the control of the quality on materials or workmanship, modifications, if any, are necessary, such modifications shall be carried out by the Contractor at no extra cost.

2.15.12 The Contract rate quoted for various items of work in the Bill of Quantities shall be deemed to be inclusive of all costs of the provisions indicated in the above mentioned clauses.

2.16 Surveying and Measuring Equipment's

2.16.1 Equipment for surveying and measurement on the work shall be procured by the Contractor for his use. The same shall also be made available to the Engineer at site for any work connected with the Contract without any additional charge.

2.17 Completion Drawings

2.17.1 The Contractor shall submit to the Engineer within two months of actual completion, "Completion" Drawings as specified below and operation and maintenance instructions for the whole of the works. These Drawings shall be accurate and correct in all respects and shall be shown to and approved by the Engineer.

2.17.2 Completion Drawings on two prints & one Polyester film shall be supplied by the Contractor.

3 SITE CLEARANCE (CLEARING AND GRUBBING)

3.1 Scope

3.1.1 This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness, rubbish etc., from the area of Works which in the opinion of the Engineer are unsuitable for incorporation in the Works, and such other areas as may be specified on the Drawings or by the Engineer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

3.2 Preservation of Property/Amenities

3.2.1 Trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all facilities within or adjacent to the site which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own expense, suitable safeguards approved by the Engineer for this purpose.

3.2.2 During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional Works to that effect vide relevant Clauses of **Chapter 5**. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control Works as stipulated in **Chapter 5**.

3.3 Methods, Tools and Equipment

3.3.1 Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation / roots / trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade / foundation / bed level. Also, all vegetation such as roots, under-growths, grass and other deleterious matter unsuitable for incorporation in the Work shall be removed between fill lines to the satisfaction of the Engineer. On the areas beyond these limits, trees and stumps required to be removed as directed by the Engineer shall be cut down to 1 m below ground level so that these do not present any unsightly appearance.

3.3.2 All branches of trees extending above the roadway shall be trimmed as directed by the Engineer.

3.3.3 All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface as these points conform to the surrounding area.

3.3.4 Ant-hills both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed and their workings, which may extend to several meters, shall be suitably treated.

3.4 Disposal of Materials

3.4.1 All materials arising from clearing and grubbing operations shall be the property of Employer and shall be disposed of by the Contractor as hereinafter provided or directed by the Engineer.

3.4.2 Trunks and stumps of trees shall be cleaned of limbs and roots and stacked. Also boulders, stones and other materials usable in construction shall be neatly stacked as directed by the

Engineer. Stacking stumps, boulders, stones etc., shall be done at specified spots with all lifts and up to a lead of 1000 m.

3.4.3 All products of clearing and grubbing which, in the opinion of the Engineer, cannot be used or auctioned shall be cleared away from the site in a manner as directed by the Engineer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction.

3.5 Measurements for Payment

3.5.1 Clearing and grubbing shall be measured on area basis in terms of hectares. Clearing and grubbing of borrow areas shall be deemed to be a part of Works preparatory to embankment construction and shall be deemed to have been included in the rates quoted for the embankment construction item and no separate payment shall be made for the same. Cutting of trees up to 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the clearing and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.

3.5.2 Cutting, including removal of stumps and roots of trees of girth above 300 mm and backfilling to required compaction shall be measured in terms of number according to the sizes given below:

1. Above 300 mm to 600 mm;
2. Above 600 mm to 900 mm;
3. Above 900 mm to 1800 mm; and
4. Above 1800 mm.

3.5.3 For this purpose, the girth shall be measured at a height of 1 m above ground or at the top of the stump if the height of the stump is less than 1 m from the ground.

3.6 Rates

3.6.1 The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm in girth as well as stumps left over after cutting of trees carried out by another agency, excavation and back-filling to required density, where necessary, and handling, salvaging, piling and disposing of the cleared materials with all lifts and up to a lead of 1000 m.

3.6.2 The Contract unit rates for cutting (including removal of stumps and roots) of trees of girth above 300 mm shall include excavation and back-filling to required compaction, handling, salvaging, piling and disposing of the cleared materials with all lifts and up to a lead of 1000 m.

3.6.3 Where a Contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the Contract unit prices for the same shall be considered as including clearing and grubbing operations.

4 DISMANTLING AND DEMOLITION

4.1 Scope

4.1.1 This work shall consist of removing, as hereinafter set forth, existing buildings, roofs, ceiling, flooring and paving, concrete and brick roofs and suspended floors, walls and columns, reinforced concrete and brick work, partitions, wood work, steel and iron work, doors and windows, pipes and sewer lines, posts or struts, fencing wire mesh, glazing, culverts, bridges, pavements, kerbs and other structures like guard-rails, utility services, catch basins, inlets, etc., which are in place but interfere with the new construction or are not suitable to remain in place, and of salvaging and disposing of the resulting materials and back filling the resulting trenches and pits.

4.1.2 Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed up to the limits and extent specified in the Drawings or as indicated by the Engineer.

4.1.3 Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

4.1.4 All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

4.2 Applicable Codes

IS: 1200-1974 (Part: XVIII)	Method of Measurements of Building and Civil Engineering Works. Demolition and Dismantling (Reaffirmed 1992) (3rd Revision).
IS: 4130-1991	Demolition of Buildings - Code of Safety (2nd Revision).

4.3 Terminology

4.3.1 The term **'Dismantling'** implies carefully separating the parts without damage and removing. This may consist of dismantling one or more parts of the structure as specified or shown on the Drawings.

4.3.2 The term **'Demolition'** implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on the Drawings.

4.4 Buildings

4.4.1 Precautions

4.4.1.1 All materials obtained from dismantling or demolition shall be the property of the Employer unless otherwise specified and shall be kept in safe custody until they are handed over to the Engineer.

4.4.1.2 The demolition shall always be well planned before hand and shall generally be done in reverse order of the one in which the structure was constructed. The operations shall be got approved from the Engineer-In-Charge before starting the work.

4.4.1.3 Due care shall be taken to maintain the safety measures prescribed in IS: 4130.

4.4.1.4 Necessary propping, shoring and or under pinning shall be provided to ensure the safety of the adjoining work or property before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Wherever specified, temporary enclosures or partitions shall also be provided, as directed by the Engineer.

4.4.1.5 Necessary precautions shall be taken to keep down the dust nuisance to the minimum.

4.4.1.6 Dismantling shall be done in a systemic manner. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry etc. shall be carefully removed first. The dismantled articles shall be removed manually or otherwise, lowered to the ground (and not thrown) and then properly stacked as directed by the Engineer.

4.4.1.7 Where existing fixing is done by nails, screws, bolts, rivets, etc., dismantling shall be done by taking out the fixing with proper tools and not by tearing or ripping off.

4.4.1.8 Any serviceable material, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the Engineer within a lead of 50 m. All unserviceable materials rubbish etc. shall be disposed off as directed by the Engineer.

4.4.1.9 The Contractor shall maintain / disconnect existing services, whether temporary or permanent, where required by the Engineer.

4.4.2 Measurements

4.4.2.1 All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated hereinafter.

1. Dimensions shall be measured correct to a cm.
2. Areas shall be worked out in sq mt correct to two places of decimal.
3. Cubical contents shall be worked out to the nearest 0.01 cum.

4.4.2.2 Parts of work required to be dismantled and those required to be demolished shall be measured separately.

4.4.2.3 Measurements of all works except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

4.4.2.4 Specifications for deduction for voids, openings etc. shall be on the same basis as that adopted for new construction of the work.

4.4.2.5 Work executed in the following conditions shall be measured separately:

1. Work in or under water and / or liquid mud;
2. Work in or under foul position.

4.4.3 Rates

4.4.3.1 The rate shall include the cost of all labour involved and tools used in demolishing and dismantling including scaffolding. The rate shall also include the charges for separating out and stacking the serviceable material properly and disposing off unserviceable material within a distance of 50 m.

4.4.3.2 The rate shall also include for temporary shoring for the safety of portions not required to be pulled down, or of adjoining property, and providing temporary enclosures or partitions, where considered necessary.

4.5 Roofs

4.5.1 Roof coverings generally including battens boarding, mats, bamboo jaffari or other subsidiary supports shall be measured in sq mt except lead sheet roof covering, which shall be measured in quintals **(Clause 3.5.4)** and stone slab roof covering which shall be measured in cum.

4.5.2 Ridges, hips and valleys shall be girthed and included with the roof area. Corrugated or semi corrugated surfaces shall be measured flat and not girthed.

4.5.3 Mud phuska on roofs shall be measured in cum.

4.5.4 Lead sheets in roofs shall be measured in quintals and hips, valleys, flashings, lining to gutter etc. Shall be included in this weight.

4.5.5 R.B. or R.C.C. roofs shall be measured as specified in **Clause 3.10**.

4.5.6 Supporting members, such as rafters, purlins, beams joists, trusses etc. where of wood shall be measured in cum and steel or iron sections in quintals.

4.6 Ceiling

4.6.1 The stripping of ceilings shall be measured in sqm.

4.6.2 Dismantling of supporting joists, beams, etc. shall be measured in cum or in quintals as specified in **Clause 3.5.6**.

4.6.3 Height above floor levels if it exceeds 3.5 m shall paid for separately.

4.7 Flooring and Paving

4.7.1 Dismantling of floors (except concrete and brick floors) shall be measured in sqm. Supports such as joints, beams etc. if any shall be measured as per **Clause 3.5.6.** Concrete and bricks paving shall be measured as per **Clause 3.8**.

4.8 Concrete and Brick Roofs and Suspended Floors

4.8.1 Demolition of floors and roofs of concrete or brick shall be measured in cum. Beams cantilevers or other subsidiary supports of similar materials shall be included in the item. In measuring thickness of roofs provided with water proofing treatments with bitumen, felts, the thickness of water proofing treatment shall be ignored.

4.9 Walls and Piers

4.9.1 Taking down walls and independent piers or columns of brick, stone or concrete shall be measured, in cum. All copings, corbels, cornices and other projections shall be included with the wall measurements.

4.9.2 In measuring thickness of plastered walls, the thickness of plaster shall be ignored.

4.9.3 Ashlar face stones, dressed stone work, precast concrete articles, etc. if required to be taken down intact shall be so stated, and measured separately in cum.

4.9.4 Cleaning bricks stacking for measurements including all extra handling and removal and disposing off the rubbish as stated shall be enumerated in thousand of cleaned bricks.

4.9.5 Cleaning stone obtained from demolished / dismantling stone masonry of any description including ashlar facing dressed stone work, stone slabs or flagging and precast concrete blocks including all extra handling and disposing of the rubbish as stated shall be measured in cum of cleaned stone.

4.9.6 Honey comb works or cavity walls of bricks stone or concrete shall be measured as solid.

4.10 Reinforced Concrete and Brick Work

4.10.1 Reinforced concrete structures and reinforced brick roof and walls shall be measured in cum and if reinforcement is required to be salvaged, it shall be so stated.

4.10.2 Where reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately in quintal of salvaged steel.

4.11 Partitions, Trellis Work, Etc.

4.11.1 Partitions or light walls of lath and plaster, trellis work, expanded metal, thin concrete or terracotta slabs and other similar materials including frame work if any shall be measured in sqm stating the over all thickness.

4.12 Wood Work

4.12.1 All wood work including karries average 40 sq cm or over in section, shall be measured in cum, while that under 40 sq cm in section, in running metres. Ballies shall be measured in running metres.

4.12.2 Boarding including wooden chajjas and sun shades along with supports shall be measured in square m in its plane.

4.13 Steel and Iron Work

4.13.1 All steel and iron work shall be measured in quintals. The weight shall be computed from standard tables unless the actual weight can readily be determined.

4.13.2 Riveted work, where rivets are required to be cut, shall be measured separately.

4.13.3 Marking of structural steel required to be re-erected shall be measured separately.

4.13.4 In framed steel items, the weight or any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

4.14 Doors and Windows

4.14.1 Dismantling of doors, windows, clerestory windows, ventilators etc. (Wood or metal) whether done separately or along with removal of wall by making recess in the wall shall be enumerated. Those exceeding 3 sqm each in area shall be measured separately. The item shall include removal of chowkhats architraves, hold fasts and other attachments.

4.14.2 If only shutters are to be taken out it shall be measured separately.

4.15 Pipes and Sewer Lines

4.15.1 Water pipe lines including rain water pipes with clamps and specials, sewer lines (salt glazed ware or concrete) etc. shall be described by their diameter and length measured in running m inclusive of joints.

4.15.2 If the joints, special and fittings etc. Are required to be separated, it shall be so stated and enumerated.

4.15.3 Pucca drains shall be measured under relevant items.

4.15.4 Value cistern, public fountain platform, fire hydrants, etc. shall be enumerated.

4.15.5 Manholes and inspection chambers shall be enumerated stating the size and depth of manhole/inspection chamber. They shall be classified into different groups depending upon

the depth, in unit of half and one m depth. The depth of the manhole shall be the distance between the top of manhole cover and invert level of the drain.

4.15.6 Ventilating shafts, gully traps, flushing cisterns and other appurtenant items of work shall be enumerated.

4.16 Posts or Struts

4.16.1 Posts or struts (wood, steel or RCC) section including taking out embedded portion shall be measured in running m.

4.17 Fencing Wire Mesh

4.17.1 Wire mesh fencing of any type with frame shall be measured in square m.

4.18 Glazing

4.18.1 Taking out any portion of serviceable glass except polished plate, from old sashes, skylights, etc. (any thickness, weight or size) raking out old putty, etc. shall be measured in square m.

4.18.2 Irregular or circular panes shall be measured as rectangle or square enveloping the same. The width and height being measured correct to the nearest 0.5 cm.

4.19 Dismantling Culverts, Bridges and Other Structures/Pavements

4.19.1 Dismantling Culverts and Bridges

4.19.1.1 The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the part of the structure to be retained and any other properties or structures nearby.

4.19.1.2 Unless otherwise specified, the superstructure portion of culverts / bridges shall be entirely removed and other parts removed below the ground level or as necessary depending upon the interference they cause to the new construction. Removal of overlaying or adjacent material, if required in connection with the dismantling of the structures shall be incidental to this item.

4.19.1.3 Where existing culvert / bridges are to be extended or otherwise incorporated in the new work, only such part or parts of the exiting structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place to project into the new work as dowels or ties are not injured during removal of concrete.

4.19.1.4 Pipe culverts shall be carefully removed in such manner as to avoid damage to the pipes.

4.19.1.5 Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. If specified in the Drawings or directed by the Engineer that the structure is to be removed in a condition suitable for re-erection, all members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

4.19.1.6 Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber when designated by the Engineer to be salvaged.

4.19.2 Dismantling Pavements and Other Structures

4.19.2.1 In removing pavements, kerbs, gutters and other structures like guard-rails, fences, manholes, catch-basins, inlets, etc. where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the Engineer.

4.19.2.2 All concrete pavements, base courses in carriageway and shoulders etc., designated for removal shall broken to pieces whose volume shall not exceed 0.02 cum and stockpiled at designated locations if the material is to be used later or otherwise arranged for disposal as directed (see **Clause 3.19.4)**.

4.19.3 Back-filling

4.19.3.1 Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

4.19.4 Disposal of Materials

4.19.4.1 All materials obtained by dismantling shall be the property of Employer. Unless otherwise specified, materials having any salvage value shall be placed in neat stacks of like materials within the right-of-way, as directed by the Engineer with all lifts and up to a lead of 1000 m.

4.19.4.2 Pipe culverts that are removed shall be cleaned and neatly piled on the right-of-way at points designated by the Engineer with all lifts and lead up to 1000 m.

4.19.4.3 Structural steel removed from old structures shall, unless otherwise specified or directed, be stored in a neat and presentable manner on blocks in locations suitable for loading. Structures or portions thereof which are specified in the Contract for re-erection shall be stored in separate piles.

4.19.4.4 Timber or lumber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed there from and shall be stored in neat piles in locations suitable for loading.

4.19.4.5 All materials obtained from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed of as directed by the Engineer with all lifts and up to a lead of 1000 m.

4.19.5 Measurements for Payment

4.19.5.1 The work of dismantling structures shall be paid for in units indicated below by taking measurements before and after, as applicable:

1.	Dismantling brick/stone masonry/concrete (plain and reinforced)	cum.
2.	Dismantling flexible and cement concrete pavement	cum.
3.	Dismantling steel structures	tonne
4.	Dismantling timber structures	cum.
5.	Dismantling pipes, guard rails, kerbs, gutters and fencing	linear m.
6.	Utility services	Nos.

4.19.6 Rates

4.19.6.1 The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. These will also include excavation and backfilling where necessary to the required compaction and for handling, salvaging, piling and disposing of the dismantled materials within all lifts and up to a lead of 1000 m.

5 CARRIAGE OF MATERIALS

5.1 Scope

This Specification covers the general requirements for carriage of materials.

5.2 General

The carriage and stacking of materials shall be done as directed by the Engineer. Any tools and plants required for the work shall be arranged by the Contractor. The carriage of materials including loading within a lead of 50m, unloading and stacking within a lead of 50m.

5.3 Responsibility for Loss or Damage

Loading, carriage, unloading and stacking shall be done carefully to avoid loss or damage to the materials. In case of any loss or damage, recovery shall be effected from the Contractor at twice the departmental issue rates of the materials. If the departmental issue rates of the materials are not available then the recovery shall be effected at twice the prevailing market rates as determined by the Engineer.

5.4 Mode of Carriage

Depending upon the feasibility and economy, the Engineer shall determine the mode of carriage viz. whether by mechanical or animal transport or manual labour.

5.5 Lead

5.5.1 All distances shall be measured over the shortest practical route and not necessarily the route actually taken.

5.5.2 Carriage by manual labour shall be reckoned in units of 50 m.

5.5.3 Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.5 km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km, it will not be ignored but paid for separately in successive stages of 50 m subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km by mechanical / animal transport.

5.6 Stacking, Covering and Protection

Material shall be stacked in such a manner as to ensure the preservation of their quality and fineness for the work. Different types of materials shall be stacked separately and in such a way that counting and measurements can be done without disturbing the stacks. Any material that is liable to be affected by rain or other adverse weather conditions shall be covered and protected against the same.

5.6.1 Earth, dismantled materials, malba and other similar materials shall be stacked as directed by the Engineer.

5.6.2 Cement bags, steel bars, structural steel sections, bricks and timber and other similar materials shall be stacked in regular tiers.

5.6.3 Pipes of RCC, SW, GI, CI, etc. shall be stacked in rows.

5.6.4 Lime, stone metal, sand and such similar materials shall be stacked as directed by the Engineer.

5.7 Measurements

Length, breadth and height of stacks shall be measured correct to a cm. The quantity shall be worked out in cubic metre correct to two places of decimal. The volume of stacks, shall be reduced by percentages as shown against each for looseness in stacking to arrive at the net quantity for payment. No reduction shall be made in respect of articles or materials for which mode of payment is by length or weight or number.

5.7.1 Earth

In loose stacks such as cart loads, lorry loads, etc.	20 %
In fills consolidated by light mechanical machinery	10 %
In fills consolidated by heavy mechanical machinery but not under OMC	5 %
In fills consolidated by heavy mechanical machinery at OMC	Nil
Consolidated fills in confined situation such as under floors etc.	Nil

5.7.2 Others

Manure or sludge	8 %
Moorum, building rubbish Lime and sand	Nil
Stone metal, 40 mm nominal size and above	7.5 %
Coarse aggregate/stone metal below 40 mm nominal size	Nil
Soling Stone / Boulder 100 mm and above	15 %
Excavated rocks	50 %

5.8 Rate

5.8.1 The rate for carriage of materials is inclusive of all the operations described above.

6 EARTHWORK, EROSION CONTROL AND DRAINAGE

6.1 Scope

6.1.1 This Specification covers the general requirements of earthwork in excavation in different materials necessary for the construction of the Works including structures, roadway, side drains, sewers and water supply lines in accordance with requirements of these Specifications and the lines, grades and cross-section shown in the Drawings or as indicated by the Engineer. This Specification also includes site grading, filling in areas as shown in Drawing, filling back around foundations, plinths and approach ramps, conveyance and disposal of surplus spoils or stacking them properly as shown on the Drawings or as directed by the Engineer and all operations covered within the intent and purpose of this Specification. It shall also include the hauling and stacking of or hauling to sites of embankment and subgrade construction, suitable cut materials as required, as also the disposal of unsuitable cut materials in specified manner, trimming and finishing of the road to specified dimensions or as directed by the Engineer.

6.1.2 Excavation for structures shall consist of the removal of material for the construction of foundation for bridges, culverts, retaining walls, headwalls, cutoff walls, pipe culverts and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the Drawings or as indicated by the Engineer. The work shall include construction of the necessary cofferdams and cribs and their subsequent removal; all necessary sheeting, shoring, bracing, draining and pumping; the removal of all logs, stumps, grubs and other deleterious matter and obstructions, necessary for placing the foundations; trimming bottoms of excavations; backfilling and clearing up the site and the disposal of all surplus material.

6.2 Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

1. IS: 783 Code of practice for laying of concrete pipes.
2. IS: 1200 Method of Measurement of Building Works (Part I).
3. IS: 3764 Safety code for excavation work.
4. IS: 3385 Code of practice for measurement of Civil Engineering Works.
5. IS: 2720 Method of test of soils (All parts)
6. IS: 1498 Classification and identification of soils for General Engineering purposes
7. IS: 2809 Glossary of terms and symbols relating to Soil Engineering
8. IS: 4081 Safety code for blasting and related drilling operations
9. IS: 4988 Glossary of terms and classifications of earth moving machinery (All Parts)

6.3 Drawings

Engineer will furnish Drawings wherever, in his opinion, such Drawings are required to show areas to be excavated / filled, sequence of priorities etc. Contractor shall follow strictly such Drawings.

6.4 Classification of Excavated Material

6.4.1 Authority for classification

The classification of excavation shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosive in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Engineer.

6.4.2 Classification

All materials involved in excavation shall be classified by the Engineer in the following manner:

6.4.2.1 Soil

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

6.4.2.2 Ordinary Rock (not requiring blasting)

This shall include:

1. Rock types such as laterites, shales and conglomerates, varieties of limestone and sandstone etc., which may be quarried or split with crow bars, also including any rock which in dry state may be hard, requiring blasting but which, when wet, becomes soft and manageable by means other than blasting;
2. Macadam surfaces such as water bound and bitumen/tar bound; soling of roads, paths etc. and hard core; compact moorum or stabilised soil requiring grafting tool or pick or both and shovel, closely applied; gravel and cobble stone having maximum dimension in any one direction between 75 and 300 mm;
3. Lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar below ground level, reinforced cement concrete which may be broken up with crow bars or pick and stone masonry in cement mortar below ground level; and
4. Boulders which do not require blasting having maximum dimension in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.

6.4.2.3 Hard Rock (requiring blasting)

This shall comprise:

1. Any rock or cement concrete for the excavation of which the use of mechanical plant and/or blasting is required;
2. Reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
3. Boulders requiring blasting.

6.4.2.4 Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under Clause 5.4.2.3 but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

6.4.2.5 Marshy Soil

This shall include soil like soft clays and peats excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

6.5 General

6.5.1 Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary work, consumable, any and everything necessary, whether or not such items are specifically stated herein for completion of the job in accordance with Specification requirements.

6.5.2 Contractor shall carry out the survey of the site before excavation and properly mark all lines and establish levels for various works such as earthwork in excavation for grading, basement, foundations, plinth filling, roads, drains, cable, trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference / grid lines at intervals as determined by Engineer based on ground profile. These shall be checked by Engineer and thereafter properly recorded.

6.5.3 The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night for ensuring safety.

6.5.4 The rates quoted shall also include the dumping of excavated materials in regular heaps, bunds, riprap with regular slopes as directed by Engineer, within the lead specified and leveling the same as to provide natural drainage. Rock / soil excavated shall be stacked properly as directed by Engineer. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

6.6 Clearing

6.6.1 The area to be excavated / filled shall be cleared as described in Chapter 2.

6.7 Timber Shoring

6.7.1 Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'Polling Boards'. These shall be of minimum 25 cm X 4 cm sections or as directed by Engineer. The boards shall generally be placed in position, vertically, side by side without any gap, on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 metres spacing, strutted with “Ballies” or as directed by Engineer. The length of the “Ballie” struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

6.7.2 Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by Engineer In- Charge. It shall be the responsibility of Contractor to take all necessary steps to prevent the sides of excavation, trenches, pits, etc., from collapsing.

6.7.3 Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only on instructions from Engineer.

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

6.7.5 In case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm X 4 cm sections shall be spaced sufficiently

apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of Engineer. In all other respects, Specification for close timbering shall apply to open timbering.

6.7.6 In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations / pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut. If, however, Engineer directs any timbering to be left-in, keeping in mind the type of construction or any other factor, Contractor shall be paid for, at the scheduled item rate, for such left-in timbering.

6.7.7 Measurement

6.7.7.1 The actual effective area of shored faces as approved by Engineer shall be measured in sqm. The area of planking embedded in the bed / sides of excavation will not be considered, nor the area supporting inclined struts in case of large pits / open excavation. All planks, boards, walling, vertical, struts, props and all other materials required for shoring and subsequent safe dismantling and removal shall be included in the quoted unit rates.

6.7.7.2 Unless separately provided for in the schedule of quantities, shoring is deemed to have been included in the unit rates quoted for excavation.

6.8 Slips and Slides

6.8.1 If slips, slides, over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Engineer. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of Contractor. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the Contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the Contractor. The classification of the debris material from the slips, slides etc., shall conform to its condition at the time of removal and payment made accordingly regardless of its condition earlier.

6.9 Dewatering

6.9.1 If water is met within the excavations due to springs, seepage, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry whenever so required or directed by the Engineer. Care shall be taken to discharge the drained water into suitable outlet as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair / restore to the original condition at his own cost or compensate for the damage. Sumps made for dewatering must be kept clear of the excavations / trenches required for further work. Method of pumping shall be approved by Engineer; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

6.9.2 All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas.

6.9.3 When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Engineer, as large, 'Well Point System' - single stage or multistage, shall be adopted. Contractor shall submit to Engineer his scheme of well point system including the stages, the spacing, number and diameter of well points, headers, etc. and the number, capacity and location of pumps for approval. Unless separately provided for in the schedule of prices, the cost of dewatering shall be included in the item rate for excavation.

6.9.4 Unless separately provided for in the schedule of quantities, dewatering is deemed to have been included in the unit rates quoted for excavation. If separately provided for, the unit of measurement shall be as indicated in the schedule of quantities.

6.10 Methods, Tools and Equipment

6.10.1 Only such methods, tools and equipment as approved by the Engineer shall be adopted / used in the work. If so desired by the Engineer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

6.11 Rock Excavation

6.11.1 Rock, when encountered, shall be removed up to the formation / bed level or as otherwise indicated on the Drawings. Where, however, unstable shales or other unsuitable materials are encountered at the formation / bed level, these shall be excavated to the extent of 500 mm below the formation / bed level or as otherwise specified. In all cases; the excavation operations shall be so carried out that at no point on cut formation / bed the rock protrudes above the specified levels. Rocks and large boulders which are likely to cause differential settlement and also local drainage problems should be removed to the extent of 500 mm below the formation / bed level in full formation / bed width including drains and cut through the side drains.

6.11.2 Where excavation is done to levels lower than those specified, the excess excavation shall be made good as per **Clauses 5.13.3 and 5.13.9** to the satisfaction of the Engineer.

6.11.3 Slopes in rock cutting shall be finished to uniform lines corresponding to slope lines shown on the Drawings or as directed by the Engineer. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface which move when pierced by the crowbar shall be removed.

6.11.4 Where blasting is to be restored to, the same shall be carried out to **Clause 5.17** and all precautions indicated therein observed.

6.11.5 Where pre-splitting is prescribed to be done for the establishment of a specified slope in rock excavation, the same shall be carried out to **Clause 5.18**.

6.11.6 For measurement of rock excavation, the overburden shall be removed first so that necessary cross-sections could be taken for measurement. Where cross sectional measurements could not be taken due to irregular configuration or where the rock is admixed with other classes of materials, the volumes shall be computed on the basis of stacks of excavated rubble after making 35 percent deduction there from.

6.12 Marsh Excavation

6.12.1 The excavation of soils from marshes/swamps shall be carried out as per the programme approved by the Engineer.

6.12.2 Excavation of marshes shall begin at one end proceed in one direction across the entire marsh immediately ahead of backfilling. The method and sequence of excavating and backfilling shall be such as to ensure, to the extent practicable, the complete removal or displacement of all muck from within the lateral limits called for on the Drawings or as stated by the Engineer, and to the bottom of the marsh, firm support or levels indicated.

6.13 Construction Operations for Roadways

6.13.1 Setting out

After the site has been cleared as per **Chapter 2**, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the Drawings or as directed by the Engineer as per the provisions of **Clause 1.10**. The Contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboos, stones, lime, mortar, concrete, etc., required in connection with the setting out of works and the establishment of bench marks. The Contractor shall be responsible for the maintenance of bench marks and other marks and stakes as long as in the opinion of the Engineer, they are required for the work.

6.13.2 Stripping and storing topsoil

When so directed by the Engineer, the topsoil existing over the sites of excavation shall be stripped to specified depths and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation is desired. Prior to stripping the topsoil, all trees, shrubs etc., shall be removed along with their roots, with approval of the Engineer.

6.13.3 Excavation

6.13.3.1 All excavations shall be carried out in conformity with the directions laid here-in-under and in a manner approved by the Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand.

6.13.3.2 While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc., as per **Clause 5.21.**

6.13.3.3 The excavations shall conform to the lines, grades, side slopes and levels shown on the Drawings or as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth / width excavated beyond the specified level / dimensions on the Drawings shall be made good at the cost of the Contractor with suitable material of characteristics similar to that removed and compacted to the requirements of **Clause 5.20**.

6.13.3.4 All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required slopes excepting that when boulders or soft materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the Engineer and the resulting cavities filled with suitable material and thoroughly compacted in an approved manner.

6.13.3.5 After excavation, the sides of excavated area shall be trimmed and the area contoured to minimise erosion and ponding, allowing for natural drainage to take place. If trees were removed, new trees shall be planted, as directed by the Engineer. The cost of planting new trees shall be deemed to be incidental to the work.

6.13.4 Excavation of road shoulders / verge / median for widening of pavement or providing treated shoulders

6.13.4.1 In works involving widening of existing pavements or providing treated shoulders, unless otherwise specified, the shoulder / verge / median shall removed to their full width and to levels shown on Drawings or as indicated by the Engineer. While doing so, care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed. If the existing pavement gets disturbed or loosened, it shall be dismantled and cut to a regular shape with sides vertical and the disturbed/loosened portion removed completely and relaid as directed by the Engineer, at the cost of the Contractor.

6.13.5 Disposal of excavated materials

6.13.5.1 All the excavated materials shall be the property of the Employer. The material obtained from the excavation of roadway, shoulders, verges, drains, trenches, cross drainage works etc., shall be used for filling up of (i) roadway embankment, (ii) the existing is in the right-of-way and (iii) for landscaping of the road as directed by the Engineer, including leveling and spreading with all lifts and lead up to 100 mm and no extra payment shall be made for the same.

6.13.5.2 All hard materials, such as hard moorum, rubble, etc., not intended for use as above shall be stacked neatly on specified land as directed by the Engineer with all lifts and lead up to 1000m.

6.13.5.3 Unsuitable and surplus material not intended for use within the lead specified above shall also, if necessary, be transported with all lifts and lead beyond initial 1000m, disposed off or used as directed by the Engineer.

6.13.6 Backfilling

6.13.6.1 Backfilling of masonry / concrete / hume pipe drain excavation shall be done with approved material after concrete / masonry / hume pipe is fully set and carried out in such a way as not to cause undue thrust on any part of the structure and / or not be cause differential settlement. All space between the drain walls and the side of the excavation shall be refilled to the original surface making due allowance for settlement, in layers not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such as mechanical tamper, rammer or plate compactor / vibrator, etc. after necessary watering, so as to achieve a density not less than the field density before excavation or as directed by the Engineer.

6.13.7 Plying of Construction Traffic

6.13.7.1 Construction traffic shall not use the cut formation and finished subgrade without the prior permission of the Engineer. Any damage arising out of such use shall be made good by the Contractor at his own expense.

6.13.8 Preservation of Property

6.13.8.1 The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sewers or other sub-surface drains, pipes, conduits and any other structures under or above ground, which may be affected by construction operations and which, in the opinion of the Engineer, shall be continued in use without any changes. Safety measures taken by the Contractor in this respect, shall be got approved from the Engineer. However, if any of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition at his expense. If the Contractor fails to do so, within the required time as directed by the Engineer or if, in the opinion of the Engineer, the actions initiated by the Contractor to replace / restore the damaged objects are not satisfactory, the Engineer shall arrange the replacement / restoration directly through any other agency at the risk and cost of the Contractor after issuing a prior notice to the effect.

6.13.9 Preparation of Cut Formation

6.13.9.1 The cut formation, which serves as a subgrade, shall be prepared to receive the sub-base / base course as directed by the Engineer.

6.13.9.2 Where the material in the subgrade (that is within 500 mm from the lowest level of the pavement) has a density less than specified in **Table 5-4,** the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of **Clause 5.20**. Any unsuitable material encountered in the subgrade level shall be removed as directed by the Engineer and replaced with suitable material compacted in accordance with **Clause 5.20.**

6.13.9.3 In rocky formations, the surface irregularities shall be corrected and the levels brought up to the specified elevation with granular base material as directed by the Engineer, laid and compacted in accordance with respective Specifications for these materials. The unsuitable material shall be disposed off in accordance with **Clause 5.13.5**. After satisfying the density requirements, the cut formation shall be prepared to receive the sub base / base course in accordance with **Clause 5.24 and 5.25** to receive the sub-base/base course.

6.13.10 Finishing Operations

6.13.10.1 Finishing operations shall include the work of properly shaping and dressing all excavated surfaces.

6.13.10.2 When completed, no point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock (hard or soft) where no point shall vary more than 300 mm from the designated slope. In no case shall any portion of the slope encroach on the roadway.

6.13.10.3 The finished cut formation shall satisfy the surface tolerances described in **Clause 902** of MoST Specifications for Roads and Bridge Works (IV Revision).

6.13.10.4 Where directed, the topsoil removed earlier and conserved (**Clauses 5.13.2 and 5.20.4.3**) shall be spread over cut slopes, where feasible, berms and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond. The depth of topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 100 mm.

6.13.11 Measurement for Payment

6.13.11.1 Excavation for roadway shall be measured by taking cross sections at suitable intervals in the original position before the work starts and after its completion and computing the volumes in cum. by the method of average end areas for each class of material encountered. Where it is not feasible to compute volumes by this method because of erratic location of isolated deposits, the volumes shall be computed by other accepted methods.

6.13.11.2 At the option of the Engineer, the Contractor shall leave depth indicators during excavations of such shape and size and in such positions as directed so as to indicate the original ground level as accurately as possible. The Contractor shall see that these remain intact till the final measurements are taken.

6.13.11.3 When volumes are calculated as in **Clause 5.11.6** for excavated material other than rock, deduction made will be to the extent of 16 percent of stacked volumes.

6.13.11.4 Works involved in the preparation of cut formation shall be measured in units indicated below:

1.	Loosening and recompacting the loosened material at subgrade	cum.
2.	Loosening and removal of unsuitable material and replacing with a suitable material and compacting to required density	cum.
3.	Preparing rocky subgrade	sqm.
4.	Stripping including storing and reapplication of topsoil	cum.
5.	Disposal of surplus material beyond initial 1000 m lead	cum.

6.13.12 Rates

6.13.12.1 The Contract unit rates for the items of roadway and drain excavation shall be payment in full for carrying out the operations required for the individual items including full compensation for:

1. Setting out;
2. Transporting the excavated materials and depositing the same on sites of embankments, spoil banks or stacking as directed within all lifts and lead up to 1000 m or as otherwise specified;
3. Trimming bottoms and slopes of excavation;
4. Dewatering;
5. Keeping the work free of water;
6. All labour, materials, tools, equipment, safety measures, testing and incidentals necessary to complete the work to Specifications.

Provided, however, where pre-splitting is prescribed to achieve a specified slope in rock excavation, the same shall be paid for vide **Clause 5.19.4.**

6.13.12.2 The contract unit rate for loosening and recompacting the loosened materials at subgrade shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

6.13.12.3 **Clauses 5.13.12.1 and 5.20.9** shall apply as regards Contract unit rate for item of removal of unsuitable material and replacement with suitable material respectively.

6.13.12.4 The Contract unit rate for item of preparing rocky subgrade **as per Clause 5.13.9** shall be full compensation for providing, laying and compacting granular base material for correcting surface irregularities including all materials, labour and incidentals necessary to complete the work and all leads and lifts.

6.13.12.5 The Contract unit rate for the items of stripping and storing topsoil and of reapplication of topsoil shall include full compensation for all the necessary operations including all lifts, but leads up to 1000 m.

6.13.12.6 The Contract unit rate for disposal of surplus earth from roadway and drain excavation shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the initial lead of 1000 m.

6.14 Construction Operation for Structures

6.14.1 Setting out

After the site has been cleared according to Chapter 2, the limits of excavation shall be set out true to lines, curves and slopes to **Clause 5.13.1**.

6.14.2 Excavation

6.14.2.1 Excavation shall be taken to the width of the lowest step of the footing and the sides shall be left plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

6.14.2.2 The depth to which the excavation is to be carried out shall be as shown on the Drawings, unless the type of material encountered is such as to require changes, in which case the depth shall be as ordered by the Engineer. Propping shall be undertaken when any foundation or stressed zone from the adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

6.14.2.3 Where blasting is to be resorted to, the same shall be carried out in accordance with **Clause 5.17** and all precautions indicated therein observed. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris etc., shall be taken to prevent any damage.

6.14.3 Dewatering and protection

6.14.3.1 Normally, open foundations shall be laid dry. Where water is met with in excavation due to stream flow, seepage, springs, rain or other reasons, the Contractor shall take adequate measures such as bailing, pumping, constructing diversion channels, drainage channels, bunds, depression of water level by well point system, cofferdams and other necessary works to keep the foundation trenches dry when so required and to protect the green concrete / masonry against damage by erosion or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor but subject to approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

6.14.3.2 Where cofferdams are required, these shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipment, etc., inside the enclosed area.

6.14.3.3 If it is determined beforehand that the foundation cannot be laid dry or the situation is found that the percolation is too heavy for keeping the foundation dry, the foundation concrete shall be laid under water by tremie pipe only. In case of flowing water or artesian springs, the flow shall be stopped or reduced as far as possible at the time of placing the concrete.

6.14.3.4 Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for any period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or other similar means.

6.14.3.5 At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the excavation area.

6.14.3.6 The Contractor shall take all precautions in diverting channels and in discharging the drained water as not to cause damage to the works, crops or any other property.

6.14.4 Preparation of Foundation

6.14.4.1 The bottom of the foundation shall be leveled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed. In the event of excavation having been made deeper than that shown on the Drawings or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation at the cost of the Contractor as per **Clause 2104.**1 of MoST Specifications for Roads and Bridge Works (IV Revision). Ordinary filling shall not be used for the purpose to bring the foundation to level.

6.14.4.2 When rock or other hard strata is encountered, it shall be freed of all soft and loose material, cleaned and cut to a firm surface either level and stepped as directed by the Engineer. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the Engineer. In the case of excavation in rock, annular space around footing shall be filled with lean concrete (1:3:6 nominal mix) upto the top level of rock.

6.14.4.3 If the depth of fill required is more than 1.5 m above the top of the footing, filling up to 1.5 m above top of footing shall be done with lean concrete (1:3:6 nominal mix) followed by boulders grouted with cement.

6.14.4.4 When foundation piles are used, the excavation of each pit shall be substantially completed before beginning pile-driving operations therein. After pile driving operations in a given pit are completed, all loose and displaced materials therein shall be removed to the elevation of the bottom of the footings.

6.14.4.5 Slips and slip-outs: If there are any slips of slip-outs in the excavation, these shall be removed by the Contractor at his own cost.

6.14.5 Public Safety

Near towns, villages and all frequented places, trenches and foundation pits shall be securely fenced, provided with proper caution signs and market with red lights as night to avoid accidents. The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS: 3764.

6.14.6 Backfilling

Backfilling shall be done with approved material after concrete or masonry is fully set and carried out in such a way as not to cause undue thrust on any part of the structure. All space between foundation masonry or concrete and the sides of excavation shall be refilled to the original surface in layers not exceeding 150 mm compacted thickness. The compaction shall be done with the help of suitable equipment such as mechanical tamper, rammer, plate vibrator etc., after necessary watering, so as to achieve a density not less than the field density before excavation.

6.14.7 Disposal of Surplus excavated materials shall be as per **Clause 5.13.5**

6.14.8 Measurement for Payment

6.14.8.1 Excavation for structures shall be measured in cum. for each class of material encountered, limited to the dimensions shown on the Drawings or as directed by the Engineer. Excavation over increased width, cutting of slopes, shorting, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for separately.

6.14.8.2 Preparation of rock foundation shall be measured in square metres. Foundation sealing, dewatering, including pumping shall be deemed to be incidental to the work unless separate provision is made for in the Contract. In the latter case, payment shall be on lump sum basis as provided in the Bill of Quantities.

6.14.9 Rates

6.14.9.1 The Contract unit rate for the items of excavation for structures shall be payment in full for carrying out the required operations including full compensation for:

1. Setting out;
2. Construction of necessary cofferdams, cribs, sheeting, shoring and bracing and their subsequent removal;
3. Removal of all logs, stumps, grubs and other deleterious matter obstructions, for placing the foundations including trimming of bottoms of excavations;
4. Foundation sealing, dewatering including pumping when no separate provision for it is made in the Contract;
5. Backfilling, clearing up the site and disposal of all surplus material within all lifts and leads up to 1000 m or as otherwise specified; and
6. All labour, material, tools, equipment, safety measures, diversion of traffic and incidentals necessary to complete the work to Specification.

6.14.9.2 The Contract unit rate for preparation of rock foundation shall be full compensation for cutting, trimming and cleaning the foundation surface and filling/sealing of all seams with cement grout or mortar including all materials, labour and incidents required for completing the work.

6.14.9.3 The Contract unit rate for transporting material from the excavation for structures shall be full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul of transportation involved beyond the initial lead of 1000 m.

6.15 Construction Operation for Sewers and Water Supply Lines

6.15.1 Setting out

After the site has been cleared according to Chapter 2, the limits of excavation shall be set out true to lines, curves and slopes to **Clause 5.13.1**.

6.15.2 Excavation:

6.15.2.1 All excavation work shall be carried out by mechanical equipment unless, in the opinion of Engineer, the work involved and time schedule permit manual work.

6.15.2.2 Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the Drawings or such other lines and grades as may be specified by Engineer. Rough excavation shall be carried out to a depth 150 mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed even below the final level and extra excavation filled up as directed by Engineer. The final excavation if so instructed by Engineer should be carried out just prior to laying the mud-mat.

6.15.2.3 Contractor may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by Engineer, at his own cost, outside the lines shown on the Drawings or directed by Engineer. Should any excavation be taken below the specified elevations. Contractor shall fill it up, with concrete of the same class as in the foundation resting thereon, up to the required elevation. No extra shall be claimed by Contractor on this account.

6.15.2.4 All excavations shall be done to the minimum dimension as required for safety and working facility. Prior approval of Engineer shall be obtained by Contractor in each individual case, for the method he proposes to adopt for the excavation, including setting out, dimensions, side slopes, dewatering, disposal, etc. This approval, however, shall not in any way relieve Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand and precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of Contractor.

6.15.2.5 Excavation shall be carried out with such tools, tackles and equipment as described herein/before. Blasting or other methods may be resorted to in the case of hard rock; however not without the specific permission of Engineer.

6.15.2.6 Engineer may also direct that in some extreme case, the rock may be excavated by heating and sudden quenching for splitting the rock. Fire-wood shall be used for burning and payment shall be made for such work as called for in the schedule of quantities.

6.15.3 Stripping loose rock:

6.15.3.1 All loose boulders, semi detached rocks (along with earthy stuff which might move therewith) not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of Engineer, to fall or otherwise endanger the workmen, equipment, or the work, etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe.

6.15.3.2 Any material not requiring removal as contemplated in the work, but which, in the opinion of Engineer, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by Engineer. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

6.15.4 Filling, Backfilling and Site Grading:

6.15.4.1 General:

1. All fill material will be subject to Engineer's approval. If any material is rejected by Engineer, Contractor shall remove the same forthwith from the site at no extra cost to the Owner. Surplus fill material shall be deposited / disposed off as directed by Engineer after the fill work is completed.

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

6.15.4.2 Material:

1. To the extent available, selected surplus spoils from excavated materials shall be used as backfill. Fill material shall be free from clods, salts, sulphates, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of moorum or earth to fill up the voids and the mixture used for filling.

2. If any selected fill material is required to be borrowed, Contractor shall make arrangements for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of Engineer. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish etc. top soil containing salts / sulphate and other foreign material shall be removed. The materials so removed shall be burnt or disposed off as directed by Engineer. Contractor shall make necessary access roads to borrow areas and maintain the same, if such access road does not exist, at his cost.

6.15.4.3 Filling in pits and trenches around foundations of structures, walls etc.:

1. As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches etc. shall be cleared of all debris, and filled with earth in layers not exceeding 15 cm., each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of Engineer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless Engineer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and levelled to proper profile as directed by Engineer or indicated on the Drawings.

6.15.4.4 Plinth Filling:

1. Plinth filling shall be carried out with approved material as described hereinbefore in layers not exceeding 15 cm, watered and compacted with mechanical compaction machines. Engineer may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 2 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at a later stage. The finished level of the filling shall be trimmed to the level / slope specified.

2. Where specified in the schedule of works, compaction of the plinth fill shall be carried out by means of 12 tonne rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. A smaller weight roller may be used only if permitted by Engineer. As rolling proceeds water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fill.

3. The thickness of each unconsolidated fill layer can in this case be up to a maximum of 300 mm. Engineer will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used.

4. Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is to the satisfaction of Engineer, but in no case less than 10 passes of the roller will be accepted for each layer.

5. The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated and filled and consolidated.

6. At some locations / areas it may not be possible to use rollers because of space restrictions etc. Contractor shall then be permitted to use pneumatic tampers, rammers etc. and he shall ensure proper compaction.

6.15.4.5 Sand filling in plinth and other places:

1. At places backfilling shall be carried out with local sand if directed by Engineer. The sand used shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 2 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until Engineer has inspected and approved the fill.

6.15.4.6 Filling in trenches:

1. Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipe and drains have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes.

2. Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centerline of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centerline of the pipe shall be done with selected earth by hand compaction or other approved means in layers not exceeding 15 cm.

3. In case of excavation of trenches in rock, the filling up to a level 30 cm. above the top of the pipe shall be done with fine materials, such as earth, moorum etc. The filling up of the level of the centerline of the pipe shall be done by hand compaction in layers not exceeding 8 cm, whereas the filling above the centerline of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm. above the top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm. mixed with fine material as available to fill up the voids.

4. Filling of the trenches shall be carried out simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

6.15.5 General site grading:

1. Site grading shall be carried out as indicated in the Drawings and as directed by Engineer. Excavation shall be carried out as specified in the Specification. Filling and compaction shall be carried out as specified under Clause 3.2.10 and elsewhere unless otherwise indicated below.

2. If no compaction is called for, the fill may be deposited to the full height in one operation and levelled. If the fill has to be compacted, it shall be placed in layers not exceeding 225 mm and levelled uniformly and compacted as indicated in **Clause 5.15.4** before the next layer is deposited.

3. To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by Contractor at his cost.

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

5. Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, Contractor shall remove the affected material and make good the slip at his cost.

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

7. If specifically permitted by Engineer, compaction can be obtained by allowing loaded trucks conveying fill or other material to ply over the fill area. Even if such a method is permitted, it will be for Contractor to demonstrate that the desired / specified compaction has been obtained. In order that the fill may be reasonably uniform throughout, the material should be dumped in place in approximately uniform layers. Traffic over the fill shall then be so routed to compact the area uniformly throughout.

8. If so specified, the rock as obtained from excavation may be used for filling and leveling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cm, approximately. After rock filling to the approximate level, as indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 tonne roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

6.15.6 Fill density:

6.15.6.1 The compaction, only where so called for, in the schedule of quantities / items shall comply with the specified (Proctor / Modified Proctor) density at moisture content differing not more than 4 percent from the optimum moisture content. Contractor shall demonstrate adequately at his cost, by field and laboratory tests that the specified density has been obtained.

6.15.7 Lead:

6.15.7.1 Lead for deposition / disposal of excavated material, shall be as specified in the respective item of work. For the purpose of measurement of lead, the area to be excavated or filled or area on which excavated material is to be deposited / disposed off shall be divided into suitable blocks and for each of the blocks, the distance between centerlines shall be taken as the lead which shall be measured by the shortest straight line route on the plan and not the actual route taken by Contractor. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or 'katcha' land / route.

6.15.8 Measurement and payment:

6.15.8.1 All excavation shall be measured net. Dimensions for purpose of payment shall be reckoned on the mean horizontal area of the excavation multiplied by the mean depth from the surface of the ground in accordance with the Drawings. Reasonable working space, beyond concrete dimensions and shuttering where considered necessary in the opinion of Engineer will be allowed in excavation and considered for payment. However, if concreting is proposed on the excavated sides, no such over- excavation will be permitted. In such cases over- excavation shall be made good by Contractor with concrete of the same class as in the foundations at his cost.

6.15.8.2 Unless otherwise specified, the unit rates quoted for excavation in different types of material shall also account for a basic lead of 50 meters for disposal as specified or directed. Only leads beyond the basic lead of 50 meters will be considered as extra lead and paid for at the rates quoted in the schedules.

6.15.8.3 Backfilling as per Specification on the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will not be paid for separately. It shall be clearly understood that the quoted rates are for excavation / packing of selected stacked material, conveying it to the place of final backfill, compaction, etc. as specified. As a rule material to be backfilled shall be stacked temporarily within the basic lead of 50 meters unless otherwise directed by the Engineer. If Engineer directs / permits a lead of over 50 meters for such material, the conveyance of the material for the extra distance over the basic lead of 50 meters for backfilling will be paid for.

6.15.8.4 Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made only for compaction as specified / directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for excavation. Payment for this work will be made based on measurement of plinth / trench dimensions filled. The plinth group levels shall be surveyed beforehand for this purpose. If no compaction is specified / desired such filling will not be separately paid for. In such an event the fill shall be levelled finished to the profile as directed at no extra cost.

6.15.8.5 Backfilling, plinth filling, etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic meters. The lead, lift etc. shall be as indicated in the schedule of quantities.

6.15.8.6 Actual quantity of consolidated sand filling shall be measured and paid in cubic meters.

6.16 Construction Operation for Surface/Sub-Surface Drains

This work shall consist of constructing surface and/or sub-surface drains in accordance with the requirements of these Specifications and to the lines, grades, dimensions and other particulars shown on the Drawings or as directed by the Engineer. Schedule of work shall be so arranged that the drains are completed in proper sequence with road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drainage.

6.16.1 Surface Drains

6.16.1.1 Surface drains shall be excavated to the specified lines, grades, levels and dimensions to the requirements of **Clause 5.13**. The excavated material shall be removed from the area adjoining the drains and if found suitable, utilized in embankment / subgrade construction. All unsuitable material shall be disposed of as directed.

6.16.1.2 The excavated bed and sides of the drains shall be dressed to bring these in close conformity with the specified dimensions, levels and slopes.

6.16.1.3 Where so indicated, drains shall be lined or turfed with suitable materials in accordance with details shown on the Drawings.

6.16.1.4 All works on drain construction shall be planned and executed in proper sequence with other works as approved by the Engineer, with a view to ensuring adequate drainage for the area and minimising erosion / sedimentation.

6.16.2 Sub-surface Drains

Sub surface drains shall be of close joined perforated pipes, open jointed unperforated pipes, surrounded by granular material laid in a trench or aggregate drains to drain the pavement courses.

6.16.2.1 Materials

1. Pipe: Perforated pipes for the drains may be of metal / asbestos cement / cement concrete / PVC, and unperforated pipes of vitrified clay / cement concrete / asbestos cement. The type, size and grade of the pipe to be used shall be as specified in the Contract. In no case, however, shall the internal diameter of the pipe be less than 100 mm. Holes for perforated pipes shall be on one half of the circumference only and conform to the spacing indicated on the Drawings. Size of the holes shall not ordinarily be greater than half of D_{85} size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm. D_{85} stands for the size of the sieve that allows 85 per cent of the material to pass through it

2. Backfill material: Backfill material shall consist of sound, tough, hard, durable particles of free draining sand-gravel material or crushed stone and shall be free of organic material, clay balls or other deleterious matter. Unless the Contract specifies any particular gradings for the backfill material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the Engineer, the backfill material shall be provided on the following lines:

    I. Where the soil met with in the trench is of fine grained type (e.g., silt, clay or a mixture thereof), the backfill material shall conform to Class I grading set out in **Table 5-1**.
    II. Where the soil met with in the trench is of coarse silt to medium sand or sandy type, the backfill material shall correspond to Class II grading of **Table 5-1**.
    III. Where soil met with in the trench is gravelly sand, the backfill material shall correspond to Class III grading of **Table 5-1**.

Thickness of backfill material around the pipe shall be as shown on the Drawings subject to being at least 150 mm all around in all cases.

Table 5-1. Grading Requirements for Filter Material

Sieve Designation	Per cent passing by weight		
	Class I	Class II	Class III
53 mm	-	-	100
45 mm	-	-	97-100
26.5 mm	-	100	-
22.4 mm	-	95-100	58-100
11.2 mm	100	48-100	20-60
5.6 mm	92-100	28-54	4-32
2.8 mm	83-100	20-35	0-10
1.4 mm	59-96	-	0-5
710 micron	35-80	6-18	-
355 micron	14-40	2-9	-
180 micron	3-15	-	-
90 micron	0-5	0-4	0-3

6.16.2.2 Trench Excavation

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown in the Drawings provided that width of trench at pipe level shall not be less than 450 mm. The excavation shall begin at the outlet end of the drain and proceed towards the upper end. Where unsuitable material is met with at the trench bed, the same shall be removed to such depth as directed by the Engineer and backfilled with approved material which shall be thoroughly compacted to the specified degree.

6.16.2.3 Laying of pipe and backfilling

1. Laying of pipe in the trench shall be started at the outlet end and proceed towards the upper end, true to the lines and grades specified. Unless otherwise provided, longitudinal gradient of the pipe shall not less than 1 in 100.

2. Before placing the pipe, backfill material of the required grading(s) shall be laid for full width of the trench bed and compacted to a minimum thickness of 150 mm or as shown on the Drawings. The pipe shall then be embedded firmly on the bed.

3. Perforated pipes, unless otherwise specified, shall be placed with their perforations down to minimise clogging. The pipe sections shall be jointed securely with appropriate coupling fittings or bands.

4. Non-perforated pipes shall be laid with joints as close as possible with the open joints wrapped with suitable pervious material (like double layer of hessian or some other material of not less than 150 mm width) to permit entry of water but prevent fines entering the pipes. In the case of non-perforated pipes with bell end, the bell shall face upgrade.

5. Upgrade end sections of the pipe installation shall be tightly closed by means of concrete plugs or plugs fabricated from the same material as the pipe and securely held in place to prevent entry of soil materials.

6. After the pipe installation has been completed and approved, backfill material of the required grading(s) (**see Clause 5.16.2.1 para 2)** shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm in thickness and thoroughly compacted. The minimum thickness of material above the top of the pipe shall be 300 mm.

7. Unless otherwise provided, sub-surface drains not located below the road pavement shall be sealed at the top by means of 150 mm thick layer of compacted clay so as to prevent percolation of surface water.

6.16.2.4 Drain outlet

The outlet for a sub-drain shall not be under water or plugged with debris but should be a free outlet discharging into a stream, culvert or open ditch. The bottom of the pipe shall be kept above high water in the ditch and the end protected with a grate or screen. For a length of 500 mm from the outlet end, the trench for pipe shall not be provided with granular material but backfilled with excavated soil and thoroughly compacted so as to stop water directly percolating from the backfill material around the pipe. The pipe in this section shall not have any perforations.

6.16.2.5 Aggregate drains

1. Aggregate drains shall be placed within the verge / shoulders after completion of the pavement. Depth, thickness and spacing of the aggregate drains shall be as shown on the plan.

2. Trenches for aggregate drains shall be excavated to a minimum width of 300 mm and to the depth shown on the plans or ordered by the Engineer. The bottom of trench shall be sloped to drain and shall be free from loose particles of soil. The trench shall be excavated so as to expose clearly the granular pavement courses to be drained.

3. Aggregate for drains shall be durable gravel, stone or slag and shall be free from vegetable matter and other deleterious substances. The grading requirements are given at **Table 5-2**. Type B grading may be used only where the drain is designed to intercept surface water flowing to the pipe and is likely to get slowly blocked. Type A grading allows a much wider range.

Table 5-2. Grading Requirements for Aggregate Drains

Sieve Size	Per cent passing by weight	
	Type A	Type B
63 mm	-	100
37.5 mm	100	85-100
19 mm	-	0-20
9.5 mm	45-100	0-5
3.35 mm	25-80	-
600 micron	8-45	-
150 micron	0-10	-
75 micron	0-5	-

6.16.2.6 Measurements for Payment

Measurement for surface and sub-surface drains shall be per running m length of the drain. Disposal of surplus material beyond 1000 m shall be measured in cum.

6.16.2.7 Rates

The Contract unit rates for surface and subsurface drains shall be payment in full for all items such as excavation, dressing the sides and bottom; providing lining, turfing, pitching, masonry, concrete and plastering; providing, laying and jointing pipes ; providing, laying and compacting backfill and bed of granular material; providing, fixing and painting of cover etc., including full compensation for all materials, labour, tools equipment and other incidentals to complete the work as shown on Drawings with all leads and lifts except for removal of unsuitable material for which the lead shall be 1000 m. Provision of inlets, gratings, sumps, outlet pipes, bedding, disbursers etc., wherever required shall be incidental to construction of drain. The Contract unit rate for disposal of surplus and unsuitable material beyond the initial 1000 m lead shall be in accordance with **Clause 5.14.9.3**

6.17 Blasting Operations

6.17.1 General

6.17.1.1 Blasting shall be carried out in a manner that completes the excavation to the lines indicated in Drawings, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer. All the statutory laws, regulations, rules, etc., pertaining to the acquisition, transport, storage, handling and use of explosives shall be strictly followed.

6.17.1.2 The Contractor may adopt any method or methods of blasting consistent with the safety and job requirements. Prior to starting any phase of the operation the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

6.17.1.3 The magazine for the storage of explosive shall be built to the designs and Specifications of the Explosives Department concerned and located at the approved site. No unauthorized person shall be admitted into the magazine which when not in use shall be kept securely locked. No matches or inflammable material shall be allowed in the magazine. The magazine

shall have an effective lightening conductor. The following shall be hung in the lobby of the magazine.

1. A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar.
2. A statement of up-to-date stock in the magazine.
3. A certificate showing the last date of testing of the lighting conductor.
4. A notice that smoking is strictly prohibited.

6.17.1.4 All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided to the satisfaction of the Engineer and in general not closer than 300 m from the road or from any building or camping area or place of human occupancy. In addition to these, the Contractor shall also observe the following instructions and any further additional instructions which may be given by the Engineer and shall be responsible for damage to property and any accident which may occur to workmen or the public on account of any operations connected with the storage, handling or use of explosives and blasting. The Engineer shall frequently check the Contractor's compliance with these precautions.

6.17.2 Materials, Tools and Equipment

6.17.2.1 All the materials, tools and equipment used for blasting operations shall be of approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be sufficiently water resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as will permit sufficient time to the firer to reach safety before explosion takes place. Detonators shall be capable of giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed from the size immediately.

6.17.3 Personnel

6.17.3.1 The blasting operation shall remain in the charge of competent and experienced supervisor and workmen who are thoroughly acquainted with the details of handling explosives and blasting operations.

6.17.4 Blasting Operations

6.17.4.1 The blasting shall be carried out during fixed hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the man in charge only.

6.17.4.2 The Contractor shall notify each public utility company having structures in proximity to the site of the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury. In advance of any blasting work within 50 m of any railway track or structures, the Contractor shall notify the concerned Railway Authority of the location, date, time and approximate duration of such blasting operations.

6.17.4.3 Red danger flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded from the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose.

6.17.4.4 The charge holes shall be drilled to required depths and at suitable places. Blasting should be as light as possible consistent with thorough breakage of material necessary for economic

loading and hauling. Any method of blasting which leads to overshooting shall be discontinued.

6.17.4.5 When blasting is done with powder, the fuse cut to the required length shall be inserted into the hole and the powder dropped in. The powder shall be gently tamped with copper rods with rounded ends. The explosive powder shall then be covered with tamping material which shall be tamped lightly but firmly.

6.17.4.6 When blasting is done with dynamite and other high explosive, dynamite cartridges shall be prepared by inserting the square cut end of a fuse into the detonator and finishing it with nippers at the open end, the detonator gently pushed into the primer leaving 1/3rd of copper tube exposed outside. The paper of the cartridge shall then the closed up and securely bound with wire or twine. The primer shall be housed into the explosive. Boreholes shall be of such size that the cartridge can easily go down. The holes shall be cleared of all debris and explosive inserted. The space of about 200 mm above the charge shall then be gently filled with dry clay, pressed home and the rest of the tamping formed of any convenient material gently packed with a wooden rammer.

6.17.4.7 At a time, not more than 10 such charges will be prepared and fired. The man in charge shall blow a siren in a recognised manner for cautioning the people. All the people shall then be required to move to safe distances. The charges shall be lighted by the man-in-charge only. The man-in-charge shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

6.17.4.8 After blasting operations, the Contractor shall compact the loose residual material below subgrade and replace the material removed below subgrade with suitable material.

6.17.5 Misfire

6.17.5.1 In case of misfire, the following procedure shall be observed:

1. Sufficient time shall be allowed to account for the delayed blast. The man-in-charge shall inspect all the charges and determine the missed charge.
2. If it is the blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.
3. In case of charges of gelignite, dynamite, etc., the man-in-charge shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 300 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired hole should explode at the same time. The man-in-charge shall at once report to the Contractor’s office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.

6.17.5.2 If a misfire has been found to be due to defective detonator or dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority directed by the Engineer for inspection to ascertain whether all the remaining materials in the box are also defective.

6.17.6 Account

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times.

6.18 Pre-splitting Rock Excavation Slopes

6.18.1 General

6.18.1.1 Pre-splitting is defined as the establishment of a specified excavation slope in rock by the controlled use of explosive and blasting accessories in properly aligned and spaced drill holes.

6.18.1.2 The pre-splitting technique shall be used for forming rock excavation slopes at location shown on the plans or as otherwise decided by the Engineer.

6.18.2 Construction Operations

6.18.2.1 Prior to starting drilling operations for pre-splitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor's methods have produced an acceptable slope.

6.18.2.2 All overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the drilling limits, or to the end of the excavation, as decided by Engineer shall be removed before drilling the presplitting holes. Particular care and attention shall be directed to the beginning and end of excavations to ensure complete removal of all overburden soil and weathered rock and to expose fresh rock to an elevation equal to the bottom of the adjacent lift of the presplitting holes being drilled.

6.18.2.3 Slope holes for presplitting shall be drilled along the line of the planned slope within the specified tolerances. The drill holes shall be not less than 60 mm nor more than 75 mm in diameter. Drilling operations shall be controlled by the use of proper equipment and technique to ensure that no hole shall deviate from the plane of the planned slope by more than 300 mm nor shall any hole deviate from being parallel to an adjacent hole by more than two-third of the planned horizontal spacing between holes.

6.18.2.4 The length of presplit holes for any individual lift shall not exceed 9 m.

6.18.2.5 The spacing of presplit holes shall not exceed 900 mm on centres and shall be adjusted to result in a uniform shear face between holes.

6.18.2.6 Auxiliary drill holes along the presplit line, not loaded or stemmed, may be ordered by the Engineer. Except for spacing, auxiliary drill holes shall conform to the provisions for presplit holes.

6.18.2.7 The line of production holes shall be placed inside the presplit lines in such a manner as to avoid damage to the presplit face.

6.18.2.8 If necessary, to reduce shatter and over break of the presplit surface, the first line of production holes shall be drilled parallel to the slope line at the top of the cut and at each bench level thereafter.

6.18.2.9 Any blasting technique, which results in damage to the presplit surface, shall be immediately discontinued.

6.18.2.10 No portion of any production hole shall be drilled within 2.5 m of a presplit plane except as approved by the Engineer. The bottom of the production holes shall not be lower than the bottom of the presplit holes.

6.18.2.11 A maximum offset of 600 mm will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern. The drilling operations shall be adjusted to compensate for drift of previous levels and for the offset at the start of new levels to maintain the specified slope plane.

6.18.2.12 The maximum diameter of explosives used in presplit holes shall not be greater than one-half the diameter of the presplit hole.

6.18.2.13 Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in presplit holes. These shall be fired as recommended by the manufacturer. Ammonium nitrate composition blasting agents will not be permitted in presplitting operations.

6.18.2.14 Stemming may be required to achieve a satisfactory presplit face. Stemming material shall be dry free-running material all of which passes 11.2 mm sieve and 90 percent of which is retained on 2.80 mm sieve. Stemmed presplit holes shall be completely filled to the collar.

6.18.2.15 All charges in each presplitting pattern shall be detonated simultaneously.

6.19 Tolerances

6.19.1 The presplit face shall not deviate more than 300 mm from the plane passing through adjacent drill holes, except where the character of the rock is such that as determined by the Engineer, irregularities are unavoidable. When completed, the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than 300 mm. These tolerances shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the side drains.

6.19.2 As longs as equally satisfactory presplit slopes are obtained, then either the slope face may be presplit before drilling for production blasting or presplitting the slope face and production blasting may be done at the same time, provided that the presplitting drill holes are fired with zero delay and the production holes are delayed starting at the row of holes farthest from the slope and progressing in steps to the row of holes nearest the presplit line, which row shall be delayed at least 50 milliseconds. In either case the presplitting holes shall extend either to the end of the excavation or for a distance of not less than 15 m beyond the limits of the production holes to be detonated.

6.19.3 Measurements for Payment

6.19.3.1 The area of presplitting to be paid for will be measured as square meters of acceptable presplit slope surface.

6.19.4 Rates

6.19.4.1 The Contract unit rate for presplitting work shall be payment in full for carrying out the required operations for obtaining acceptable presplit slope surfaces. The quantity of rock excavated through the production / presplit holes shall be paid for as per **Clause 5.13.12.1**.

6.20 Embankment Construction

6.20.1 Scope

These Specifications shall apply to the construction of embankments including sub grades, earthen shoulders and miscellaneous backfills with approved materials obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrade, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the Drawings or as directed by the Engineer.

6.20.2 Physical Requirements of materials

6.20.2.1 The materials used in embankments, sub grades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of those or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/subgrade.

6.20.2.2 The following types of material shall be considered unsuitable for embankment:

1. Materials from swamps, marshes and bogs;
2. Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS: 1498.
3. Materials susceptible to spontaneous combustion;
4. Materials in a frozen conditions;
5. Clay having liquid limit exceeding 70 and plasticity index exceeding 45; and
6. Materials with salts resulting in leaching in the embankment.

6.20.2.3 Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50 percent when tested as per IS: 2720 Part 40) shall not be used as a fill material. Where expansive clay with acceptable "free swelling index" value is used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

6.20.2.4 Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO_3) per litre when tested in accordance with BS: 1377 Test 10, but using a 2:1 water-soil ratio shall not be deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementitious materials forming part of the Permanent Works.

6.20.2.5 Materials with a total sulphate content (expressed as $SO_{3)}$ exceeding 0.5 percent by mass, when tested in accordance with BS: 1377 Test 9 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

6.20.2.6 The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when being placed in the embankment and 50 mm when placed in the subgrade. However, the Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

6.20.2.7 Ordinarily, only the materials satisfying the density requirements given in **Table 5-3** shall be employed for the construction of the embankment and the subgrade.

Table 5-3. Density Requirements of Embankment and Subgrade Materials

Sr.	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2270 (Part 8)
1.	Embankments up to 3 metres height, not subjected to extensive flooding.	Not less than 15.2 kN/cum.
2.	Embankments exceeding 3 metres height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cum.
3.	Sub grades and earthen shoulders / verges / backfill	Not less than 17.5 kN/cum.

Notes:

1. *This Table is not applicable for lightweight fill material e.g. cinder, fly ash etc.*
2. *The Engineer may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.*
3. *The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per **Table 5-4**.*

6.20.3 General requirements of materials

6.20.3.1 The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation under the same Contract.

6.20.3.2 The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

6.20.3.3 Borrow Materials

1. Where the materials are to be obtained from designated borrow areas, the location, size and shape of these areas shall be as indicated by the Engineer and the same shall not be opened without his written permission. Where specific borrow areas are not designated by the Employer / the Engineer, arrangement for locating the source of supply of material for embankment and subgrade as well as compliance to environmental requirements in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable, shall be the sole responsibility of the Contractor.

2. Borrowpits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width from the toe of the embankment required as per the consideration of stability with a minimum width of 10 m.

3. Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plants is operating at the place of deposition.

4. No excavated acceptable material other than surplus to requirements of the Contract shall be removed from the site. Should the Contractor be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising there from.

5. Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

6. The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

7. The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the Engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in Table 5-4 shall yield the design CBR value of the subgrade.

Table 5-4. Compaction Requirements for Embankment and Subgrade

Sr	Type of work/ material	Relative compaction as percentage of max. laboratory dry density as per IS: 2720 (Part 8)
1.	Subgrade and earthen shoulders	Not less than 97
2.	Embankment	Not less than 95
3.	Expansive Clays	
	a) Subgrade and 500 mm portion just below the subgrade	Not allowed
	b) Remaining portion of embankment	Not less than 90

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

1. The values of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
2. A graph of density plotted against moisture content from which each of the values in (1) above of maximum dry density and optimum moisture content were determined.
3. The Dry density-moisture content-CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the Engineer, it shall from the basis for compaction.

6.20.4 Construction Operations for Embankments

6.20.4.1 Setting out

After the site has been cleared to **Chapter 2,** the work shall be set out to **Clause 1.10**. The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment / subgrade shall be built sufficiently wider than the design dimension so that surplus materials may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

6.20.4.2 Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the Engineer and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair / restore it to original condition or compensate the damage at his own cost. If the embankment is to be constructed under Water, **Clause 5.20.5.6** shall apply.

6.20.4.3 Stripping and Storing topsoil

In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the Engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily trafficked either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

6.20.4.4 Compacting ground supporting Embankment / Subgrade

1. When necessary, the original ground shall be leveled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in **Table 5-4**.

2. In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density as given in **Table 5-4**, the ground shall be loosened up to a level 0.5 m below the subgrade level, watered and compacted in layers in accordance with **Clause 5.20.4.5 and 5.20.4.6** to not less than 97 percent of dry density as given in **Table 5-4**.

3. Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced by approved materials laid in layers to the required degree of compaction.

4. Embankment or subgrade work shall not proceed until the foundations of embankments/subgrade have been inspected by the Engineer for satisfactory condition and approved.

5. Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed buy borehole logs shall be carried our in a manner and to the depth as desired by the Engineer. Where the ground on which and embankment is to be built has any of the material types (1) to (6) in **Clause 5.20.2.2,** at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

6.20.4.5 Spreading material in layers and bringing to appropriate moisture content

1. The embankment and subgrade material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader and compacted as per **Clause 5.20.4.6**. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in **Table 5-4** and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

2. Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such construction, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surfaces but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, discing or harrowing until and uniform moisture content is obtained throughout the depth of the layer.

3. If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

4. Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1% above to 2% below the optimum moisture content determined in accordance with IS: 2720 (Part 7) or IS: 2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at

moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

5. After adding the required amount of water, the soil shall be processed by means of graders, harrows, rotary mixers or as otherwise approved by the Engineer unit the layer is uniformly wet.

6. Clods or hard lumps of earth shall be broken to have a maximum size of 75 mm when being placed in the embankment and a maximum size of 50 mm when being placed in the subgrade.

7. Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the Engineer, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other vehicular traffic uniformly over them. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength as the material had before it was damaged.

8. Embankments and other areas of unsupported fills shall not be constructed with steeper side slopes, or to greater widths than those shown in the Contract, except to permit adequate compaction at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material.

9. Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as per **Clause 5.20.5.1** immediately before placing the subsequent fill.

10. All permanent faces of side slopes of embankments and other areas of fill formed shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the Engineer by tracking a tracked vehicle, considered suitable by the Engineer, on the slope or any other method approved by the Engineer.

6.20.4.6 Compaction

1. Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Smooth wheeled, vibratory, pneumatic tyred, sheepfoot or pad foot rollers, etc., of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

2. The compaction shall be done with the help of vibratory roller of 80 to 100 kN static weight with plain or pad foot drum or heavy pneumatic tyred roller of adequate capacity capable of achieving required compaction.

3. The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the Engineer for approval.

4. Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

5. Each layer of the material shall be thoroughly compacted to the densities specified in **Table 5-4.** Subsequent layers shall be placed only after the finished layer has been tested according to **Clause 903.2.2** of MoST Specifications for Roads and Bridge Works (IV Revision) and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture / density gauge used in accordance with agreed procedure and the gauge is calibrated to provide results identified to that obtained from tests in accordance with IS: 2720 (Part 28). A record of the same shall be maintained by the Contractor.

6. When density measurement reveal any soft areas in the embankment / subgrade / earthen shoulders, further compaction shall be carried out as directed by the Engineer. If inspite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements and satisfaction of the Engineer.

6.20.4.7 Drainage

The surface of the embankment / subgrade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

6.20.4.8 Repairing of damages caused by rain / spillage of water

The soil in the affected portion shall be removed in such areas as directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with **Clause 5.20.4.6.** If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery / equipment for the purpose.

6.20.4.9 Finishing operations

1. Finishing operations shall include the work of shaping and dressing the shoulders / verge / roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the Drawings or a directed by the Engineer subject to the surface tolerance described in **Clause 902** of MoST Specifications for Roads and Bridge Works (IV Revision). Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

2. The topsoil, removed and conserved earlier **(Clause 5.13.2 and 5.20.4.3)** shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

3. Where directed, the slopes shall be turfed with sods in accordance with **Clause 5.22**. If seeding and mulching of slopes is prescribed, this shall be done to the requirement of **Clause 5.23**.

4. When earthwork operations have been substantially completed, the road area shall be cleared of all debris, and ugly scars in the construction area responsible for objectionable appearance eliminated.

6.20.5 Construction of Embankment and Subgrade under Special Conditions

6.20.5.1 Earthwork for widening existing road embankment

1. When an existing embankment and / or subgrade is to be widened and its slope are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment / subgrade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment / subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

2. Where the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of small vibratory rollers / plate compactors / power rammers of any other appropriate equipment approved by the Engineer. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

6.20.5.2 Earthwork for embankment and subgrade to be placed against sloping ground:

1. Where an embankment / subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed / scarified as required in **Clause 5.20.5.1** before placing the embankment / subgrade material. Extra earthwork involved in benching or due to ploughing / scarifying etc. shall be considered incidental to the work.

2. For wet conditions, benches with slightly inward fall subsoil drains at the lowest point shall be provided as per the Drawings, before the fill is placed against sloping ground.

3. Where the Contract requires construction of transverse subsurface drain at the cut-fill interface, work on the same shall be carried out to **Clause 5.16** in proper sequence with the embankment and subgrade work as approved by the Engineer.

6.20.5.3 Earthwork over existing road surface:

Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

1. If the existing road surface is of granular or bituminous type and lies within 1 m of the new subgrade level, the same shall be scarified to a depth of 50 mm or more if specified, so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new subgrade level is compacted to the desired density.

2. If the existing road surface is of cement concrete type and lies within 1 m of the new subgrade level the same shall be removed completely.

3. If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be permitted to stay in place without any modification.

6.20.5.4 Embankment and subgrade around structures:

1. To avoid interference with the construction of abutments, wing walls or return walls of culvert / bridge structures, the Contractor shall, at points to be determined by the Engineer suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

2. Unless directed otherwise, the filling around culverts, bridges and other structures up to a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the Engineer but in any case not until the concrete or masonry has been in position for 14 days. The embankment and subgrade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer.

3. The material used for backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS: 2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in Appendix 6 of IRC:78 (Standard Specifications and

Code of Practice for Road Bridges-Section VII) in respect of the type of material, the extent of backfill, its laying and compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of **Table 5-4.**

4. Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in **Clause 2502** of MoST Specifications for Roads and Bridge Works (IV Revision) **/ Clause 5.16.2.1 Para 2** unless otherwise specified in the Contract.

5. Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

6.20.5.5 Construction of Embankment over Ground Incapable of Supporting Construction Equipment:

Where embankment is to be constructed across ground which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the Engineer. The Contractor, if so desired by him, may also use suitable geosynthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the Engineer, the embankments could be constructed in the approved manner over such ground by the use of lighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer shall be the responsibility of the Contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the Contract will be the responsibility of the Contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in **Clause 5.20.4.**

6.20.5.6 Embankment construction under water

Where filling or backfilling is to be placed under water, only acceptable granular material or rock shall be used unless otherwise approved by the Engineer. Acceptable granular material shall consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

6.20.5.7 Earthwork for high embankment

1. In the case of high embankments, the Contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The Contractor shall then furnish the soil test data and design of high embankment for approval of the Engineer, who reserve the right to accept or reject it.

2. If necessary, stage construction of fills and any controlled rates of filling shall be carried out in accordance with the Contract including installation of instruments and its monitoring.

3. Where required, the Contractor shall surcharge embankments or other areas of till with approved material for the periods specified in the Contract. If settlement of surcharged fill results in any surcharging material, which is unacceptable for use in the fill being surcharged, lying below formation level, the Contractor shall remove the unacceptable material and dispose it as per direction of the Engineer. He shall then bring the resultant level up to formation level with acceptable material.

6.20.5.8 Settlement period

Where settlement period is specified in the Contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wingwall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the Contract or as directed by the Engineer.

6.20.6 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and / or subgrade without the prior permission of the Engineer. Any damage arising out of such use shall, however, be made good by the Contractor at his own expense as directed by the Engineer.

6.20.7 Surface Finish and Quality Control of Work

The surface finish of construction of subgrade shall conform to the requirements of **Clause 902** of MoST Specifications for Roads and Bridge Works (IV Revision). Control on the quality of materials and works shall be exercised in accordance with **Clause 903** of MoST Specifications for Roads and Bridge Works (IV Revision).

6.20.8 Subgrade Strength

6.20.8.1 It shall be ensured prior to actual execution that the borrow area material to be used in the subgrade satisfies the requirements of design CBR.

6.20.8.2 Subgrade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on undisturbed samples cut out from the compacted subgrade in CBR mould fitted with cutting shoe or on remoulded samples, compacted to the field density at the field moisture content.

6.20.9 Measurements for Payment

6.20.9.1 Earth embankment/subgrade construction shall be measured separately by taking cross sections at intervals in the original position before the work starts and after its completion and computing the volumes of earthwork in cubic metres by the method of average end areas.

6.20.9.2 The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from roadway and drainage excavation. For this purpose, it shall be assumed that one cum. of suitable material brought to site from road and drainage excavation forms one cum. of compared fill and all bulking or shrinkage shall be ignored.

6.20.9.3 Construction of embankment under water shall be measured in cum.

6.20.9.4 Construction of high embankment with specified material and in specified manner shall be measured in cum.

6.20.9.5 Stripping including storing and reapplication of topsoil shall be measured in cum.

6.20.9.6 Work involving loosening and recompacting of ground supporting embankment / subgrade shall be measured in cum.

6.20.9.7 Removal of unsuitable material at embankment / subgrade foundation and replacement with suitable material shall be measured in cum.

6.20.9.8 Scarifying existing granular / bituminous road surface shall be measured in square metres.

6.20.9.9 Dismantling and removal of existing cement concrete pavement shall measured vide **Clause 202.6** of MoST Specifications for Roads and Bridge Works (IV Revision).

6.20.9.10 Filter medium and backfill material behind abutments, wing walls and other retaining structures shall be measured as finished work in position in cum.

6.20.10 Rates

6.20.10.1 The Contract unit rates for the items of embankment and subgrade construction shall be payment in full for carrying out the required operations including full compensation for:

1. Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;
2. Setting out;
3. Compacting ground supporting embankment / subgrade except where removal and replacement of unsuitable material or loosening and recompacting is involved;
4. Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and subgrade as applicable;
5. Cost of watering or drying of material in borrow areas and / or embankment and subgrade during construction as required.
6. Spreading in layers bringing to appropriate moisture content and compacting to Specification requirements;
7. Shaping and dressing top and slopes of the embankment and subgrade including rounding of corners;
8. Restricted working at sites of structures;
9. Working on narrow width of embankment and subgrade;
10. Excavation in all soils from borrow pits / designated borrow areas including clearing and grubbing and transporting the material to embankment and subgrade site with all lifts and leads unless otherwise provided for in the Contract;
11. All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;
12. Dewatering; and
13. Keeping the embankment / completed formation free of water as per **Clause 5.25**.

6.20.10.2 In case the Contract unit rate specified is not inclusive of all leads, the unit rate for transporting material beyond the initial lead, as specified in the Contract for construction of embankment and subgrade shall be inclusive of full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the specified initial lead.

6.20.10.3 **Clause 5.13.12.5** shall apply as regards Contract unit rates for items of stripping and storing top soil and of reapplication of topsoil.

6.20.10.4 **Clause 5.13.12.2** shall apply as regards Contract rates for items of loosening and recompacting the embankment / subgrade foundation.

6.20.10.5 **Clause 5.13.12.1 and 5.20.9** shall apply as regards Contract rates for items of removal of unsuitable material and replacement with suitable material respectively.

6.20.10.6 The Contract unit rate for scarifying existing granular / bituminous road surface shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. This will also comprise of handling, salvaging, stacking and disposing of the dismantled materials within all lifts and up to a lead of 1000 m or as otherwise specified.

6.20.10.7 **Clause 202.7** of MoST Specifications for Roads and Bridge Works (IV Revision) shall apply as regards Contract unit rate for dismantling and removal of existing cement concrete pavement.

6.20.10.8 The Contract unit rate for providing and laying filters material behind abutments shall be payment in full for carrying out the required operations including all materials, labour, tools, equipment and incidentals to complete the work to Specifications.

6.20.10.9 **Clause 5.20.5.6** shall apply as regards Contract unit rate for construction of embankment under water.

6.20.10.10 **Clause 5.20.5.7** shall apply as regards Contract unit rate for construction of high embankment. It shall include cost of instrumentation, its monitoring and settlement period, where specified in the Contract or directed by the Engineer.

6.21 Soil Erosion and Sedimentation Control

6.21.1 Scope

This work shall consist of measures as shown on plans or as directed by the Engineer to control soil erosion, sedimentation and water pollution, through use of berms, dikes, sediment basins, fibre mats, mulches, grasses, slope drains, and other devices.

6.21.2 Materials

All materials shall meet commercial grade standards and shall be approved by the Engineer before being used in the work.

6.21.3 Construction Operations

6.21.3.1 Prior to the start of the relevant construction, the Contractor shall submit to the Engineer for approval his schedules for carrying out temporary and permanent erosion / sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment / subgrade construction, bridges and other structures across water course, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion / sedimentation control on service road and borrowpits and his plan for disposal of waste materials. Work shall not be started until the erosion / sedimentation control schedules and methods of operations for the applicable construction have been approved by the Engineer.

6.21.3.2 The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor may be directed to provide immediate permanent or temporary erosion and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other water courses, lakes, reservoirs etc. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as required on the plans.

6.21.3.3 The Contractor shall be required to incorporated all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

6.21.3.4 Temporary erosion / sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage nor associated with permanent control features on the Project.

6.21.3.5 Where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion or sedimentation control features can follow immediately thereafter if the project conditions permit; otherwise temporary erosion or sedimentation control measure may be required between successive construction stages. Under no conditions shall a large surface area of

erodible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the Engineer.

6.21.3.6 The Engineer may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion / sedimentation control measures shall be taken immediately to the extent feasible and justified.

6.21.3.7 In the event temporary erosion, sedimentation and pollution control measures become necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the work as scheduled or ordered by the Engineer, these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness of failure to install permanent controls, will be performed as ordered by the Engineer.

6.21.3.8 Temporary erosion, sedimentation and pollution control may include construction work outside the right-of-way where such work is necessary as result of road construction such as borrow pit operations, service roads and equipment storage sites.

6.21.3.9 The temporary erosion, sedimentation and pollution control features installed by the Contractor shall be acceptably maintained by him till these are needed, unless otherwise agreed by the Engineer.

6.21.4 Measurements for Payment

6.21.4.1 The soil erosion, sedimentation and pollution control works will be measured in terms of units specified in the Bill of Quantities for the respective items.

6.21.5 Rates

6.21.5.1 The contract unit rate for different items of soil erosion, sedimentation and pollution control works shall be payment in full for carrying out all required operations including full compensation for all labour, tools, equipment and incidents to complete the works to the Specifications.

6.22 Turfing with Sods

6.22.1 Scope

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations shown on the Drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favorable for establishment of the sod.

6.22.2 Materials

6.22.2.1 The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be use, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have freed of debris.

6.22.2.2 Thickness of the sod shall be as uniform as possible, with some 50-80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm X 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather

shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

6.22.3 Construction Operations for Turfing with Sods

6.22.3.1 Preparation of earth bed

1. The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

2. Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the plans. Spreading shall not be done when the ground is excessively wet.

3. Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans. After spreading, the materials are incorporated in the soil by discing or other means to the depths shown on the plans.

6.22.3.2 Placing the sods

1. The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

2. On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its through compaction.

6.22.3.3 Staking the sods

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

6.22.3.4 Top dressing

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

6.22.3.5 Watering and maintenance

1. The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

2. The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

6.22.4 Measurement for Payment

Turfing with sods shall be measured as finished work in square metres.

6.22.5 Rate

6.22.5.1 The Contract unit rate for turfing with sods shall mean payment in full for carrying out all the required operations explained above including compensation for:

1. Furnishing all the materials to be incorporated in the Works with all leads and lifts; and
2. All labour, tools, equipment and incidental to complete the work in accordance with these Specifications.

6.22.5.2 The Contract unit rate for application of topsoil shall be as per **Clause 5.13.12.5**.

6.23 Seeding and Mulching

6.23.1 Scope

This shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting and placing and incorporation the same on embankment slopes or other locations designated by the Engineer or shown in the Contract documents.

6.23.2 Materials

6.23.2.1 Seeds

The seeds shall be approved quality and type suitable for the soil on which these are to be applied, and shall have acceptable purity and germination to requirements set down by the Engineer.

6.23.2.2 Fertilizer

This shall consist of standard commercial materials and conform to the grade specified. Organic manure shall be fully putrefied organic matter such as cow dung.

6.23.2.3 Mulching materials

This shall consist of straw, hay wood shavings or sawdust and shall be delivered dry. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as mulch or be injurious to the plant growth.

6.23.2.4 Topsoil

Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall be contain less than 2 per cent and more than 12 per cent organic matter.

6.23.2.5 Bituminous Emulsion

A suitable grade of bituminous cutback or emulsion used as a tie down for mulch shall be as described in the Contract document or as desired by the Engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

6.23.2.6 Netting

Jute netting shall be undyed jute yarn woven into a uniform open weave with approximate 2.5 cm square openings. Geonetting shall be made of uniformly extruded rectangular mesh

having mesh opening of 2 cm x 2 cm. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sq. m.

6.23.3 Seeding Operations

6.23.3.1 Seed-bed Preparation

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, median etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the plans, unless otherwise approved by the Engineer. The see-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm in smallest dimension and larger shall be removed. The soil shall be excavated on the contour to a depth of 100 mm. All clods large than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the Engineer. Compaction shall be by slope compactor, cleated tractor or similar equipment approved by the Engineer. Equipment shall be so designed and constructed as to produce a uniform rough textured surface ready for seeding and mulching and which will bond the topsoil to the underlying material. The entire area shall be covered by a minimum of 4 passes or 2 round trips of the roller or approved equipment.

6.23.3.2 Fertilizer application

Fertilizer to the required quantities shall be spread and thoroughly incorporated into the soil surface as a part of the seed-bed preparation.

6.23.3.3 Planting of seeds

All seeds shall be planted uniformly at the approved rate. Immediately after sowing, the area shall be raked, dragged or otherwise treated so as to cover the seeds to a depth of 6 mm. The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

6.23.3.4 Soil Moisture and Watering requirements

Soil moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting. Watering off the seeded areas shall be carried out as determined by the Engineer.

6.23.4 Mulching, Applying Bituminous Emulsion and Jute Netting / Geonetting

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. When called for in the Contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 liters per hectare. Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. Jute netting / Geonetting shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the plans or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they shall overlap a minimum of 100 mm. Jute netting / Geonetting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil

6.23.5 Maintenance

The Contractor shall maintain all seeded and mulched areas until final acceptance. Maintenance shall include protection of traffic by approved warning signs or barricades and repairing any areas damaged following the seeding and mulching operations. If mulched

areas become damaged, the area shall be reshaped and then seeded and mulched again as originally specified.

6.23.6 Measurement for payment

Seeding and mulching shall be measured as finished work in square metres.

6.23.7 Rate

The Contract unit rate for seeding and mulching shall be payment in full for carrying out all the required operations including full compensation for all materials, labour, tools and incidentals.

6.24 Preparation and Surface Treatment of Formation

6.24.1 Preparation and surface treatment of the formation, that is top of the subgrade, shall be carried out only after completion of any specified subgrade drainage and unless otherwise agreed by the Engineer, immediately prior to laying the sub-base or the road base where no sub-base is required. The sequence of operations shall be as follows:

1. All surfaces below carriageway, lay byes, footways and hard shoulders shall, after reinstatement of any soft areas to the required Specifications be well cleaned and freed of mud and slurry.

2. The surface shall be compacted by 4 passes of a smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

3. The formation shall, wherever necessary, be regulated and trimmed to the requirements of **Clause 5.20.4.9** with motor grader.

4. The trimmed formation shall be rolled by one pass of smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

6.24.2 Where the completed formation is not immediately covered with sub base or road base material, its moisture content shall be maintained to prevent cracking in the formation by suitable measures as approved by the Engineer. The entire work of surface treatment of formation shall be deemed as incidental to the work of sub-base / base course to be provided on the subgrade and as such no extra payment shall be made for the same.

6.25 Works to be Kept Free of Water

6.25.1 The Contractor shall arrange for the rapid dispersal of water collected / accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangement shall be made in respect of all earthwork including excavation for pipe trenches, foundations or cuttings.

6.25.2 The Contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

6.25.3 The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

6.26 Water Courses at Culverts

6.26.1 Excavation carried out in the diversion, enlargement deepening or straightening water courses at culverts, where necessary, shall include the operations such as clearing, grubbing, removal of vegetation, trimming of slopes, grading of beds, disposal of excavated materials, pumping, timbering etc., necessary for dealing with the flow of water.

6.26.2 The beds and sloping sides of water courses shall, where shown on the Drawings, be protected against the action of water by rubble paving to form a flat or curved surface as indicated. The protection shall consist of large smooth faced stones or of blocks of precast concrete. Stones for rubble paving shall be roughly dressed square. No stone shall be less than 255 mm in depth nor less than 0.02 cum. in volume and no rounded boulders shall be used. After completion of construction of culverts, temporary diversion of water course, if any, shall be closed and water course restored for flow through the culvert as per the direction of the Engineer.

6.26.3 Measurements for Payment

The work for water courses at culverts as stated above shall be measured in terms of units specified in the Bill of Quantities for respective items. The temporary diversion of channel to facilitate construction of culverts, its closure and restoration to original water course shall be considered incidental to the work of construction of culverts and no extra payment shall be made for the same.

6.26.4 Rates

The contract unit rates for different items for water courses at culverts shall be payment in full for carrying out all required operations including full compensation for all cost of materials, labour, tools, equipment and other incidentals to complete the work to the Specification.

6.27 Construction of Rock Fill Embankment

6.27.1 Scope

In normal circumstances, the embankment should not be constructed with rock fill material. However, where specifically permitted by the Engineer because of imperative economic or technical reasons, construction of rock fill embankments shall be in accordance with the lines, grades and cross-sections as shown in Drawings or as directed by the Engineer. Rock fill shall not be used at least for a depth of 500 mm below the formation level. There should be a minimum of 500 mm thick earthen cushion over the rock fill.

6.27.2 Material

6.27.2.1 The size of rock pieces used in rock fill embankments shall be such that they can be deposited in layers so as to suit the conditions evaluated in the field compaction trials or as directed by the Engineer. The rock fill shall consist of hard, durable and inert material, preferably maximum size not exceeding 300 mm and percent finer than 125 mm not exceeding 10 per cent.

6.27.2.2 Argillaceous rocks (clay, shales etc.), unburnt colliery stock and chalk shall not be used in rock fill.

6.27.2.3 The rock fragments and blinding material required for filling the voids shall also satisfy the above requirements.

6.27.3 Spreading and Compaction

6.27.3.1 The material shall be tipped, spread and leveled in layers extending to the full width of embankment by a suitable dozer. Fragments of rock shall then be spread on the top of layer to the required extent and layer compacted by minimum of 5 passes of vibratory roller having

static weight 8-10 tones. The compacted thickness of each layer shall not exceed 500 mm. After compaction of each layer, the surface voids shall be filled with broken fragments. Next layer, where required, shall be placed in the same manner, above the earlier compacted layer.

6.27.3.2 The top layer of rock fill, on which normal earth fill will rest, shall be thoroughly blinded with suitable granular material to seal its surface.

6.27.4 Measurements for Payment

Measurement shall be made by taking cross-section at intervals in the original position before the work starts and after its completion and computing the volume in cum by the method of average end areas.

6.27.5 Rate

The Contract unit rate shall be paid in full for carrying out all the above operations including cost of rock fill, broken fragments and blinding material and shall provide full compensation for all items as per **Clause 5.20.10.1 and 5.20.10.2**.

7 SURFACE AND SUB-SURFACE GEOTECHNICAL EXPLORATION

7.1 General

7.1.1 The objective of sub-surface exploration is to determine the suitability or otherwise of the soil or rock surrounding the foundation and soil parameters and rock characteristics for the design of foundation by in-situ testing or testing of samples/cores taken out of exploration. The sub-surface exploration shall be planned in such a way that different types of soil up to the desired depth and their profile for the full proposed length of the bridge can be recorded and other information such as mechanical and physical properties like grain-size distribution, sensitivity, any existence of deleterious material in soil or ground water, etc., are determined along with soil parameters and rock characteristics. The sub-surface exploration shall also throw light on porosity of rock and subsidence due to mining, ground water level, artesian condition, if any, likely sinking and driving effort, likely constructional difficulties, etc.

7.1.2 Field Investigation

1. Reconnaissance
2. Preliminary Explorations
3. Detailed Explorations

7.1.2.1 Reconnaissance includes a review of available topographic and geological information, aerial photographs and data from previous investigations and site examination.

7.1.2.2 Preliminary investigation shall include the study of existing geological information, previous site reports, geological maps; air photos, etc., and surface geological examination. For large and important structures the information may be supplemented by geophysical methods. In some cases where no previous sub-strata data are available, exploratory geophysical investigation may need to be supplemented by resorting to a few bore-holes. These will help to narrow down the number of sites under consideration and also to locate the most desirable location for detailed sub-surface investigation like bore or drill holes, sounding probes, etc.

7.1.2.3 The scope of detailed investigation for bridges may be decided based on data obtained after preliminary investigations. Based on data obtained after preliminary investigations, the bridge site, type of structure with span arrangement and the location and type of foundations, shall be tentatively decided. Thereafter, the scope of detailed investigation including the extent of exploration, number of bore-holes, type of soundings, type of tests, number of tests, etc., shall be decided, so that adequate data considered to be necessary for the detailed design and execution, are obtained.

7.1.2.4 The width of exploration: One purpose of detailed exploration for high embankments is to ascertain the compressibility of the clayey strata. It is, therefore, necessary that detailed and well illustrated description of the characteristics of stratification should be prepared. After the general shape and trend of the boundaries of the various soil deposits have been determined and rough assessment of their strength has been made by sub-surface sounding, with or without sampling in exploratory boring, the location of bore-hole(s) for undisturbed sampling shall be decided. At least one representative undisturbed sample should be collected from each strata. When homogeneous strata is very thick, one representative sample shall be collected for each 3 m thickness of the strata.

7.1.3 Soil investigation for foundations shall contain a programme for boring and retrieval of samples. The field work shall consist of excavation, drilling of bore-holes for the purposes of collection of undisturbed and disturbed samples, standard penetration tests, in-situ vane tests, static and dynamic cone penetration tests, other field tests, as specified by the Engineer and preparation of bore-logs. Collection and preservation for testing of disturbed and undisturbed samples from boreholes, borrow pits, etc., as specified by the Engineer shall form a part of the above, All in-situ tests shall be supplemented by laboratory investigations. Relevant Indian Standards such as IS: 1498, IS: 1888, IS: 1892, IS: 2131, IS: 2132, IS: 2720, IS: 4434 and IS: 4968 and Appendix I of IRC:78, etc., shall be followed for guidance.

7.1.4 The soundings by dynamic method shall be carried out in bore-holes using a standard sampler as specified in IS: 2131.

7.2 Preliminary Investigation

7.2.1 Foundations

7.2.1.1 Preliminary exploration shall be carried out to determine the soil profile showing the boundaries between the different soil types and between loose and dense parts in the same type of deposits. For guidance reference may be made to IRC: 75. For this purpose, as a first step, a suitable type of sub-surface sounding (e.g., static or dynamic cone penetration test) shall be carried out. As many soundings as necessary should be made, until the penetration data is complete enough to leave no doubt concerning the general shape and the trend of boundaries of the various soil deposits., Exploratory drill holes should then be made at one or two locations where average condition prevails and near those few points where the penetration diagrams indicate maximum deviations from the average.

7.2.1.2 The exploration shall cover the entire length of the bridge and also extend at either side for a distance about twice the depth below bed of the last main foundations. If there is any necessity for designing investigation for approaches particularly on soft soil or with high embankment or there is a possibility of considering alternatives between viaduct or earthen embankment, the extended length and location of the borings beyond the proposed location of abutment should determined and executed.

7.2.1.3 The depth of exploration should be at least $1\ ^{1}/_{2}$ times the minimum width of foundation below the proposed foundation level. Where such investigation end in any unsuitable or questionable foundation material the exploration shall be extended to a sufficient depth into firm and stable solid or rock but not less than four times the minimum depth of foundation below the earlier contemplated foundation level... In case of good sound rock the stipulation of minimum depth may be decreased based on difficulty to conduct core drilling and the minimum depth may be restricted to 3 metres.

7.2.2 Guide bund and Embankment

The depth of exploration should include all strata likely to affect stability of embankment, guide bund and/or cause undesirable settlement. In general, the requirement of settlement governs the depth of exploration for high embankments in particular. However, borings can be terminated at shallower depths when firm strata or bed rock is encountered. Ordinarily, the boring shall be taken to a depth of at least 1.5 times the height of embankment and guide bund. However, where highly compressible strata are encountered, the boring may have to be taken deeper. In order to ensure that firm strata is sufficiently thick, the boring should extend 3 metre into the firm strata.

7.3 Detailed Exploration

7.3.1 The exploration shall cover the entire length of the bridge and also extend at either end for a distance of about twice the depth below bed of the last main foundation to assess the effect of the approach embankment on the end foundations. Generally the sub-surface investigations (preliminary and detailed) for bridges shall extend to a depth below the anticipated foundation level equal to about one and a half times the width of the foundation. However, where such investigations end in any unsuitable or questionable foundation material, the exploration shall be extended to a sufficient depth into firm and stable soils or to rock.

7.3.2 The type and extent of exploration shall be divided into the following groups as per requirement of foundation design and likely method of data collection:

1. Foundation requiring shallow depth of exploration
2. Foundation requiring large depth of exploration
3. Fills behind abutments and protection works

7.3.3 Location Boring

Where the data made available by detailed exploration indicates appreciable variation or where variations in a particular foundation are likely to appreciably affect the construction (specially in case of bridge foundations resting on rock), it will be necessary to resort to additional bores/soundings to establish complete profile of the underlying strata. The additional borings/soundings shall be decided depending upon the extent of variation at a particular foundation location and should cover the entire area of the particular foundation.

7.3.4 Construction Stage Exploration

Whenever a change in the sub-soil strata/rock profile in encountered during construction, explorations shall be resorted to establish the correct data for further decisions.

7.3.5 Logging of bore-holes by radio-active methods shall be done for detailed investigations as specified in the contract or in special provisions.

7.3.6 For bridge works, the investigations shall be comprehensive enough to enable the designer to estimate or determine the following:

1. the engineering properties of the soil/rock,
2. the location and extent of soft layers and gas pockets, if any, under the hard founding strata,
3. the geological condition like type of rock, faults, fissures or subsidence due to mining, porosity etc.,
4. the ground water level,
5. artesian conditions, if any,
6. quality of water in contact with the foundation,
7. the depth and extent of scour,
8. suitable depth of foundation,
9. the bearing capacity of the foundation,
10. probable settlement and probable differential settlement of the foundations
11. likely sinking or driving effort, and
12. likely construction difficulties.

7.4 Exploration for Bridge Foundations Resting on Rock

7.4.1 Investigation and interpretation of data for rock is specialized work. To arrive at the characteristic strength of rock mass, reliance shall be placed more on in-situ tests in comparison to laboratory tests. An engineering geologist shall also be associated in the exploration programme.

7.4.2 Identification and classification of rock types for engineering purposes may in general be limited to broad, basic geological classes in accordance with accepted practice. Strength of parent rock alone is of limited value because overall characteristics depend considerably on character, spacing and distribution of discontinuities of the rock mass, such as the joints, bedding planes, faults and weathered seams. An important factor affecting the behaviour is the weathered zone at top.

7.4.3 Basic Information Required from Explorations

1. Depth of rock strata and its variation over the site,
2. Whether isolated boulder or massive rock formation,
3. Extent and character of weathered zone,
4. Structure of rock - including bedding planes, faults, fissures, solution cavities etc.,
5. Properties of rock material - strength, geological formation, etc.,
6. Erodibility of rock to the extent possible,
7. Colour of water.

7.4.4 Exploration Programme

If preliminary investigations have revealed presence of rock within levels where the foundation is to rest, it is essential to take up detailed investigation to collect necessary information mentioned in **Clause 6.4.3**. The exploratory bore-hole shall be drilled into the rock to a depth of about 3 metres to distinguish a boulder from a continuous rock formation.

7.4.5 The extent of exploration shall be adequate enough to give a complete picture of the rock profile both in depth and across the channel width to asses the constructional difficulties in reaching the foundation levels.

7.4.6 The depth of boring in rock depends primarily on local geology, erodibility of the rock, extent of structural loads to be transferred to foundation etc. Normally, it shall pass through the upper weathered or otherwise weak zone, well into the sound rock. Minimum depth of boring in sound rock shall be 3 metres.

7.4.7 Detailed Investigation for Rock

7.4.7.1 This covers sounding, boring and drilling. An adequate investigation programme shall be planned to cover the whole area for general characteristics and in particular the foundation location, to obtain definite information regarding rock-depth and its variation over the foundation area. The detailed programme of exploration will depend on the type and depth of over-burden, the size and importance of the structure, etc. To decide this, geophysical methods adopted at the preliminary investigation stage will be helpful, this data being supplemental by sounding, bore-holes and drill holes.

7.4.7.2 Drilling through rock is a very specialised work and every care shall be taken to notice and record any small change during drilling. The time required to drill through a certain depth, amount of core recovery, physical condition, length of pieces of core, joints, colour of water residue, weathering and evidence of disturbance and other effects shall be carefully noticed and entered in the drilling log. for guidance, IS: 5313 may be referred to. The data shall be presented in accordance with IS: 4464.

7.4.7.3 The cores shall be stored properly in accordance with IS: 4078.

7.4.7.4 The rock cores obtained shall be subjected to following laboratory tests:

1. Visual identification for texture, structure, composition, colour and grain size.
2. Laboratory tests shall be done for specific gravity, porosity and moisture content.

7.4.7.5 In-situ tests shall be made in accordance with IS: 7292; IS: 7317; and IS: 7746. In addition, laboratory tests can also be made on samples.

7.4.7.6 Use of in-situ tests for measuring strength and deformation characteristics shall be made. Use of bore-hole photography will be desirable to evaluate the presence of faults, fissures or cavities, etc.

7.4.8 Special Cases

7.4.8.1 Investigation for conglomerate

A drill hole shall be made same as for rock. The samples collected shall be subjected suitable tests depending upon the material, special care shall be taken to ascertain erodibility of the matrix. Where possible, specially for shallow foundation, Plate Load Test shall be conducted.

7.4.8.2 Investigation for laterites

The investigation shall be generally similar to that required for cohesive soils, use of penetration tests shall be preferred, if suitable correlation charts are available. This may be static or dynamic penetration tests or vane shear tests. In the case of hard laterite, recourse

may have to be made to core drilling as for soft rocks. For laterites at shallow depths, use of Plate Load Test may be advantageous.

7.4.9 Caution

7.4.9.1 The interpretation of laboratory results on rock samples depends upon the relationship of the specimens tested to the overall rock characteristics, enumerated in Appendix I of IRC: 78. For this purpose, care shall be exercised in the choice of specimen size and its orientation in relation to the joint pattern.

7.4.9.2 In some cases, the foundation behaviour will be dominated by a possible mode of failure involving movement along some joint surface, fissures or weak layer within a generally strong rock system and also by possible weathering. In-situ shear tests may be conducted wherever feasible, as such tests are likely to give more representative data than the shear tests conducted on core samples.

7.4.10 Presentation of Data

The data shall be given in diagrammatic form in 3 sheets giving the following details:

1. Sheet 1: Plan showing the position of bore-holes clearly marked so as to fix the position at a future date.
2. Sheet 2: This shall contain the bore-log chart and test results of the samples separately for each bore-hole/pit etc.
3. Sheet 3: This shall contain pictorial representation of the borelog data to get an overall picture of the soil profile at the cross-section of the river.

Note: For guidance, refer to IRC: 78

7.5 Boring

7.5.1 Boring shall be done by any of the following methods depending on the soil type and types of samples required for the investigation:

1. Auger Boring
2. Shell and Auger Boring
3. Percussion Boring
4. Wash Boring
5. Rotary Boring

7.5.2 For preliminary and detailed sub-surface investigation only rotary drills shall be used. The casing shall also be invariably provided with diameters not less than 150 mm up to the level of rock, if any. However, use of percussion or wash boring equipment shall be permitted only to penetrate through bouldery or gravelly strata for progressing the boring but not for the collection of samples. While conduction detailed borings, the resistance to the speed of drilling i.e., rate of penetration, core loss, etc., as already specified in Appendix 3 of IRC: 78 shall be carefully recorded to evaluate the different types of strata and to distinguish specially sand from sandstone, clay from shale, etc.

7.6 Records of Borings and Trial Pits

7.6.1 The field records for the preliminary and detailed exploration shall contain the date when the boring was made, the location of the boring with reference to a permanent system of co-ordinates and the elevation of the ground surface with respect to a permanent bench mark. They shall include elevation at which the water table and the upper boundary of each of the successive soil strata were encountered, the investigator's clarification of the layer on the basis of general information obtained from field examination (refer to Appendix 2.1 of IRC:75) and the value of the resistance obtained by means of Standard Penetration Test. The type of tools used for borings shall be recorded. If the tools were changed, the depth at which the change was made and the reason thereof shall also be noted. Incomplete and abandoned

borings shall be described with no less care than successfully completed drill holes. The notes shall contain everything of significance observed on the job such as the elevation at which wash water was lost from the hole.

7.6.2 For all borings and trial pits, necessary information as detailed below shall be given. A site plan showing the disposition of the bore holes shall also be attached:

1. Agency
2. Location with reference map
3. Pit/Bore-hole number
4. reduced level (R.L.) of ground surface or other reference point
5. Dates of starting and completion
6. Name of supervisor
7. Scales of plans and sections
8. Dimensions, methods of advancing exploration such as by hand tools, blasting, boring, etc.
9. General description of strata met with and RLs at which they are met
10. Position and altitude of contacts, faults, strong joint, slacken sides, etc.
11. Inflow of water, methods of controlling the water, required capacity of pumps for dewatering
12. The level at which the sub-soil water is met with
13. Dip and strike of bedding and of cleavage.
14. Visual description of strata
15. Results of field tests e.g. SPT, in-situ vane shear test etc.
16. Any other information and remarks.

7.6.3 Upon removal of sampling tube, the length of the sample in the tube and the length between the top of the tube and the top of the sample in the tube shall be measured and recorded.

7.7 Methods of Sampling

There are two types of samples viz., (a) Disturbed sample (b) Undisturbed sample. The usual methods for sampling conforming to IS: 1892 and IS: 2132 are given ahead:

Name of Ground	Type of Sample	Method of Sampling
Soil	Disturbed Undisturbed	Hand Samples / Auger Samples / Shell Samples Hand Samples / Tube Samples
Rock	Disturbed Undisturbed	Wash Samples from percussion or rotary drilling Cores

7.8 Procedure for Taking Samples

7.8.1 For proper identification of sub-surface material, sample should be recovered containing all the constituents of the materials in their proper proportion. In clayey deposits such samples could be collected by split spoon samplers. In the case of sandy deposits, sampling spoons shall be fitted with suitable devices for retaining samples. All data required for soil identification (Appendix 2.1 of IRC: 75) should be collected from the samples so extracted when undisturbed samples, which are more desirable for collection of some of the data, are not available. Penetration test should be carried out with the standard split-spoon sampler or penetrometers if the soil is coarse grained. When it is known in advance that the soil profile is fairly regular, preliminary and detailed investigation may be combined. Tube samplers can be used in place of split spoon samplers for collecting samples in clayey strata.

7.8.2 Disturbed Soil Samples

7.8.2.1 Disturbed samples of soil shall be obtained in the course of excavation and boring. For procuring samples from below the ground water level, where possible, special type of sampler shall be used. Where Standard Penetration Test is conducted, representative samples shall be obtained from the split spoon. While collecting disturbed samples from borrow areas it shall be ensured that the samples collected represented all types of borrow materials to be used in the construction of embankment and sub-grade.

7.8.2.2 The size of sample generally requited shall be as given in Table 6-1.

Table 6-1 Size of Soil Sample Required

Sr.	PURPOSE OF SAMPLE	SOIL TYPE	WEIGHT OF SAMPLE REQUIRED (kg)
1.	Soil identification, natural moisture content tests, mechanical analysis and index properties, chemical tests	Cohesive soils Sands and Gravel	1 3
2.	Compression tests	Cohesive soils and sand	12.5
3.	Comprehensive examination of construction material and borrow area soil including soil stabilisation	Cohesive soils and sands Gravelly soil	25 - 50 50 - 100

7.8.2.3 While taking out disturbed soil samples, Standard Penetration Test may also be conducted to find out the bearing capacity of the sub-soils at specified levels.

7.8.3 Undisturbed Soil Samples

7.8.3.1 The location of the bore-hole shall be as indicated on the Drawing or given by the Engineer. The depth of the bore-hole shall be as indicated on the Drawing or shall be governed by the criteria given therein or as directed by the Engineer.

7.8.3.2 Samples shall be obtained in such a manner that their moisture content and structure do not get altered. This may be ensured by careful protection and packing and by use of correctly designed sampler.

7.8.3.3 Standard Penetration Test may have to be conducted in each case to obtain additional data as directed by Engineer. In soft clay, in-situ vane shear test as per IS: 4434 may have to be conducted. Where all the three operations have to be carried out in one layer, the sequence shall be undistributed soil sampling followed by in-situ vane shear test, followed by Standard Penetration Test.

7.8.3.4 For compression test samples, core of 40 mm diameter and about 150 to 200 mm length may sufficient, but for other laboratory tests, a core of 100 mm diameter and 300 mm length shall be taken as far as possible, unless otherwise specified by the Engineer.

7.8.3.5 The upper few millimetres of both types of sample shall be rejected as the soil at the bottom of the bore hole usually gets disturbed by the boring tools.

7.8.4 Rock Samples

7.8.4.1 Disturbed samples

The sludge from percussion borings or from rotary borings which have failed to yield a core, shall be collected for a disturbed sample. It may be recovered from circulating water by settlement in a trough.

7.8.4.2 Undisturbed samples

Block samples taken from the rock formation shall dressed to a size of about 90 x 75 x 50 mm. For core samples - cores of rock shall be taken by means of rotary drills fitted with a coring bit with core retainer, if warranted.

7.8.4.3 In case of rock at shallow depths which can be conveniently reached, test pits or trenches are the most dependable and valuable methods since they permit a direct examination of the surface, the weathered zone and presence of any discontinuities. It is also possible to take representative samples for tests. For guidance, IS: 4453 may be referred to.

7.9 Protection, Handling and Labeling of Samples

7.9.1 Care shall be taken in handling and labeling of samples so that they are received in a fit state for examination and testing and can be correctly identified as coming from a specified trial pit or boring.

7.9.2 The disturbed material in the upper end of the tube shall be completely removed before applying wax for sealing. The length and type of sample so removed should be recorded.

7.9.3 The soil at the lower end of the tube shall be reamed to a distance of about 20 mm. After cleaning, both ends shall be sealed with wax applied in a way that will prevent wax from entering the sample. Wax used for sealing should not be heated to more than a few degrees above its melting temperature. The empty space in the samplers, if any, should be filled with moist with moist soil, saw dust, etc., and the ends covered with tight fittings caps.

7.9.4 Labels giving the following information should be affixed to the tubes:

1. Tube number
2. Job designation
3. Sample location
4. Boring number
5. Sample number
6. Depth
7. Penetration
8. Gross recovery ratio

7.9.5 The tube and boring numbers should be marked in duplicate. Duplicate markings of the boring number and sample number on a sheet which will not be affected by moisture should be enclosed inside the tube.

7.10 Tests for Exploration of Shallow Foundations of Bridges

7.10.1 Test pits or trenches are the most dependable and valuable methods of exploration since they permit direct visual examination and more reliably the type of soil and their stratification. This will also allow in-situ tests like plate bearing tests, shear tests and uni-axial jacking tests, etc.

7.10.2 Tests shall be conducted on undisturbed samples, which may be obtained from open pits. The use of Plate Load Test (as per IS: 1888) is considered desirable to ascertain the safe bearing pressure and settlement characteristics. A few exploratory bore holes or soundings shall be made to safeguard against presence of weak strata underlying the foundation. This shall extend to a depth of about 1½ times the proposed width of foundation.

7.10.3 The laboratory results shall correlate with in-situ tests like Plate Load Tests and Penetration Test results.

7.11 Tests for Exploration for Deep Foundations of Bridges

7.11.1 The tests to be conducted at various locations for properties of soil., etc., are different for cohesive and cohesionless soils. These are enumerated below and shall be carried out, wherever practicable, according to soil type.

7.11.1.1 Cohesionless soil

1. Classification tests, density, etc.
2. Field tests:
   - Plate Load test as per IS: 1888
   - Dynamic Penetration test as per IS: 2131 and Use of Dynamic Cone penetration test as per IS: 4968 (Part 1 or Part 2) may be conducted where considered appropriate.
3. Laboratory tests: Shearing strength test - triaxial or box shear tests - in case of the possibility of rise of water table, the test shall be done on saturated samples.

7.11.1.2 Cohesive soil

1. Classification tests, density, etc.
2. Field tests:
   - Plate Load test
   - Unconfined Compression Test as per IS: 2720 (Part 10)
   - Vane shear test as per IS: 4434
   - Static cone Penetration test as per IS: 4968 (Part 3).
3. Laboratory tests: Shearing strength test - triaxial tests (IS: 2720 Part 9). Consolidation Test (IS: 2720 Part 17).

7.11.2 The sub-surface exploration for bridge works can be divided into 3 zones:

1. between bed level and upto anticipated maximum scour depth (below H.F.L.)
2. from the maximum scour depth to the foundation level.
3. from foundation to about 1½ times the width of the foundation below it.

7.11.3 The sub-soil water shall be tested for chemical properties to ascertain the hazard of deterioration to foundations. Where dewatering is expected to be required, permeability characteristics shall be determined.

7.11.4 For the different zones categorised in **Clause 6.11.2** the data required, such as soil classification, particle size distribution, shearing strength characteristics, method of sampling disturbed and undisturbed samples, testing, including particle size distribution, shear strength, unconfined compression test, shall be complied with.

7.12 Testing of Material for Guide Bund and High Embankment and Its Foundations

7.12.1 The soil properties for the embankment foundation shall be as specified in particular Specifications and shall be got verified prior to construction operation. In case the actual soil properties do not match the particular Specification, then embankment design shall be revised.

7.12.2 Field investigation for the embankment material should be carried out to collect general information as indicated in IRC: 75. For details refer to **Clause 5.20**. Field investigations for sub-soil strata shall consist of taking minimum two bore holes for each approach to a bridge along centre line of the alignment at a distance of 50 m and 120 m behind the abutment positions on both sides. The depth of bore holes below the ground level may ordinarily be 2.5 times the maximum height of the embankment subject to minimum depth of 20 m. Thin walled sampling tubes of 100 mm internal diameter and 450 mm minimum length conforming to IS: 2132 shall be used for collecting undisturbed samples from bore-holes at an interval of 2.5 to 3.5 m. Standard penetration test should be conducted immediately after undisturbed sample is collected.

7.12.3 In addition to the relevant identification tests, mentioned in IRC: 75, it shall be necessary to conduct some of the following tests on the undisturbed samples collected from the sub-strata. The choice of test is primarily determined by the type of soil, type of stability analysis (vide Table 6-2), availability of apparatus and cost of investigation.

Table 6-2 Shear Strength Tests for Stability Analysis

Sr.	Stage in Life of Embankment	Strength Parameters	Shear Test	Type of Analysis
1.	(a) During construction or immediate post-construction	c_{uu}, ∅uu	Unconsolidated undrained triaxial shear test on undisturbed samples and on compacted embankment material	Total stress analysis
2.	(b) During construction or immediate post-construction	S_u	Unconfined compression test in laboratory or vane shear test	Total stress analysis
3.	(c) During construction or immediate post-construction	C'∅'	Consolidated undrained test with pore-pressure measurement on as compacted soil samples of embankment materials and on disturbed samples	Effective stress analysis
4.	Long term stability	C'∅'	Consolidated undrained test with pore-pressure measurement on as compacted soil samples of embankment materials and on disturbed samples	Effective stress analysis

7.12.4 Laboratory Investigations of Embankment Material

7.12.4.1 The following tests should be conducted on representative samples of embankment material:

Sr.	TEST	TEST METHOD
1.	Gradation Test (Sieve Analysis)	IS: 2720 (Part 4)
2.	Atterberg Limit Test	IS: 2720 (Part 5)
3.	Standard Proctor Test	IS: 2720 (Part 7)
4.	Natural Moisture Content	IS: 2720 (Part 2)

7.12.4.2 In addition to the above, there is need for shear strength tests on compacted samples of the till material. For this purpose, the relative compaction should be 95 per cent of the Standard Proctor maximum dry density and moisture content, same as that likely to prevail in the embankment during the period covered by the stability analysis or to be used in the field during construction. Undrained test shall be run on cohesive soils and shear strength parameters should be ascertained for the ranges of normal pressures which are likely to be experienced in the field. In cases where effective stress analysis is required to be done, pore-pressure measurements should also be made during the undrained tests and effective strength and pore-pressure parameters should found to out. For fill material of cohesionless soils, a direct shear box test (IS: 2720 - Part 13) may be conducted to ascertain shear strength of soil.

7.12.4.3 The results of reconnaissance, field and laboratory investigations for embankments shall be consolidated into a well-knit report. The record of findings and recommendations, if any, may be presented in the form of written test, graphs, figures and tables, as appropriate for different types of data and findings.

7.12.4.4 Information and data to be contained in the report should include general location map, pertinent geological information on reconnaissance observations, sub-soil properties (Fig. 2.1 of IRC: 75), boring logs and summary of sub-soil properties (Fig. 2.2 of IRC: 75), graphs and tables related to laboratory investigations, results of borrow area investigations (Fig 2.3 of IRC: 75) and recommendations, if any.

7.12.4.5 The undisturbed samples shall be collected from each layer of sub-soil unless the stratum is such that undisturbed samples cannot be collected using ordinary sampler. Where indicates by the Engineer, undisturbed samples shall be collected using piston sampler or core-cutter or such special devices. In thick layers undisturbed samples shall be collected at 3 m interval.

7.13 Measurements for Payment

In case of bridge and road structures, the work of boring and trial pits shall be considered as incidental to the foundation works and nothing extra shall be paid unless otherwise specified in the contract. In cases where it is specified to be paid separately, like contract for soil investigation, the work shall be measured in running metres for boring, in cubic meters for trial pits, in number of samples for collection of disturbed and undisturbed samples and in number of tests for each type of test.

7.14 Rate

The contract unit rate shall include the cost of all labour, materials, tools and plant and equipment required for doing the boring or making pits as per these Specifications, taking out and packing the samples, sending and getting them tested in approved laboratories and making available the test report as specified or directed by the Engineer inclusive of all incidental costs to complete the work as per the Specifications.

8 MATERIALS FOR STRUCTURES

8.1 Scope

8.1.1 Materials to be used in the work shall conform to the Specifications mentioned on the Drawings, the requirements laid down in this section and Specifications for relevant items of work covered under these Specifications.

8.1.2 If any material, not covered in these Specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Engineer.

8.2 Sources of Material

8.2.1 The Contractor shall notify the Engineer of his proposed sources of materials prior to delivery. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

8.3 Bricks

8.3.1 Burnt clay bricks shall conform to the requirement of IS: 1077, except that the minimum compressive strength when tested flat shall not be less than 8.4 MPa for individual bricks and 10.5 MPa for average of 5 specimens. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to local practice with a tolerance of ± 5 per cent.

8.4 Stones

8.4.1 Stones shall be of the type specified. It shall be hard, sound, free from cracks, decay and weathering and shall be freshly quarried from an approved quarry. Stone with round surface shall not be used.

8.4.2 The stones, when immersed in water for 24 hours, shall not absorb water by more than 5 per cent of their dry weight when tested in accordance with IS: 1124.

8.4.3 The length of stones shall not exceed 3 times its height nor shall they be less than twice its height plus one joint. No stone shall be less in width than the height and width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

8.5 Cast Iron

8.5.1 Cast Iron shall conform to IS: 210. The grade number of the material shall not be less than 14.

8.6 Cement

8.6.1 Cement to be used in the works shall be any of the following types with the prior approval of the Engineer:

1. Ordinary Portland Cement, 33 Grade, conforming to IS: 269.
2. Rapid Hardening Portland Cement, conforming to IS: 8041.
3. Ordinary Portland Cement, 43 Grade, conforming to IS: 8112.
4. Ordinary Portland Cement, 53 Grade, conforming to IS: 12269.
5. Sulphate Resistant Portland Cement, conforming to IS: 12230.

8.6.2 Cement conforming to IS: 269 shall be used only after ensuring that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 540 kg/cum. of concrete.

8.6.3 Cement conforming to IS: 8112 and IS: 12269 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28-day range can be achieved by finer grinding and higher constituent ratio of C_3S/C_2S, where C_3S is Tricalcium Silicate and C_2S is Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine tune the mix design from strength considerations.

8.6.4 Cement conforming to IS: 12330 shall be used when sodium sulphate and magnesium sulphate are present in large enough concentration to be aggressive to concrete. The recommended threshold values as per IS: 456 are sulphate concentration in excess of 0.2 percent in soil substrata or 300 ppm (0.03 percent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the sea coast, chemical factories, and agricultural land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. Cement conforming to IS: 12330 shall be carefully selected from strength considerations to ensure that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 540 kg/cum. of concrete.

8.6.5 Cement conforming to IS: 8041 shall be used only for precast concrete products after specific approval of the Engineer.

8.6.6 Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement also, total sulphur content calculated as sulphuric anhydride (SO_3) shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate percent by mass is upto 5 or greater than 5 respectively.

8.7 Lime

8.7.1 Lime used shall conform to IS: 712-1984.

8.7.2 Building limes are classified as follows:

Class A	Eminently hydraulic lime used for structural purposes.
Class B	Semi hydraulic lime used for masonry mortars.
Class C	Fat Lime used for finishing coat in plastering, white washing etc., and addition of Pozzolanic material for Masonry Mortar.
Class D	Magnesium lime used for finishing coat in plastering, white washing etc.
Class E	Kankar lime used for masonry mortars.

8.7.3 Quick Lime

8.7.3.1 Quick Lime shall be supplied in the form of lumps and not in powder. Soon after delivery, lump line shall be separated from powder and all underburnt/overburnt lumps and the powder removed. Quick lime shall not be used directly in the work and shall invariably be slaked and converted to lime putty before used.

8.7.4 Hydrated Lime

8.7.4.1 Hydrated Lime shall be in the form of a fine dry powder. It shall be supplied in suitable containers such as jute bags lined with water proofing membrane. The bags shall bear marking indication the class of lime, net weight, date of manufacture and the brand name. It shall be used within 4 months of its date of manufacture.

8.8 Coarse Aggregates

8.8.1 For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or

other approved inert material. They shall not consist pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregate having positive alkali silica reaction shall not be used. All coarse aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386 Parts I to VIII.

8.8.2 The Contractor shall submit for the approval of the Engineer, the entire information indicated in Appendix A of IS: 383.

8.8.3 Maximum nominal size of coarse aggregate for various structural components in PCC, RCC or PSC, shall conform to **Chapter 9**.

8.8.4 The maximum value for flakiness index for coarse aggregate shall not exceed 35 percent. The coarse aggregate shall satisfy the following requirements of grading:

IS Sieve Size	Percent by Weight Passing the Sieve		
	40 mm	20 mm	12.5 mm
63 mm	100	-	-
40 mm	95-100	100	-
20 mm	30-70	95-100	100
12.5 mm	-	-	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

8.9 Sand/Fine Aggregates

8.9.1 For masonry work, sand shall conform to the requirements of IS: 2116.

8.9.2 For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, fine aggregate shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorised sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregate shall conform to IS: 383 and test for conformity shall be carried out as per IS: 2386 (Part I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modules of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

8.9.3 Sand/fine aggregate for structural concrete shall conform to the following grading requirements:

IS Sieve Size	Percent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-10	12-40
150 micron	0-10	0-10	0-10

8.9.4 Broken Brick (Burnt Clay) Fine aggregate

8.9.4.1 Broken Brick (Burnt Clay) Fine Aggregate, also known as Surkhi, shall be made by grinding well burnt (but not under or over burnt) broken bricks as specified in IS: 3068-1986. It shall not contain any harmful impurities, such as iron, pyrites, salts, coal, mica, shale or similar

laminated or other materials in such form of quantity as to adversely affect hardening, strength, durability or appearance of the mortar. The maximum quantities of clay, fine silt, fine dust and organic impurities in surkhi (all taken together) shall not exceed five percent by weight. The particle size grading of surkhi for used in lime mortars shall be within the limits specified in Table below:

IS Sieve Designation	Percentage passing (by wt)
4.75 mm	100
2.36 mm	90-100
1.18 mm	70-100
600 microns	40-100
300 microns	5-70
150 microns	0-15

8.10 Steel

8.10.1 Cast Steel

8.10.1.1 The use of cast steel shall be limited to bearings and other similar parts. Steel for castings shall conform to Grade 280-520N of IS: 1030. In case where subsequent welding is unavoidable in the relevant cast steel components, the letter N at the end of the grade designation of the steel casting shall be replaced by letter W. 0.3 percent to 0.5 per cent copper may be added to increase the corrosion resistance properties.

8.10.2 Steel for Prestressing

8.10.2.1 The prestressing steel shall conform to either of the following:

1. Plain hand drawn steel wire conforming to IS: 1785 (Part I) and IS: 1785 (Part II).
2. Cold drawn indented wire conforming to IS: 6003.
3. High tensile steel bar conforming to IS: 2090.
4. Uncoated stress relieved strands conforming to IS: 6006.

8.10.3 Reinforcement / Untensioned Steel

8.10.3.1 For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, the reinforcement / untensioned steel as the case may be shall consist of the following grades of reinforcing bars:

Grade Designation	Bar Type conforming to governing IS Specification	Characteristic Strength fy MPa	Elastic Modulus GPa
S 240	IS: 432 Part I Mild Steel Bar	240	200
S 415	IS: 1786 High Yield Strength Deformed Bars	415	200

8.10.3.2 Other grades of bars conforming to IS: 432 and IS: 1786 shall not be permitted.

8.10.3.3 All steel shall be procured from original producers, no re-rolled steel shall be incorporated in the work.

8.10.3.4 Only new steel shall be delivered to the site. Every bar shall be inspected before assembling on the work and defective, brittle or burnt bar shall be discarded. Cracked ends of bars shall be discarded.

8.10.3.5 Fusion-bonded epoxy coated reinforcing bars shall meet the requirements of IS: 13620. Additional requirements for the use of such reinforcement bars have been given below:

1. Patch up materials shall be procured in scared containers with certificates from the agency who has supplied the fusion bonded epoxy bars.
2. PVC coated G.I. binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.
3. Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.
4. The cut ends and damaged portions shall be touched up with repair patch up material
5. The bars shall be cut by saw-cutting rather than flame cutting.
6. While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.
7. The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque polyethylene sheets or such other approved materials.
8. While concreting, the workmen or trolleys shall not directly move on coated bars but can move on wooden planks placed on the bars.

8.10.3.6 When specified in the contract, protective coating prescribed by the CECRI shall be provided in conformance to Specifications given in Appendix 1000/I. The CECRI coating process shall be allowed to be implemented at the site of works provided a representative of the Institute is present throughout the duration of the coating process who shall certify that the materials and workmanship are in accordance with prescribed Specifications developed by the Institute.

8.10.4 Grey Iron Castings

8.10.4.1 Grey Iron Castings to be used for the bearings shall have the following minimum properties:

1.	Minimum Ultimate Tensile Strength	370 MPa
2.	Modulus of Elasticity	147000 MPa
3.	Brinell Hardness	230 MPa
4.	Shear Strength	370 MPa
5.	Compressive Strength	1370 MPa

8.10.4.2 The testing shall be as specified in IS: 210.

8.10.5 Steel Forgings

8.10.5.1 Forged steel pins shall comply with **Clause 3, 3A or 4 of IS: 1875** and steel forgings shall comply with **Clause 3, 3A or 4 of IS: 2004**. Raw materials of the forging will be taken as per IS: 1875 with minimum reduction ratio of 1.8:1. Alternatively, if forgoing is made from ingot, a minimum reduction ratio between the ingot and forging will be 4:1. Forging shall be normalised.

8.10.6 Structural Steel

8.10.6.1 Unless otherwise permitted herein, all structural steel shall before fabrication comply with the requirement of the following Indian Standards:

IS: 226	Structural Steel (Standard Quality)
IS: 961	Structural Steel (High Tensile)
IS: 2062	Weldable Structural Steel
IS: 8500	Weldable Structural Steel (medium & high strength qualities)
IS: 1148	Hot rolled rivet bars (upto 40mm dia) for structural purposes
IS: 1149	High tensile rivet bars for structural purposes
IS: 1161	Steel tubes for structural purposes
IS: 4923	Hollow Steel sections for structural use
IS: 11587	Structural weather resistant steel
IS: 808	Specifications for Rolled Steel Beam, Channel and Angle Sections
IS: 1239	Mild Steel Tubes

IS: 1730	Dimension for Steel Plate, sheet and strip for structural and general engineering purposes
IS: 1731	Dimension for Steel flats for structural and general engineering purposes
IS: 1732	Dimension for round and square steel bars for structural and general engineering purposes
IS: 1852	Rolling and cutting tolerances for hot rolled steel products

8.10.6.2 The use of structural steel not covered by the above standards may be permitted with the specific approval of the authority. Refer to Section 1900 for further details.

8.10.7 Stainless Steel

8.10.7.1 Stainless steel shall be austenitic chromium-nickel steel, possessing rust, acid and heat resistant properties conforming to IS: 6603 and IS: 6911. Mechanical properties/grade for such stainless steel shall be as specified by the accepting authority, but in no case be inferior to mild steel. Generally, stainless steel is available as per AISI grades. AISI 304 which is equivalent to grade 04Cr18Ni110 of IS: 6911 satisfies the requirements of mechanical properties of structural steel. Other grades of stainless steel for specific purposes may be provided as per specific requirements. For application in adverse/corrosive environment, stainless steel shall conform to AISI 316L or 02G17 Ni Mo2 of IS: 6911.

8.10.8 Bitumen

8.10.8.1 The bitumen shall be paving bitumen of Penetration Grade S65 or A 65 (60/70) as per Indian Standard Specifications for “Paving Bitumen” IS: 73. In case of non-availability of bitumen of this grade, S90 (80/1-00) grade bitumen may be used with the approval of the Engineer. Guidance to selection of the grade of bitumen may be taken from **Appendix 4** of MoST Specifications for Roads and Bridge Works (IV Revision).

8.11 Water

8.11.1 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. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. As a guide, the following concentrations represent the maximum permissible values:

1. To neutralise 200 ml sample of water, using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal NaOH.

2. To neutralise 200 ml sample of water, using methyl orange as an indicator, it should not require more than 10 ml of 0.1 normal HCl.

3. The permissible limits for solids shall be as follows when tested in accordance with IS: 3025:

1.	Organic	200 mg/lit
2.	Inorganic	3000 mg/lit
3.	Sulphates (SO_4)	500 mg/lit
4.	Chlorides (Cl)	500 mg/lit *
5.	Suspended matter	2000 mg/lit

* *In case of structures of lengths 30m and below, the permissible limit of chlorides may be increased upto 1000 mg/lit.*
All samples of water (including potable water) shall be tested and suitable measures may be where necessary to ensure conformity of the water to the requirements states herein.

4. The pH value shall not be less than 6.

8.12 Timber

8.12.1 The timber used for structural purposes shall conform to IS: 883.

8.13 Concrete Admixtures

8.13.1 General

8.13.1.1 Admixtures are materials added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or hardened state.

8.13.1.2 Concrete admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers with proven track record, quality assurance and full fledged laboratory facilities for the manufacture and testing of concrete.

8.13.1.3 The Contractor shall provide the following information concerning each admixture after obtaining the same from the manufacturer:

1. Normal dosage and detrimental effects, it any, of under dosage and over dosage.
2. The chemical names of the main ingredients in the admixtures.
3. The chloride content, if any, expressed as a percentage by weight of the admixture.
4. Values of dry material content, ash content and relative density of the admixture which can be used for Uniformity Tests.
5. Whether or not the admixture leads to the entertainment of air when used as per the manufacturer's recommended dosage and it so to what extent.
6. Where two or more admixtures are proposed to be used in any one mix, confirmation as to their compatibility.
7. There would be no increase in risk of corrosion of the reinforcement or other embedments as a result of using the admixture.

8.13.2 Physical and Chemical Requirements

8.13.2.1 Admixtures shall conform to the requirements of IS: 9103. In addition, the following conditions shall be satisfied:

1. "Plasticisers" and "Super - Plasticisers" shall meet the requirements indicated for "Water reducing Admixture".
2. Except where resistance to freezing and thawing and to disruptive action of deicing salts is necessary, the air content of freshly mixed concrete in accordance with the pressure method given in IS: 1199 shall not be more than 2 per cent higher than that of the corresponding control mix and in any case not more than 3 per cent of the test mix.
3. The chloride content of the admixture shall not exceed 0.2 per cent when tested in accordance with IS: 6925. In addition, the maximum permissible limit of chloride content of all the constituents as indicated in **Chapter 9** shall also be observed.
4. Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

   The tests that shall be performed along with permissible variations in the same are indicated below:

   - Dry Material Content: to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer.
   - Ash content: to be within 1 per cent of the value stated by the manufacturer.

   Relative density (for liquid admixtures): to be within 2 percent of the value stated by the manufacturer.

5. All tests relating to the concretes admixtures shall be conducted periodically at an independent laboratory and compared with the date given by the manufacturer.

8.14 Reinforced Concrete Pipes

8.14.1 Reinforced concrete pipes for highway structures shall be of NP4 type conforming to the requirements of IS: 458. For other items, it shall be NP3 type unless otherwise shown on the Drawing, conforming to the requirements of IS: 458.

8.15 Storage of Materials

8.15.1 General

8.15.1.1 All materials may be stored at proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and restorage of the materials. All such materials even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

8.15.2 Brick

8.15.2.1 Bricks shall not be dumped at site. They shall be stacked in regular tiers as they are unloaded, to minimise breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different situations shall be stacked separately.

8.15.3 Aggregates

8.15.3.1 Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained If necessary, the ground shall be covered with 50 mm plank.

8.15.3.2 Coarse aggregates, unless otherwise agreed by the Engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size in 25 mm or less and 3 sizes when the nominal size is 32 mm or more). Aggregates placed directly on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.

8.15.3.3 In the case of fine aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the Engineer.

8.15.3.4 Broken Brick (Burnt Clay) Fine Aggregate (Surkhi) shall be stacked on a hard surface or platform so as to prevent the admixture of clay, dust, vegetation and other foreign matter. It shall be also protected from rain and dampness and kept under adequate covering.

8.15.4 Cement

8.15.4.1 Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to 4 months.

8.15.4.2 Each consignment shall be stored separately so that, it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to the Employer.

8.15.4.3 The Contractor shall prepare and maintain proper records on site in respect of delivery, handling, storage and use of cement and these records shall be available for inspection by the Engineer at all times.

8.15.4.4 The Contractor shall make a monthly return to the Engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

8.15.5 Lime

Lime shall be stored in water proof sheds. Hydrated lime shall be stored in the same manner as cement. Lime which has been damaged by moisture or air-slaking shall not be used. All damaged and rejected lime shall be removed from the site of work forthwith.

8.15.6 Reinforcement / Untensioned Steel

8.15.6.1 The reinforcement bars, when delivered on the job, shall be stored above the surface of the ground upon platforms, skids, or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

8.15.7 Prestressing Materials

8.15.7.1 All prestressing steel, sheathing, anchorages and sleeves or coupling must be protected during transportation, handling and storage. The prestressing steel, sheathing and other accessories must be stored under cover from rain or damp ground and protected from the ambient atmosphere if its is likely to be aggressive. Storage at site must be kept to the absolute minimum.

1. Tendon: Wire, strand and bar from which tendons are to be fabricated shall be stored about 300 mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of any oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances, tendon material shall be subjected to any welding operation or on site heat treatment or metallic coating such as galvanising. Storage facilities and the procedures for transporting material into or out of store shall be such that the material does not become kinked or notched. Wire or strand shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5 mm dia, coils of about 2 m diameter without breaks or joints shall be obtained from manufacturer and stored. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.
2. Anchorage Components: The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The use of correctly formulated oils and greases or of other corrosion preventing materials is recommended where prolonged storage is required. Such protective material shall be guaranteed by the producer to be non-aggressive and non-degrading.

8.15.7.2 Prestressing steel shall be stored in a closed store having single door with double locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility or initial rusting of prestressing steel during storage. The prestressing steel shall be coated with water solvable grease. The prestressing steel should be absolutely clean and without any signs of rust.

8.15.7.3 All prestressing steel shall be stored at least 30 cm above ground level and it shall be invariably wrapped by protective cover of tar paper or polythene or any other approved material.

8.15.7.4 The Contractor should see that prestressing steel shall be used within 3 months of its manufacture. He should chalk out his programme in this respect precisely, so as to avoid initial corrosion before placing in position.

8.15.8 Water

8.15.8.1 Water shall be stored in containers / tanks covered at top and cleaned at regular intervals in order to prevent intrusion by foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface shall not be permitted. The intake pipe shall be enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60 m of water below the intake at all times.

8.16 Tests and Standard of Acceptance

8.16.1 All materials, even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use. Independent testing or cement for every consignment shall be done by the Contractor at site in the laboratory approved by the Engineer before use. Any cement with lower quality than those shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

8.16.2 Testing and Approval of Material

8.16.2.1 The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

8.16.2.2 The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant Specifications. The testing of all the materials shall be carried out by the Engineer or his representative for which the Contractor shall make all the necessary arrangements and bear the entire cost.

8.16.2.3 Tests which cannot be carried out in the field laboratory have to be got done at the Contractor's cost at any recognised laboratory/testing establishments approved by the Engineer.

8.16.3 Sampling of Materials

8.16.3.1 Samples provided to the Engineer or his representative for their retention are to be in labeled boxes suitable for storage.

8.16.3.2 Samples required for approval and testing must be supplied well in advance by at least 48 hours or minimum period required for carrying out relevant tests to allow for testing and approval. Delay to works arising from the late submission of samples will not be acceptable as a reason for delay in the completion of the works.

8.16.3.3 If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall be borne by the Contractor.

8.16.4 Rejection of Materials not Conforming to the Specifications

8.16.4.1 Any stack or batch of material(s) of which sample(s) does not conform to the prescribed tests and quality shall be rejected by the Engineer or his representative and such materials shall be removed from site by the Contractor at his own cost. Such rejected materials shall not be made acceptable by any modifications.

8.16.5 Testing and Approval of Plant and Equipment

8.16.5.1 All Plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works shall be in accordance with manufacturer's Specifications and shall be got approved by the Engineer before use.

9 STRUCTURAL STEEL

9.1 Scope

These Specification cover the general requirements of furnishing, fabricating, transporting, erecting and painting structural steel, rivet steel, cast steel, steel forgings, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the Drawings and as desired by the Engineer.

9.2 Applicable Codes

9.2.1 The provisions of the latest Indian Standards listed below, but not restricted to, form part of these Specifications:

IS 226	Structural Steel (Standard Quality)
IS: 800	Code of Practice for Use of Structural Steel in General Building Construction
IS: 813	Scheme for Symbols for Welding.
IS: 814	Covered Electrodes for Metal Are Welding of Structural Steel (Part I & II).
IS: 815	Classification and Coding of Covered Electrodes for Metal Are Welding of Structural Steel.
IS: 816	Code of Practice for Use of Metal Are Welding for General Construction in Mild Steel.
IS: 817	Code of Practice for Training and Testing of Metal Are Welders.
IS: 822	Code of Procedures for Inspection of Welds.
IS: 823	Code of Procedure for Manual Metal Are Welding of Mild Steel.
IS: 961	Structural Steel (High Tensile)
IS: 1024	Code of Practice for Use of Welding in Bridges.
IS: 1148	Hot Rolled Steel Rivet Bars (Upto 40 Mm Diameters) for Structural Purposes.
IS: 1387	General Requirements for The Supply of Metallurgical Material.
IS: 1477	Part I, Code of Practice for Painting of Ferrous Metals in Buildings - Pretreatment.
IS: 1599	Method for Bend Test for Steel Products Other Then Sheets, Strip., Wire and Tube.
IS: 1608	Method for Tensile Testing of Steel Products.
IS: 1731	Dimensions for Steel Flats for Structural and General Engineering Purposes.
IS: 1852	Rolling and Cutting Tolerances for Hot-Rolled Steel Products.
IS: 1915	Code of Practice for Steel Bridges.
IS: 2101	Allowable Deviations for Dimensions Without Specified Tolerances.
IS: 7318	Part I Fusion for Assembly of Structural Joints Using High Tensile Friction Grip Fasteners.
IS: 7318	Part I Fusion Welding of Steel.

9.2.2 Other I.S. Codes and I.R.C. codes pertaining to the items of structural steel not specifically listed shall also be deemed to come under the purview of this clause.

9.3 General

9.3.1 Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pits or other defects affecting its strength and durability.

9.3.2 The acceptance of any material on inspection at the mill i.e., rolling mills, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective.

9.3.3 Unless specified otherwise, high tensile steel rivet conforming to IS: 1149 shall be used for members of high tensile steel confirming to IS: 961 and shall not be used for mild steel members.

9.3.4 Unless specified otherwise, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS: 4000.

9.3.5 Cast iron shall not be used in any portion of the bridge structure, except where it is subject to direct compression.

9.4 Materials

9.4.1 All materials conform to **Chapter 7.** Special requirements are given below:

9.4.1.1 Mild steel for bolts and nuts shall conform to IS: 226 but have a minimum tensile strength of 44 kg/sq. mm. and minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS: 961 but with a minimum tensile strength of 58 kg/sq. mm. High strength friction grip bolts shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these Specifications) specified by the Engineer or included in the special provisions.

9.4.1.2 For cast steel, the yield stress shall be determined and shall not be less than 50 percent of the minimum tensile strength.

9.4.1.3 Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

9.4.1.4 Parallel barrel drifts shall have a tensile strength not less than 55 kg/sq. mm. with elongation of not less than 20 percent measured on a gauge length of $4\sqrt{So}$ (So = Cross sectional area).

9.4.2 Materials for castings and forgings, fasteners and welding consumable shall be as under:

9.4.2.1 Castings and Forgings: Steel castings and forgings shall comply with requirements for the following Indian Standards, as appropriate:

IS: 1030	Carbon Steel Castings for General Engineering Purposes
IS: 1875	Carbon Steel Billets, Blooms, Slabs, Bars for Forgings
IS: 2004	Carbon Steel Forgings for General Engineering Purposes
IS: 2644	High Tensile Steel Castings
IS: 4367	Alloy & Tool Steel Forgings for General Industrial Use

9.4.2.2 Fasteners: Bolts, nuts, washers and rivets shall comply with following or relevant IS standards as appropriate:

IS: 1929	Hot Forges Steel Rivets for Hot Closing (12-36 mm Dia)
IS: 2155	Cold Forged Steel Rivets for Hot Closing (6-16 mm Dia)
IS: 1363	Hexagon Head Bolts, Screw and Nuts Product Grade C
IS: 1364	Hexagon Head Bolts, Screw & Nuts Product Grade A & B
IS: 1367	Technical Supply Conditions for Threaded Steel Fastener (Parts 1 To 18)
IS: 3640	Hexagon Fit Bolts
IS: 3757	High Tensile Friction Grip Bolts
IS: 6623	High Strength Structural Nuts
IS: 6639	Hexagon Bolts for Steel Structure
IS: 5624	Foundation Bolts
IS: 7002	Prevailing Torque Type Steel Hexagon Lock Nuts
IS: 5369	Plain Washers and Lock Washers - General Requirements
IS: 5370	Plain Washers with Outside Dia = 3 X Inside Dia
IS: 5372	Taper Washers for Channels (ISMC)
IS: 5374	Taper Washers for I Beams (ISMB)
IS: 6610	Heavy Washers for Steel Structures
IS: 6649	Hardened and Tempered Washers for High Strength Structural Bolts and Nuts

9.4.2.3 Welding consumable

Welding consumable shall comply with the following Indian Standards as appropriate:

IS: 814 (Part I)	Covered Electrodes for Metal Arc Welding of Structural (Part 1) Steel for Welding Other Than Sheets.
IS: 814 (Part II)	for Welding Sheets
IS: 1278	Filler Rods and Wires for Gas Welding
IS: 1395	Low and Medium Alloy Steel Covered Electrodes for Manual Metal Arc Welding
IS: 3613	Acceptance Test for Wire Flux Combinations for Submerged Arc Welding of Structural Steel
IS: 7280	Bare Wire Electrodes for Gas Shielded Arc Welding of Structural Steel
IS: 6419	Welding Rods and Bare Electrodes for Gas Shielded Arc Welding of Structural Steel
IS: 6560	Molybdenum and Chromium-Molybdenum Low Alloy Steel Welding Rods and Bare Electrodes for Gas Shielded Arc Welding

9.4.3 In aggressive environment, corrosion resistant steel can be used. These are low-alloyed steels containing a total of 1 per cent - 2 per cent alloys, in particular, copper, chromium, nickel and phosphorus.

9.4.4 Paints

9.4.4.1 All materials for paints and enamels shall conform to the requirements specified on the Drawings or other special provisions laid down by the Engineer.

9.4.4.2 The type of paints which can be used shall be as follows:

1. Ordinary i.e., paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy.
2. Chemical Resistant - one pack type (ready for use) and two pack type (mixed before use.)
3. Vinyl
4. Chlorinated rubber
5. Bituminous
6. Epoxy
7. Polyurethane
8. Zinc rich

9.4.4.3 Unless otherwise specified, paints shall conform to the relevant IS Specifications. The paints which have been tested for the following qualities as per Specifications given in the relevant IS codes only shall be used:

1. Weight test (weight for 10 litre of paint, thoroughly mixed)
2. Drying time
3. Consistency
4. Dry thickness and rate of consumption

9.5 Fabrication

9.5.1 General

9.5.1.1 All work shall be in accordance with the Drawings and as per these Specifications with care being taken that all parts of an assembly fit accurately together. All members shall carry mark number and item number and, if required, serial number.

9.5.1.2 Unless specifically required under the contract, corresponding parts need not be interchangeable, but the parts shall be match marked as required under **Clause 8.5.7.**

9.5.1.3 Templates, jigs and other appliances used for ensuring the accuracy of the work shall be of mild steel; where specially required, these shall be bushed with hard steel. All measurements shall be made by means of steel tape or other device properly calibrated. Where bridge materials have been used as templates for drilling, these shall be inspected and passed by the Engineer before they are used in the finished structure.

9.5.1.4 All structural steel members and parts shall have straight edges and blunt surfaces. If necessary, they shall be straightened or flattened by pressure unless they are required to be of curvilinear forms. They shall also be free from twist. Pressure applied for straightening or flattening shall be such as would not injure the materials. Hammering shall not be permitted. Adjacent surfaces or edges shall be in close contact or at uniform distance throughout.

9.5.1.5 The Contractor shall submit his programme of work to the Engineer for his approval at least at least 15 days before the commencement of fabrication. This programme shall include the proposed system of identification and erection marks together with complete details of fabrication and welding procedures.

9.5.1.6 The Contractor shall prepare shop Drawings for fabricating any member and obtain approval of the Engineer before the start of work. Complete information regarding the location, type, size and extent of all welds shall be clearly shown on the shop Drawings. These Drawings shall distinguish between shop and field welds.

9.5.2 Preparation of Edges and Ends

9.5.2.1 All structural steel-parts, where required, shall be sheared, cropped, sawn or flame cut and ground accurately to the required dimension and shape.

9.5.2.2 End/edge planing and cutting shall be done by any one of the following prescribed methods or leat as rolled:

1. Shearing, cropping, sawing, machining, machine flame cutting.
2. Hand flame cutting with subsequent grinding to a smooth edge.
3. Sheared edges of plate not more than 16 mm thick with subsequent grinding to smooth profile, which are for secondary use such as stiffeners and gussets.

9.5.2.3 If ends of stiffeners are required to be fitted, they shall be ground, so that the maximum gap over 60 per cent of the contact area does not exceed 0.25 mm.

9.5.2.4 Where flame cutting or shearing is used, at least one of the following requirements shall be satisfied.

1. The cut edge is not subjected to applied stress.
2. The edge is incorporated in weld
3. The hardness of cut edge does not exceed 350 HV 30
4. The material is removed from edge to the extent of 2 mm or minimum necessary, so that the hardness is less than 350 HV 30.
5. Edge is suitably heat treated by approved method to the satisfaction of the Engineer and shown that cracks had not developed by dye penetrant or magnetic particle test.
6. Thickness of plate is less than 40 mm for machine flame cutting for materials conforming to IS: 226 and IS: 2062. The requirement of hardness below 350 HV 30 of flame cut edges should be specified by the Engineer.

9.5.2.5 Wherever specified by the Engineer, the flame cut edges shall be ground or machined over and above the requirement (1) to (6)

9.5.2.6 Where machining for edge preparation in butt joint is specified, the ends shall be machined after the members have been fabricated.

9.5.2.7 Outside edges of plate and section, which are prone to corrosion shall be smoothed by grinding or filing.

9.5.2.8 In the case of high tensile steel at least 6 mm of the material from the flame cut edge shall be removed by machining.

9.5.2.9 Longitudinal edges of all plates and cover plates in plate girders and built-up members shall be machined except in the following cases:

1. Rolled edges of single universal plates or flats may not be machined.
2. Covers to single flange plates may be left unmachined.
3. Machine flame cutting instead of machining is acceptable for edges of single plates in compression and for edges of single plates, 25 mm or less thick, in tension
4. Edges of single shaped plates over 25 mm thick not capable of being machined by ordinary method may be machine flame cut and the end surface ground.
5. Edges of universal plates or flats of the same nominal width used in tiers may be left unmachined, if so authorised by the Engineer.

9.5.2.10 All edges of splice and gusset plates 12 mm thick and over shall be machined and those less than 12 mm thick may be sheared and ground.

9.5.2.11 The ends of plates and sections forming the main components of plate girders or of build-up members shall be machined, machine flame cut, sawn or hand flame cut and ground.

9.5.2.12 Where ends of stiffeners are required to be fitted, they shall be machined, machine flame cut, sawn, sheared and ground, or hand flame cut and ground.

9.5.2.13 The ends of lacing bar shall be rounded unless otherwise required.

9.5.2.14 Others edges and ends of mild steel parts may be sheared and any burrs at edges shall be removed.

9.5.3 Preparation of Holes

9.5.3.1 Drilling and punching

9.5.3.1.1 Holes for rivets, black bolts, high strength bolts and countersunk bolts / rivets (excluding close tolerance and turn fitted bolts) shall be either punched or drilled. The diameter of holes shall be 1.5 mm larger for bolts / rivets less than 25 mm dia and 2.0 mm for more than or equal to 25 mm.

9.5.3.1.2 All holes shall be drilled except for secondary members such as, floor plate, hand rails etc. Members which do not carry the main load can be punched subject to the thickness of member not exceeding 12 mm for material conforming to IS: 226.

9.5.3.1.3 Holes through more than one thickness of material or when any of the main material thickness exceeds 20 mm for steel conforming to IS: 2062 or 16 mm for steel conforming to IS: 961, IS: 8500, shall either be sub-drilled or sub-punched to a diameter of 3 mm less than the required size and then reamed to the required size. The reaming of material more than one thickness shall be done after assembly.

9.5.3.1.4 Where several plates or sections form a compound member, they shall, where practicable, be firmly connected together by clamps or tacking bolts, and the holes be drilled through the group in one operation. Alternatively, and in case of repetition work, the plates and sections may be drilled separately from jigs and templates. Jigs and templates shall be checked at least once after every 25 operations. All burrs shall be removed.

9.5.3.1.5 In the case of repetition of spans, the erection of every span shall not be insisted upon, except where close tolerance or turned bolts are used, provided that methods are adopted to ensure strict interchangeability. In such cases, one span in ten or any number less than ten of each type shall be erected from pieces selected at random by the Engineer and should there be any failure of the pieces to fit, all similar spans shall be erected complete. In the event of

spans being proved completely interchangeable, all corresponding parts shall carry the same mark so that sorting of the materials at site is facilitated.

9.5.3.2 Block drilling

Where the number of plates to be riveted exceeds three or the total thickness is 90 mm or more, the rivet holes, unless they have been drilled through steel bushed jigs, shall be drilled out in place 3 mm all round after assembling., In such cases, the work shall be thoroughly bolted together.

9.5.3.3 Size of holes

The sizes of holes in millimetres are given in Table 8-1 below:

Table 8-1: Diameter of Holes for Rivets

Dia of Holes (mm)	Nominal dia of Rivets (mm)
13.5	12
15.5	14
17.5	16
19.5	18
21.5	20
23.5	22
25.5	24
29.0	27
32.0	30
35.0	33

9.5.3.4 Close tolerance bolts and barrel bolts

9.5.3.4.1 For holes for close tolerance and turn fitted bolts, the diameter of the holes shall be equal to the nominal diameter of the bolt shank minus 0.15 mm to 0.0 mm.

9.5.3.4.2 The members to be connected with close tolerance or turn fitted bolts shall be firmly held together by service bolts or clamped and drilled through all thicknesses in one operation and subsequently reamed to required size within specified limit of accuracy as specified in IS: 919 tolerance grade H8.

9.5.3.4.3 The holes not drilled through all thicknesses at one operation shall be drilled to smaller size and reamed after assembly.

9.5.3.5 Holes for high strength friction grip bolts

All holes shall be drilled after removal of burrs. Where the number of; lies in the grip does not exceed three, the diameters of holes shall be 1.6 mm larger than those of bolts and for more than three plies in grip, the diameters of hole in outer plies shall be as above and dia of holes in inner plies shall not be less than 1.6 mm and not more than 3.2 mm larger than those in bolts, unless otherwise specified by the Engineer.

9.5.3.6 Removal of burrs

The work shall be taken apart after drilling and all burrs left by drilling and the sharp edges of all rivet holes completely removed.

9.5.4 Rivet and riveting

9.5.4.1 The diameter of rivets shown on the Drawings shall be the size before heating. Each rivet shall be of sufficient length to form a head of the standard dimension as given in IS handbook of Steel Sections, Part I. It shall be free from burrs on the underside of the head. When countersunk heads are required, the heads shall fill the counter sunk. The included angle of the head shall be as follows:

1. For plates over 14 mm thickness 90 degrees
2. For plates upto and including 14 mm thickness 120 degrees

9.5.4.2 The tolerance on the diameter of rivets shall be in accordance with IS: 1148 and IS: 1149 for mild steel rivets and high tensile steel rivets respectively and unless otherwise specified, the tolerance shall be minus tolerance.

9.5.4.3 Rivets shall be driven when hot so as to fill the hole as completely as possible and shall be of sufficient length to form a head of standard dimension. When counter-sunk head is required, the head shall fill the counter-sunk hole. Projection after counter-sinking shall be ground off wherever necessary.

9.5.4.4 Rivets shall be heated uniformly to a “light cherry red” colour between 650 degrees Celsius to 700 degrees Celsius for hydraulic riveting and “orange colour” for pneumatic riveting of mild steel rivets and shall be red hot from head to the point when inserted and shall be upset in its entire length so as to fill the hole as completely as possible when hot. Rivets, after being heated and before being inserted in the hole shall be made from scale by striking the hot rivet on a hard surface.

9.5.4.5 Wherever possible, the rivets shall be machine driven preferable by direct acting riveters. The driving pressure shall be maintained on the rivets for a short time after the upsetting is completed. High tensile steel rivets shall be heated upto 1100 degrees Celcius. Any rivet, whose point is heated more than prescribed, shall not be driven.

9.5.4.6 Where flush surface is required, any projecting metal shall be chipped or ground off.

9.5.4.7 Before riveting is commenced, all work shall be properly bolted up so that the various sections and plates are in close contact throughout. Drifts shall only be used for Drawing the work into position and shall not be used to such an extent as to distort the holes. Drifts of a larger size than the nominal diameter of the hole shall not be used. The riveting shall be done by hydraulic or pneumatic machine unless otherwise specified by Engineer.

9.5.4.8 Driven rivets, when struck sharply on the head by a quarter pound rivet testing hammer, shall be free from movement and vibrations. Assembled riveted joint surfaces, including those adjacent to the rivet heads, shall be free from scale, dirt, loose scale, burrs, other foreign materials and defects that would prevent solid seating of parts.

9.5.4.9 All loose or burnt rivets and rivets with cracked or badly formed defective heads or with heads which are unduly eccentric with the shanks, shall be removed and replaced. In removing rivets, the head shall be sheared off and the rivet punched out so as not to injure the adjacent metal and, if necessary, they shall be drilled out. Recupping or recaulking shall not be permitted. The parts not completely riveted in the shop shall be secured by bolts to prevent damage during transport and handling.

9.5.5 Bolts, Nuts and Washers

9.5.5.1 Black bolts (black all over)

Black bolts are forged bolts in which the shanks, heads and nuts do not receive any further treatment except cutting of screw threads. They shall be true to shape and size and shall have the standard dimensions ad shown on the Drawings.

9.5.5.2 Close tolerance bolts

Close tolerance bolts shall be faced under the head and turned on the shank.

9.5.5.3 Turned barrel bolts

The diameter of the screwed portion of turned barrel bolts shall be 1.5 mm smaller than the diameter of the barrel unless otherwise specified by the Engineer. The diameter of the bolts as given on the Drawing shall be the nominal diameter of the barrel. The length of the barrel shall be such that it bears fully on all the parts connected. The threaded portion of each bolt shall project through the nut by at least one thread. Faces of heads and nuts bearing on steel work shall be machined.

9.5.5.4 High strength friction bolts and bolted connections

The general requirement shall be as per relevant IS Specifications mentioned in **Clause 5.3** of (Fasteners) of IRC:24. Unless otherwise specified by the Engineer, bolted connections of structural joints using high tensile friction grip bolts shall comply with requirements mentioned in IS: 4000.

9.5.5.5 Washers

1. In all cases where the full bearing area of the both is to be developed, the bolt shall be provided with a steel washer under the nut of sufficient thickness to avoid any threaded portion of the bolt being within the thickness of the parts bolted together and to prevent the nut when screwed up, from bearing on the bolt.

2. For close tolerance or turned barrel bolts, steel washers whose faces give a true bearing shall be provided under the nut. The washer shall have a hole diameter not less than 1.5 mm larger than the barrel and a thickness of not less than 6 mm so that the nut when screwed up, will not bear on the shoulder of the bolt.

3. Taper washers with correct angle of taper shall be provided under all heads and nuts bearing on bevelled surfaces.

4. Spring washers may be used under nuts to prevent slackening of the nuts when excessive vibrations occur.

5. Where the heads or nuts bear on timber, square washers having a length of each side not less than three times the diameter of bolts or round washers having a diameter of $3\ ^{1}/_{2}$ times the diameter of bolts and with a thickness not less than one quarter of diameter shall be provided.

9.5.5.6 Studs

Ordinary studs may be used for holding parts together, the holes in one of the parts being tapped to take the thread of the stud. Counter-sunk may be used for making connections where the surfaces are required to be clear of all obstruction, such as protruding heads of bolts or rivets, studs may also be welded on the steel work in the positions required.

9.5.5.7 Service bolts

Service bolts shall have the same clearance as black bolts and where it is required that there should be no movement prior to final riveting, sufficient drifts or close tolerance bolts shall be used to locate the work.

9.5.5.8 Tightening bolts

1. Bolted connection joints with black bolts and high strength bolts shall be inspected for compliance of Codal requirements.

2. The Engineer shall observe the installation and tightening of bolts to ensure that correct tightening procedure is used and shall determine that all bolts are tightened. Regardless of tightening method used, tightening of bolts in a joint should commence at the most rigidly fixed or stiffest point and progress towards the free edges, both in initial snugging and in final tightening.

3. The tightness of bolts in connection shall be checked by inspection wrench, which can be torque wrench, power wrench or calibrated wrench.

4. Tightness of 10 percent bolts, but not less than two bolts, selected at random in each connection shall be checked by applying inspection torque. If no nut or bolt head is turned by this application, connection can be accepted as properly tightened, but if any nut or head has turned all bolts shall be checked and, if necessary, re-tightened.

9.5.5.9 Drifts

The barrel shall be drawn or machined to the required diameter for a length of not less than one diameter over the combined thickness of the metal through which the drifts have to pass. The diameter of the parallel barrel shall be equal to the nominal diameter of the hole subject to a tolerance of +0 mm and - 0.125 mm. Both ends of the drift for a length equal to $1\ ^{1}/_{2}$ times the diameter of the parallel portion of the bar shall be turned down with a taper to a diameter at the end equal to one-half that of parallel portion.

9.5.6 Pins and Pin Holes

9.5.6.1 Pins

The pins shall be parallel throughout and shall have a smooth surface free from flaws. They shall be of sufficient length to ensure that all parts connected thereby shall a have full bearing on them. Where the ends are threaded, they shall be turned to a smaller diameter at the ends for the thread and shall be provided with a pilot nut, where necessary, to protect the thread when being drawn to place. Pins more then 175 mm in length or diameter shall be forged and annealed.

9.5.6.2 Pin holes

Pin holes shall be bored true to gauge, smooth, straight at right angles to the axis of the member and parallel with each other, unless otherwise required. The tolerance in the length of tension members from outside to outside of pin holes and of compression members from inside to inside pin holes shall be one millimetre. In build-up members, the boring shall be done after the members have been riveted or welded. The specified diameter of the pin hole shall be its minimum diameter. The resulting clearance between the pin and the hole shall not be less than 0.5 mm and not more than 1.0 mm.

9.5.7 Shop erection and Match Marking

9.5.7.1 Before being dispatched, the steel work shall be temporarily erected in the fabrication shop for inspection by the Engineer either wholly or in such portion as the Engineer may require so that he may be satisfied both in respect of the alignment and fit of all connections. For this purpose, sufficient number of parallel drifts and service bolts tightly screwed up shall be employed. All parts shall fit accurately and be in accordance with Drawings and Specifications.

9.5.7.2 The steel work shall be temporarily assembled at place of fabrication. Assembly shall be of full truss or girder, unless progressive truss or girder assembly, full chord assembly, progressive chord assembly or special complete structure assembly is specified by the Engineer.

9.5.7.3 The field connections of main members of trusses, arches, continuous beams, spans, bends, plate girders and rigid frame assembled, aligned, accuracy of holes and camber shall be checked by Engineer and then only reaming of sub-size holes to specified size shall be taken up.

9.5.7.4 After the work has been passed by the Engineer and before it is dismantled., each part shall be carefully marked for re-erection with distinguishing marks and stamped with durable markings. Drawings showing these markings correctly shall be supplied to the Engineer.

9.5.7.5 Unloading, handling and storage of steel work as per these Specifications shall be the responsibility of the Contractor. The cost of repairs or of rejected material, its removal and the cost of transporting replacement material to the site shall be borne by the Contractor.

9.5.7.6 Where close tolerance or turned barrel bolts are used for those cases where interchangeability is not insisted upon, each span shall be erected and members of each span marked distinctly.

9.5.8 Welding

9.5.8.1 All welding shall be done with prior approval of the Engineer and the workmanship shall conform to the Specifications of IS: 823 or other relevant Indian Standards as appropriate.

9.5.8.2 When material thickness is 20 mm or more, special precautions like preheating shall be taken as laid down in IA: 823. Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other discontinuities. Surface shall also be free from loose or thick scale, slag rust, moisture, oil and other foreign materials. Surfaces within 50 mm of any weld location shall be free from any paint or other material that may prevent proper welding or cause objectionable fumes during welding.

9.5.8.3 The general welding procedures including particulars of the preparation of fusion faces for metal arc welding shall be carried out in accordance with IS: 9595.

9.5.8.4 The welding procedures for shop and site welds including edge preparation of fusion faces shall be submitted in writing in accordance with **Clause 22 of IS: 9595** for the approval of the Engineer before commencing fabrication and shall also be as per details shown on the Drawings. Any deviation from above has to be approved by Engineer. Preparation of edges shall, wherever practicable, be done by machine methods.

9.5.8.5 Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planning and shall be left free of slag. Manual flame cutting shall be permitted by the Engineer only where machine cutting is not practicable.

9.5.8.6 Electrodes to be used for metal arc welding shall comply with relevant IS Specifications mentioned in IRC:24. Procedure test shall be carried out as per IS: 8613 to find out suitable wire-flux combination for welded joint.

9.5.8.7 Assembly of parts for welding shall be in accordance with provisions of IS: 9595.

9.5.8.8 The welded temporary attachment should be avoided as far as possible, otherwise the method of making any temporary attachment shall be approved by the Engineer. Any scars from temporary attachment shall be removed by cutting, chipping and surface shall be finished smooth by grinding to the satisfaction of the Engineer.

9.5.8.9 Welding shall not be done when the air temperature is less than 10 degrees Celsius. Welding shall not be done when the surfaces are moist, during periods of strong winds or in snowy weather unless the work and the welding operators are adequately protected.

9.5.8.10 For welding of any particular type of joint, welders shall qualify to the satisfaction of the Engineer in accordance with appropriate welders qualification test as prescribed in any of the Indian Standards IS: 817, IS: 1966, IS: 1393, IS: 7307 (part I), IS: 7310 (Part I) and IS: 7318 (part I) as relevant.

9.5.8.11 In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as to avoid distortion and minimise shrinkage stress.

9.5.8.12 All requirements regarding pre-heating of parent material and interpass temperature shall be in accordance with provision of IS: 9595.

9.5.8.13 Peening of weld shall be carried out wherever specified by the Engineer:

1. If specified, peening may be employed to be effective on each weld layer except first.
2. The peening should carried out after weld has cooled by light blows from a power hammer using a round nose tool. Care shall be taken to prevent scaling or flaking of weld and base metal from over peening.

9.5.8.14 Where the Engineer has specified the butt welds are to be ground flush, the loss of parent metal shall not be greater than that allowed for minor surface defects. The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by use of extension pieces, cross runs or other means approved by the Engineer. Extension piece shall be removed after the joint has cooled and the ends of the weld shall be finished smooth and flush with the faces of the abutting parts.

9.5.8.15 The joints and welds listed below are prohibited type, which do not perform well under cyclic loading.

1. Butt joints are fully welded throughout their cross-section.
2. Groove welds made from one side only without any backing grip
3. Intermittent groove welds
4. Intermittent fillet welds
5. Bevel-grooves and J-grooves in butt joints for other than horizontal position.
6. Plug and slot welds

9.5.8.16 The run-on and run-off plate extension shall be used providing full throat thickness at the end of butt welded joints. These plates shall comply with the following requirements.

1. One pair of “run-on” and one pair of “run-off” plates prepared from same thickness and profile as the parent metal shall be attached to start and finish of all butt welds preferably by clamps.
2. When “run-on” and “run-off” plates shall be removed by flame cutting, it should be cut at more than 3 mm from parent metal and remaining metal shall be removed by grinding or by any other method approved by the Engineer.

9.5.8.17 Welding of stud shear connectors

1. The stud shear connectors shall be welded in accordance with the manufacturer’s instructions including preheating.
2. The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanised or cadmium plated prior to welding.
3. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder is adequately protected.
4. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs.
5. The procedural trial for welding the stud shall be carried out when specified by the Engineer.

9.5.9 Tolerances

9.5.9.1 Tolerances in dimensions of components of fabricated structural steel work shall be specified on the Drawings and shall be subject to the approval of the Engineer before fabrication. Unless specified, all parts of an assembly shall fit together accurately within tolerances specified in Table 8-2.

9.5.9.2 A machined bearing surface, where specified by the Engineer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5m.

Table 8-2 Fabrication Tolerances

Sr.	INDIVIDUAL COMPONENTS	TOLERANCE
1.	Length a) Member with both ends finished for contact bearing b) Individual components of members with end plate connection c) Other members I. Upto and including 12 M II. Over 12 M	 ± 1 mm + 0 mm - 2 mm ± 2 mm ± 3.5 mm
2.	Width a) Width of built-up girders b) Deviation in the width of members required to be inserted in other members	 ± 3 mm + 0 mm ⎫ - 3 mm ⎭
3.	Depth Deviation in the depths of solid web and open web grinders	 + 3 mm ⎫ - 2 mm ⎭
4.	Straightness a) Deviation from straightness of columns I. In elevation II. In plan	 L/3000 subject to a maximum of 15 mm where L is length of member + 5 mm ⎫ - 0 mm ⎭ L/1000 subject to a maximum of 10 mm
5.	Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces	 3 mm
6.	Deviation from flatness of plate of webs of build-up members in a length equal to the depth of the member	0.005d to a maximum of 2mm where d is depth of the member
7.	Tilt of flange of plate girders a) At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings b) at other places	 0.005 b to a minimum of 2 mm where b is width of the member 0.015 b to a maximum of 4 mm where b is width of the member
8.	Deviation from squareness of flange to web of columns and box girders	L/1000, where L is nominal length of the diagonal
9.	Deviation from squareness of fixed base plate (not machined) to axis of column. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate	D/500, where D is the distance from the column axis to the point under consideration on the base plate
10.	Deviation from squareness of machined ends to axes of columns	D/1000, where D is as defined in 9 above
11.	Deviation from squareness of machines ends to axes of beams or girder	D/1000, where D is as defined in 9 above
12.	Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends	1/600 of depth of member subject to a maximum of 1.5 mm

9.6 Erection

9.6.1 General

9.6.1.1 The provisions of this item shall apply to erection of steel bridge superstructures or main members of bridge superstructures, composed of steel, which span between supports.

9.6.1.2 If the sub-structure and the superstructure are built under separate contracts, the department will provide the substructure, constructed to correct lines, dimensions and elevations properly finished and will establish the lines and the elevation required for setting steel.

9.6.1.3 The Contractor shall erect the structural steel, remove the temporary construction, and do all the work required to complete the construction included in the contract in accordance with the Drawings and the Specifications and to the entire satisfaction of the Engineer.

9.6.2 Organisation and Equipment

9.6.2.1 The Contractor shall submit erection plans prepared by the fabricator, showing a method and procedure of erection, compatible with the details of fabrication.

9.6.2.2 A detailed scheme must be prepared showing stage-wise activities, with complete Drawings and working phase-wise instructions. This should be based on detailed stage-wise calculation and take into account Specifications and capacity of erection equipment machinery, tools, tackles to be used and temporary working loads as per Codal provisions.

9.6.2.3 The scheme should be based on site conditions e.g., hydrology, rainfall, flood timings and intensity, soil and sub-soil conditions in the river bed and banks, maximum water depth, temperature and climatic conditions and available working space, etc.

9.6.2.4 The scheme should indicate precisely the type of temporary fasteners to be used as also the minimum percentage of permanent fasteners to be fitted during the stage erection. The working Drawings should give clearly the temporary jigs, fixtures, clamps, spacer supports, etc.

9.6.2.5 Unless otherwise provided in the contract, the Contractor shall supply and erect all necessary false work and staging and shall supply all labour, tools, erection plant and other materials necessary to carry out the work complete in all respects.

9.6.2.6 The Contractor shall supply all rivets, bolts, nuts, washers, etc., required to complete erection at site with an allowance for wastage, etc., of $12^{1}/_{2}$ percent of the net number of field rivets, bolts, washers required, or a minimum of five number of each item.

9.6.2.7 Service bolts and nuts, ordinary platters, washers and drifts for use in the erection of work shall be supplied at 60 percent (45 per cent bolts and 15 per cent drifts) of the number of field rivets per span in each size (this includes wastage). A reduction in the quantities of service bolts, etc., may however, be specified by the Engineer if more than one span of each type is ordered.

9.6.2.8 Prior to actual commencement of erection all equipment, machinery, tools, tackles, ropes, etc., need to be tested to ensure their efficient working. Frequent visual inspection is essential in vulnerable area to detect displacements, distress, drainages, etc.

9.6.2.9 Deflection and vibratory tests shall be conducted in respect of supporting structures, launching truss as also the structure under erection and unusual observations reviewed; looseness of fittings are to be noted.

9.6.2.10 For welded structures, welders' qualifications and skill are to be checked as per standard norms. Non-destructive tests of joints as per designer's directives are to be carried out.

9.6.2.11 Precision non-destructive testing instruments available in the market should be used for noting various important parameters of the structures frequently and systematic record is to be kept.

9.6.2.12 Safety requirements should conform to IS: 7205, IS: 7273 and IS: 7269 as applicable and should be a consideration of safety, economy and rapidity.

9.6.2.13 Erection work should start with complete resources mobilised as per latest approved Drawings and after a thorough survey of foundations and other related structural work. In case of work of magnitude, maximum mechanisation is to be adopted.

9.6.2.14 The structure should divided into erectable modules as per the scheme This should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.

9.6.2.15 The structure shall be set out to the required lines and levels. The stocks and masses are to be carefully preserved. The steelworks should be erected, adjusted and completed in the required position to the specified line and levels with sufficient drifts and bolts. Packing materials are to be available to maintain this condition. Organised “Quality Surveillance” checks need to be exercised frequently.

9.6.2.16 Before starting work, the Contractor shall obtain necessary approval of the Engineer as to the method adopted for erection, the number and character of tools and plants. The approval of the Engineer shall not relieve the Contractor of his responsibility for the safety of his method or equipment or from carrying out the work fully in accordance with the Drawings and Specifications.

9.6.2.17 During the progress of work, the Contractor shall have a competent Engineer or foreman in charge of the work, who shall be adequately experienced in steel erection and acceptable to the Engineer.

9.6.3 Handling and Storing of Materials

9.6.3.1 Suitable area for storage of structures and components shall be located near the site of work. The access road should be free from water logging during working period and the storage area should be on leveled and firm ground.

9.6.3.2 The store should be provided with adequate handling equipment e.g., road mobile crane, gantries, derricks, chain pulley blocks, winch of capacity as required. Stacking area should be planned and have racks, stands sleeper, access tracks, etc., and properly lighted.

9.6.3.3 Storage should be planned to suit erection work sequence and avoid damage or distortion. Excessively rusted, bent or damaged steel shall be rejected. Methods of storage and handling steel, whether fabricated or not shall be subject to the approval of the Engineer.

9.6.3.4 Fabricated materials are to be stored with erection marks visible such as not to come into contact with earth surface or water and should be accessible to handling equipment.

9.6.3.5 Small fitting hand tools are to be kept in containers in covered stores.

9.6.3.6 All materials, consumable, including raw steel or fabricated material shall be stored Specification-wise and size-wise above the ground upon platforms, skids or other supports. It shall be kept free from dirt and other foreign matter and shall be protected as far as possible from corrosion and distortion. The electrodes shall be stored Specification-wise and shell be kept in dry warm condition in properly designed racks. The bolts, nuts, washers and other fasteners shall be stored on racks above the ground with protective oil coating in gunny bags. The paint shall be stored under cover in air-tight containers.

9.6.3.7 IS: 7293 and IS: 7969 dealing with handling of materials and equipment for safe working should be followed. Safety nuts and bolts as directed are to be used while working. The

Contractor shall be held responsible for loss or damage to any material paid for by the Department while in his care or for any damage to such material resulting from his work.

9.6.4 Formwork

9.6.4.1 The formwork shall be properly designed, substantially built and maintained for all anticipated loads. The Contractor, if required, shall submit plans for approval to the Engineer. Approval of the plans, however, shall not relieve the Contractor of his responsibility.

9.6.5 Straightening Bent Material

9.6.5.1 The straightening of plates, angles and other shapes shall be done be methods not likely to produce fracture or any injury. The metal shall not be heated unless permitted by the Engineer for special cases, when the heating shall not be to a temperature higher than that producing a dark “cherry red” colour, followed by as slow cooling as possible. Following the straightening of a bend or buckle the surface shall be carefully investigated for evidence of fracture. Sharp kinks and bends may be the cause for rejection of material.

9.6.6 Assembling Steel

9.6.6.1 The parts shall be accurately assembled as shown on the Drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

9.6.6.2 Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tendon chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.

9.6.6.3 All joint surface for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, plane normal to bolt axis, otherwise suitable tapered washer shall be used.

9.6.6.4 All fasteners shall have a washer under nut or bolt head whichever is turned in tightening.

9.6.6.5 Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened up as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.

9.6.6.6 Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

9.6.6.7 The field riveting, welding, bolted and pin connection shall conform to the requirements of **Clause 8.5** as appropriate.

9.6.6.8 The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer and his approval of the method of correction obtained. The correction shall be made in the presence of the Engineer.

9.6.7 Field Inspection

9.6.7.1 General

All materials, equipment and work of erection shall be subject to the inspection of the Engineer who shall be provided with all facilities including labour and tools required at all reasonable times. Any work found defective is liable to be rejected.

9.6.7.2 No protective treatment shall be applied to the work until the appropriate inspection and testing has been carried out. The stage inspection shall be carried out for all operations so as to ensure the correctness of fabrication and good quality. Girder dimensions and camber shall not be finally checked until all welding and heating operations are completed and the member has cooled to a uniform temperature.

9.6.7.3 Testing of material: Structural steel shall be tested for mechanical and chemical properties as per various IS codes as may be applicable and shall conform to requirements specified in IS: 226, IS: 2062, IS: 11587, IS: 1977, IS: 8500 and IS: 961 etc.,

1. Rivets, bolts, nuts, washers, welding consumable, steel forging, casting and stainless steel shall be tested for mechanical and chemical properties in the appropriate IS Code.
2. Rolling and cutting tolerance shall be as per IS: 1852. The thickness tolerance check measurements for the plate and rolled sections shall be taken at not less then 15 mm from edge.
3. Laminations in plates shall be carried out by ultra-sonic testing or any other specified methods.
4. Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Engineer for his decision.
5. Chipping, grinding, machining or ultrasonic testing shall be used to determine depth of imperfection.

9.6.7.4 Bolted connections

1. Bolts and bolted connection joints with high strength friction grip bolts shall be inspected and tested according to IS: 4000.
2. Rivets and riveted connection shall be inspected and tested for compliance of Codal requirements.
3. The firmness of joint shall be checked by 0.2 mm filler gauge, which shall not go inside under the rivet head by more than 3 mm. There shall not be any gap between members to be riveted.
4. Driven rivets shall be checked with rivet testing hammer. When struck sharply on head with rivet testing hammer, rived shall be free from movement and vibration.
5. All loose rivets and rivets with cracks, badly formed or different heads or with heads which are eccentric with shanks, shall be cut out and replaced.
6. The alignment of plates at all blotted splice joints and welded butt joints shall be checked for compliance with Codal requirements.
7. Testing of flame cut and sheared edges is to be done, where the hardness criteria given in the code are adopted. Hardness testing shall be carried out on six specimens.

9.6.7.5 Welding and welding consumable

1. Welding procedure, welded connection and testing shall be in compliance with Codal requirements.
2. All facilities necessary for stage inspection during welding and on completion shall be provided to the Engineer or their inspecting Authority by manufacturer.
3. Adequate means of identification either by identification mark or other record shall be provided to enable each weld to be traced to the welder(s) by whom it was carried out.
4. All metal arc welding shall be in compliance with IS: 9595 provisions.

5. The method of inspection shall be in accordance with IS: 822 and extent of inspection and testing shall be in accordance with the relevant standards or in the absence of such a standards, as agreed with the Engineer.
6. Procedure tests: The Destructive and Non-Destructive test of weld shall be carried out according to IS: 7307 (Part I).
7. The particular length of welds in webs to be tested shall be agreed with the Engineer, in case of (2) or (3).
8. Where specified by the Engineer, bearing stiffeners or bearing diaphragms adjacent to welds, flange plates adjacent to web/flange welds, plates at cruciform welds, plates in box girder construction adjacent to corner welds or other details shall be ultrasonically tested after fabrication.
9. Any lamination, lamellar tearing or other defect found shall be recorded and reported to Engineer for his decision.
10. Testing or Welding for Cast Steel: The testing of weld for cast steel shall be carried out as may be agreed to by the Engineer.
11. Stud Shear Connectors: Stud shear connectors shall be subjected to the following tests:
12. The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer to the satisfaction of the Engineer.
13. The selected stud head stroked with 6 kg hammer shall be capable of lateral displacement of approximately 0.25 the height of the stud from its original position. The stud weld shall not show any sign of crack or lack of fusion.
14. The studs whose welds have failed the tests given in (1) and (2) shall be replaced.

9.6.7.6 Inspection requirement

1. The fabricated member/component made out of rolled and build-up section shall be checked for compliance of the tolerances given in Table 1900-2. Inspection of member/components for compliance with tolerances, and the check for deviations shall be made over the full length.
2. During checking, the inspection requirement shall be placed in such a manner that local surface irregularities do not influence the results.
3. For plate, out-of-plane deviation shall be checked at right angle to the surface over the full area of plate.
4. The relative cross-girder or cross frame deviation shall be checked over the middle third of length of the cross girder or frame between each pair of webs and for cantilever at the end of member.
5. The web of rolled beam or channel section shall be checked for out-of-plane deviation in longitudinal direction equal to the depth of the section.
6. During inspection, the component/member shall not have any load or external restraint.
7. Inspection Stages: The inspection to be carried out for compliance of tolerances shall include but not be limited to the following stages:
    - For completed parts, component/members on completion of fabrication and before any subsequent operation such as surface preparation, painting, transportation, erection.
    - For webs of plate and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints, on completion of site joint
    - For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased on completion of site assembly.
8. Where on checking member/component for the deviations in respect of out-of-plane of out-of-straightness at right angles to the plate surface, and any other instances, exceed tolerance, the maximum deviation shall be measured and recorded. The recorded measurements shall be submitted to the Engineer who will determine whether the component/member may be accepted without rectification, with rectification or rejected.

9.7 Painting

9.7.1 General

9.7.1.1 Unless otherwise specified, all metal work shall be given approved shop coats as well as field coats of painting. The item of work shall include preparation of metal surfaces, application of protective covering and drying of the paint coatings and supply of all tools, scaffolding, labour and materials necessary.

9.7.1.2 Coatings shall be applied only to dry surfaces and the coated surfaces shall not be exposed to rain or frost before they are dry. The coatings shall be applied to all surfaces excluding shear connectors and inner surfaces of fully sealed hollow sections. Care shall be taken during coating of adjacent surfaces to build up primer on the shear connectors.

9.7.1.3 Types of paints

1. Ordinary Paints

These include paints based on drying oils, alkyd resin, modified alkyd resin, phenolic varnish epoxy, etc. Alkyd resin paints for the protection steel structures are based partly on natural oils and partly on synthetic resins. These paints shall be used for steel structures in atmospheres which are not too aggressive. Oil based paints can be used for steel structures in cases where the surface preparation cannot be ideal. Ordinary painting can generally be sub-divided into two groups:

- Primary Coats

This shall be applied immediately after the surface preparation and should have the properties of adhesion, corrosion inhibition and imperviousness to water and air.

- Finishing Coats

These are applied over the primary coat and should have the properties of durability, abrasion resistance, aesthetic appearance and smooth finish.

2. Chemical Resistant Paints

The more highly corrosion resistant paints can be divided into two main groups:

- One pack paints (ready for use)
- Two pack paints (mixed before use)

The two pack paints shall be mixed together immediately before use since they are workable thereafter only for a restricted period of time and dry up as a result of a reaction between their components and yield hard tough films with resistance to abrasion.

3. Vinyl Paints

These are based on polyvinyl resins such as polyvinyl-chloride (PVC) and polyvinyl-acetate, etc. Certain types of vinyl resin paints yield thick, relatively soft and rubber like coatings with good chemical resistance. They can be repainted without difficulty.

4. Chlorinated Rubber Paints

These paints also have good chemical resistance. The main fields of applications shall be in aggressive environments. In general, chlorinated rubber paints do not have a high gloss.

5. Bituminous Paints

As a paint vehicle, bituminous is inferior, but because of the low price, this should be applied in greater thickness (upto several millimetres) and may be suitable for some situations. A significant advantage of bitumen paints is their impermeability to ingress of water. However, bituminous paints do not withstand effectively detrimental effects of oil.

6. Epoxy Paints

These resin paints have good adherence to a well prepared sub-strata. They are mechanically strong and resistant to chemicals. A disadvantage of epoxy resin paints is that it can rapidly become dull when exposed to strong sunlight. These disadvantages do not, however, greatly influence their protective power.

7. Polyurethane Paints

The chemical and mechanical behaviour of polyurethane paint resembles those of epoxy paint very much. However, polyurethane paint retains its gloss for a longer period. Because of the high price of polyurethane paint, a combination of the two viz., polyurethane epoxy paints may sometimes be used.

8. Zinc Rich Paints

Instead of introducing an inhibitive pigment into paint, metallic zinc can be used and such paints can provide cathodic protection to steel.

9.7.1.4 Surfaces which are inaccessible for cleaning and painting after fabrication shall be painted as specified before being assembled for riveting.

1. All rivets, bolts, nuts, washers etc., are to be thoroughly cleaned and dipped into boiling linseed oil conforming to IS: 77.

2. All machined surfaces are to be well coated with a mixture of white lead conforming to IS: 34 and Mutton Tallow conforming to IS: 887.

3. For site paintings, the whole of steel work shall be given the second cover coat after final passing and after touching up the printer and cover coats, if damaged in transit.

9.7.1.5 Choice of painting system

The choice of suitable painting system is dependent on factors such as:

1. Available application methods viz. brush, roller or spray
2. Durability in specific environment
3. Availability of skilled manpower
4. Cost / benefit etc.,

It is therefore necessary to consult various manufacturers of paint and ascertain the above aspects while deciding on the appropriate choice of painting system.

9.7.1.6 Quality of paint

The paints which have been tested for the following qualities as per the Specifications given in the relevant IS codes should only be used:

1. Weight Test (weight per 10 litre of paint thoroughly mixed)
2. Drying time
3. Flexibility and Adhesion
4. Consistency
5. Dry thickness and rate of consumption

9.7.1.7 Unless otherwise specified, all painting and protective coating work shall be done in accordance with IS: 1477 (Part 1).

9.7.2 Surface Preparation

9.7.2.1 Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer.

1. Dry or wet grit / Sand blasting
2. Picking which should be restricted to single plates, bars and sections
3. Flame cleaning

9.7.2.2 Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, primary coat shall be applied while the metal is still warm.

9.7.2.3 All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

9.7.3 Coatings

9.7.3.1 Prime coat to be used shall conform to the Specification of primers approved by the Engineer. Metal coatings shall be regarded as priming coatings. Primer shall be applied to the blast cleaned surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning.

9.7.3.2 All coats shall be compatible with each other. When metal coatings are used, the undercoat shall be compatible with the metal concerned. The undercoat and finishing coat shall preferably be from the same manufacturer. Successive coats of paints shall be of different shades or colours and each shall be allowed to dry thoroughly before the next is applied. Particular care shall be taken with the priming and painting of edges, corners, welds and rivets. Typical guidelines for epoxy based paints and the conventional painting system for bridge girders as given below may be compiled with:

1. Epoxy Based Painting

- Surface preparation: Remove oil/grease by use of petroleum hydrocarbon solution (IS: 1745) and Grit blasting to near white metal surface.
- Paint system: 2 coats of epoxy zinc phosphate primer - 60 micron; Total 5 coats = 200 micron

2. Conventional Painting System for areas where corrosion is not severe

- Priming Coat: One heavy coat or ready mixed paint, red lead primer conforming to IS: 102 or One coat of ready mixed zinc chrome primer conforming to IS: 104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS: 2074 or Two coats of Zinc chromates red oxide primer conforming to IS: 2074.

- Finishing Coats: Two cover coats of red oxide paint conforming to IS: 123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

3. Conventional Painting System for areas where corrosion is severe

- Priming Coat: Two coats of ready mixed red lead primer conforming to IS: 102 or One coat of ready mixed zinc chrome primer conforming to IS: 104 followed by one coat of zinc chromate conforming oxide primer to IS: 2074.

- Finishing Coats: Two coats of aluminium paint conforming to IS: 2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

9.7.4 Painting in the Shop

9.7.4.1 All fabricated steel shall be painted in the shops after inspection and acceptance with at least one priming coat, unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanised surfaces.

9.7.4.2 Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

9.7.4.3 Field contact surfaces and surfaces to be in contact with cement shall be painted with primer only. No paint shall be applied within 50 mm of designed location of field welds. Paint shall be completely dried before loading and transporting to site.

9.7.4.4 Surface not in contact but inaccessible after shop assembly shall receive the fully specified protective treatment before assembly.

9.7.4.5 Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is expected to impair the quality of site welds.

9.7.4.6 Exposed machined surfaces shall be adequately protected.

9.7.5 Painting at Site

9.7.5.1 Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

9.7.5.2 Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

9.7.5.3 Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

9.7.5.4 Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

9.7.5.5 Specified protective treatment shall be completed after erection.

9.7.6 Methods of application

9.7.6.1 The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and shall be as approved by the Engineer. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas hard to gain access to for painting and areas shaded for spray application shall be coated first by brushing.

9.7.6.2 Oil based red lead primers must be applied by brush only, taking care to work into all corners and crevices.

9.7.6.3 The primer, intermediate and finishing coats shall all be applied so as to provide smooth coatings of uniform thickness. Wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes shall not be accepted. Where the Engineer so directs, the coating shall be removed by abrasive blast cleaning and replaced at the Contractor's expense.

9.7.7 Guideline of Specifications for Protective Coating System in Different Environments

9.7.7.1 Since the seriousness of the problem of corrosion depends upon atmospheric conditions and these vary enormously, there is no single protective system or method of application that is suitable for every situation.

9.7.7.2 However, as a guide, broad recommendations are given in Table 8-3 for various types of coatings in various environmental conditions which should be compiled with. Approximate life to first maintenance is also indicated and can be used as a guide.

Table 8-3: Recommendations for Types of Protective Coatings

Sr.	System	Environment
1.	Wire brush to remove all loose rust and scale; 2 coats drying oil type primer; 1 under coat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness = 150 μm	Suitable for mild conditions where appearance is of some importance and where regular maintenance is intended. This system may deteriorate to a marked extent if it is exposed to moderate aggressive atmospheric conditions for lengthy period
2.	Wire brush to remove all loose rust and scale; 2 coats drying oil type primer, 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 μm	Similar to (I) but where appearance is not very important provides longer life in mild condition. Will provide upto 5 years life to first maintenance in polluted inland environment.
3.	Blast clean the surface; 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat alkyd type. Today dry film thickness: 130 - 150 μm	Compared to (I) this would provide a longer life in mild conditions and could be used in less mild situation e.g. inland polluted, where maintenance could easily be carried out at regular intervals
4.	Blast clean the surface; 2 coats of drying type oil primer, 1 undercoat micaceous iron oxide pigmented drying oil type paint. Total dry film thickness: 165 - 190 μm	Suitable for general structural steel work exposed to ordinary polluted inland environments where appearance is not of primary importance
5.	Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer, 1 undercoat of high build chlorinated rubber; 1 finishing cost of chlorinated rubber. Total dry film thickness: 200 μm	Suitable for structures in reasonably aggressive conditions e.g. near the coast. Will provide long-term protection than (iv) in non-coastal situations. Also suitable for aggressive interior situations such as industrial areas.
6.	Blast clean the surface; 350 - 450 μm thickness, coal tar epoxy.	Suitable for sea water splash zones or for conditions of occurrence of frequent salt sprays.
7.	Pickle; hot dip galvanised (Zinc) Total thickness: 85 μm	Suitable for steel working reasonably mild conditions Life of 15 - 20 years before first maintenance could expected in many situations
8.	Grit blast, hot dip galvanised. (Zinc) Total thickness = 140 μm	Provides a longer life than (vii) because of thicker zinc coating.
9.	Grit blast; 1 coat of sprayed zinc / aluminium followed by suitable sealer Total thickness = 150 μm	Expected to provide long term protection approx. 15 - 20 years in aggressive atmosphere

9.8 Tests and Standards of Acceptance

9.8.1 The materials shall be tested in accordance with relevant IS Specifications and necessary test certificate shall be furnished. Additional tests, if required, shall be got carried out by the Contractor at his own cost.

9.8.2 The fabrication, furnishing, erecting, painting of structural steel work shall be in accordance with these Specifications and shall be checked and accepted by the Engineer.

9.9 Measurements for Payment

9.9.1 The measurements of this item shall be in tonnes based on the net weight of metal in the fabricated structure computed on the basis of nominal weight of materials.

9.9.2 The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the Drawings on the following basis:

- Rolled or cast steel: 7.84×10^{-3} kg/cc.
- Cast Iron: 7.21×10^{-3} kg/cc.

9.9.3 Weight of structural sections shall be nominal weight

9.9.4 Weight of castings shall be computed from the dimensions shown on the Drawings with an addition of 5 per cent for fillets and over-runs.

9.9.5 Weight of weld fillets and the weight of protective coatings shall not be included.

9.9.6 Weight of rivet heads shall be computed by taking the weight of 100 snap heads as given in Table 8-4.

9.9.7 When specially agreed upon, allowance for snap heads may be taken as a flat percentage of the total weight. This percentage may be taken as 3 per cent or modified by mutual agreement.

Table 8-4: Weight of Rivet Heads

Dia of Rivet as manufactured (mm)	Weight of 100 snap heads (kg)
12	1.3
14	2.1
16	3.4
18	4.45
20	6.1
22	8.1
24	10.5
27	15.0
30	20.5
33	27.2

9.9.8 The Contractor shall supply detailed calculation sheets for the weight of the metal in the fabricated structure.

9.9.9 No additions shall be made for the weight of protective coating or weld fillets.

9.9.10 Where computed weight forms the basis for payment, the weight shall be calculated for exact cut sizes of members used in the structure, deductions being made for all cuts, except for rivet holes. Additions shall be made for the rivet heads as mentioned above.

9.9.11 When specially agreed upon, the basis for payment may be the bridge weight complete, according to Specifications included in special provisions of the Contract.

9.10 Rate

9.10.1 The contract unit rate for the completed structural steel work shall include the cost of all materials, labour, tools, plant and equipment required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and complete final erection as shown on the Drawings and as specified in these Specifications.

10 STRUCTURAL CONCRETE AND MORTAR

10.1 Scope

This Specification covers the general requirements for concrete to be used on jobs using on-site production facilities including requirements in regard to the quality, handling, storage of ingredients, proportioning, batching, mixing and testing of concrete and also requirements in regard to the quality, storage, bending and fixing of reinforcement. This also covers the transportation of concrete from the mixer to the place of final deposit and the placing, curing, protecting, repairing and finishing of concrete.

10.2 Applicable Codes and Specifications

10.2.1 The following Specifications, standards and codes are made a part of this Specification. All Standards, Specifications, Codes of Practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of discrepancy between this Specification and those referred to herein, this Specification shall govern.

10.2.2 Materials

IS: 269	Specification for Ordinary, Rapid-Hardening and Low Heat Portland Cement.
IS: 455	Specification for Portland Blast Furnace Slag Cement.
IS: 1489	Specification for Portland-Pozzolana Cement.
IS: 4031	Methods of Physical Tests for Hydraulic Cement.
IS: 650	Specification for Standard Sand for Testing of Cement.
IS: 383	Specification for Coarse and Fine Aggregates From Natural Sources for Concrete.
IS: 2386	Methods of Test for Aggregates for Concrete. (Part I To VIII)
IS: 516	Method of Test for Strength of Concrete.
IS: 1199	Method of Sampling and Analysis of Concrete.
IS: 3025	Method of Sampling and Test (Physical and Chemical) Water Used In Industry.
IS: 432	Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement. (Part I & II)
IS: 1139	Specification for Hot Rolled Mild Steel and Medium Tensile Steel Deformed Bar for Concrete Reinforcement.
IS: 1566	Specification for Plain Hard Drawn Steel Wire Fabric for Concrete (Part I) Reinforcement.
IS: 1785	Specification for Plain Hard Drawn Steel Wire for Prestressed Concrete.
IS: 1786	Specification for Cold Twisted Steel Bars for Concrete Reinforcement.
IS: 2090	Specification for High Tensile Steel Bars Used In Prestressed Concrete.
IS: 4990	Specification for Plywood for Concrete Shuttering Work.
IS: 2645	Specification for Integral Cement Water-Proofing Compounds.
BS4461	Cold Worked Steel Bars for The Reinforcement of Concrete.
IS: 4098	Lime Pozzolana Mixture (1st Revision) (Amendment 2)

10.2.3 Equipment

IS: 1791	Specification for Batch Type Concrete Mixers.
IS: 2438	Specification for Roller Pan Mixer.
IS: 2505	Specification for Concrete Vibrators, Immersion Type.
IS: 2506	Specification for Screen Board Concrete Vibrators.
IS: 2514	Specification for Concrete Vibrating Tables.
IS: 3366	Specification for Pan Vibrators.
IS: 4656	Specification for Form Vibrators for Concrete.
IS: 2722	Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket Type).
IS: 2750	Specification for Steel Scaffoldings.
IS: 2438	Roller Fan Mixer (Reaffirmed 1990)

10.2.4 Codes of Practice

IS: 456	Code of Practice for Plain and Reinforced Concrete.
IS: 1343	Code of Practice for Prestressed Concrete.
IS: 457	Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and Other Massive Structures.
IS: 3370	Code of Practice for Concrete Structures for Storage of Liquids (Part I to IV)
IS: 3955	Code of Practice for Composite Construction.
IS: 3201	Criteria for Design and Construction of Precast Concrete Trusses.
IS: 2204	Code of Practice for Construction of Reinforced Concrete Shell Roof.
IS: 2210	Criteria for The Design of R.C. Shell Structures and Folded Plates.
IS: 2751	Code of Practice for Welding of Mild Steel Bars Used for Reinforced Concrete Construction.
IS: 2502	Code of Practice for Bending and Fixing Vibrators for Consolidating Concrete.
IS: 3558	Code of Practice for Use of Immersion Vibrators for Consolidating Concrete.
IS: 3414	Code of Practice for Design and Installation of Joints In Buildings.
IS: 4014	Code of Practice for Steel Tubular Scaffolding. (Part I & II)
IS: 2571	Code of Practice for Laying Insitu Cement Concrete Flooring.
IS: 2250	Code of Practice for Preparation and Use of Masonry Mortar (1st Revision)

10.2.5 Construction Safety

IS: 3696	Safety Code for Scaffolds and Ladders. (Part I& II)
IS: 3385	Code of Practice for Measurement of Civil Engineering Works.

10.2.6 Measurement

IS: 1200	Method of Measurement of Building Works.
IS: 3385	Code of Practice for Measurement of Civil Engineering Works.

10.2.7 In the event that state, city or other governmental bodies have requirements more stringent than those set forth in this Specification, such requirement shall be considered part of this Specification and shall supersede this Specification where applicable.

10.3 General

10.3.1 The quality of materials and method and control of manufacture and transportation of all concrete work irrespective of mix, whether reinforced or otherwise, shall conform to the applicable portions of this Specification.

10.3.2 Engineer shall have the right to inspect the source(s) of material(s), the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and Engineer's approval obtained, prior to starting of concrete work.

10.4 Materials

10.4.1 All materials shall conform to the requirements laid in **Chapter 7**.

10.4.2 Steel Reinforcement

10.4.2.1 Laps

Laps and splices for reinforcement shall be as shown on the Drawings. Splices in adjacent bars shall be staggered and the locations of all splices, except those specified on the Drawings, shall be approved by Engineer. The bars shall not be lapped unless the length required exceeds the maximum available length of bars at site.

10.4.2.2 Bending

1. Reinforcing bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done in cold and without damaging the bars. This is considered as a part of reinforcement bending fabrication work.

2. All bars shall be accurately bent according to the sizes and shapes shown on the detailed working Drawings / bar bending schedules. They shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and rebent in a manner that will injure the material and bars containing cracks or splits shall be rejected. They shall be bent cold, except bars of over 25 mm in diameter which may be bent hot if specifically approved by Engineer. Bars which depend for their strength on cold working, shall not be bent hot. Bars bent hot shall not be heated beyond cherry red colour (nor exceeding 845^{o}C) and after bending, shall be allowed to cool slowly without quenching. Bars incorrectly bent shall be used only if the means used for straightening and rebending be such as shall not, in the opinion of Engineer, injure the material. No reinforcement shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

10.4.2.3 Fixing

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position shown in the Drawings by the use of blocks, spacers and chairs as per IS: 2502 to prevent displacement during placing and compaction of concrete. Bars intended to be in contact at crossing points shall be securely bound together at all such points with number 16 gauge annealed soft iron wire. The vertical distances required between successive layers of bar in beams or similar members shall be maintained by the provision of mild steel spacer bars at such intervals that the main bars do not perceptibly sag between spacer bars.

10.4.2.4 Welding of Bars

When permitted or specified on the Drawings, joints of reinforcement bars shall be butt welded so as to transmit their full strength. Welded joints shall preferably be located at points where the reinforcement steel will not be subject to more than 75 % of the maximum permissible stresses and the welded joints should be staggered such that, at any one section, not more than 33% of bars are welded. Only electric arc welding using a process which excludes air from the molten metal and conforms to any or all other special provisions for the work will be accepted. Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding and when welding is done two or three stages, the previous surfaces shall be cleaned properly. Ends of bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before welding. Only competent welders shall be employed on the work. The MS electrodes used for welding shall conform to IS: 814. Welded pieces of reinforcement shall be tested. Specimens shall be taken from the actual site and their number and frequency of test shall be as directed by the Engineer.

10.4.2.5 Cover

Unless indicated otherwise on the Drawings, clear concrete cover for reinforcement (exclusive of plaster or other decorative finish) shall be as follows:

1. At each end of reinforcing bar, not less than 25 mm nor less than twice the diameter of the bar.
2. For a longitudinal reinforcing bar in a column, not less than 40 mm, nor less than the diameter of the bar. In case of columns of minimum dimension of 20 cm. or under, with reinforcing bars of 12 mm and less in diameter, a cover of 25 mm may be used.

3. For longitudinal reinforcing bars in a beam, not less than 25 mm nor less than the diameter of the bar.
4. For tensile, compressive, shear, or other reinforcement in a slab or wall, not less than 13 mm, nor less than the diameter of such reinforcement.
5. For any other reinforcement, not less than 13 mm, nor less than the diameter of such reinforcement.
6. For footings and other principal structural members in which the concrete is deposited directly against the ground, cover to the bottom reinforcement shall be 75 mm. If concrete is poured on a layer of lean concrete the bottom cover may be reduced to 50 mm.
7. For concrete surfaces exposed to the weather or the ground after removal of forms, such as retaining walls, grade beams, footing sides and top, etc., not less than 50 mm for bars larger than 16 mm diameter and not less than 40 mm for bars 16 mm diameter or smaller.
8. Increased cover thickness shall be provided, as indicated on the Drawings, for surfaces exposed to the action of harmful chemicals (or exposed to earth contaminated by such chemical), acid, alkali, saline atmosphere, sulphurous smoke, etc.
9. For reinforced concrete members, totally or periodically immersed in sea water or subject to sea water spray, the cover of concrete shall be 50 mm more than those specified in (1) to (5) above.
10. For liquid retaining structures, the minimum cover to all steel shall be 40 mm or the diameter of the main bar, whichever is greater. In the presence of sea water and soils and waters of a corrosive character the cover shall be increased by 10 mm.
11. Protection to reinforcement in case of concrete exposed to harmful surroundings may also be given by providing a dense impermeable concrete with approved protective coatings, as specified on the Drawings. In such a case the extra cover mentioned in (8) and (9) above, may be reduced by Engineer to those shown on the Drawings.
12. The correct cover shall be maintained by cement mortar cubes or other approved means. Reinforcement for footings, grade beams and slabs on subgrade shall be supported on precast concrete blocks as approved by Engineer. The use of pebbles or stones shall not be permitted.
13. The 28 day crushing strength of cement mortar cubes / precast concrete cover blocks shall be atleast equal to the specified strength of concrete in which these cubes / blocks are embedded.
14. The minimum clear distance between reinforcing / bars shall be in accordance with IS: 456 or as shown in Drawings.

10.4.2.6 Inspection

Erected and secured reinforcement shall be inspected and approved by Engineer prior to placement of concrete.

10.4.2.7 Payment

For payment of work done under this item, the actual quantity of steel embedded in concrete as calculated and approved by Engineer, irrespective of the level or the height at which the work is done, shall be taken. The unit rate for reinforcement shall include all wastage, binding wire, etc. for which no separate payment shall be made. Laps as shown in Drawings or as approved by Engineer and minimum number of chairs and spacer bars shall be measured and paid for.

10.4.3 Steel shapes encased in concrete

Structural steel columns, beams, girders and bracings to be encased in concrete shall be unpainted, if so indicated on the Drawings. The encasing shall be done in concrete with 10 mm maximum size aggregate and a cube strength not less than 150 Kg/cm2 at 28 days unless otherwise specified in Drawings. The steel member shall be wrapped with galvanized wire mesh of the size indicated on the Drawings. The galvanized wire mesh shall be kept 20 mm from the edge or surface of the steel member and shall beheld in position securely. The steel member will have a minimum cover of 50 mm unless otherwise indicated on the Drawings. Where the clear cover to steel is more than 75 mm, mild steel bar and concrete with 20 mm coarse aggregate can be used.

10.5 Controlled Concrete

10.5.1 All concrete in the works shall be "Controlled Concrete" as defined in IS: 456, unless it is a nominal mix concrete such as 1:3:6, 1:4:8 or 1:5:10. Whether reinforced or otherwise, all controlled concrete works to be carried out under this Specification shall be divided into the following classification:

10.5.2 Minimum compressive strength of 15 cm. Cubes at 7 and 28 days after mixing, conducted in accordance with IS: 516

Class	Preliminary test Kg/cm^2		Work test Kg/cm2		Max. size of aggregate	Location for use
	At 7 days	At 28 days	At 7 days	At 28 days		
M400	335	500	270	400	20	As shown in schedule of quantity
M350	300	440	235	350	20	
M300	250	380	200	300	40 or 20	
M250	220	320	170	250	40 or 20	
M200	175	260	135	200	40 or 20	
M150	135	200	100	150	40 or 20	

Note: It shall be very clearly understood that whenever the class of concrete such as M200 is specified it shall be Contractor's responsibility to ensure that minimum crushing strength stipulated for the respective class of concrete is obtained at works. The maximum total quantity of aggregate by weight per 50 Kg. of cement shall not exceed 450 Kg., except when otherwise specifically permitted by Engineer.

10.6 Mix Design

10.6.1 This is to investigate the grading of aggregates, water cement ratio, workability and the quantity of cement required to give preliminary and works cubes of the minimum strength specified. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made. Mix proportioning shall be based on the principles given in IS: 456-2000 and SP: 23-1982 “Handbook for Design Mix Concrete.”

10.6.2 Whenever there is a change either in required strength of concrete, or water-cement ratio or workability or the source of aggregates and / or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions. While designing mix proportions, over-wet mixes shall always be avoided.

10.6.3 While fixing the value for water / cement ratio for preliminary mixes, assistance may be derived from the graph (Appendix A IS: 456) showing the relationship between the 28-day compressive strengths of concrete mixes with different water / cement ratios and the 7 day compressive strength of cement tested in accordance with IS: 269.

10.6.4 Preliminary tests

10.6.4.1 Tests specimens shall be prepared with at least two different water / cement ratios for each class of concrete, consistent with workability required for the nature of the work. The materials and proportions used in making preliminary tests shall be similar in all respects to those, to be actually employed in the works as the object of these tests is to determine the proportions of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength. It will be Contractor's sole responsibility to carry out statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed:

10.6.4.2 Materials shall be brought to the room temperature and all materials shall be in a dry condition. The quantities of water, cement and aggregates for each batch shall be determined by weight to an accuracy of 1 part in 1000 parts.

10.6.5 Mixing Concrete

10.6.5.1 For all works, concrete shall be mixed in a mechanical mixer which along with other accessories shall be kept in first class working condition and so maintained through out the construction. Mixing shall be continued till materials are uniformly distributed and a uniform colour of entire mass is obtained and each individual particle of the coarse aggregate shows a complete coating of mortar containing its proportionate amount of cement. In no case, the mixing be done for a period of not less than two minutes after all ingredients have been put into the mixer. In case of hand mixing, quantity of cement shall be increased by 10% above that specified in **Clause 9.6.1,** the cost of increased cement quantity being borne by the Contractor. Hand mixing shall be permitted only under exceptional conditions and the Contractor must take the permission of the Engineer in advance. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting a new batch. Unless otherwise agreed by the Engineer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate. The mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

10.6.6 Consistency

10.6.6.1 The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test, care should be taken to ensure that no water or other material is lost, the material used for the slump test may be remixed with the remainder of the concrete for making the specimen test cubes. the period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

10.6.7 Size of Test Cubes

10.6.7.1 Compression tests of concrete cubes shall be made as per IS: 516 on 15 cm cubes. Each mould shall be provided with a metal base plate having no leakage. The base plate shall be preferably attached to the mould when assembled and shall be positively and rigidly held together. Before placing concrete, the mould and base plate shall be cleaned and oiled. The dimensions and internal faces of the mould shall be accurate within the following limits:

1. Height and distance between the opposite faces of the mould shall be of specified size + 0.2 mm. The angle between the adjacent internal faces and between internal faces and top and bottom planes of mould shall be 90^{o} + 0.5^{o}. The interior faces of the mould shall be plane surfaces with a permissible variation of 0.03 mm.

10.6.8 Compacting

10.6.8.1 Concrete tests cubes shall be moulded by placing fresh concrete in the mould and compacted as specified in IS: 516.

10.6.9 Curing

10.6.9.1 Curing shall be as specified in IS: 516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of $27^{o}C \pm 2^{o}C$ for 2 hours ± 1/2 hr. from the time of adding water to the dry ingredients. Thereafter in clean, fresh water and kept at $27^{o} \pm 2^{o}C$ temperature until seven days. A record of maximum and minimum temperatures at the places of storage of the cubes shall be maintained during the period they remain in storage.

10.6.10 Testing of Specimens

10.6.10.1 The strength shall be determined based on not less than five cube test specimens for each age and each water cement ratio. All these laboratory test results shall be tabulated and furnished to Engineer. The test results shall be accepted by Engineer if the average compressive strengths of the specimens tested is not less than the compressive strength specified for the age at which specimens are tested, subject to the condition that only one out of the five consecutive tests may give a value less than the specified strength for that age. Engineer may direct Contractor to repeat the tests if the results are not satisfactory and also

to make such changes as he considers necessary to meet the requirements specified. All these preliminary tests shall be conducted by Contractor at his own cost in an approved laboratory.

10.7 Proportioning, Consistency, Batching and Mixing of Concrete

10.7.1 Proportioning

10.7.1.1 Aggregate

The proportions which shall be decided by conducting preliminary tests shall be by weight. These proportions of cement, fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weigh batchers conforming to IS: 2722 capable of controlling the weights within one percent of the desired value. Except where it can be shown to the satisfaction of Engineer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions. The different sizes shall be stocked in separate stock piles. The grading of coarse and fine aggregate shall be checked as frequently as possible, as determined by Engineer, to ensure maintaining of grading in accordance with the sample used in preliminary mix design. The material shall be stock piled well in advance of use.

10.7.1.2 Cement

The cement shall be measured by weight.

10.7.1.3 Water

Only such quantity of water shall be added to the cement and aggregates in the concrete mix as to ensure dense concrete, specified surface finish, satisfactory workability, consistent with the strength stipulated for each class of concrete. The water added to the mix shall be such as not to cause segregation of material or the collection of excessive free water on the surface of the concrete.

10.7.1.4 Definition of Water / Cement Ratio.

The water cement (W/C) ratio is defined as the weight of water in the mix (including the surface moisture of the aggregates) divided by the weight of cement in the mix.

10.7.1.5 Water / Cement Ratio

The actual water cement ratio to be adopted shall be determined in each instance by Contractor and approved by Engineer.

10.7.1.6 Proportioning by Water / Cement Ratio

The W/C ratio specified for use by Engineer shall be maintained. Contractor shall determine the water content of the aggregates as frequently as directed by Engineer In- Charge as the work progresses and as specified in IS: 2386 (part III) and the amount of mixing water added at the mixer shall be adjusted as directed by Engineer so as to maintain the specified by W/C ratio. To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made.

10.7.2 Consistency and slump

10.7.2.1 Concrete shall be of a consistency and workability suitable for the condition of the job. After the amount of water required is determined, the consistency of the mix shall be maintained throughout the progress of the corresponding parts. Compacting factor tests, in accordance with IS: 1199, shall be conducted from time to time to ensure the maintenance of such consistency.

10.7.2.2 The following table gives a range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Engineer.

Types of Construction	Slump in mm	
	Maximum	Minimum
Reinforced foundation walls and footings	75	25
Plain footings, caissons and substructure walls	75	25
T.G. and massive compressor foundations	50	25
Slabs, Beams and reinforced walls	100	25
Pumps & miscellaneous Equipment	75	25
Building columns	100	25
Pavements	50	25
Heavy mass construction	50	25

10.7.3 Batching and mixing of concrete

10.7.3.1 The materials and proportions of concrete materials as established by the preliminary tests for the mix design shall be rigidly followed for all concrete on the project and shall not be changed except when specifically permitted by Engineer.

10.7.3.2 Concrete shall be produced only by weigh batching the ingredients. The mixer and weigh batchers shall be maintained in clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked. They shall be set up level on a firm base and the hopper shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. However, Engineer In- Charge may permit volume batching by subsequent conversion of the weights of important pours involving concrete of not more than 0.25 cubic metres, on days when other pours involving weigh batching are not likely to be taken up. Concrete shall be of strength stipulated in the respective items. All concrete shall be mixed in mechanically operated batch mixers complying with IS: 1791 and of approved make with suitable provision for correctly controlling the water delivered to the drum.

10.7.3.3 The quantity of water actually entering the drum shall be checked with the reading of the gauge or valve setting, when starting a job. The test should be made while the mixer is running. The volume of the mixed material shall not exceed the manufacturer's rated mixer capacity. The batch shall be charged into the mixer so that some water will enter the drum in advance of cement and aggregates. All water shall be in the drum by the end of the first 15 seconds of the specified mixing time. Each batch shall be mixed until the concrete is uniform in colour, for a minimum period of two minutes after all the materials and water are in the drum. The entire contents of the drum shall be discharged in one operation before the raw materials for the succeeding batches are fed into the drum.

10.7.3.4 Each time the work stops, the mixer shall be cleaned out and when next commencing the mixing, the first batch shall have 10% additional cement to allow for sticking in the drum.

10.7.4 Sampling and testing concrete in the field

10.7.4.1 Facilities required for sampling materials & concrete in the field, if Engineer so desires, shall be provided by Contractor at no extra cost. The following equipment with operator shall be made available at Engineer's request (all must be in serviceable condition)

Sr.	EQUIPMENT	QUANTITY
1	Concrete cube testing machine suitable for 15 c cm cubes of 100 Tones capacity with proving calibration ring	1 No.
2	Cast Iron cube moulds 15 cm size.	6 Nos.(min.)
3	Slump cone complete with tamping road	1 set
4	Laboratory balance to weigh upto 5 Kg, with sensitivity of 10 gm.	1 No.
5	IS Sieves for coarse and fine aggregates.	1 set
6	Electric oven with thermostat upto 120°C.	1 No.
7	Flakiness gauge.	1 No.
8	Elongation index gauge.	1 No.
9	Sedimentation pipette.	1 No.
10	Pycnometer.	1 No.
11	Calibrated glass jar 1 litre capacity.	2 Nos.
12	Glass flasks & metal containers.	As required
13	Chemical reagents like sodium hydroxide, tannic acid, litmus papers etc.	As required
14	Laboratory balance of 2 Kg capacity and of sensitivity of 1 gm.	1 No.

Note: Arrangement can be made by Contractor to have the cubes tested in an approved laboratory in lieu of a testing machine at site at his expense, with the prior consent of the Engineer.

10.7.4.2 Sampling for strength of concrete:

At least 6 test cubes of each class of concrete shall be taken for every 150 cum. concrete or part thereof. Such samples shall be drawn on each day for each type of concrete. of each set of 6 cubes, three shall be tested at 7 days age and three at 28 days age. The laboratory test results shall be tabulated and furnished to Engineer. Engineer will pass the concrete if average strength of the specimens tested is not less than the strength specified, subject to the condition that only one out of three consecutive tests may give a value less than the specified strength but this shall not be less than 90% of the specified strength.

10.7.4.3 Consistency:

Slump tests shall be carried out as often as demanded by Engineer and invariably from the same of concrete from which the test cubes are made. Slump tests shall be done immediately after sampling.

10.7.5 Admixtures:

10.7.5.1 Admixtures may be used in concrete only with the approval of Engineer based upon evidence that, with the passage of time, neither the compressive strength nor its durability will reduce. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement, or embedded steel parts. When calcium chloride is permitted to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water in an amount not to exceed 1½ percent of the weight of the cement in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixtures shall be used as per manufacturer's instructions and in the manner and with the control specified by Engineer. However, the specific requirements as given in **Chapter 7** shall be adhered to.

10.7.5.2 Air entraining agents:

Where specified and approved by Engineer, neutralized vinsol resin or any other approved air entraining agent may be used to produce the specified amount of air in the concrete mix and these agents shall confirm to the requirements of ASTM standard 6-260; Air Entraining Admixtures for Concrete. The recommended total air content of the concrete is 4% ± 1%. The method of measuring air content shall be as per IS: 1199.

10.7.5.3 Water reducing admixtures:

Where specified and approved by Engineer water reducing lignosulfonate mixture shall be added in quantities specified by Engineer. The admixtures shall be added in the form of a solution.

10.7.5.4 Retarding admixtures:

Where specified and approval by Engineer, retarding agents shall be added to the concrete mix in quantities specified by Engineer.

10.7.5.5 Water proofing agent:

Where specified and approved by Engineer, water proofing agent confirming to IS: 2645, shall be added in quantities specified by Engineer.

10.7.5.6 Other admixtures:

Engineer may at his discretion instruct Contractor to use any other admixture in the concrete.

10.7.6 Optional Tests

10.7.6.1 Engineer, if he so desires, may order tests to be carried out on cement, sand, coarse aggregate, water in accordance with the relevant Indian Standards.

10.7.6.2 Tests on cement shall include:

1. Fineness test
2. Test for normal consistency
3. Test for setting time
4. Test for soundness
5. Test for tensile strength
6. Test for compressive strength
7. Test for heat of hydration (by experiment and by calculations) in accordance with IS: 269.

10.7.6.3 Tests on sand shall include:

1. Sieve test
2. Test for organic impurities
3. Decantation test for determining clay and silt content
4. Specific gravity test
5. Test for unit weight and bulkage factor
6. Test for sieve analysis and fineness modulus.

10.7.6.4 Tests on coarse aggregate shall include

1. Sieve analysis
2. Specific gravity and unit weight of dry, loose and rodded aggregate
3. Soundness and alkali aggregate reactivity
4. Petrographic examination
5. Deleterious materials and organic impurities
6. Test for aggregate crushing value.

10.7.6.5 Any or all these tests would normally be ordered to be carried out only if Engineer In- Charge feels the materials are not in accordance with the Specifications or if the specified concrete strengths are not obtained and shall be performed by Contractor at an approved test laboratory. If the tests are successful, owner shall pay for all such optional tests otherwise Contractor shall have to pay for them.

10.7.6.6 If the works cubes do not give the stipulated strengths, Engineer reserves the right to ask Contractor to dismantle such portions of the work, which in his opinion are unacceptable and re-do the work to the standard stipulated, at Contractor's cost. The unit rate for concrete shall be all inclusive, including making preliminary mix design and test cubes, works, cubes, testing them as per Specification, slump tests, optional tests, etc. complete.

10.7.6.7 Load test on members or any other tests:

In the event of any work being suspected of faulty material or workmanship or both, Engineer requiring its removal and reconstruction may order, or Contractor may request that it should be load tested in accordance with the following provisions:

1. The test load shall be 125 percent of the maximum super- imposed load for which the structure was designed. Such test load shall not be applied before 56 days after the effective hardening of concrete. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members. The test load shall be maintained for 2 hours before removal.

2. If within 24 hours of the removal of the load, the structure does not show a recovery of at least 75 percent of the maximum deflection shown during the 24 hours under load, the test loading shall be repeated after a lapse of at least 72 hours. The structure shall be considered to have failed to pass the test if the recovery after the second test is not at least 75 percent of the maximum deflection shown during the second test. If the structure is certified as failed by the Engineer, the cost of the load test shall be borne by the Contractor.

3. Any other tests, e.g. taking out in an approved manner concrete cores, examination and tests on such cores removed from such parts of the structure as directed by Engineer In-Charge, sonic testing etc. shall be carried out by Contractor if so directed.

Unsatisfactory tests:

1. Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction Contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required by Engineer / Owner. Contractor shall bear the cost of so doing, unless the failure of the member or members to fulfill the test conditions is proved to be solely due to faulty design. The cost of load and other tests shall be borne by Contractor if the tests show unsatisfactory results; otherwise such costs will be borne by Owner.

10.7.7 Concrete in alkali soils and alkaline water:

10.7.7.1 Where concrete is liable to attack from alkali salts or alkaline water, special cements containing low amount of tricalcium aluminate shall be used, if so specified on the Drawings. Such concrete shall have a minimum 28 days compressive strength of 250 kg/cm² and shall contain not less than 370 Kg of cement per cubic metre of concrete. If specified, additional protection shall be obtained by the use of a chemically resistant stone facing or a layer or Plaster of Paris covered with suitable fabric, such as jute, thoroughly impregnated with tar.

10.7.8 Preparation prior to concrete placement, final inspection and approval

10.7.8.1 Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled. Temporary openings shall be provided to facilitate inspection, especially at bottom of columns and wall forms, to permit removal of saw dust, wood shavings, binding wire, rubbish, dirt etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings / holes shall be later suitably plugged.

10.7.8.2 The various traders shall be permitted ample time to install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedments to be cast in the concrete as indicated on the Drawings or as is

necessary for the proper execution of the work. Contractor shall cooperate fully with all such agencies, and shall permit the use of scaffolding, formwork etc. by other trades at no extra cost.

10.7.8.3 All embedded parts, inserts etc. supplied by Owner or Contractor shall be correctly positioned and securely held in the forms to prevent displacement during depositing and vibrating of concrete.

10.7.8.4 All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by Engineer. The use of all such templates, fixtures etc. shall be deemed to be included in the rates. Slots, openings, holes, pockets etc. shall be provided in the concrete work in the positions indicated in the Drawings or as directed by Engineer.

10.7.8.5 Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.

10.7.8.6 Prior to concrete placement all work shall be inspected and approved by Engineer and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected at Contractor's cost.

10.7.8.7 Approval by Engineer of any and all materials and work as required herein shall not relieve Contractor from his obligation to produce finished concrete in accordance with the Drawings and Specifications.

10.7.9 Rain or wash water:

10.7.9.1 No concrete shall be placed in wet weather or on a water covered surface. Any concrete that has been washed by heavy rains shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage which may be caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. To avoid flow of water over / around freshly placed concrete, suitable drains & sumps shall be provided.

10.7.10 Bonding mortar:

10.7.10.1 Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with a bonding mortar as specified in paragraph 24.7 of this section.

10.7.11 Transportation:

10.7.11.1 All buckets, containers or conveyers used for transporting concrete shall be mortar-tight. Irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of Engineer and concrete shall not be rehandled before placing.

10.7.12 Retempered or contaminated concrete:

10.7.12.1 Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by Engineer.

10.7.12.2 Cleaning of equipment:

10.7.12.3 All equipment used for mixing, transporting and placing of concrete shall be maintained in clean condition. All pans, buckets, hoppers, chutes, pipelines and other equipment shall be thoroughly cleaned after each period of placement.

10.8 Procedure for Placing of Concrete:

10.8.1 Engineer's approval of equipment & methods:

10.8.1.1 Before any concrete is placed, the entire placing programme, consisting of equipment, layout, proposed procedures and methods shall be submitted to Engineer for approval if so demanded by Engineer and no concrete shall be placed until Engineer's approval has been received. Equipment for conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing, without segregation of materials, considering the size of the job and placement location.

10.8.2 Time interval between mixing and placing

10.8.2.1 Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer, and once compacted it shall not be disturbed.

10.8.3 Avoiding segregation

10.8.3.1 Concrete shall, in all cases, be deposited as nearly as practicable directly in its final position, and shall not be rehandled or caused to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts or impair its strength. For locations where direct placement is not possible, and in narrow forms, Contractor shall provide suitable drop and "Elephant Trunks" to confine the movement of concrete.

10.8.3.2 Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

10.8.4 Placing by manual labour

10.8.4.1 Except when otherwise approved by Engineer, concrete shall be placed in the shuttering by shovels or other approved implements and shall not be dropped from a height more than 1.0 M or handled in a manner which will cause segregation.

10.8.5 Placing by mechanical equipment

10.8.5.1 The following Specification shall apply when placing of concrete by use of mechanical equipment is specifically called for while inviting bids or is warranted considering the nature of work involved.

10.8.5.2 The control of placing shall begin at the mixer discharge by a vertical drop into the middle of the bucket or hopper and this principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

10.8.6 Type of Buckets.

10.8.6.1 Central-bottom-dump buckets of a type that provides for positive regulation of the amount and rate of deposition of concrete in all dumping position shall be employed.

10.8.7 Operation of Bucket

10.8.7.1 Placing concrete in large open areas, the bucket shall be spotted directly over the position designated and then lowering for dumping. The open bucket shall clear the concrete already in place and the height of drop shall not exceed 1.00 M. The bucket shall be opened slowly to avoid high vertical bounce. Dumping of buckets on the swing or in any manner which results in separation of ingredients or disturbance of previously placed concrete will not be permitted.

10.8.8 Placement in restricted forms

10.8.8.1 Concrete placed in restricted forms by barrows, buggies, short chutes hand shoveling shall be subject to the requirement for vertical delivery of limited height to avoid segregation and shall be deposited as nearly as practicable in its final position.

10.8.9 Chuting

10.8.9.1 Where it is necessary to use transfer chutes, specific, approval of Engineer must be obtained to type, length, slopes, baffles, vertical terminals and timing of operations. These shall be so arranged that an almost continuous flow of concrete is obtained at the discharge and without segregation. To allow for the loss of mortar against the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the waste water shall be kept clear of the forms. Concrete shall not be permitted to fall from the end of the chutes by more than 1.0 M. Chutes, when approved for use, shall have slopes not flatter than 1 vertical: 3 horizontal and not steeper than 1 vertical: 2 horizontal. Chutes shall be of metal or metal lined and of rounded cross section. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surface of the concrete in the forms.

10.8.10 Placing by pumping / pneumatic placers

10.8.10.1 Concrete may be conveyed and placed by mechanically operated equipment e.g. pumps or pneumatic placers, only with the written permission necessary for conveying concrete by this method.

10.8.10.2 When pumping is adopted, before pumping of concrete is started, the pipeline shall be lubricated with one or two batches of mortar composed of one part cement and two parts sand. The concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

10.8.10.3 When pneumatic placer is used, the manufacturer's advice on layout of pipeline shall be followed to avoid blockages and excessive wear. Restraint shall be provided at the discharge box to take care for the reaction at this end.

10.8.10.4 Manufacturer's advice shall be followed regarding concrete quality and all other related matters when pumping / pneumatic placing equipment are used.

10.8.11 Concrete in layers

10.8.11.1 Concrete, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 to 90 cm or as directed by Engineer. These shall be placed as rapidly as practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit, shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum of shoveling. Any tendency to segregation shall be corrected by shoveling stones. Such a condition shall be corrected by redesign of mix or other means, as directed by Engineer.

10.8.12 Bedding of layers

10.8.12.1 The top surface of each pour and Bedding planes shall be approximately horizontal unless otherwise instructed.

10.8.13 Compaction

10.8.13.1 Concrete shall be compacted during placing, with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, is free of pockets of coarse aggregate fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms or against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results.

10.8.14 Type of Vibrators

10.8.14.1 Vibrators shall conform to IS Specifications. Type of vibrator to be used shall depend on the structure where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to the transmit the vibration and string enough not to be damaged by it. Immersion vibrators shall have "no load" frequency, on the size of the vibrator.

10.8.14.2 Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

10.8.15 Use of Vibrators

10.8.15.1 The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention shall be paid to vibration at the top of lift e.g. in a column or wall.

10.8.16 Melding Successive Batches

10.8.16.1 When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the succeeding layers.

10.8.17 Penetration of Vibrator

10.8.17.1 The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the underlayer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

10.8.18 Vibrating Against Reinforcement

10.8.18.1 Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

10.8.19 Use of Form Attached Vibrators

10.8.19.1 Form attached vibrators shall be used only with specific authorization of Engineer.

10.8.20 Use of Surface Vibrators

10.8.20.1 The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, such as highways, runways and similar constructions, surface vibration by specially designed vibrators may be permitted, upon approval of Engineer.

10.8.21 Stone pockets and Mortar Pondages

10.8.21.1 The formation of stone pockets or mortar pondages in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for through bonding, as directed by Engineer.

10.8.22 Placement interval

10.8.22.1 Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for atleast 24 hours after the final set of concrete and before the start of a subsequent placement.

10.8.23 Special provision in placing

10.8.23.1 When placing concrete in walls with openings, in floors of integral slabs and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined be Engineer In- Charge.

10.8.24 Placing concrete through reinforcing steel

10.8.24.1 When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to temporarily move the top aside to get proper placement and restore reinforcing steel to design position.

10.8.25 Bleeding

10.8.25.1 Bleeding or free water on top of concrete being deposited into the forms, shall be a cause to stop the concrete pour and the conditions causing this defect corrected before any further concreting is resumed.

10.9 Construction Joints and Keys

10.9.1 Concrete shall be placed without interruption until completion of the part of the work between predetermined construction joints, as specified hereinafter. Time lapse between the pouring of adjoining units shall be as specified on the Drawings or as directed by Engineer.

10.9.2 If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made where the work is stopped. Joints shall be either vertical or horizontal, unless shown otherwise on Drawings. In case of an inclined or curved member, the joint shall be at right angles to the axis of the member. Vertical joints shall be formed against a stop board; horizontal joints shall be level and wherever possible, arranged so that the joint lines coincide with the architectural features of the finished work. Battens shall be nailed to he formwork to ensure a horizontal line and if directed, shall also be used to form a grooved joint. For tank walls and similar works joints shall be formed as per IS: 3370. Concrete that is in the process of setting shall not be disturbed or shaken by traffic either on the concrete itself or upon the shuttering. Horizontal and vertical construction joints and shear keys shall be located and shall conform to the requirements of the plans unless otherwise directed by Engineer. Where not described, the joint shall be in accordance with the following:

1. Column Joint

In a column, the joint shall be formed 75 mm below the lowest soffit of the beams including haunches if any. In flat slab construction, the joint shall be 75 mm below the soffit of column capital. At least 2 hours shall elapse after depositing concrete in columns, piers or walls, before depositing in beams, girders or slabs supported thereon.

2. Beam and Slab Joints

Concrete in a beam shall be placed throughout without a joint but if the provision of a joint is unavoidable the joint shall be vertical and at the centre or within the middle third of the span unless otherwise shown on Drawings. Where a beam intersects a girder, the joints in the girder shall be offset by a distance equal to twice the width of the beam and additional reinforcement provided for shear. The joints shall be vertical throughout the full thickness of the concrete member. A joint in a slab shall be vertical and parallel to the principal reinforcement. Where it is unavoidably at the right angles to the principal reinforcement, the joint shall be vertical and at the middle of the span.

3. Joints in Liquid Retaining Structures

Vertical construction joints in watertight construction will not be permitted unless indicated on the Drawings. Where a horizontal construction joint is required to resist water pressure, special care shall be taken in all phases of its construction to ensure maximum water-tightness.

10.9.3 Dowels

10.9.3.1 Dowels for concrete work, not likely to be taken up in the near future, shall be wrapped in tar paper & burlap.

10.9.4 Mass Foundations

10.9.4.1 Mass Foundations shall be poured in lifts not exceeding 1.5m. in height unless otherwise indicated on the Drawings or approved by Engineer.

10.9.5 Treatment of construction joints on resuming concreting

10.9.5.1 A drier mix shall be used for the top lift of horizontal pours to avoid laintance. All laintance and loose stones shall be thoroughly and carefully removed by wire brushing / hacking and surface washed.

10.9.5.2 Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and loose matter removed and then treated with a thin layer of cement group of proportion specified by Engineer and worked well into the surface. The new concrete shall be well worked against the prepared face before the grout mortar sets. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

10.10 Curing, Protecting, Repairing and Finishing

10.10.1 Curing

10.10.1.1 All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponded water, continuously saturated covering of sacking, canvas, hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even- textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as the one used for mixing concrete.

10.10.1.2 Certain types of finish or preparation for overlaying concrete must be done at certain stages of the curing process and special treatment may be required for specific concrete surface finish.

10.10.1.3 Curing of concrete made of high alumina cement and supersulphated cement shall be carried out as directed by Engineer.

10.10.1.4 Curing with water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin immediately after the concrete has hardened. Water shall be applied to unformed concrete surfaces within 1 hour after concrete has set. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

10.10.1.5 Continuous Spraying:

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliance of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by Engineer.

10.10.1.6 Alternate Curing Methods:

Whenever, in the judgment of Engineer, it may be necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during the curing period.

10.10.1.7 For curing of concrete in pavements, side-walks, floors, flat roofs or other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by Engineer. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

10.10.1.8 Curing Compounds:

Surface coating type curing compounds shall be used only by special permission of Engineer. Curing compounds shall be liquid type white pigmented, conforming to U.S. Bureau of Reclamation Specification. No curing compound shall be used on surfaces where future blending with concrete, water or acid proof membrane, or painting is specified.

10.10.1.9 Curing Equipment:

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

10.10.2 Protecting fresh concrete:

10.10.2.1 Fresh concrete shall be protected from the elements, from defacements and damage due to construction operations by leaving forms in place for an ample period as specified later in this Specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by Engineer shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials etc. that may impair the strength and / or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that workmen enter the area of freshly placed concrete, Engineer may require that bridges be placed over the area.

10.10.3 Repair and replacement of unsatisfactory concrete

10.10.3.1 Immediately after the shuttering is removed, the surface of concrete shall be very carefully gone over and all defective areas called to the attention of Engineer who may permit patching of the defective areas or also reject the concrete unit either partially or in its entirely. Rejected concrete shall be removed and replaced by Contractor at no additional expense to Owner.

10.10.3.2 Holes left by form bolts etc. shall be filled up and made good with mortar composed of one part of cement to one and half parts of sand passing 2.36 mm IS sieve after removing any loose stones adhering to the concrete. Mortar filling shall be struck off flush at the face of the concrete. Concrete surfaces shall be finished as described under the particular items of work.

10.10.3.3 Superficially honeycombed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of Engineer and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by Engineer, the surface of the exposed concrete placed against shuttering to remove fine or other irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding.

10.10.3.4 If reinforcement is exposed or the honey combing occurs at vulnerable positions e.g. ends of beams or columns it may be necessary to cut out the member completely or in part and reconstruct. The decision of Engineer shall be final in this regard.

10.10.3.5 If only patching is necessary, the defective concrete shall be cut out till solid concrete is reached (or to a minimum depth of 25 mm) the edges being cut perpendicular to the affected surface or with a small under cut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place.

10.10.3.6 An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

10.10.3.7 Use of Polymers:

The use of polymers for bonding fresh concrete used for repairs will be permitted upon written approval of Engineer In- Charge. polymers shall be applied in strict accordance with the instruction of the manufacturer.

10.10.3.8 Method of Repair:

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows:

1. The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops. A 5 mm thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly proud of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers. After an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finished obtained by wiping with hessian, a steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportions as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible.

2. Mortar filling by air pressure (guniting) shall be used for repair of areas too large and / or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by Engineer, to match the shade of the patch with the original concrete.

10.10.3.9 Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, water-saturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days.

10.10.3.10 Approval by Engineer:

All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of Engineer. All fillings shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

10.10.4 Finishing:

10.10.4.1 This Specification is intended to cover the treatment of concrete surfaces of all structures. Areas requiring special finish not covered by this Specification shall be clearly indicated on the Drawings and special Specifications shall be furnished.

10.10.4.2 Finish for Formed Surfaces

1. The type of finish for formed concrete surfaces shall be as follows, unless otherwise specified by the Engineer In- Charge:

2. For surfaces against which backfill or concrete is to be placed, no treatment is required except repair of defective areas.

3. For surfaces below grade which will receive waterproofing treatment, the concrete shall be free of surface irregularities which would interfere with proper application of the waterproofing material which is specified for use.

4. Unless specified, surfaces which will be exposed when the structure is in service shall receive no special finish, except repair of damaged or defective concrete, removal of fins and abrupt irregularities, filling of holes left by form ties and rods and clean up of loose or adhering debris.

10.10.4.3 Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless the Drawing specifies a horizontal surface or shows the slope required, the tops of narrow surfaces such as stair treads, walls, curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surfaces such as walkways, roads, parking areas and platforms shall be sloped about 1 in 50. Surfaces that will be covered by backfill or concrete, subfloors to be covered with concrete topping, terrazzo or quarry tile, and similar surfaces shall be smooth screeded and leveled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tile toppings such as outside decks, floors of galleries and sumps, parapets, gutters, sidewalks, floors & slabs, shall be consolidated, screeded and floated. Excess water & laitance shall be removed before final finishing. Floating may be done with hand or power tools and started as soon as the screeded surface has attained a stiffness to permit finishing operations and these shall be the minimum required to produce a surface uniform in texture and free from screen marks or other imperfections. Joints and edges shall be tooled as called for on the Drawings or as directed by Engineer In- Charge.

10.10.4.4 Standard Finish for Exposed Concrete

1. Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the job.

2. Unless otherwise specified on the Drawings, the standard finish for exposed concrete shall be a smooth finish.

3. A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels and form linings shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms the joint marks shall be smoothened off and all blemishes, projections, etc. removed leaving the surfaces reasonably smooth and unmarred.

10.10.4.5 Integral Cement concrete Finish

When specified on the Drawings an integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified on the Drawings, as per IS: 2571. The surface shall be compacted and then floated with a wood float or power floating machine. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or trowelling of the finish shall be permitted only after all surface water has evaporated. Dry cement or a mixture of dry cement and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix.

10.10.4.6 Rubbed Finish

A rubbed finish shall be provided only on exposed concrete surfaces as specified on the Drawings. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets leveled and voids and / or damaged sections immediately saturated with water and repaired by filling with a concrete or mortar of the same composition as was used in the surface. The surfaces shall then be thoroughly wetted and rubbed with carborundum or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.

10.10.5 Protection

10.10.5.1 All concrete shall be protected against damage until final acceptance by Engineer / Owner.

10.11 Formwork

10.11.1 The formwork shall consist of shores, bracings, sides of beams and columns, bottom of slabs including ties, anchors, hangers, inserts and shall be properly designed and planned for the work. False work shall be so constructed that vertical adjustments can be made to compensate for take up and settlements. Wedges may be used at the top or bottom of timber shores, but not at both ends, to facilitate vertical adjustment or dismantling of the formwork.

10.11.2 Design of formwork

10.11.2.1 The design and engineering of the formwork as well as its construction shall be the responsibility of Contractor. If so instructed, the Drawings and / or calculations for the design of the formwork shall be submitted to Engineer In- Charge for approval before proceeding with work, at no extra cost to Owner. Engineer's approval shall not however relieve Contractor of the full responsibility for the design and construction of the formwork. The design shall take into account all the loads vertical as well as lateral, that the forms will be carrying including live and vibration loadings.

10.11.3 Camber

Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The formwork shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per metre (1 to 25) or as directed by the Engineer, so as to offset the subsequent deflection. For cantilevers the camber at free end shall be 1/50th of the projected length or as directed by the Engineer.

10.11.4 Tolerances

10.11.4.1 Tolerance is specified as permissible variation from lines, grade or dimensions given in Drawings. No tolerances specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerances will be permitted.

10.11.4.2 Tolerance for R.C. Buildings

1. Variation from the plumb
   - In the lines and surfaces of columns, piers, walls and in arises 5 mm per 2.5 m. or 25 mm, whichever is less.
   - For exposed corner columns and other conspicuous lines.
     In any bay or 5 m maximum - 5 mm
     In 10 m or more - 10 mm

2. Variation from the level or from the grades indicated on the Drawings.
   - In slab soffits, ceilings, beam soffit, and in arises
     In 2.5 m - 5 mm
     In any bay or 5 m maximum - 8 mm
     In 10 m or more - 15 mm
   - For exposed lintels, sills, parapets, horizontal groves and other conspicuous lines.
     In any bay or 5 m maximum - 5 mm
     In 10m or more - 10 mm

3. Variation of the linear building lines from established position in plan and related position of columns, wall and partitions.
   In any bay or 5 m maximum - 10 mm
   In 10 m or more - 20 mm

4. Variation in the sizes and locations of sleeves, openings in walls and floors
   5 mm except in the case of anchor bolts.

5. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls
   Minus - 5 mm
   Plus - 10 mm

6. Footings
   - Variation in dimension in plans
     Minus - 5 mm
     Plus - 10 mm
   - Misplacement or eccentricity
     2% of footing width in the direction of misplacement but not more than 50 mm
   - Reduction in thickness
     Minus - 5% of specified thickness subject to a maximum of 50 mm.
   - Variation in steps
     In a flight of stairs : Rise - 3 mm; Tread - 5 mm
     In consecutive steps: Rise - 1.5 mm; Tread - 3 mm

10.11.4.3 Tolerances in other Concrete Structures

1. All Structures
   - Variation of the constructed linear outline from established position in plan.
     In 5 m - 10 mm
     In 10 m or more - 15 mm
   - Variations of dimensions to individual structure features from established positions.
     In 20 m or more - 25 mm
     In buried construction - 50 mm
   - Variation from plumb, from specified batter or from curved surfaces of all structures.
     In 2.5 m - 10 mm
     In 5 m - 15 mm
     In 10 m or more - 25 mm
     In buried-construction - Twice the above amounts
   - Variation from level or grade indicated on Drawings in slab, beams, soffits, horizontal groves and visible arises.
     In 2.5 - 5 mm
     In 7.5 m or more - 10 mm
     In buried-construction - Twice the above amounts
   - Variation in cross-sectional dimensions of columns beams, buttresses, piers and similar members.
     Minus - 5 mm
     Plus - 10 mm
   - Variation in the thickness of slabs, walls, arch sections and similar members
     Minus - 5 mm
     Plus- - 10 mm

2. Footing for columns, piers, walls, buttresses and similar members
   - Variation of dimensions in plan
     Minus - 10 mm
     Plus - 50 mm
   - Misplacement or eccentricity
     2% of footing width in the direction of misplacement but not more than 50 mm.
   - Reduction in thickness
     5% of specified thickness subject to a max. of 50 mm.

10.11.4.4 Tolerances in other types of structures shall generally conform to those given in **Clause 2.4** of Recommended Practice for Concrete Formwork (ACI 347)

10.11.4.5 Tolerances in fixing anchor bolts shall be as follows:

1. Anchor bolts without sleeves : ± 1.5 mm in plan
2.
3. Anchor bolts with sleeves : ± 5.0 mm in elevation
   - For bolts upto & including 28 mm diameter : ± 5 mm in all directions.
   - For bolts 32 mm diameter and above : ± 3 mm in all direction.

4. Embedded parts : ± 5 mm in all direction.

10.11.5 Type of formwork

10.11.5.1 Formwork may be of timber, plywood, metal, plastic or concrete. For special finishes the formwork may be lined with plywood, steel sheets, oil tempered hard board, etc. Sliding forms and slip forms may be used with the approval of Engineer.

10.11.6 Formwork requirements

10.11.6.1 Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as called for on the Drawings. Ample studs, walers, braces, ties, straps, shores, etc.

shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of the form. In special cases where form vibrators are to be used, the shuttering shall be close boarded. Timber shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps or other surface defects in contact with concrete. Faces coming in contact with the concrete shall be free from adhering grout, plaster, paint, projecting nails, splits or other defects. Joints shall be sufficiently tight to prevent loss of water and fine material from concrete.

10.11.6.2 Plywood shall be used for Exposed Concrete surfaces; where called for. Sawn and wrought timber may be used for unexposed surfaces. Inside faces of forms for concrete surfaces which are to be rubbed finished shall be planned to remove irregularities or unevenness in the face. Formwork with linings will be permitted.

10.11.6.3 All new and used form lumber shall be maintained in a good condition with respect to shape, strength, rigidity, water tightness, smoothness and cleanliness of surfaces. Form lumber unsatisfactory in any respect shall not be used and; if rejected by Engineer, shall be removed from the site.

10.11.6.4 Shores supporting successive stories shall be placed directly over those below or be so designed and placed that the load will be transmitted directly on to them Truss supports shall be provided for shores that cannot be secured on adequate foundations.

10.11.6.5 Formwork, during any stage of construction showing signs of distortion or distorted to such a degree that the intended concrete work will not conform to the exact contours indicated on the Drawings, shall be repositioned and strengthened. Poured concrete affected by the faulty formwork, shall be removed in its entirety and the formwork corrected prior to placing new concrete.

10.11.6.6 Excessive construction camber to compensate for shrinkage settlement, etc. that may impair the structural strength of members will not be permitted.

10.11.6.7 Forms for substructure concrete may be omitted when, in the opinion of Engineer the open excavation is firm enough to act as the form. Such excavations shall be slightly larger than required by the Drawings to compensate for irregularities in excavation and to ensure the design requirements.

10.11.6.8 Forms shall be so designed and constructed that their removal will not damage the concrete. Face formwork shall provide true vertical and horizontal joints, conform to the architectural features of the structure as to location of joints and be as directed by Engineer.

10.11.6.9 Where Exposed smooth or rubbed concrete finishes are required, the forms shall be constructed with special care so that the resulting concrete surfaces require a minimum finish.

10.11.7 Bracing, struts and props

10.11.7.1 Shuttering shall be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the concrete and also due to the movement of men and other materials. Bamboo shall not be used as props or cross bearers.

10.11.7.2 The shuttering for beams and slabs shall be so erected that the shuttering on the sides of the beams and under the soffit of slabs can be removed without disturbing the beam bottoms. Repropping of beams shall not be done except when props have to be reinstated to take care of construction loads anticipated to be in excess of the design load. Vertical props shall be supported on wedges or other measures shall be take whereby the props can be gently lowered vertically while striking the shuttering.

10.11.7.3 If the shuttering for a column is erected for the full height of the column, one side shall be left open and built up in sections as placing of concrete proceeds, or windows may be left for pouring concrete from the sides to limit the drop of concrete to 1.0 M or as directed by Engineer.

10.11.8 Mould oil

10.11.8.1 Care shall be taken to see that the faces of form-work coming in contact with concrete are perfectly cleaned and two coats of mould oil or any other approved materials applied before fixing reinforcement and placing concrete. Such coating shall be insoluble in water, non-staining and not injurious to the concrete. It shall not become flaky or be removed by rain or wash water. Reinforcement and / or other items to be cast in the concrete shall not be placed until coating of the forms is complete. Adjoining concrete surfaces shall also be protected against contamination from the coating materials.

10.11.9 Chamfers and fillets

10.11.9.1 All corners and angles exposed in the finished structure shall be formed with mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise specified, shall be 20 mm X 20 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

10.11.10 Vertical construction joint chamfers

10.11.10.1 Vertical construction joints on faces which will be exposed at the completion of the work shall be chamfered as above except where not permitted by Engineer for structural or hydraulic reasons.

10.11.11 Wall ties

10.11.11.1 Wire ties passing through the walls shall not be allowed. In their place bolts passing through sleeves shall be used.

10.11.12 Reuse of forms

10.11.12.1 Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes that may leak suitably plugged and joints examined and when necessary, repaired and the inside retreated to prevent adhesion, to the satisfaction of Engineer. Warped lumber shall be resized. Contractor shall equip himself / herself with enough shuttering to complete the job in the stipulated time.

10.11.13 Removal of forms

10.11.13.1 Contractor shall record on the Drawing or on a special register the date upon which the concrete is placed in each part of the work and the date on which the shuttering is removed therefrom.

10.11.13.2 In no circumstances shall forms be struck until the concrete reaches a strength of at least twice the stress due to self weight and any construction / erection loading to which the concrete may be subjected at time of striking formwork.

10.11.13.3 Informal circumstances (generally where temperatures are above 20°C) forms may be struck after expiry of the following periods:

Item	Ordinary Portland cement concrete	Rapid hardening Portland cement concrete
1. Walls, columns and vertical sides of beams	24 to 48 hours or as directed by the Engineer	24 hours
2. Slabs (props left under).	3 days	2 days
3. Beam soffits (Props left under)	7 days	4 days
4. Removal of props to slabs: • Spanning upto 4.5 m • Spanning over 4.5 m	 7 days 14 days	 4 days 8 days
5. Removal of props to beams & arches: • Spanning upto 6 m. • Spanning over 6 m.	 14 days 21 days	 8 days. 12 days.

10.11.13.4 Striking shall be done slowly with utmost care to avoid damage to arises and projections and without shock or vibration, by gently easing the wedges. If after removing the formwork, it is found that timber has been embedded in the concrete, it shall be removed and made good as specified earlier.

10.11.13.5 Reinforced temporary openings shall be provided, as directed by Engineer, to facilitate removal of formwork which otherwise may be inaccessible.

10.11.13.6 Tie rods, clamps, form bolts, etc. which must be entirely removed from walls or similar structures shall be loosened neither sooner than 24 hours nor later than 40 hours after the concrete has been deposed. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of walls and grade beams will not be permitted.

10.11.13.7 For liquid retaining structures no sleeves for through bolts shall be used nor shall through bolts be removed as indicated in **Clause 9.11.13.6**. The bolts, in this case, shall be cut at 25 mm depth from the surface and then the hole shall be made good by sand cement mortar of the same proportions as the concrete just after striking the formwork.

10.12 Foundation Bedding, Bonding and Jointing

10.12.1 All surfaces upon or against which concrete will be placed shall be suitably prepared by thoroughly cleaning, washing and dewatering, as may be indicated in the plans or as Engineer, may direct, to meet the various situations encountered in the work.

10.12.2 Soft or spongy areas shall be cleaned out and back filled with either a soil-cement mixture, lean concrete or clean sand fill compacted to a minimum density of 90% Modified Proctor, unless otherwise mentioned in Schedule of Quantities.

10.12.3 Prior to construction of formwork for any item where soil will act as bottom form, approval shall be obtained from Engineer as to the suitability of the soil.

10.12.4 Preparation of rock strata of foundations

10.12.4.1 To provide tight bond with rock foundations, the rock surface shall be prepared and the following general requirements shall be observed.

10.12.4.2 Concrete shall not be deposited on large sloping rock surfaces. Where required by Engineer or as indicated on the plans, the rock shall be cut to form rough steps or benches to provide roughness or a more suitable bearing surface.

10.12.4.3 Rock foundation stratum shall be prepared by picking, barring, wedging and similar methods which will leave the rock in an entirely sound and unshattered condition.

10.12.4.4 Shortly before concrete is placed, the rock surface shall be cleaned with high pressure water and air jet even though it may have been previously cleaned in that manner.

10.12.4.5 Prior to placing concrete, the rock surface shall be kept wet for a period of 2 to 4 hours unless otherwise directed by Engineer.

10.12.4.6 Before placing concrete on work surfaces all water shall be removed from depressions to permit thorough inspection and proper bonding of the concrete to the rock.

10.12.5 Preparation of earth strata of foundations

10.12.5.1 All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft, yielding solid shall be removed and replaced with suitable earth well compacted as directed by Engineer. Where specified, lean concrete shall be provided on the earth stratum for receiving concrete. The surface of absorptive soils against which concrete is to be placed shall be moistened thoroughly so that no moisture will be drawn from the freshly placed concrete and later shall help to cure the concrete.

10.12.6 Preparation of concrete surfaces

10.12.6.1 The preparation of concrete surfaces upon which additional concrete is to be placed later, shall preferably be done by scarifying and cleaning while the concrete is between its initial and final set. This method shall be used wherever practicable and shall consist of cutting the surface with picks and stiff brooms and by use of an approved combination of air and water jet as directed by Engineer. Great care shall be taken in performing this work to avoid removal of too much mortar and the weakening of the surface by loosening of aggregate.

10.12.6.2 When it is not practicable to follow the above method, it will be necessary to employ air tools to remove laitance and roughen the surface.

10.12.6.3 The final required result shall be a pitted surface from which all dirt, unsound concrete, laitance and glazed mortar have been removed.

10.12.7 Bonding Treatment (Mortar)

10.12.7.1 After rock or concrete surfaces upon which new concrete is to be placed have been scarified, cleaned and wetted as specified herein, they shall receive a bonding treatment, immediately before placement of the concrete.

10.12.7.2 The bonding medium shall be a coat of cement-sand mortar. The mortar shall have the same cement-sand proportions as the concrete which shall be placed on it. The water-cement ratio shall be determined by placing conditions and as approved by Engineer.

10.12.7.3 Bonding mortar shall be placed in sufficient quantity to completely cover the surface about 10 mm thick for rock surface and about 5 mm thick for concrete surfaces. It shall be brushed or broomed over the surface and worked thoroughly into all cracks, crevices and depressions. Accumulations or puddles of mortar shall not be allowed to settle in depressions and shall be brushed out to a satisfactory degree, as determined by Engineer.

10.12.7.4 Mortar shall be placed at such a rate that it can be brushed over the surface just in advance of placement of concrete. Only as much area shall be covered with mortar as can be covered with concrete before initial set in the mortar takes place. The amount of mortar that will be permitted to be placed at any one time, on the area which it is to cover, shall be in accordance with Engineer's directions.

10.12.8 Cleaning and bonding formed construction joints

10.12.8.1 Vertical construction joints shall be cleaned as specified above or by other methods approved by Engineer. In placing concrete against formed construction joints, the surface of the joints, where accessible, shall be coated thoroughly with the specified bed-joint bonding mortar immediately before they are covered with concrete or by scrubbing with wire brooms dipped into the fresh concrete. Where it is impracticable to apply such a mortar coating, special precautions shall be taken to ensure that the new concrete is brought into intimate contact with the surface of the joint by careful puddling and spading with aid of vibrators and suitable tools.

10.12.9 Expansion and contraction joints

10.12.9.1 Provision shall be made for expansion and contraction in concrete by use of special type joints at locations shown on the Drawing. Contraction joint surfaces shall be treated as per the Specifications on the Drawings or as directed by Engineer.

10.12.10 Hot weather requirement

10.12.10.1 All concrete work performed in hot weather shall be in accordance with IS: 456 except as herein modified.

10.12.10.2 Admixtures may be used only when approved by Engineer.

10.12.10.3 Adequate provisions shall be made to lower concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use of reflective paints on mixers, etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38^{o}C.

10.12.10.4 Consideration shall be given to shading aggregate stockpiles from direct rays of the sun and spraying stockpiles with water, use of cold water when available, and burying, insulating, shading and / or painting white the pipe lines and water storage tanks and conveyances.

10.12.10.5 In order to reduce loss of mixing water, the aggregates, wooded forms, subgrade, adjacent concrete and other moisture absorbing surfaces shall be well wetted prior to concreting. Placement and finishing shall be done as quickly as possible.

10.12.10.6 Extra precautions shall be taken for the protection and curing of concrete. Consideration shall be given to continuous water curing and protection against high temperatures and drying hot winds for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

10.13 Placing Concrete Underwater

10.13.1 Under all ordinary conditions all foundations shall be completely dewatered and concrete placed in the dry. However, when concrete placement under water is necessary, all work shall conform to IS: 456 and the procedure shall be as described in the following paragraphs:

10.13.2 Method of placement

10.13.2.1 Concrete shall be deposited underwater by means of tremies, or drop bottom buckets of approved type.

10.13.3 Direction, Inspection and Approved

10.13.3.1 All work requiring placement of concrete underwater shall be designed, directed and inspected with due regard to local circumstances and purposes. All underwater concrete shall be placed according to the plans or Specifications and as directed and approved by Engineer.

10.14 Precast Concrete

10.14.1 Precast concrete shall comply with IS: 456 and with the following requirements:

10.14.1.1 All precast units shall be cast on a suitable bed or platform with firm foundation and free from wind.

10.14.1.2 Contractor shall be responsible for the accuracy of the level or shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit.

10.14.2 Striking forms

10.14.2.1 Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches a strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

10.14.3 Precast units

10.14.3.1 The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending. Contractor shall satisfy Engineer or his representative that the methods proposed to adopt for these operations will not over-stress or otherwise effect seriously the strength of the precast units. The reinforced side of the units shall be distinctly marked.

10.14.4 Curing

10.14.4.1 All precast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits. Otherwise curing practice as given in **Clause 9.6.9** shall be followed.

10.15 Slots, Openings, etc.

10.15.1 Slots, openings or holes, pockets etc. shall be provided in the concrete work in the positions indicated in the Drawings or as directed by Engineer. Any deviation from the approved Drawings shall be made good by Contractor at his own expense, without damaging any other work. Sleeves, bolts, inserts, etc. shall also be provided in concrete work where so specified.

10.16 Grouting

10.16.1 Standard grout

10.16.1.1 Grout shall be provided as specified on the Drawings.

10.16.1.2 The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows:

Use	Grout Thickness	Mix Proportions	Max W/C Ratio
Fluid Mix.	Under 25 mm	One part Portland Cement to one part sand.	0.44
General	25 mm and over but less than 50 mm.	One part Portland Cement to two parts of sand	0.53
Stiff Mix	50 mm and above.	One part Portland Cement to 3 parts of sand.	0.53

10.16.1.3 Sand

1. Sand shall be such, as to produce a flowable grout without any tendency to segregate.

2. Sand, for general grouting purposes, shall be graded within the following limits:
   Passing IS 2.36 mm sieve. 95 to 100%
   Passing IS 2.18 mm sieve. 65 to 95%
   Passing IS 300 micron sieve. 10 to 30%
   Passing IS 150 micron sieve. 3 to 10%

3. Sand for fluid grouts, shall have the fine material passing the 300 and 150 micron sieves at the upper limits Specified above.

4. Sand, for stiff grouts, shall meet the usual grading Specifications for concrete.

10.16.1.4 Surfaces to be grouted shall be thoroughly roughened and cleaned of all foreign matter and latency.

10.16.1.5 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.

10.16.1.6 Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water.

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

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

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

10.16.1.10 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.

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

10.16.1.12 Variations in grout mixes and procedures shall be permitted if approved by Engineer.

10.16.2 Special grout

10.16.2.1 Special grout, where specified on the Drawings, shall be provided in strict accordance with the manufacturer's instructions / Specifications on the Drawings.

10.17 Inspection

10.17.1 All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer.

10.17.2 All materials supplied by Contractor and all work or construction performed by Contractor rejected as not in conformance with the Specifications and Drawings, shall be immediately replaced at no additional expense to the Owner.

10.17.3 Approvals of any preliminary materials or phase or work shall in no way relieve the Contractor from the responsibility of supplying concrete and or producing finished concrete in accordance with the Specifications and Drawings.

10.17.4 All concrete shall be protected against damage until final acceptance by Engineer or his representative.

10.18 Clean-up

10.18.1 Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.

10.18.2 All debris i.e. empty containers, scrap wood, etc. shall be removed to "dump" daily or as directed by Engineer.

10.18.3 The finished concrete surfaces shall be left in a clean condition satisfactory to Engineer.

10.19 Measurement and Rate

10.19.1 The cement concrete shall be measured in cubic meters. In reinforced concrete the volume occupied by the reinforcement shall not be deducted.

10.19.2 Any concrete used in excess of the theoretical dimensions as shown on the Drawings will not be paid for.

10.19.3 The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account of such items as leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the schedule of quantities. No extra claim shall also be entertained due to change in the number, position and / or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift or scaffolding etc. All these factors should be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

10.19.4 Payments of concrete will be made on the basis of unit rates quoted for the respective items in the schedule of quantities. No deduction in the concrete quantity will be made for reinforcements, inserts etc. and opening less than 1/20 of a sqm. in area where concrete is measured in sqm. and 1/150 cum. where concrete is measured in cum. Where no such deduction for concrete is made, payment for shuttering work provided for such holes, pockets, etc. will not be made. Similarly the unit rates for concrete work shall be inclusive or exclusive of shuttering as provided for in the schedule of quantities. Where formwork is paid for separately, it shall be very clearly understood that payment for form propping, scaffolding, etc. complete.

10.19.5 Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned upto the underside of slabs.

10.19.6 The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement etc. complete. Only if reinforcement is used, it shall be measured and paid for separately under item rate.

10.20 Preparation of Mortars and its Grade

10.20.1 Grade of Masonry Mortar

10.20.1.1 The grade of masonry mortar will be defined by its compressive strength in N/mm^2 at the age of 28 days as determined by the standard procedure detailed in IS: 2250-1981.

10.20.2 For proportioning the ingredients by volume, the conversion of weight into volume shall be made on the following basis:

1.	Dry hydrated lime	700 kg/cum
2.	Burnt Clay Pozzolana	860 kg/cum
3.	Lime Pozzolana mixture	770 kg/cum
4.	Coarse Sand (dry)	1280 kg/cum
5.	Fine sand (dry)	1600 kg/cum
6.	fly Ash	590 kg/cum

10.20.3 Lime Mortar

10.20.3.1 Lime mortar shall be prepared using lime putty obtained by slaking quick-lime or dry hydrated lime powder and sand with or without the addition of Pozzolana in the specified proportions.

10.20.3.2 Proportioning

The ingredient in specified proportions shall be measured using boxes of suitable sizes. Sand and pozzolanic material shall be measured on basis of their dry volume.

10.20.3.3 Lime Putty

1. Lime putty shall be prepared from quick lime which is quite fresh and in the from of lumps. For the preparation of lime putty, three large tanks shall be made, one tank shall be at a level higher than the other, so that the contents from the upper tank can flow into the lower tank by gravity. The tank at the higher level may be 50 cm deep and the other tanks may be 80 cm deep.

2. The lumps of quick lime for slaking shall be broken to size between 50 mm and 100 mm. Medium and slow slaking limes may be broken to size smaller than 50 mm for expeditious slaking. The tank at the higher level shall be cleaned of all unslaked stones of lime and other materials left over from previous slaking and filled to half the depth will water and sufficient quick lime added gradually to fill up the tank to about half the depth of water. Lime shall be added to water and not water to lime. Stirring and hooing shall be started at once, taking care that lime does not get exposed above water. The mix shall be stirred all through the slaking process and continued at least 5 minutes after the boiling has stopped, and as the mix thickens more water shall be added. The lime in a state of suspension shall then be allowed to flow through IS sieve designation 4.75 mm into the tank at the lower level., where it shall be kept standing for at least 72 hours. Water at top is removed leaving lime putty in the form of paste. Lime putty so formed shall be kept wet till it is completely used. It can be stored without getting spoiled for a fortnight provided it is protected from drying out.

10.20.3.4 Mixing and Grinding

1. Using lime putty: Lime putty and sand in the specified proportion shall be mixed on a water tight platform or in trough. Specified Pozzolanic material may also be added in the required proportion if its use has been indicated. The mix can be put to use after grinding by the following methods:

   (i) Using power driven mobile roller pan mixer conforming to IS: 2438-1963 or as directed by the Engineer.
   (ii) Using manually driven or animal driven mortar mill where mortar shall be grounded by not less than 180 revolutions or, for a minimum of three house. The mortar shall be continuously racked and turned over during grinding particular from corners and sides. Water shall be added as required during grinding, so as to get a stiff plaster of necessary working consistency.

   However, preference will be given to the method under Para (i) above.

2. Using lime powder: Where the mortar is to be made using dry hydrated lime powder, the mixing of ingredients shall be done in a mechanical mixer unless otherwise permitted by the Engineer in writing. After dry mixing is complete, just sufficient quantity of water shall be added to get mortar of required working consistency. The mortar shall be mixed at least for three minutes after the addition of water.

3. Where mechanical mixer is not available, the mixing may be allowed by manually operated mixer with the written order to the Engineer. The mixing time shall be suitably increased to get the mortar of working consistency.

4. The Engineer may, however, permit hand mixing at his discretion, taking into account the nature, magnitude and location of the work and practicability of the use of these machines etc., of where items involving small quantities are to be done or if, in his opinion the use of the mechanical mixers is not feasible. In cases, where mechanical mixers are not to be used, the Contractor shall take permission of the Engineer in writing before the commencement of work. The ingredients of the mortar which can be used within 30 minutes shall then be mixed dry on a watertight masonry platform or in troughs by hand mixing and then the mortar shall be kneaded back and forth for 10 to 15 minutes with the addition of required quantity of water to get mortar of necessary working consistency.

10.20.3.5 Precaution

Lime mortar shall be used as soon as possible after mixing or grinding. As a rule mortar shall be used on the day it is made. If eminently hydraulic lime (Class A) as present as an ingredient, the mortar shall be used within four hours after mixing or grinding in mortar mill or mixture. Lime mortar made with semi-hydraulic lime (Class B) or fat time (Class C) and Pozzolana as ingredients shall be used within 36 hours of mixing or grinding and lime sand mortar within 72 hours. After the close of each day's work, mixing trough pans shall be thoroughly washed and cleaned. Lime mortar shall be kept damp with wet sack or by any other suitable means and shall on no account be allowed to dry.

10.20.4 Cement Mortar

10.20.4.1 This shall be prepared by mixing cement and sand with or without the addition of Pozzolana as specified.

10.20.4.2 Proportioning

Cement bag weighting 50 kg shall be taken as 0.035 cubic metre. Other ingredients in specified proportion shall be measured using boxes of size 40 X 35 X 25 cm. Sand shall be measured on the basis of its dry volume.

10.20.4.3 Mixing

The mixing of mortar shall be done in mechanical mixers operated manually or by power as decide by Engineer. The Engineer may, however, permit hand mixing at his discretion taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the used of mechanical mixer is not to be used, the Contractor shall take permission of the Engineer in writing before the commencement of the work.

1. Mechanical Mixing: Cement and sand in the specified proportions shall be mixed dry thoroughly in a mixer. Water shall then be added gradually and wet mixing continued for at least three minutes. Only the required quantity of water shall be added which will produce mortar of workable consistency but not stiff paste. Only the quantity of mortar, which can be used within 30 minutes of its mixing shall be prepared at a time. Mixer shall be cleaned with water each time before suspending the work.

2. Hand Mixing: The measured quantity of sand shall be leveled on a clean masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly

mixed dry by being turned over and over, backwards and forwards, several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a masonry trough with just sufficient quantity of water to bring the mortar to a stiff plaster of necessary working consistency.

10.20.4.4 Precautions

Mortar shall be used as soon as possible after mixing and before it begins to set, and in any case within half hour, after the water is added to the dry mixture.

10.20.5 Cement Lime Mortar

10.20.5.1 This shall be prepared by mixing cement, lime putty/dry hydrated lime powder and sand in specified proportions. Mixing shall be done in a mechanical mixer (Operated manually or by power as decided by Engineer).

10.20.5.2 The Engineer may, however, permit hand mixing at his discretion, taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In case, where mechanical mixers are not to be used, the Contractor shall take permission of the Engineer in writing before the commencement of the work.

10.20.5.3 Proportioning

Cement, lime putty/dry hydrated lime and sand shall be taken in specified proportions. Cement bag weighing 50 kg shall be taken as 0.035 cubic metre. Other ingredients in specified proportion shall be measured using boxes of size 40 x 35 x 25 cm. Sand shall be measured on the basis of its dry volume.

10.20.5.4 Mixing and Grinding

1. Mechanical Mixing: Lime putty and sand shall be mixed and ground in the manner described in **Clause 9.20.3.4.1(i)** before mixing the same with cement. In case where factory made dry hydrated lime powder is used, prior grinding of lime and sand is not necessary. In that case mixing may be done in one operation in mechanical mixer. Only quantity of this mixture which could be used within two hours of its mixing with cement, shall be taken out and mixed thoroughly with specified quantity of cement in mechanical mixer.
2. Hand Mixing: Cement and sand shall be mixed dry thoroughly on clean and water tight masonry platforms or in troughs. Lime putty shall be mixed with water to make mild of lime, which shall be added to the mixture of cement and sand. The mixture shall be kneaded back and forth for about 10 minutes with addition of milk of lime to obtain mortar to workable consistency.

10.20.5.5 Precautions

Mortar shall be used as soon as possible after mixing and maximum within two hours. Mortar unused for more than 2 hours shall be rejected and removed from the site of work. Mixture of lime putty and sand can be kept for 72 hours for preparation of lime cement mortar in respect of Class ‘B’ and ‘C’ lime and for six hours in case of Class ‘A’ lime provided it is kept damp and not allowed to dry.

11 BRICK MASONRY

11.1 Description

11.1.1 This work shall consist of construction of structures with bricks jointed together by cement mortar in accordance with the details shown on the Drawings or as approved by the Engineer.

11.2 Applicable Codes

11.2.1 The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

IS - 1077	Specifications for common burnt clay building bricks
IS - 1200	Measurements for Building works
IS - 1725	Specifications for solid cement blocks used in general building construction
IS - 1905	Code of practice for structural safety of buildings: Masonry walls.
IS - 2116	Sand for masonry mortars
IS - 2180	Specification for heavy duty burnt clay building bricks
IS - 2185	Specification for concrete masonry units: Hollow and solid concrete blocks
IS - 2212	Code of practice for brick work
IS - 2222	Specification for burnt clay perforated building bricks
IS - 2691	Specification for burnt clay facing bricks
IS - 3115	Specification for lime based blocks
IS - 3414	Code of practice for design and installation of joints in buildings
IS - 3466	Specification for masonry cement
IS - 3861	Method of measurement of plinth, carpet and rentable areas of buildings.
IS - 3952	Specification for burnt clay hollow blocks for walls and partitions
IS - 4098	Specification for lime-pozzolana mixture
IS - 4139	Specification for sand lime bricks
IS - 4441	Code of practice for use of silicate type chemical resistant mortars.
IS - 4442	Code of practice for use of sulphur type chemical resistant mortars

11.2.2 Others I.S. Codes not specifically mentioned here but pertaining to the use of bricks for structural purposes form part of these Specifications.

11.3 Materials

11.3.1 All materials to be used in the work shall confirm to the requirements laid down in Chapter 7.

11.4 Personnel

11.4.1 Only trained personnel shall be employed for construction and supervision.

11.5 Cement Mortar

11.5.1 Cement and sand shall be mixed in specified proportions given in the Drawings. Cement shall be proportioned by weight, taking the unit weight of cement as 1.44 tonne per cubic metre. Sand shall be proportioned by volume taking into account due allowance for bulking. All mortar shall be mixed with a minimum quantity of water to produce desired workability consistent with maximum density of mortar. The mix shall be clean and free from injurious type of soil/acid/alkali/organic matter or deleterious substances.

11.5.2 The mixing shall preferably be done in a mechanical mixer operated manually or by power. Hand mixing can be resorted to as long as uniform density of the mix and its strength are assured subject to prior approval of the Engineer. Where permitted, specific permission is to be given by the Engineer. Hand mixing operation shall be carried out on a clean water-tight platform, where cement and sand shall be first mixed dry in the required proportion by being turned over and over, backwards and forwards several times till the mixture is of uniform colour. Thereafter, minimum quantity of water shall be added to bring the mortar to the

consistency of a stiff paste. The mortar shall be mixed for at least two minutes after addition of water.

11.5.3 Mortar shall be mixed only in such quantity as required for immediate use. The mix which has developed initial set shall not be used. Initial set of mortar with ordinary Portland Cement shall normally be considered to have taken place in 30 minutes after mixing. In case the mortar has stiffened during initial setting time because of evaporation of water, the same can be re-tempered by adding water as frequently as needed to restore the requisite consistency, but this re-tampering shall not be permitted after 30 minutes. Mortar unused for more than 30 minutes shall be rejected and removed from site of work.

11.6 Soaking of Bricks

11.6.1 All bricks shall be thoroughly soaked in a tank filled with water for a minimum period of one hour prior to being laid. Soaked bricks shall be removed from the tank sufficiently in advance so that they are skin dry at the time of actual laying. Such soaked bricks shall be stacked on a clean place where they are not contaminated with dirt, earth, etc.

11.7 Joints

11.7.1 The thickness of joints shall not exceed 10 mm. All joints on exposed faces shall be tooled to give concave finish.

11.8 Laying

11.8.1 All brickwork shall be laid in an English bond, even and true to line, in accordance with the Drawing or as directed by the Engineer, plumb and level and all joints accurately kept. Half and cut bricks shall not be used except when necessary to complete the bond. Closer in such cases shall be cut to the required size and used near the ends of the walls. The bricks used at the face and also at the angles forming the junction of any two walls shall be selected whole bricks of uniform size, with true and rectangular faces.

11.8.2 All bricks shall be laid with frogs up on a full bed of mortar except in the case of tile bricks. Each brick shall be properly bedded as set in position by slightly pressing while laying, so that the mortar gets into all their surface pores to ensure proper adhesion. All head and side joints shall be completely filled by applying sufficient mortar to brick already placed and on brick to be placed. All joints shall be properly flushed and packed with mortar so that no hollow spaces are left. No bats or cut bricks shall be used except to obtain dimensions of the different courses for specified bonds or wherever a desired shape so requires.

11.8.3 The brick work shall be built in uniform layers, and for this purpose wooden straight edge with graduations indicating thickness of each course including joint shall be used. Corners and other advanced work shall be raked back. Brickwork shall be done true to plumb or in specified batter. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. Vertical joints in alternate courses shall come directly one over the other. During construction, no part of work shall rise more than one metre above the general construction level, to avoid unequal settlement and improper jointing. Where this is not possible in the opinion of the Engineer, the works shall be raked back according to the bond (and not toothed) at an angle not steeper than 45 degrees with prior approval of the Engineer. Toothing may also be permitted where future extension is contemplated.

11.8.4 Before laying bricks in foundation, the foundation slab shall be thoroughly hacked, swept clean and wetted. A layer of mortar not less than 12 mm thick shall be spread on the surface of the foundation slab and the first course of bricks shall be laid.

11.9 Jointing Old and New Work

11.9.1 Where fresh masonry is to join the masonry that is partially/entirely set, the exposed jointing surface of the set masonry shall be cleaned, roughened and wetted, so as to effect the best

possible bond with the new work. All loose bricks and mortar or other material shall be removed.

11.9.2 In the case of vertical or inclined joints, it shall be further ensured that proper bond between the old and new masonry is obtained by interlocking the bricks. Any portion of the brickwork that has been completed shall remain undisturbed until thoroughly set.

11.9.3 In case of sharp corners specially in skew bridges, a flat cutback of 100 mm shall be provided so as to have proper and bonded laying of bricks.

11.10 Curing

11.10.1 Green work shall be protected from rain by suitable covering and shall be kept constantly moist on all faces for a minimum period of seven days. Brick work carried out during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period. Top of the masonry work shall be left flooded with water at the close of the day. Watering may be done carefully so as not to disturb or wash out the green mortar.

11.10.2 During hot weather, all finished or partly completed work shall be covered or wetted in such a manner as will prevent rapid drying of the brickwork.

11.10.3 During the period of curing of brick work, it will be suitably protected from all damages. At the close of day's work or for other period of cessation, watering and curing shall have to be maintained. Should the mortar perish i.e., become dry, white or powdery, through neglect of curing, work shall be pulled down and rebuilt as directed by the Engineer. It any stains appear during watering, the same shall be removed from the face.

11.11 Scaffolding

11.11.1 The Scaffolding shall be sound, strong and safe to withstand all loads likely to come upon it. The holes which provide resting space for horizontal members shall not be left in masonry under one metre in width or immediately near the skew backs of arches. The holes left in the masonry work for supporting the scaffolding shall be filled with dense concrete and made good. Scaffolding shall be got approved by the Engineer. However, the Contractor shall be responsible for its safety.

11.12 Weep Holes

11.12.1 Weep holes shall conform to **Clause 2706** of MoST Specifications for Road and Bridge Works (IV Revision).

11.13 Equipment

11.13.1 All tools and equipment used for mixing, transporting and laying of mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

11.14 Finishing of Surfaces

11.14.1 General

11.14.1.1 All brickwork shall be finished in a workmanlike manner with the thickness of joints, manner of striking or tooling as described in these above Specifications.

11.14.1.2 The surfaces can be finished by "joining " or "pointing" or by "plastering" as given in the Drawings.

11.14.1.3 For a surface which is to be subsequently plastered or pointed, the joints shall be squarely raked out to a depth of 15 mm, while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted.

11.14.1.4 The mortar for finishing shall be prepared as per **Clause 10.5**.

11.14.2 Jointing

11.14.2.1 In jointing, the face of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work. The faces of brick work shall be cleaned to remove any splashes of mortar during the course of raising the brick work.

11.14.3 Pointing

11.14.3.1 Pointing shall be carried out using mortar not leaner than 1:3 by volume of cement and sand or as shown on the Drawing. The mortar shall be filled and pressed into the raked joints before giving the required finish. The pointing shall be ruled type for which it shall, while still green, be ruled along the centre with half round tools of such width as may be specified by the Engineer. The super flush mortar shall then be taken off from the edges of the lines and the surface of the masonry shall be cleaned of all mortar. The work shall conform to IS: 2212.

11.14.4 Plastering

11.14.4.1 Plastering shall be done where shown on the Drawing. Superficial plastering may be done, if necessary, only in structures situated in fast following rivers or in severely aggressive environment.

11.14.4.2 Plastering shall be started from top and worked down. All putlog holes shall be properly filled in advance of the plastering while the scaffolding is being taken down. Wooden screeds 75 mm wide and of the thickness of the plaster shall be fixed vertically 2.5 to 4 meters apart, to act as gauges and guides in applying the plaster. The mortar shall be laid on the wall between the screeds using the plaster's float and pressing the mortar so that the raked joints are properly filled. The plaster shall be finished off with a wooden straight edge reaching across the screeds. The straight edge shall be worked on the screeds with a small upward and sideways motion 50 mm to 75 mm at a time. Finally, the surface shall be finished off with a plasterer's wooden float. Metal floats shall not be used.

11.14.4.3 When recommencing the plastering beyond the work suspended earlier, the edges of the old plaster shall be scrapped, cleaned and wetted before plaster is applied to the adjacent areas.

11.14.4.4 No portion of the surface shall be left unfinished for patching up at a later period.

11.14.4.5 The plaster shall be finished true to plumb surface and to the proper degree of smoothness as directed by the Engineer.

11.14.4.6 The average thickness of plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less than the specified by more than 3 mm.

11.14.4.7 Any cracks which appear in the surface and all portions which should hollow when tapped, or are found to be soft or otherwise defective, shall be cut in rectangular shape and re-done as directed by the Engineer.

11.14.5 Curing of Finishes

11.14.5.1 Curing shall be commenced as soon as the mortar used for finishing has hardened sufficiently not to be damaged during curing. It shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages.

11.14.6 Scaffolding for Finishes

11.14.6.1 Stage scaffolding shall be provided for the work. This shall be independent of the structure.

11.15 Architectural Coping for Wing / Return / Parapet Wall

11.15.1 This work shall consist of providing an Architectural coping for wing/return/parapet walls.

11.15.2 The material used shall be cement mortar 1:3 or as shown on the Drawings prepared in accordance with **Clause 10.5.**

11.15.3 The cement mortar shall be laid evenly to an average thickness of 15 mm to the full width of the top of the wall and in continuation a band of 15 mm thickness and 150 mm depth shall be made out of the mortar along the top outer face of the walls.

11.16 Acceptance of Work

11.16.1 All work shall be true to the lines and levels as indicated on the Drawing or as directed by the Engineer, subject to tolerances as indicated in these Specifications.

11.16.2 Mortar cubes shall be tested in accordance with IS: 2250 for compressive strength, consistency of mortar and its water retentivity. The frequency of testing shall be one sample for every 2 cubic metres of mortar, subject to a minimum 3 samples for a day's work.

11.16.3 In case of plaster finish, the minimum surface thickness shall not be less than the specified thickness by more than 3 mm.

11.17 Measurements for Payment

11.17.1 All brick work shall be measured in cubic metres. Any extra work done by the Contractor over the specified dimensions shall be ignored.

11.17.2 In arches, the length of arch shall be measured as the mean length between the extrados and intrados.

11.17.3 The work of plastering and pointing shall be measured in square meters of the surface treated.

11.17.4 Architectural coping shall be measured in linear metres.

11.18 Rate

11.18.1 The contract unit rate for brick work shall include the cost of all labour, materials, tools and plant, scaffolding and other expenses incidental to the satisfactory completion of the work, sampling, testing and supervision as described in these Specifications and as shown on the Drawings.

11.18.2 The contract unit rate for plastering shall include the cost of all labour, materials, tools and plant, scaffolding and all incidental expenses, sampling and testing and supervision as described in these Specifications.

11.18.3 The contract unit rate for pointing shall include erecting and removal of scaffolding, all labour, materials, and equipment incidental to complete the pointing, raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing and watering, sampling and testing and supervision as described in these Specifications.

11.18.4 The contract unit rate for architectural coping shall include cost of all labour, materials, tools and plant, sampling and testing and supervision as described in these Specifications.

12 STONE MASONRY

12.1 Description

12.1.1 This work shall consist of the construction of structures with stones jointed together by cement mortar in accordance with the details shown on the Drawings and these Specifications or as approved by the Engineer.

12.2 Materials

12.2.1 All materials used in stone masonry shall confirm to **Chapter 7** except cement mortar for stone masonry which shall confirm to **Clause 10.5.**

12.3 Personnel

12.3.1 Only trained personnel shall be employed for construction and supervision.

12.4 Type of Masonry

12.4.1 The type of masonry used for structures shall be random masonry (coursed or uncoursed) or coursed rubble masonry (First sort.). However, for bridge work generally, course rubble stone masonry shall be used. The actual type of masonry used for different parts of structures shall be specified on the Drawings.

12.4.2 For facing work, ashlar masonry shall be used where indicated on the Drawings.

12.5 Construction Operations

12.5.1 General Requirements

12.5.1.1 The dressing of stone shall be as specified for individual type masonry work and it shall also conform to the general requirements of IS: 1597 and requirement for dressing of stone covered in IS: 1129. Other specific requirements are covered separately with respect to particular types of rubble stone work.

12.5.2 Laying

12.5.2.1 The masonry work shall be laid to lines, levels, curves and shapes as shown in the plan. The height in each course shall be kept same and every stone shall be fine tooled on all beds joints and face full and true. The exposed faces shall be gauged out, grooved, regulated and sunk or plain moulded as the case may be. The faces of each stone between the draft be left rough as the stone comes from quarry except where sacrificial layer is to be provided or plastering is resorted to due to aggressive environment.

12.5.2.2 Stones shall be sufficiently wetted before laying to prevent absorption of water from mortar.

12.5.2.3 Stratified stones must be laid on their natural beds. All bed joints shall be normal to the pressure upon them.

12.5.2.4 Stones in the hearting shall be laid on their broadest face that gives a better opportunity to fill the spaces between stones.

12.5.2.5 The courses of the masonry shall ordinarily be pre-determined. They shall generally be of the same height. When there is to be variation in the height of courses, the larger courses are to be placed at lower levels, heights of courses decreasing gradually towards the top of the wall. The practice of placing loose mortar on the course and pouring water on it to fill the gaps in stones is not acceptable. Mortar may be fluid mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar.

12.5.2.6 In tapered walls, the beds of the stones and the planes of course should be at right angles to the batter. In case of bridge piers with batter on both sides, the course shall be horizontal.

12.5.2.7 The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately on placement and solidly embedded in mortar before it has set. Clean chips and spalls shall be wedged into the mortar joints and bed wherever necessary to avoid thick beds or joints of mortar. When the foundation masonry is laid directly on rock, the face stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding over the rock. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar. For masonry works over rock, a leveling course of 100 mm thickness and in concrete M 15 shall be laid over rock and then stone masonry work shall be laid without foundation concrete block.

12.5.2.8 Face works and hearting shall be brought up evenly but the top of each course shall not be leveled up by the use of flat chips.

12.5.2.9 For sharp corners specially in skew bridges, through stones shall be used in order to avoid spalling of corners.

12.5.2.10 In case any stone already set in mortar is disturbed or the joints broken, it shall be taken out without disturbing the adjoining stones and joints. Dry mortar and stones thoroughly cleaned from the joints and stones and the stones reset in fresh mortar. Attempt must never be made to slide one stone on top of another, freshly laid.

12.5.2.11 Shaping and dressing shall be done before the stone is laid in the work. No dressing and hammering, which will loosen the masonry, will be allowed after it is once placed. All necessary chases for joggles, dowels and clamps should be formed before hand.

12.5.2.12 Sufficient transverse bonds shall be provided by the use of bond stone extending from the front to the back of the wall and in case of thick wall from outside to the interior and vice versa. In the latter case, bond stones shall overlap each other in their arrangement.

12.5.2.13 In case headers are not available, precast headers of M 15 concrete shall be used. Cast-in-situ headers are not permitted.

12.5.2.14 Stones shall break joint on the face for at least half the height of the course and the bond shall be carefully maintained throughout.

12.5.2.15 In band work at all angle junctions of walls the stones at each alternate course shall be carried into each of the respective walls so as to unite the work thoroughly.

12.5.2.16 The practice of building up thin faces tied with occasional through stones and filling up the middle with small stuff or even dry packing is not acceptable.

12.5.2.17 All quoins and angles of the opening shall be made from selected stones, carefully squared and bedded and arranged to bond alternately long and short in both directions.

12.5.2.18 All vertical joints shall be truly vertical. Vertical joints shall be staggered as far as possible. Distance between the nearer vertical joints of upper layer and lower shall not be less than half the height of the course.

12.5.2.19 Only rectangular shaped bond stones or headers shall be used. Bond stones shall overlap each other by 150 mm or more.

12.5.2.20 All connected masonry in a structure shall be carried up nearly at one uniform level throughout but when breaks are unavoidable the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

12.5.3 Random Masonry (Uncoursed and Coursed)

12.5.3.1 **Dressing**: Stone shall be hammer dressed on the face, the sides and beds to enable it to come in proximity with the neighboring stone. The bushing on the exposed face shall not be more than 40 mm.

12.5.3.2 **Insertion of chips**: Chips and spalls of stone may be used wherever necessary to avoid thick mortar beds or joints and it shall be ensured that no hollow spaces are left anywhere in the masonry. The chips shall not be used below hearting stones to bring these upto the level of face stones. Use of chips shall be restricted to filling of interstices between the adjacent stones in hearting and they shall not exceed 20 percent of the quantity of stone masonry.

12.5.3.3 **Hearting stones**: The hearting or interior filling of the wall face shall consist of rubble stones not less than 150 mm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. The hearting should be laid nearly level with facing and backing.

12.5.3.4 **Bond stones**: Through bond stones shall be provided in masonry upto 600 mm thickness and in case of masonry above 600 mm thickness, a set of two or more bond stones overlapping each other at least by 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous limestone and sandstones, etc.,) the bond stone shall extend only about two-third into the wall, as through stones in such cases may give rise to penetration of dampness and therefore, for all thicknesses of such masonry, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. One bond stones or a set of bond stones shall be provided for every 0.50 sq. m. of the masonry surface.

12.5.3.5 **Quoin stone**: Quoin stone i.e., stone specially selected and nearly dressed for forming an external angle in masonry work, shall not be less then 0.03 cubic metre in volume.

12.5.3.6 **Plum stone**: The plum stones are selected long stones embedded vertically in the interior of the masonry to form a bond between successive courses and shall be provided at about 900 mm intervals.

12.5.3.7 **Laying**: The masonry shall be laid with or without courses as specified. The quoin shall be laid header and stretcher alternately. Every stone shall be fitted to the adjacent stone so as to form neat and close joint. Face stone shall extend and bond well in the back. These shall be arranged to break joints, as much as possible, and to avoid long vertical lines of joints.

12.5.3.8 **Joints**: The face joints shall not be more than 20 mm thick, but shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar.

12.5.4 Square Rubble - Coursed Ruble (First Sort)

12.5.4.1 **Dressing**: Face stones shall be hammer dressed on all beds and joints so as to give them rectangular shape. These shall be square on all joints and beds. The bed joints shall be chisel drafted for at least 80 mm back from the face and for at least 40 mm for the side joints. No portion of dressed surface shall show a depth of gap more than 6 mm from the straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints. The requirements regarding bushing shall be the same as for random rubble masonry.

12.5.4.2 **Hearting stones**: The hearting or interior filling of the wall face shall consist of flat bedded stone carefully laid, on prepared beds in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of masonry. while using chips it shall be ensured that no hollow spaces are left anywhere in the masonry.

12.5.4.3 **Bond stones**: The requirements regarding through or bond stone shall be the same as for random ruble masonry, but these, shall be provided at 1.5 metre to 1.8 metre apart clear in every course.

12.5.4.4 **Quoin stone**: The quoins shall be of the same height of the course in which these occur and shall be formed of header stones not less than 450 mm in length. They shall be laid lengthwise alternately along each face, square in their beds which shall be fairly dressed to a depth of at least 100 mm.

12.5.4.5 **Face stone**: face stones shall tail into the work for not less than their heights and at least one-third of the stones shall tail into the work for a length not less than twice their height. These shall be laid as headers and stretchers alternately.

12.5.4.6 **Laying**: The stones shall be laid on horizontal courses and all vertical joints should be truly vertical. The quoin stones should be laid header and stretcher alternately and shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 100 mm.

12.5.4.7 **Joints**: The face joints shall not be more than 10 mm thick, but shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar.

12.5.5 Ashlar Masonry (Plain Ashlar)

12.5.5.1 **Dressing**: Every stone shall be cut to the required size and shape, chisel dressed on all beds and joints so as to be free from all bushing. Dressed surface shall not show a depth of gap of more than 3 mm from straight edge placed on it. The exposed faces and joints, 6 mm from the face shall be fine tooled so that a straight edge can be laid along the face of the stone in contact with every point. All visible angles and edges shall be true and square and free from chipping. The corner stones(quoins) shall be dressed square and corner shall be straight and vertical.

12.5.5.2 **Bond Stones**: Through bond stones shall be provided in masonry upto 600 mm thickness and in case of masonry above 600 mm thickness, a set of two or more bond stones overlapping each other at least by 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous limestone and sandstones, etc.,) the bond stone shall extend only about two-third into the wall, as through stones in such cases may give rise to penetration of dampness and, therefore, for all thickness of such masonry a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. One bond stone or a set of bonds tones shall be 1.5 metres to 1.8 metres apart clear in every course.

12.5.5.3 **Laying**: The face stone shall be laid header and stretcher alternately, the header being arranged to come as nearly as possible in the middle of stretchers above and below. Stones shall be laid in regular courses not less than 300 mm in height and all courses of the same height unless otherwise specified. No stone shall be less in width than its height or less in length than twice its height, unless otherwise specified.

12.5.5.4 **Joints**: All joints shall be full of mortar. These shall not less than 3 mm thick. Face joints shall be uniform throughout, and a uniform recess of 20 mm depth from face shall be left with the help of a stone plate during the progress of work.

12.5.5.5 **Pointing**: Pointing shall be carried out using mortar not leaner than 1:3 by volume of cement and sand or as shown on the Drawing. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing shall conform to **Clause 10.13.3** of the Specification. The work shall conform to IS: 2212. The thickness of joints shall not be less

than 3 mm for Ashlar masonry. However, the maximum thickness of joints in different works shall be as follows:

Random Rubble	20 mm
Coursed Rubble	15 mm
Ashlar Masonry	5 mm

12.5.6 Curing

Curing shall conform to **Clauses 10.10** and **10.13.5**

12.5.7 Scaffolding

For scaffolding **Clause 10.11** shall apply.

12.5.8 Weep Holes

Weep holes shall conform to **Clause 2706** of MoST Specifications for Road and Bridge Works (IV Revision).

12.5.9 Joining with Existing Structures

For Jointing with existing structures, the Specifications given under **Clause 10.9** shall apply.

12.5.10 Architectural Coping For Wing/Return/Parapet Walls

Architectural coping for wing/return/parapet wall shall conform to **Clause 10.15**.

12.5.11 Tests and standard of acceptance

12.5.11.1 All work shall be done to the lines and levels as indicated on he Drawing or as directed by the Engineer subject to tolerances as specified in these Specifications.

12.5.11.2 Mortar cubes shall be taken in accordance with IS: 2250 for compressive strength, consistency of mortar and its water retentivity. The frequency of testing shall be one sample for every two cubic metres of mortar subject to a minimum 3 samples for a day's work.

12.6 Measurement for Payment

12.6.1 Stone masonry shall be measured in cubic metres. In arches, the length of arch shall be measured as the mean length between the extrados and intrados.

12.6.2 The work of pointing shall be measured in square metres. Architectural coping shall be measured in linear metres.

12.7 Rate

12.7.1 The contract unit rate of stone masonry shall include the cost of all labour, materials, tools and plant, scaffolding, sampling and testing, supervision and other expenses incidental to the satisfactory completion of the work as described herein above.

12.7.2 The contract unit rate for pointing shall include erecting and removal of scaffolding, all labour, materials and equipment incidental to complete pointing, raking out joints, cleaning, wetting, filling with mortar, trowelling, pointing and watering, sampling and testing and supervision as described in these Specifications.

12.7.3 The contract rate for architectural coping shall include the cost of all labour, materials, tools, and plant, sampling and testing and supervision as described in these Specifications.

13 FINISHING

13.1 Scope

These Specifications cover the general requirements of different kinds of finishes.

13.2 Applicable Codes

IS: 16-1991 (Part:I)	Shellac:Part:I-Hand Made Shellac (3rd Revision).
IS: 16-1991 (Part:II)	Shellac:Part: II-Machine Made Shellac (3rd Revision)
IS: 75-1973	Linseed Oil, Raw and Refined (Reaffirmed 1990) (2nd Revision)
IS: 77-1976	Ready Mixed Paint, Brushing, Red Lead, Non setting, Priming (Reaffirmed 1991)(Revised)
IS: 102-1962	Specification for Ready Mixed Paint, Brushing, Zinc Chrome, Priming (Reaffirmed 1993) (2nd Revision)
IS: 104-1979	Ready Mixed Paint, brushing, priming Plaster to Indian Standard Colour No. 361, 631 White and off White (Reaffirmed 1993) (1st Revision)
IS: 109-1968	Ready Mixed Paint, Brushing, priming Plaster to Indian Standard Colour No. 361, 631 White and off White (Reaffirmed 1993) (1st Revision)
IS: 117-1964	Ready Mixed Paint, Brushing, Finishing Exterior, Semigloss for General Purposes to Indian Standards Colours (Reaffirmed 1988) (Revised)
IS: 133-1993	Enamel, Interior (a) Under Coating (b) Finishing (3rd Revision)
IS: 137-1965	Ready Mixed Paint, Brushing, Matt or Egg Shell Flat, Finishing Interior to Indian Standard Colour as required (Revised 1993)
IS: 158-1981	Ready Mixed Paint, Brushing, Bituminous Black, Lead Free, Acid, Alkali and Heat Resisting (Reaffirmed 1988) (3rd Revision)
IS: 217-1988	Specification for Cut Back Bitumen (2nd Revision)
IS: 218-1983	Specification for Creosote and Anthracene Oil for Use As Wood Preservatives (Reaffirmed 1990) (2nd Revision)
IS: 290-1961	Coal Tar Black Paint (Reaffirmed 1991) (1st Revision)
IS: 337-1975	Varnish, Finishing Interior (Reaffirmed 1991) (1st Revision)
IS: 341-1973	Black Japan, Types ‘A’, ‘B’ & ‘C’ (Reaffirmed 1991) (1st Revision)
IS: 345-1952	Wood Filter, Transparent - Liquid (withdrawn)
IS: 347-1975	Varnish, Shellac for General Purposes (Reaffirmed 1991) (1st Revision)
IS: 348-1968	French Polish (Reaffirmed 1991) (1st Revision)
IS: 419-1967	Putty for Use On Window Frames (Reaffirmed 1992) (1st Revision)
IS: 427-1965	Distemper, Dry Colour as Required (Reaffirmed 1993) (Revised)
IS: 428-1969	Distemper, Oil Emulsion, Colour as Required (Reaffirmed 1993) (1st Revision)
IS: 524-1983	Varnish, Finishing, Exterior, Synthetic Air Drying (Reaffirmed 1990) (2nd Edition)
IS: 533-1973	Gum Spirit of Turpentine (Oil of Turpentine) (Reaffirmed 1990) (1st Revision)
IS: 712-1984	Specification for Building Limes (Reaffirmed 1991) (3rd Revision)
IS: 1200-1976 (Part:XII)	Method of Measurements of Building and Civil Engineering Works: Part:XII-Plastering and Pointing (Reaffirmed 1992) (3rd Revision)
IS: 1200-1987	Method of Measurements of Building and Civil Engineering Works:
IS: 1200-1994 (Part:XIII)	Method of Measurements of Building and Civil Engineering Works: Part 13 White Washing, Colour Washing Distempering and Painting of Building surfaces. (5th Revision)
IS: 1200-1987 (Part:XV)	Method of Measurements of Building and Civil Engineering Works: Part:XV-Painting Polishing, Varnishing etc. (Reaffirmed 1992) (4th Revision)
IS: 2339-1963	Aluminum Paint for General Purposes, In Dual Container (Reaffirmed 1993)
IS: 2932-1994	Enamel, Synthetic, Exterior (a) Undercoating, (b) Finishing (2nd Revision)

IS: 2933-1975	Enamel, Exterior (a) Undercoating (b) Finishing (Reaffirmed 1991) (1st Revision)
IS: 5410-1992	Cement Paint (1st Revision)
IS: 5411-1974 (Part:I)	Plastic Emulsion: Paint Part I for Interior Use (Reaffirmed 1991) (1st Revision)
IS: 6278-1971	Code of Practice for White Washing and Colour Washing (Reaffirmed 1991).

13.3 12 mm Lime Plaster

13.3.1 Scaffolding

13.3.1.1 For all exposed brick work or tile work, double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

13.3.1.2 For all other work in buildings, single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one metre in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

Note: In case of special type of brick work, scaffolding shall be got approved from Engineer in advance.

13.3.2 Preparation of Surface

13.3.2.1 The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

13.3.3 Mortar

13.3.3.1 The mortar of specified mix shall be used. Lime mortar shall be as specified in **Chapter 9.**

13.3.4 Application of Plaster

13.3.4.1 Ceiling plaster shall be completed before commencement of wall plaster.

13.3.4.2 Plastering shall be started from the top and worked down towards the floor. All put-log holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied, horizontally and vertically, at not more than 2 metres intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thin strips of bamboo about one metre long to ensure through filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and side ways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or sandy granular texture is required. Excessive troweling or over working the float shall be avoided. During this process, a solution of lime putty shall be applied on the surface to make the later workable.

13.3.4.3 All corners, arrises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arrises, provision of grooves at junctions etc., where required shall be done without any extra payments. Such

rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

13.3.4.4 When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped cleaned and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to properly joint together. Plastering work shall be closed at the end of the day on the body of wall and not nearer than 15 cm to any corners or arrises. It shall not be closed on the body of the features such as plasters, bands and cornices, nor at the corners of arrises. Horizontal joints in plaster work shall not also occur on parapet tops and copings as these invariably lead to leakages.

13.3.4.5 No portion of the surface shall be left out initially to be patched up later on.

13.3.5 Finish

13.3.5.1 The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

13.3.6 Thickness

13.3.6.1 The thickness of the plaster specified shall be measured exclusive of the thickness of key i.e. grooves or open joints in brick work. Average thickness of plaster shall not be less than the specified thickness of 12mm. The minimum thickness over any portion of the surface shall not be less than specified thickness by more than 3 mm. The average thickness should be regulated at the time of plastering by keeping suitable thickness of the gauges. Extra thickness required in dubbing behind rounding of corners at junctions of wall or in plastering of masonry cornices etc., will be ignored.

13.3.7 Curing

13.3.7.1 Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of seven days. During this period, it shall be suitably protected from all damages at the Contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

13.3.8 Precaution

13.3.8.1 Any cracks which appear in the surface and all portions which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer.

13.3.8.2 When ceiling plaster is done, it shall be finished to chamfered edge at an angle at its junction with a suitable tool when plaster is being done. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove not deeper than 6 mm drawn with any suitable method with the wall while the plaster is green.

13.3.8.3 To prevent surface cracks appearing between junctions of column/beam and walls, 150 mm wide chicken wire mesh should be fixed with U nails 150 mm centre to centre before plastering the junction. The plastering of walls and beam/column in one vertical plane should be carried out in one go. For providing and fixing chicken wire mesh with U nails payment shall be made separately.

13.3.9 Measurements

13.3.9.1 Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

13.3.9.2 Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick work.

13.3.9.3 The measurement of wall plaster shall be taken between the walls or partitions (the dimensions before the plaster shall be taken) for the length and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any shall be deducted.

13.3.9.4 The following shall be measured separately from wall plaster.

1. Plaster bands 30 cm wide and under
2. Cornice beadings and architraves or architraves moulded wholly in plaster.
3. Circular work not exceeding 6 m in radius.

13.3.9.5 Plaster over masonry pilasters will be measured and paid for as plaster only.

13.3.9.6 A coefficient of 1.63 shall be adopted for the measurement of one side plastering on honey comb work having 6 x 10 cm opening.

13.3.9.7 Moulded cornices and coves.

1. Length shall be measured at the centre of the girth.
2. Moulded cornices and coves shall be given in square metres the area being arrived at by multiplying length by the girth.
3. Flat or weathered top to cornices when exceeding 15 cm in width shall not be included in the girth but measured with the general plaster work.
4. Cornices which are curved in their length shall be measured separately.

13.3.9.8 Exterior plastering at a height greater than 10 m from average ground level shall be measured separately in each storey height. Patch plastering (in repairs) shall be measured as plastering new work, where the patch exceed 2.5 sqm. extra payment being made for preparing old wall, such as dismantling old plaster, raking out the joints and cleaning the surface. Where the patch does not exceed 2.5 sqm in area it shall be measured under the appropriate item under sub head 'Repairs to Buildings'.

13.3.9.9 Deductions in measurements, for opening etc., will be regulated as follows:

1. No deduction will be made for openings or ends of joists, beams, posts, girders, steps etc., upto 0.5 sqm in area and no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall.
2. Deduction for opening exceeding 0.5 sqm but not exceeding 3 sqm each shall be made for reveals, jambs soffits sills, sills, etc., of these openings.
3. When both faces of walls are plastered with same plaster, deductions shall be made for one face only.
4. When two faces of walls are plastered with different types of plaster or if one face is plastered and other is pointed or one face is plastered and other is unplastered, deduction shall be made from the plaster or pointing on the side of frame for the doors, windows etc., on which width of reveals is less than that on the other side but on deduction shall be made on the other side.
5. Where width of reveals on both faces of wall are equal, deduction of 50% of area of opening on each faces shall be made from area of plaster and/or pointing as the case may be.
6. For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each plastered face of wall.
   Note:
   - *Different qualities of plastering referred in this **Clause** shall not include '18 mm plastering with terrazo finish' as given in **Clause 12.3.3.1** as the method of measurement in the case of the later is different. In such cases where the plaster on the other face consists of a plaster with terrazo finish method of addition and deductions for the ordinary plaster face shall be regulated as if that face alone is*

plastered and the other is given an entirely different type of non-comparable treatment.

- *For opening exceeding 3 sqm in area, deduction will be made in the measurements for the full opening of the wall treatment on both faces, while at the same time, jambs, sills and soffits will be measured for payment.*
- *In measuring jambs, sills and soffits, deduction shall not be made for the area in contact with the frame of doors, windows etc.*

13.3.10 Rate

13.3.10.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

13.4 15 mm Thick Lime Plaster

13.4.1 15 mm thick lime plaster shall be done on rough side of single or half brick work. The average thickness of plaster shall not be less than 15 mm and the minimum thickness of the plaster at any place shall not be less than 10 mm. All other details shall be as specified **Clause 12.3**.

13.5 Cement Plastering

13.5.1 The cement plaster shall be 12 mm, 15 mm or 20 mm thick as specified in the item.

13.5.2 Scaffolding and preparation of surface shall be as specified under **Clause 12.3.1**.

13.5.3 Mortar

13.5.3.1 The mortar of the specified mix using the type of sand described in the item shall be used. It shall be as specified in **Chapter 9**. For external work and under coat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

13.5.4 Application

13.5.4.1 The Specifications as in **Clause 12.3.4** shall apply except in the following respects:

1. Beating with thin bamboo strips shall not be done on the cement plaster, and;
2. No lime putty solution shall be applied on the face when finishing. Further the plastering and finishing shall be completed within half and hour of adding water to the dry mortar.

13.5.5 Thickness

13.5.5.1 Where the thickness required as per description of the item is 20 mm the average thickness of the plaster shall not be less than 20 mm whether the wall treated is of brick or stone. In the case of brick work, the minimum thickness over any portion of the surface shall be not less than 15 mm while in case of stone work the minimum thickness over the bushings shall be not less than 12 mm.

13.5.6 Curing

13.5.6.1 Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

13.5.6.2 The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the Contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

13.6 Cement Plaster with a Floating Coat of Neat Cement

13.6.1 The cement plaster shall be 12, 15 or 20 mm thick, finished with a floating coat of neat cement, as described in the item.

13.6.2 Specifications for this item of work shall be same as described in **Clause 12.5** except for the additional floating coat which shall be carried out as below:

13.6.2.1 When the plaster has been brought to a true surface with the wooden straight edge (**Clause 12.5.4**) it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the Specifications described in **Clause 12.5.4** shall apply.

13.7 6 mm Cement Plaster on Cement Concrete and Reinforced Cement Concrete Work

13.7.1 Scaffolding

13.7.1.1 Stage scaffolding shall be provided for the work. This shall be independent of the walls.

13.7.2 Preparation of Surface

13.7.2.1 Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushed. In addition concrete surfaces to be plastered shall be pock marked with a pointed tool, at spacings of not more than 5 cm. Centres, the pock being made not less then 3 mm deep. This is to ensure a proper key for the plaster. The mortar shall be washed off and surface, cleaned of all oil, grease etc. and well wetted before the plaster is applied.

13.7.3 Mortars

13.7.3.1 Mortars of the specified mix using the types of sand described in the item shall be used. It shall be as specified in **Chapter 9.**

13.7.4 Application

13.7.4.1 To ensure even thickness and a true surface, gauges of plaster 15 X 15 cm. shall be first applied at not more than 1.5 m intervals in both directions to serve as guides for the plastering. Surface of these gauged areas shall be truly in the plane of the finished plaster surface. The plaster shall be then applied in a uniform surface to a thickness slightly more than the specified thickness and shall then be brought to true and even surface by working a wooden straight edge reaching across the gauges. Finally the surface shall be finished true with a trowel or with wooden float to give a smooth or sandy granular texture as required. Excess troweling or over working of the floats shall be avoided. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

13.7.4.2 Plastering of ceiling shall not be commenced until the slab above has been finished and centering has been removed. In the case of ceiling of roof slabs, plaster shall not be commenced until terrace work has been completed. These precautions are necessary in order that the ceiling plaster is not disturbed by the vibrations set up in the above operations.

13.7.5 Finish

13.7.5.1 The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

13.7.6 Thickness

13.7.6.1 The average thickness of plaster shall not be less than 6 mm. The minimum thickness over any portion of the surface shall not be less than 5 mm.

13.7.7 Curing

13.7.7.1 The Specifications shall be as detailed in **Clause 12.5.6.**

13.7.8 Precautions

13.7.8.1 These shall be as described in **Clause 12.3.8**.

13.7.9 Measurements

13.7.9.1 Length and breadth shall be measured correct to a cm. and its area shall be calculated in sqm. correct to two places of decimal. Dimensions before plastering shall be taken.

13.7.9.2 Thickness of plaster shall be exclusive of the thickness of the key i.e., depth or rock marks and hacking.

13.7.9.3 Plastering on ceiling at height greater than 5 m above the corresponding floor level shall be so described and shall be measured separately stating the height in stages of 1 m or part thereof.

13.7.9.4 Plastering on the sides and soffits of the projected beams of ceiling at a height greater than 5 m above the corresponding floor level shall be measured and added to the quantity measured under **Clause 12.7.9.3**.

13.7.9.5 Plastering on spherical and groined ceiling and circular work not exceeding 6 m in radius, shall be measured and paid for separately.

13.7.9.6 Flowing soffits (viz., portion under spiral stair case etc.,) shall be measured and paid for separately.

13.7.9.7 Ribs and mouldings on ceiling shall be measured as for cornices, deductions being made from the plastering on ceiling in case the width of the moulding exceed 15 cm.

13.7.9.8 The mode of measurement of exterior plaster and patch plastering (in repairs) shall be as laid down in **Clause 12.3.9.8.**.

13.7.9.9 Deduction shall not be made for openings or for ends of columns, or columns caps of 0.5 sqm each in area and under. No additions will be made either for the plastering of the sides of such openings. For openings etc. of areas exceeding 0.5 sqm deduction will be made for the full opening but the sides of such opening shall be measured for payment.

13.7.10 Rate

13.7.10.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

13.8 6 mm Cement Plaster on top of wall for Slab Bearing

13.8.1 Cement plaster shall be 6 mm thick finished with a floating coat of neat cement and thick coat of lime wash on top of walls for bearing of slabs.

13.8.2 Application

13.8.2.1 The plaster shall be applied over the cleaned and wetted surface of the wall. When the plaster has been brought to a true surface with the wooden straight edge (**Clause 12.5.4.1**) it shall be

uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the Specifications described in **Clause 12.5.4** shall apply.

13.8.3 Lime wash

13.8.3.1 This shall be applied in a thick coat after curing the plaster for three days.

13.8.4 Measurements

13.8.4.1 Length and breadth shall be measured correct to a cm and area worked out in sqm correct to two places of decimal.

13.8.5 Rate

13.8.5.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

13.9 Neat Cement Punning

13.9.1 The Specifications given for floating coat described in **Clause 12.6.2** shall apply.

13.9.2 Specification for scaffolding and curing shall be as described in **Clauses 12.5.1** and **12.5.6** respectively.

13.9.3 Specifications for Finish and Precautions shall be as described in **Clause 12.3.5 and 12.3.8.**

13.9.4 Measurements

13.9.4.1 The measurements for neat cement punning shall be taken over the finished work. The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm correct to two places of decimal.

13.9.4.2 Punning over Plaster on bands, skirting, coping, cornices, drip courses, string courses etc., shall not be measured separately but only as wall surfaces. In these cases the measurements shall be taken girthed over the above features.

13.9.4.3 Punning over Plaster on circular work also, of any radius shall be measured only as wall surfaces, and not separately.

13.9.4.4 Neat cement punning in patch repairs irrespective of the size of the patch shall be measured as new work, and in this case the rate shall include for cutting the patch to rectangular shape before Neat cement punning.

13.9.4.5 Deductions in measurements for openings shall be regulated generally as described in **Clause 12.3.9.9.**

13.9.5 Rate

13.9.5.1 The rate shall include the cost of all labour and materials involved in all the operations described above.

13.10 Rough Cast Plaster

13.10.1 Rough cast finish comprises of a mixture of sand and gravel in specified proportions dashed over a freshly plastered surface.

13.10.2 Scaffolding

13.10.2.1 Scaffolding shall be done as specified in **Clause 12.3.1**.

13.10.3 Preparation of Surface

13.10.3.1 The joints shall be raked out, dust and loose mortar, shall be brushed out. The surface shall be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

13.10.4 Mortar

13.10.4.1 Mortar of specified mix using the type of sand described in the item shall be used, where coarse sand is to be used, the fineness modulus of the sand shall not be less than 2.5 mm.

13.10.5 Application

13.10.5.1 The plaster base over which rough cast finish is to be applied shall consist of two coats, under layer 12 mm thick and top layer 10 mm.

13.10.5.2 12 mm under layer

This shall be applied in the same manner as specified in **Clause 12.3.4** under 18 mm lime plaster except that the surface shall not be beaten with bamboo strips.

13.10.5.3 Top layer

The top layer shall be applied a day or two after the under layer has taken initial set. The latter shall not be allowed to dry out, before the top layer is laid on. The mortar used for applying top layer shall be sufficiently plastic and of rich mix 1:3 (1 cement, 3 fine sand) or as otherwise specified so that the mix of sand and gravel gets well pitched with the plaster surface. In order to make the base plastic, about 10 % of finely grinded hydrated lime by volume of cement, shall be added when preparing mortar for the top layer.

13.10.6 Finish

13.10.6.1 It shall be ensured that the base surface which is to receive cast mixture is in plastic state. The rough cast mixture shall consist of sand or gravel or crushed stone of uniform colour from 2.36 mm to 12.5 mm or as specified and in the proportions as specified accurately to the effect required. The mixture shall be wetted and shall be dashed on the plaster base in plastic state by hand scoop so that the mix gets well pitched into the plaster base. The mix shall again be dashed over the vacant spaces if any so that the surface represents a homogeneous surfaces of sand mixed with gravel. A sample of rough cast plaster shall be got approved by the Engineer.

13.10.7 Specification for other details like precautions, measurement and rate shall be as described under Laying.

13.11 18 mm Plastering with Terrazzo Finish

13.11.1 Scaffolding

13.11.1.1 Double scaffolding shall invariably be adopted.

13.11.2 Preparation of Surface

13.11.2.1 The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence, if any, shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

13.11.2.2 In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

13.11.3 Mortar

13.11.3.1 The mortar shall be prepared as specified in **Chapter 9.**

13.11.3.2 12 mm under coat

This shall generally consist of cement mortar 1:3 (1 cement: 3 coarse sand) unless otherwise specified in the item.

13.11.3.3 6 mm Top coat

The Specifications as in **Clause 22.11.3** shall hold good as far as applicable.

13.11.4 Applications

13.11.4.1 12 mm Under Coat

This shall be applied in the manner specified in **Clause 12.5.4** except that when the plaster has been brought to a true surface with a wooden straight edge, the surface shall be left rough and furrowed 2 mm deep with a scratching tool diagonally both ways to form key for the top coat. The scratched lines shall be at not more than 15 cm apart. The surface shall be kept wet till the finishing coat is applied.

13.11.4.2 6 mm Top Coat

The top coat shall be applied after the under coat has sufficiently set but not dried, and in any case within 48 hours and finished in the same manner as specified under “40 mm marble chips flooring” as far as applicable.

13.11.4.3 All corners, arrises, angles and junctions shall be truly vertical or horizontal as the case may be, arrises shall be carefully and neatly finished and rubbed smooth. Rounding or chamfering corners, arrises, junctions etc. where required shall be true to template and shall be carried out without any extra payment.

13.11.5 Finish

13.11.5.1 The finished surface shall be smooth, highly polished and absolutely even so that when light from side ways is reflected on it, it does not show any kind of waviness.

13.11.6 Thickness

13.11.6.1 The thickness of the under coat of plaster specified shall be exclusive of the thickness of key. The average thickness of the under coat shall not be less than 12 mm whether the wall treated is of brick or stone. In the case of brick work the minimum thickness over any portion of the surface shall not be less than 10 mm while in the case of stone work, the minimum thickness over the bushing shall not be less than 6 mm.

13.11.6.2 6 mm finishing coat shall be uniformly 6 mm thick over the under coat in the case of both brick and stone masonry.

13.11.7 Curing

13.11.7.1 Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

13.11.7.2 The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the Contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so the curing for the specified period thereafter can be watched.

13.11.8 Precautions

13.11.8.1 Any cracks which appear in the surface and all portions, which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer. In addition care shall be taken that the finish of the rectified work is indistinguishable from the rest of the portions and does not show as a patch.

13.11.9 Measurements

13.11.9.1 Measurements of length and breadth shall be correct to a cm and its area shall be calculated correct to two places of decimal. The measurement of plaster shall be taken between the wall or partition (being the dimension before plastering)

13.11.9.2 Measurement of the work as actually done with deductions of opening etc., addition of jambs, sills and soffits shall be taken. However, openings less than 5 sq. dm in area will be ignored.

13.11.9.3 Skirting not exceeding 30 cm in height shall be measured in sqm separately, stating the number of coats, thickness of each coat and whether plain, chamfered or beaded on top.

13.11.9.4 Circular work not-exceeding 6 m in radius shall also be separately measured.

13.11.9.5 Moulded cornices and coves shall be measured as follows:

1. Length shall be measured at the centre of the girth.
2. Moulded cornices and coves shall be given in sqm the area being arrived at by multiplying length by the girth.
3. Flat or weathered top to cornices when exceeding 15 cm in width shall not be included in the girth but measured with the general plaster work.
4. Cornices which are curved in their length shall be measured separately.

13.11.10 Rate

13.11.10.1 The rate shall include the cost of all labour and materials involved in the operations described above.

13.12 Plain Bands of Cement Mortar

13.12.1 'Plain Band' is a plaster strip of uniform width not exceeding 30 cm and of uniform thickness, provided for decorative or other purposed flush with, sunk below or projecting beyond, the wall plaster. A flush band is one where due to the difference in mix or shade of the mortar, the band is executed as separate and distinct operation from the wall plaster.

13.12.2 Thickness

13.12.2.1 The thickness of a raised band is the thickness of the projection beyond the plane of the wall plaster.

13.12.2.2 In the case of a flush or a sunk band, the thickness will be the thickness of the plaster measured from the untreated wall surface.

13.12.3 Preparation of surfaces and application

13.12.3.1 In the case of flush or sunk bands the joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing the scraping.

The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

13.12.3.2 In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

13.12.3.3 In case of raised band, the surface shall prepared as specified in **Clause 12.3.3** except in following respects (a) beating with thin bamboo strips shall not be done and (b) the lime putty solution shall be applied on a surface when Finishing. The surface of the wall plaster behind the band shall be left rough and furrowed 2 mm deep with a scratching too, diagonally both ways to form key for the band. No reduction in the rate for the above backing wall plaster shall, however, be made for not finishing the same smooth.

13.12.4 Mortar

13.12.4.1 Mortar of the mix and type of sand specified in the description of the item shall be used.

13.12.5 Finish

13.12.5.1 The bands shall be finished exactly to the size as shown in the Drawings. The horizontal or vertical lines of bands shall be truly parallel and straight and the surfaces shall be finished truly plane and smooth. The lines and surfaces shall be checked and smooth. The lines and surfaces shall be checked with fine threads for straightness, level and accuracy.

13.12.6 Scaffolding, Curing and Precaution shall be as described under **Clause 12.5.**..

13.12.7 Measurements

13.12.7.1 Length will be measured in running metres correct to a cm. The length shall be taken along the finished face. The width shall not be measured by girth. For width of band 30 cm or below, the width shall be measured in cm correct to 5 mm. The quantity shall be calculated in metre-cm units.

13.12.8 Rate

13.12.8.1 The rate shall include the cost of all labour and materials involved in all the operations described above. Nothing extra shall be paid for mitres, stops nor for bands on curved surfaces of whatever radius, they may be. The rate is also inclusive of all rounding or chamfering at corners, arrisers, providing grooves at junctions etc.

13.13 Cement Water Proofing Compound

13.13.1 It shall be used for cement mortar for plastering or concrete work.

13.13.2 Water Proofing Compound

13.13.2.1 Integral cement water proofing compound conforming to IS: 2645 and of approved brand and manufacture, enlisted by the Engineer from time to time shall be used.

13.13.3 The Contractor shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the description of the item. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.

13.13.4 It shall be measured by weight.

13.13.5 The rate shall include the cost of all labour and materials involved in all the operations described above.

13.14 White Washing with Lime

13.14.1 Scaffolding

13.14.1.1 Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface which is being white washed.

13.14.1.2 For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

Note: In case of special type of brick work, scaffolding shall be got approved from Engineer in advance.

13.14.1.3 Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls.

13.14.1.4 For white washing the ceiling, proper stage scaffolding shall be erected.

13.14.2 Preparation of Surface

13.14.2.1 Before new work is white washed, the surface shall be thoroughly brushed free from mortar droppings an foreign matter.

13.14.3 Preparation of lime wash

13.14.3.1 The lime wash shall be prepared from fresh stone white lime. The lime shall be thoroughly slaked on the spot, mixed and stirred with sufficient water to make a thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth, 40 gm of gum dissolved in hot water, shall be added to each 10 cubic decimeter of the cream. The approximate quantity of water to be added in making the cream will be 5 litres of water to one kg of lime.

13.14.3.2 Indigo (Neel) upto 3 gm per kg of lime dissolved in water, shall then be added and stirred well. Water shall then be added at the rate of about 5 litres per kg. of lime to produce a milky solution.

13.14.4 Application

13.14.4.1 The white wash shall be applied with moonj brushes to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top downwards, another from the bottom upwards over the first stroke, and similarly one stroke horizontally from the right and another from the left before it dries.

13.14.4.2 Each coat shall be allowed to dry before the next one is applied. Further each coat shall be inspected and approved by the Engineer-n-Charge before the subsequent coat is applied. No portion of the surface shall be left out initially to be patched up later on.

13.14.4.3 For new work, three or more coats shall be applied till the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surface shall not show any signs of cracking and peeling nor shall it come off readily on the hand when rubbed.

13.14.5 Protective Measures

13.14.5.1 Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed, shall be protected from being splashed upon. Splashings and droppings, if any

shall be removed by the Contractor at his own cost and the surfaces cleaned. Damages if any to furniture or fittings and fixtures shall be recoverable from the Contractor.

13.14.6 Measurements

13.14.6.1 Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals.

13.14.6.2 Measurement for Jambs, Soffits and sills, etc. for openings shall be described in **Clause 12.3.9**.

13.14.6.3 Corrugated surfaces shall be measured flat as fixed and the area so measured shall be increased by the following percentages to allow for the girthed area.

Corrugated asbestos cement sheet	20 %
Semi corrugated asbestos cement sheet	10 %

13.14.6.4 Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

13.14.6.5 The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sqcm each with material similar in composition to the surface to be prepared.

13.14.6.6 Work on old treated surfaces shall be measured separately and so described.

13.14.7 Rate

13.14.7.1 The rate shall include all material and labour involved in all the operations described above.

13.15 Satna Lime Washing

13.15.1 Satna lime wash shall be used as a base coat where so specified. The Specifications for 'white washing with lime' shall apply except that Satna or Katni quality lime shall be used in place of Narnaul or Dehradun quality lime and the wash will be mixed to a thicker consistency. The other details and Specifications described in **Clause 12.14** will apply in toto.

13.16 Colour Washing

13.16.1 The mineral colours, not affected by lime, shall be added to white wash. Indigo (Neel) shall however, not be added. No colour wash shall be done until a sample of the colour wash of the required tint or shade has been got approved from the Engineer. The colour shall be of even tint or shade over the whole surface. If it is blotchy or otherwise badly applied, it shall be redone by the Contractor.

13.16.2 For new work, the priming coat shall be of white wash with lime or with whiting as specified in the description of the item. Two or more coats, shall then be applied on the entire surface till it represents a smooth and uniform finish.

13.16.3 The finished dry surface shall not be powdery and shall not readily come off on the hand when rubbed.

13.16.4 Other Specifications as described under **Clause 12.14**.

13.17 Dry Distempering

13.17.1 Materials

13.17.1.1 Dry distemper of required colour (IS: 427) and of approved brand and manufacture from the Engineer before application of the distemper. The dry distemper colour as required shall be

stirred slowly in clean water using 6 decilitres (0.6 litre) of water per kg of distemper or as specified by the makers. Warm water shall preferably be used. It shall be allowed to stand for at least 30 minutes (or if practicable over night) before use. The mixture shall be well stirred before and during use to maintain an even consistency.

13.17.1.2 Distemper shall not be mixed in large quantity than is actually required for one day's work.

13.17.2 Preparation of Surface

13.17.2.1 Before new work is distempered, the surface shall be thoroughly brushed free from mortar droppings and other foreign mater and sand papered smooth.

13.17.2.2 New plastered surfaces shall be allowed to dry for at least two months, before applying, distemper.

13.17.3 Pitting in plaster shall be made good with plaster of Paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

13.17.4 Priming Coat

13.17.4.1 A priming coat of whiting shall be applied over the prepared surface in case of new work, if so stipulated in the description of the item. No white washing coat shall be used as a priming coat for distemper.

13.17.4.2 The treated surface be allowed to dry before distemper coat is given.

13.17.5 Application

13.17.5.1 In the case of new work, the treatment shall consist of a priming coat of whiting followed by the application of two or more coats of distemper till the surface shows as even colour.

13.17.5.2 For application of each coat the entire surface shall be coated with mixture uniformly, with proper distemper brushes (ordinary white wash brushed shall not be allowed) in horizontal strokes followed immediately by vertical ones which together shall constitute one coat.

13.17.5.3 The subsequent coats shall be applied only after the previous coat has dried.

13.17.5.4 The finished surface shall be even and uniform and shall show not brush marks.

13.17.5.5 Enough distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day.

13.17.5.6 After each day's work, the brushes shall be washed in hot water and hung down to dry. Old brushes which are dirty or caked with distemper shall not be used.

13.17.5.7 The Specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under **Clause 12.14**.

13.18 Oil Emulsion (Oil Bound) Washable Distempering

13.18.1 Materials

13.18.1.1 Oil emulsion (Oil Bound) washable distemper (IS: 428) of approved brand and manufacture shall be used. The primer where used as on new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's works shall be prepared.

13.18.1.2 The distemper and primer shall be brought by the Contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the Contractor and the Engineering-in-charge. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by the Engineer.

13.18.2 Preparation of the Surface

13.18.2.1 For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of pairs mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

13.18.2.2 Pitting in plaster shall be made good with plaster of Paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patches surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

13.18.3 Application

13.18.3.1 The priming coat shall be with distemper primer or cement primer, as required in the description of the item. The application of the distemper primer shall be as described in **Clause 12.18.2.2**.

Note: If the wall surface plaster has not dried completely, cement primer shall be applied before distempering the walls, but if distempering is done after the wall surface is dried completely, distemper primer shall be applied.

13.18.3.2 Oil bound distemper is not recommended to be applied, within six months of the completion of wall plaster. However, newly plastered surfaces if required to be distempered before a period of six months shall be given a coat of alkali resistant priming paint conforming to IS: 109 and allowed to dry for atleast 48 hours before distempering is commenced.

13.18.3.3 Distemper Coat

1. For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes in horizontal strokes followed immediately by vertical ones which together constitutes one coat.
2. The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain as an even shade.
3. A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.
4. 15 cm double bristled distemper brushes shall be used. After each days work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

13.18.4 The Specifications in respect of scaffolding, protective measures and measurements shall be as described under **Clause 12.14**.

13.18.5 Rate

13.18.5.1 The rate shall include the cost of all labour and materials involved in all the above operations (including priming coat) described above.

13.19 Cement Primer Coat

13.19.1 Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on asbestos cement surfaces before oil emulsion distemper paints are applied on them. The cement primer is composed of a medium and pigment which are resistant to the alkalis present in the cement lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats of oil emulsion distemper paints.

13.19.2 Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion paints etc.

13.19.3 Preparation of the Surface

13.19.3.1 The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any uneveness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filing up the undulations and then sand papering the same after it is dry.

13.19.4 Application

13.19.4.1 The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil emulsion paint is applied.

13.19.5 The Specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under **Clause 12.14**.

13.20 Cement Paint

13.20.1 Materials

13.20.1.1 The cement paint shall be (conforming to IS: 5410) of approved brand and manufacture.

13.20.1.2 The cement paint shall be brought to the site of work by the Contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the Engineer.

13.20.2 Preparation of Surface

13.20.2.1 For new work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement paint shall be applied over patches after wetting them thoroughly.

13.20.3 Preparation of mix

13.20.3.1 Cement paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency. In all cases the manufacturer's instructions shall be followed meticulously.

13.20.3.2 The lids of cement paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement paint rapidly becomes air set due to its hygroscopic qualities.

13.20.3.3 In case of cement paint brought in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

13.20.4 Application

13.20.4.1 The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement paint shall be as per manufacturer's Specification. The completed surface shall be watered after the day's work.

13.20.4.2 The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

13.20.4.3 For new work, the surface shall be treated with three or more coats of water proof cement paint as found necessary to get uniform shade.

13.20.5 Precaution

13.20.5.1 Water proof cement paint shall not be applied on surface already treated with white wash, colour wash, distemper dry or oil bound, varnishes, paints etc. It shall not be applied on gypsum, wood and metal surfaces.

13.20.6 The Specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under **Clause 12.14**. The coefficient for cement paint on RCC Jalli shall be the same as provided in Sr.No.7 of Table 12-1 for painting trellis for Jaffri work.

13.21 Painting

13.21.1 Materials

13.21.1.1 Paints, oils varnishes etc. of approved brand and manufacture shall be used. Only ready mixed paint (exterior grade) as received from the manufacturer without any admixture shall be used.

13.21.1.2 If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer shall be used.

13.21.1.3 Approved paints, oil or varnishes shall be brought to the site of work by the Contractor in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least of fortnight's work. The empties shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Engineer.

13.21.2 Commencing Work

13.21.2.1 Painting shall not be started until the Engineer has inspected the items of work to be painted satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm.

13.21.2.2 Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work.

13.21.2.3 The room should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the paint work being started.

13.21.3 Preparation of Surface

13.21.3.1 The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer after inspection, before painting is commenced.

13.21.4 Application

13.21.4.1 Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its containers, when applying also, the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

13.21.4.2 The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly kin a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

13.21.4.3 Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be brought to the requisite consistency by adding a suitable thinner.

13.21.4.4 Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and dust cleaned off before the next coat is laid.

13.21.4.5 No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

13.21.4.6 No hair marks from the brush or clogging of paint puddles in the corners of panels, angles of mouldings etc. Shall be left on the work.

13.21.4.7 In painting doors and windows, the putty round the glass panes must also be painted but care must be taken to see that no paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting. However, bottom edge of the shutters where the painting is not practically possible, need not be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters.

13.21.4.8 On painting steel work, special care shall be taken while painting over bolts, nuts, rivets overlaps etc.

13.21.4.9 The additional Specifications for primer and other costs of paints shall be as according to the detailed Specifications under the respective headings.

13.21.5 Brushes and Containers

13.21.5.1 After work, the brushes shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

13.21.6 Measurements

13.21.6.1 The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated.

13.21.6.2 Small articles not exceeding 0.1 sqm of painted surfaces where not in conjunction with similar painted work shall be enumerated.

13.21.6.3 Painting upto 10 cm in width or in girth and not in conjunction with similar painted work shall be given in running metres and shall include cutting to line where so required.

13.21.6.4 Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sqm. irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

13.21.6.5 In measuring painting, varnishing, oiling etc. of joinery and steel work etc. the coefficients as indicated in following tables shall be used to obtain the area payable. The coefficients shall be applied to the areas measured flat and not girthed.

Table 12-1: Equivalent Plain Areas of Uneven Surface

Sr.	Description of work	How measured	Multiplying coefficients
I.	WOOD WORK DOORS, WINDOWS ETC.		
1.	Panelled or framed and braced doors, windows etc.	Measured flat (not girthed including)	1.30 (for each side)
2.	Ledged and battened or ledged, battened and braced doors, windows etc.	Chowkhat or frame, Edges, chocks, cleats, etc. shall be deemed to be included in the item.	
3.	Flush doors etc.	-do-	1.20 (for each side)
4.	Part panelled and part glazed or gauzed doors, window etc. (excluding painting of wire gauze portion)	-do-	1.00 (for each side)
5.	Fully glazed or gauzed doors, windows etc. (Excluding painting of wire gauze portion)	-do-	0.80 (for each side)
6.	Fully venetioned or louvered doors, windows etc.	-do-	1.80 (for each side)
7.	Trellis (or Jaffri) work one way or two way	Measured flat overall, no deduction shall be made for open spaces, supporting members shall not be measured separately	2 (for painting all over)
8.	Carved or enriched work	Measured flat	2 (for each side)
9.	Weather boarding	Measured flat (not girthed) supporting frame work shall not be measured separately	1.20 (for each side)
10.	Wood shingle roofing	Measured flat (not girthed)	1.10 (for each side)
11.	Boarding with cover fillets and match boarding	Measured flat (not girthed)	1.05 (for each side)
12.	Tile and slate battening	Measured flat overall no deductions shall be made for open spaces	0.80 (for painting all over)

Sr.	Description of work	How measured	Multiplying coefficients
II.	STEEL WORK DOORS, WINDOWS ETC.		
13.	Plain sheeted steel doors or windows	Measured flat (not girthed) including frame edges etc.	1.10 (for each side)
14.	Fully glazed or gauzed steel doors and windows (excluding painting of wire gauze portion)	-do-	0.50 (for each side)
15.	Partly panelled and partly glazed or gauzed doors and windows (excluding painting of wire gauze portion)	-do-	0.80 (for each side)
16.	Corrugated sheeted steel doors or windows	-do-	1.25 (for each side)
17.	Collapsible gates	Measured flat	1.50 (for painting all over)
18.	Rolling shutters of interlocked laths	Measured flat (size of opening) all over jamb guides, bottom rails and locking arrangement etc. Shall be included in the item (top cover shall be measured separately)	1.10 (for each side)
III.	GENERAL		
19.	Expanded metal, hard drawn steel wire fabric of approved quality, grill works and gratings in guard Bars, balustrades railing partitions and MS Bars in windows frames	Measured flat overall: no deduction shall be made for open spaces: supporting members shall not be measured separately	1 (for paint all over)
20.	Open palisade fencing and gates including standards, braces, rails stays etc. in timber or steel	-do- (see note No.12)	1(for paint all over)
21.	Corrugated iron sheeting in roofs, side cladding etc.	-do-Measured flat (not girthed)	1.14 (for each side)
22.	AC corrugated iron sheeting in roofs, side cladding etc.	-do-	1.20 (for each side)
23.	AC semi corrugated sheeting in roofs, side cladding etc. or Nainital pattern using plain sheets	-do-	1.10 (for each side)
24.	Wire gauze shutters including painting of wire gauze	-do-	1.00 (for each side)

Explanatory notes for Table 12-1

1. *Measurements for doors windows etc., shall be taken flat (and not girthed) over all including chowkhuts or frames, where provided. Where Chowkhuts or frames are not provided, the shutter measurements shall be taken.*
2. *Where doors, windows etc., are of composite types other than those included in the above Table 12-1, the different portion shall be measured separately with their appropriate coefficients, the centre line of the common rail being taken as the dividing line between the two portions.*
3. *The coefficients for door and windows shall apply irrespective of the size of frames and shutter members.*
4. *In case steel frames are used the area of doors, windows shutters shall be measured flat excluding frames.*
5. *When the two faces of door, window etc., are to be treated with different specified finishes, measurable under separate items, the edges of frames and shutters shall be*

treated with one orother type of finish as ordered by the Engineer and measurement of this will be deemed to be included in the measurement of the face treated with that finish.

6. *In the case where shutters are fixed on both faces of the frames, the measurement for the door frame and shutter on one face shall be taken in the manner already described, while the additional shutter on the other side face will be measured for the shutter only excluding the frame.*
7. *Where shutters are provided with clearance at top or / and bottom each exceeding 15 cm height, such openings shall be deducted from the overall measurements and relevant coefficient shall be applied to obtain the area payable.*
8. *Collapsible gates shall be measured for width from outside to outside of gate in its expanded position and for height from bottom to top of channel verticals. No separate measurements shall be taken for the top and bottom guide rails rollers, fittings etc.*
9. *Coefficients for sliding doors shall be the same as for normal types of doors in the table. Measurements shall be taken outside to outside of shutters, and no separate measurements shall be taken for the painting guide rails, rollers, fittings etc.*
10. *Measurements of painting as above shall be deemed to include painting all iron fittings in the same or different shade for which no extra will be paid.*
11. *The measurements of guard bars, expanded metal, hard drawn steel wire fabric of approved quality, grill work and gratings, when fixed in frame work, painting of which is once measured else where shall be taken exclusive of the frames. In other cases the measurements shall be taken inclusive of the frames.*
12. *For painting open palisade fencing and gates etc., the height shall be measured from the bottom of the lowest rail, if the palisades do not go below it, (or from the lower end of the palisades, it they project below the lowest rail,) upto the top of rails or palisades whichever are higher, but not up to the top of standards when the latter are higher than the top rails or the palisades.*

13.21.6.6 Width of moulded work of all other kinds, as in hand rails, cornices, architraves shall be measured by girth.

13.21.6.7 For trusses, compound girders, stanchions, lattice girders, and similar work, actual areas will be measured in sqm. and no extra shall be paid for painting on bolt heads, nuts, washers etc. even when they are picked out in a different tint to the adjacent work.

13.21.6.8 Painting of rain water, soil, waste, vent and water pipes etc. shall be measured in running metres of the particular diameter of the pipe concerned. Painting of specials such as bends, heads, branches, junctions, shoes, etc., shall be included in the length and no separate measurements shall be taken for these or for painting brackets, clamps etc.

13.21.6.9 Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual.

13.21.6.10 Flag staffs, steel chimneys, aerial masts, spires and other such objects requiring special scaffolding shall be measured separately.

13.21.7 Precautions

13.21.7.1 All furnitures, fixtures, glazing, floors etc. shall be protected by covering and stains, smears, splashings, if any shall be removed and any damages done shall be made good by the Contractor at his cost.

13.21.8 Rate

13.21.8.1 Rates shall include cost of all labour and materials involved in all the operations described above and in the particular Specifications given under the several items.

13.22 Painting Priming Coat on Wood, Iron or Plastered Surfaces

13.22.1 Primer

13.22.1.1 The primer for wood work, iron work or plastered surface shall be as specified in the description of item.

13.22.1.2 Primer for plaster/wood work/iron and steel/aluminium surfaces shall be as specified below:

Sr.	Surfaces	Primer to be used
1.	Wood work (hard and soft wood)	Pink conforming to IS: 3536
2.	Resinour wood and plywood	Aluminium primer conforming to IS: 3585
3.	(A) Aluminium and light alloy (B) Iron, Steel Galvanized steel	Zinc chromate primer conforming to IS: 104 Oxide Zinc chromate Primer conforming IS: 2074
4.	Cement/Conc/RCC/brick work, Plastered surfaces, asbestos surfaces to receive Oil bound distemper or paint finish.	Cement primer conforming to IS: 109

13.22.1.3 The primer shall be ready mixed primer of approved brand and manufacture.

13.22.1.4 Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg: 1 litre.

13.22.1.5 Where primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg: 1 litre: 1 litre.

13.22.1.6 The Specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

1. White lead: The White lead shall be pure and free from adulterants like barium sulphate and whiting. It shall conform to IS: 103.
2. Red lead: This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall conform to IS: 102.
3. Raw Linseed Oil: Raw linseed oil shall be lightly viscous but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30 degree C shall be between 0.923 and 0.928.

   Note: The oil shall be mellow and sweet to taste with very little smell. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS: 75. The oil shall be of approved brand and manufacture.

4. Double boiled linseed oil: This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30 degree C. It shall dry with a glossy surface. It shall confirm in all respects to IS: 77. The oil shall be of approved brand and manufacture.
5. Turpentine: Mineral turpentine i.e., petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of oleeresin of conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall conform to IS: 533.

13.22.1.7 All the above materials shall be of approved manufacture and brought to site in their original packing in sealed condition.

13.22.2 Preparation of surface

13.22.2.1 Wooden surface

The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material conforming to IS: 345 with same shade as paint shall be used where specified. The surface treated for knotting shall be dry before paint is applied. After obtaining approval of Engineer for wood work, the priming coat shall be applied before the wood work, is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping and the latter is therefore liable to crack

13.22.2.2 Iron & Steel Surface

1. All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.
2. All dust and dirt shall be thoroughly wiped away from the surface.
3. If the surface is wet, it shall be dried before priming coat is undertaken.

13.22.2.3 Plastered Surface

The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations, shall be filled up with plaster of Paris and rubbed smooth.

13.22.3 Application

13.22.3.1 The primer shall be applied with brushes, worked well into the surface and spread even and smooth. The painting shall be done by crossing and laying off as described in **Clause 12.21.4**.

13.22.4 Treatment on steel for aggressive environment

13.22.4.1 A second coat of ready mixed red oxide zinc chromate primer may be applied where considered necessary in aggressive environment such as near Industrial Establishment and Coastal regions where the steel members are prone to corrosion. The second coat (which shall be paid for separately) is to be applied after placing the member in position and just before applying paint. The second coat of primer is not necessary in case of painting with synthetic enamel paint as it is applied over an under coat of ordinary paint.

13.22.4.2 The Specifications described under **Clause 12.21** shall hold good so far as they are applicable.

13.23 Painting with Ready Mixed Paint

13.23.1 Ready mixed paints of approved brand and manufacture and of the required shades shall be used. They shall conform in all respects to the relevant IS Specifications.

13.23.2 Painting on New Surface

13.23.2.1 The surface which has not been painted earlier, or the paint had been removed by paint remover, burning, caustic soda etc. shall be considered to be new surface.

13.23.3 Preparation of Surface

13.23.3.1 Wood work

The surface shall be cleaned and all uneveness removed as specified in **Clause 12.22.2.1** knots if visible, shall be covered with a preparation of red lead. Holes and indentations on the surface shall be filled in with glazier's putty or wood putty conforming to IS: 419 and rubbed smooth before painting is done. The surface should be thoroughly dry before painting.

13.23.3.1.1 Iron and Steel work

The priming coat shall have dried up completely before painting is started. Rust and scaling shall be carefully removed by scraping or by brushing with steel wire brushes. All dust and dirt shall be carefully and thoroughly wiped away.

13.23.3.2 Plastered surface

The priming coat shall have dried up completely before painting is started. All dust or dirt that has settled on the priming coat shall be thoroughly wiped away before painting is started.

13.23.4 Application

13.23.4.1 The Specifications described in **Clause 12.21.4** shall hold good as far as applicable. The number of coats to be applied will be as stipulated in the item. The painted surface shall present a uniform appearance and glossy finish, free from streaks, blisters etc.

13.23.4.2 The Specifications described in **Clause 12.21** shall hold good in so far as they are applicable

13.24 Painting Ready Mixed Paint over G.S. Sheets

13.24.1 Ready mixed paint, suitable for painting over G.S. sheets, of approved brand and manufacture and of the required shade shall be used. New or weathered G.S. Sheets shall be painted with a priming coat of one coat of red oxide zinc chromate paint. Primer shall be applied before fixing sheets in place.

13.24.2 Preparation of Surface

13.24.2.1 Painting new surface

1. The painting of new G.S. sheets not usually be done till the sheets have weathered for about a year. When new sheets are to be painted before they have weathered they shall be treated with a mordant solution prepared by the mixing 38 gm of copper acetate in a litre of soft water or 13 gm hydrochloric acid in a solution of 13 gm each of copper chloride, copper nitrate and ammonium chloride dissolved in a litre of soft water. This quantity of solution is sufficient for about 235 sqm. to 280 sqm of area and is applied for ensuring proper adhesion of paint. The painting with the mordant solution will be paid for separately.
2. Before painting on new or weathered G.S. sheets, rust patches shall be completely cleaned with coarse emery paper and brush. All grease marks shall also be removed and the surface washed and dried and rusted surface and the surface washed and dried and rusted surface shall be touched with ready mixed paint of red lead.

13.24.3 Application

13.24.3.1 The number of coats to be applied shall be as in the description of item. In the case of C.G.S. sheets, the crowns of the corrugations shall be painted first and when these get dried the general coat shall be given to ensure uniform finish over the entire surface.

13.24.3.2 The second or additional coats shall be applied when the previous coat has dried.

13.24.4 The Specifications described in **Clause 12.21** shall hold good so far as they are applicable.

13.25 Painting Cast Iron Rain Water, Soil, Waste and Vent Pipes and Fittings

13.25.1 The primer shall be prepared on site or shall be of approved brand and manufacture as specified in the item.

13.25.2 Paint shall be anti-corrosive bitumastic paint aluminum paint or other type of paint as specified in the description of the item.

13.25.3 Painting New Surface

13.25.3.1 Preparation of Surface

The surface shall be prepared for priming coat as described in **Clause 12.22.2.2**.

13.25.3.2 Application

The number of coat of painting over the priming coat shall be as stipulated in the description of the item. The application of paint over priming coat shall be carried out as specified in **Clause 12.23**.

13.25.4 Measurements

13.25.4.1 Measurements will be taken over the finished line of pipe including specials etc. In running meters, correct to a cm.

13.25.4.2 Pipes of different diameters of bore shall be measured and paid for separately.

13.25.4.3 Specials and fittings such as holder bet clamps, plugs etc. will not be measured separately.

13.25.5 Rate

13.25.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above, including painting of all specials and fittings.

13.25.5.2 Specifications described in **Clause 12.21** shall hold good as far as they are applicable.

13.26 Painting with Wood Preservative

13.26.1 Oil type wood preservative of specified quality and approved make, conforming to IS: 218 - 1983 shall be used. Generally, it shall be Creosote Oil Type -1 or Anthracene Oil.

13.26.2 Painting of New Surface

13.26.2.1 Preparation of surface

Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

13.26.3 Application

13.26.3.1 The preservative shall be applied liberally with a stout brush and not daubed with rags of cotton waste. It shall be applied with a pencil brush at the joints of the wood work. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

13.26.3.2 The Specifications described in **Clause 12.21** shall hold good in so far as they are applicable.

13.27 Coal Tarring

13.27.1 Coal tar of approved manufacture conforming to IS: 290 shall be used. The tar, to every litre of which 200 gm of unslaked lime had been added, shall be heated till it begins to boil. It must then be taken off the fire and kerosene oil added to it slowly as the rate of one part of kerosene oil to six or more parts by volume and stirred thoroughly. The addition of lime is for preventing the tar from running.

13.27.2 Coal Tarring New Surface

13.27.2.1 Preparation of surface

This shall be done as specified in **Clause 12.22.2** except that sand papering is not necessary. Where iron work is to be painted it shall be freed from scales and rust before painting.

13.27.2.2 Application

The mixture shall be applied as hot as possible with a brush. The second coat shall be applied only after the first coat has thoroughly dried up. Where possible, the article to be tarred, shall be dipped in the hot mixture for better results. The quantity of tar to be used for the first or second coat shall be not less then 0.16 and 0.12 liter per sqm respectively. Thinning with kerosene oil shall be suitable done to ensure this. The Specifications described in **Clause 12.21** shall hold good in all other respects, so far as they are applicable.

13.28 Wall Painting with Plastic Emulsion Paint

13.28.1 The plastic emulsion paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These paints are to be used on internal surfaces except wooden and steel.

13.28.2 Plastic emulsion paint as per IS: 5411 of approved brand and manufacture and of the required shade shall be used.

13.28.3 Painting on new surface

13.28.3.1 The wall surface shall be prepared as specified in **Clause 12.21.3**.

13.28.4 Application

13.28.4.1 The number of coats shall be as stipulated in the item. The paint will be applied in the usual manner with brush, spray or roller. The paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surface to 2 to 3 hours on non-absorbent surfaces.

13.28.4.2 The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacture's instructions.

13.28.4.3 The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

13.28.5 Precautions

13.28.5.1 Old brushes if they are to be used with emulsion paints, should be completely dried of turpentine or oil paints by washing in warm soap water.

13.28.5.2 Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush.

13.28.5.3 In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

13.28.5.4 Splashes on floors etc. Shall be cleaned out without delay as they will be difficult to remove after hardening.

13.28.5.5 Washing of surfaces treated with emulsion paints shall not be done within 3 to 4 weeks of application.

13.28.5.6 Other details shall be as specified in **Clause 12.21** as far as they are applicable.

13.29 Painting with Enamel Paint

13.29.1 Enamel Paint (conforming to IS: 2933-1975) of approved brand and manufacture and of the required colour shall be used.

13.29.2 For the under coat, the paint of same quality but of shade to suit that of the top coat shall be used.

13.29.3 Preparation of surface and application shall be as specified under **Clause 12.23** for painting of new surfaces or old surfaces, as the case may be.

13.29.4 Other details shall be as specified in **Clause 12.21** as for as applicable.

13.30 Painting with Synthetic Enamel Paint

13.30.1 Synthetic enamel paint (confirming to IS: 2932) of approved brand and manufacture and of the required colour shall be used for the top coat and an undercoat of ordinary paint of shade to match top coat as recommended by the same manufacture as for the top coat shall be used.

13.30.2 Painting of New Surface

13.30.2.1 Preparation of surface shall be as specified in **Clause 12.23.3.**

13.30.2.2 Application

The number of coats including the undercoat shall be as stipulated in the item.

13.30.2.3 Under Coat

One coat of the specified ordinary paint of shade suited to the shade of the top coat, shall be applied and allowed to dry overnight. It shall rubbed next day with the finest grace of wet abrasive paper to ensure a smooth and even surface, fee from brush marks and all loose particles dusted off.

13.30.2.4 Top Coat

Top coats of synthetic enamel paint of desired shade shall be applied after the undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

13.30.2.5 Other details shall be as specified in **Clause 12.21** as far as they are applicable.

13.31 Painting with Aluminium Paint

13.31.1 Aluminium paint shall be (conforming to IS: 2339) of approved brand and manufacture. The paint comes in compact dual container with the paste and the medium separately. The two shall be mixed together to proper consistency before use.

13.31.2 Preparation of Surface

13.31.2.1 Steel Work (New Surface)

All rust and scales shall be removed by scraping or brushing with steel wire brushes and then smoothened with sand paper. The surface shall be thoroughly cleaned of dust.

13.31.2.2 C.G.S. Sheets (New Surfaces)

The preparation of surface shall be as described in **Clause 12.24.2.1.**

13.31.3 Application

13.31.3.1 The number of coats to be applied shall be as given in the item. Each coat shall be allowed to dry for 24 hours and lightly rubbed down with fine grade sand paper and dusted off before the next coat is applied. The finished surface shall present an even and uniform appearance.

13.31.3.2 As aluminium paste is likely to settle in the container, care shall be taken to frequently stir the paint during used. Also the paint shall be applied and laid off quickly, as surface is otherwise not easily finished.

13.31.4 Other details shall be as specified in **Clause 12.21** as far as they are applicable.

13.32 Painting with Acid Proof Paint

13.32.1 Acid proof paint of approved brand and manufacture and of the required shade shall be used.

13.32.2 Preparation of surface and application shall be as specified under **Clause 12.23**.

13.32.3 Other details shall be as specified in **Clause 12.21** as far as they are applicable.

13.33 Painting with Anti-Corrosive Bitumastic Paint

13.33.1 Ready mixed plant (conforming to IS: 158-1981) shall be of approved brand and manufacture. It shall be black, lead free, acid-alkali-heat-water resistant.

13.33.2 Preparation of surface and application shall be as specified in **Clause 12.23** for painting on new or old surfaces ad the case may be.

13.33.3 The drying time between consecutive coats, however, shall be not less then 3 hours.

13.33.4 Other details shall be as specified in **Clause 12.21** as far as applicable.

13.34 Varnishing

13.34.1 Ordinary copal varnish or superior quality spray varnish shall be used. The work includes sizing of transparent wood filler.

13.34.2 Varnish (conforming to IS: 347 for the finishing and undercoats) shall be of the approved manufacturer.

13.34.3 Varnishing on new surface

13.34.3.1 Preparation of surface

New wood work to be varnished shall have been finished smooth with a carpenter's plane. Knots shall be cut to a slight depth. Cracks and holes shall be cleaned of dust. The knots, cracks etc. shall then be filled in with wood putty made as follows:

1. The fillings when dry shall be rubbed down with a carpenter's file and then the entire surface shall rubbed down perfectly smooth with medium grained and fine sand papers and wiped with dry clean cloth so that it presents uniform appearance. In no case shall sand papers be rubbed across the grains, as in this case event he finest marks will be visible when the varnishing is applied.

13.34.3.2 Sizing or Transparent Wood Filler Coat

The surface shall then be treated with either glue sizing or with transparent wood filler coat at stipulated in the description of item.

1. Sizing

- When sizing is stipulated, an application of thin clean size shall be applied hot on the surface. When dry, the surface shall be rubbed down smooth with sand paper and cleaned. It shall then be given another application of glue size nearly cold. The sized wood work shall again be rubbed down smoothly with fine sand paper and cleaned. The surface shall be perfectly dry and all dust shall be removed not only from the surface but also from the edges and joints before varnishing is commenced. If the wood work is to be stained, the staining color shall be mixed with the second coat of the size which must be applied evenly and quickly keeping the color on the flow.
- Any joining up with work already dry will show badly. The object of application of the glue size is to seal the pores in wood to prevent absorption of the oil in the varnish.
- Glue sizing is inadvisable on floors, table tops and other horizontal surfaces likely to carry wet household utensils which are likely to disturb the size coatings and thus expose bare wood.
- Where glue sizing is omitted to be done the rate for the work shall be suitably reduced.

2. Transparent wood Filler Coat

- Where instead of glue sizing, transparent wood filler application is stipulated in the item, then the surface prepared as described in **Clause 12.34.3.1** shall be given as application of the filler with brush or rag in such a way that the filler fills up all the pores and indentations and levels up the surface. It shall be allowed to dry for 24 hours. Then it shall be cut and rubbed with emery paper so that the surface of the wood is laid bare, with the filler only the pores and crevices of the wood.

13.34.3.3 Application of Varnish

1. The number of coats to be applied shall be as stipulated in the description of the item.
2. The undercoat shall be with a flatting varnish. This dries hard and brittle and when cut and rubbed down to produce a smooth surface enhances the gloss of the finishing varnish. The top coat shall be given with stipulated brand of finishing varnish.
3. The varnish shall be applied liberally with a full brush and spread evenly with short light strokes to avoid frothing. If the work is vertical the varnish shall be crossed and recrossed and then laid off, latter being finished on the upstrokes so that varnish, as it sets flows down and eliminates brush marks, the above process will constitute one coat. It the surface is horizontal, varnish shall be worked in every direction, with light quick strokes and finish in one definite direction so that it will set without showing brush marks, in handling and applying varnish care should be taken to avoid forming froth or air bubbles. Brushes and containers shall be kept scrupulously clean.

4. Rubbing down and flatting the surface shall be done after each coat except the final coat with fine sand paper.
5. The work shall be allowed to dry away from drought and damp air. The finished surface shall then present a uniform appearance and fine flossy surface free from streaks, blister etc.
6. Any varnish left over in the small container shall not be poured back into the stock tin, as it will render the latter unite unfit for use.
7. Special fine haired varnishing brushes shall be used and not ordinary paint brushes. Brushes shall be well worn and perfectly clean.

13.35 French Spirit Polishing

13.35.1 Pure shellac conforming to IS: 16 varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit. Suitable pigment shall be added to get the required shade. Ready made polish conforming to IS: 348 can also be used.

13.35.2 Polishing New Surface

13.35.2.1 Preparation of Surface

The surface shall be cleaned All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 kg of whiting per litre of spirit. The surface shall again be rubbed down perfectly smooth with glass paper and wiped clean.

13.35.2.2 Application

1. The number of coats of polish to be applied shall be as described in the item.
2. A pad of woolen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood, in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to give an even level surface. A trace of linseed oil on the face of the pad facilities this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

13.35.2.3 Measurements, Rate and other details shall be as specified in **Clause 12.21** as far as they are applicable.

13.36 Lettering with Paint

13.36.1 Black Japan paint (conforming to IS: 341) or ready mixed paint as ordered by the Engineer shall be used. The paint shall be of approved brand and manufacture. Ordinary ready mixed paint shall be of the shade required by the Engineer.

13.36.2 Lettering on New Surface

13.36.2.1 Application

1. The letters and figures shall be to the heights and width as ordered by the Engineer. These shall be stenciled or drawn in pencil and got approved before painting. They shall be of uniform size and finished neatly. The edges shall be straight or in pleasant smooth curves. The thickness of the lettering shall be as approved by the Engineer. Lettering shall be vertical or slanting as required.
2. Two or more coats or paint shall be applied till uniform colour and glossy finish are obtained.

13.36.2.2 Measurements

1. Measurements shall be taken in terms of letter cm (the measurement related to the vertical height of the lettering). The letter heights shall be measured correct to a cm.
2. Dots, dashes, punctuations and other similar marks or lines shall not be measured for payment.
3. In Devanagari / Kannada script Dots & Matras occurring with the letters shall not be measured. Half letter shall be measured as full letter. The height of letters shall be measured excluding the Matras projecting above the heading and Matras below the letters.

13.36.2.3 Rate

Rate shall include the cost of all labour and materials involved in the operations described above. The rate per cm height of letter shall hold good irrespective of the width of the letters or figures or the thickness of the lettering. The same rate will apply irrespective of whether black Japan or ready mixed paint of any shade as required is used.

14 ROADS AND PAVEMENTS

14.1 Granular Sub-Base

14.1.1 Scope

14.1.1.1 This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the Drawings or as directed by the Engineer.

14.1.2 Materials

14.1.2.1 The material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table 13-1.

14.1.2.2 While the grading in Table 13-1 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding gradings for the coarse-graded materials for each of the three maximum particle sizes are given at Table 13-2. The grading to be adopted for a project shall be as specified in the Contract.

14.1.2.3 Physical requirements

14.1.2.3.1 The material shall have a 10 percent fineness value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part III). The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part 3):; if this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.

Table 13-1. Grading for Close-Graded Granular Sub-Base Materials

IS sieve	Per cent by weight passing the IS sieve		
Designation	Grade I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30	25	20

Table 13-2. Grading for Coarse Graded Granular Sub-Base Materials

IS Sieve Designation	Percent by weight passing the IS Sieve		
	Grading I	Grading II	Grading III
75.00 mm	100	-	-
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	< 10	< 10	< 10
CBR Value (Minimum)	30	25	20

Note: The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS: 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

14.1.3 Strength of Sub-base

14.1.3.1 It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

14.1.3.2 When directed by the Engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the “quality” of materials, as may be necessary.

14.1.4 Construction Operations

14.1.4.1 Preparation of subgrade

14.1.4.1.1 Immediately prior to the laying of sub-base, the subgrade already finished to applicable **Clauses of Chapter 5** shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80-100 kN smooth wheeled roller.

14.1.4.2 Spreading and compacting

14.1.4.2.1 The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade with the help of mortar grade of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

14.1.4.3 When the sub-base materials consists of combination of materials mentioned in **Clause 13.1.2**, mixing shall be done mechanically by the mix-in-place method.

14.1.4.4 Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

14.1.4.5 Moisture content of loose material shall be checked in accordance with IS: 2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS: 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

14.1.4.6 Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm, the compaction shall be done with the help of vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 MN/m^2 or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

14.1.4.7 Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

14.1.4.8 Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

14.1.5 Surface Finish and Quality Control of Work

14.1.5.1 The surface finish of construction shall conform to the requirements of **Section 902** of MoST Specifications for Road and Bridge Works (IV Revision).

14.1.5.2 Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

14.1.6 Arrangement for Traffic

14.1.6.1 During the period of construction, the arrangement of traffic shall be done as per **Clause 1.9.2.**

14.1.7 Measurements for Payment

14.1.7.1 Granular sub-base shall be measured as finished work in position in cubic metres.

14.1.7.2 The protection of edges granular sub-base extended over the full formation as shown in the Drawing shall be considered incidental to the work of providing granular sub-base and as such not extra payment shall be made for the same.

14.1.8 Rate

14.1.8.1 The contract unit rate for granular sub-base shall be payment in full for carrying out the required operations including full compensation for:

1. Making arrangements for traffic to **Clause 1.9.2** except for initial treatment to verges, shoulders and construction of diversions;

2. Furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and life;
3. All labour; tools, equipment and incidentals to complete the work to the Specifications;
4. Carrying out the work in part widths of road where directed; and
5. Carrying our the required tests for quality control.

14.2 Water Bound Macadam Sub-Bas/Base

14.2.1 Scope

14.2.1.1 This work shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonding together with screening, binding material where necessary and water laid on a properly prepared subgrade/sub-base/base or existing pavement, as the case may be and finished in accordance with the requirements of these Specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the Engineer.

14.2.1.2 It is, however, not desirable to lay water bound macadam on an existing thin black topped surface without providing adequate drainage facility for water that would get accumulated at the interface of existing bituminous surface and water bound macadam.

14.2.2 Materials

14.2.2.1 Coarse aggregates

14.2.2.1.1 Coarse aggregates shall be either crushed or broken stone, crushed slag, overburnt (Jhama) brick aggregate or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Material other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel/shingle is used, not less then 90 per cent by weight of the gravel, shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 13-3. The type and size range of the aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water adsorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part 5).

14.2.2.2 Crushed or broken stone

14.2.2.2.1 The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

Table 13-3: Physical Requirements of Coarse Aggregates for Water Bound Macadam for Sub-Base/Base Courses

Sr.	Test	Test Method	Requirements
1.	* Los Angeles Abrasion Value or ** Aggregate Impact value	IS: 2386 (Part -4) IS: 2386 (Part-4) or IS: 5640**	40 per cent (Max.) 30 per cent (Max.)
2.	Combined Flakiness and Elongation Indices (total)***	IS: 2386 (Part-1)	30 per cent (Max.)

* *Aggregate may satisfy requirements of either of the two tests.*

** *Aggregates like brick metal, kankar, laterite etc. Which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS: 5640*

*** *The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone and crushed slag*

14.2.2.3 Crushed slag

14.2.2.3.1 Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other deleterious materials. The weight of crushed slag shall not be less than 11.2 kN per m^3 and the percentage of glossy material shall not be more than 20. It should also comply with the following requirements:

1. Chemical stability : To comply with requirements of appendix of BS:1047
2. Sulphur content : Maximum 2 per cent
3. Water absorption : Maximum 10 per cent

14.2.2.4 Overburnt (Jhama) brick aggregates

14.2.2.4.1 Jhama brick aggregates shall be made from overburnt bricks or brick bats and be free from dust and other objectionable and deleterious materials.

14.2.2.5 Grading requirement of coarse aggregates

14.2.2.5.1 The coarse aggregates shall conform to one of the Gradings given in Table 13-4 as specified, provided, however, the use of Grading No. 1 shall be restricted to sub-base courses only.

Table 13-4, Grading Requirements of Coarse Aggregates

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
1.	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2.	63 mm to 45 mm	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3.	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note: The compacted thickness for a layer with Grading 1 shall be 100 mm while for layer with other Gradings i.e., 2 & 3, it shall be 75 mm.

14.2.2.6 Screenings

14.2.2.6.1 Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (Other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 per cent.

14.2.2.6.2 Screenings shall conform to the grading set forth in Table 13-5. The consolidated details of quantity of screenings required for various grades of stone aggregates are given in Table 13-6. The table also gives the quantities of materials (loose) required for 10 m^2 for sub-base/base compacted thickness of 100/75 mm.

14.2.2.6.3 The use of screenings shall be omitted in the case of soft aggregates such as brick metal, kankar, laterites, etc. As they are likely to get crushed to a certain extent under rollers.

Table 13-5: Grading for Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by weight passing the IS Sieve
A	13.2 mm	13.2 mm 11.2 mm 5.6 mm 180 micron	100 95-100 15-35 0-10
B	11.2 mm	11.2 mm 5.6 mm 180 mm	100 90-100 15-35

Table 13-6: Approximate Quantities of Coarse Aggregates and Screenings Required for 100/75 mm Compacted Thickness of Water Bound Macadam (WBM) Sub-Base /Base Course for 10m^2 Area

Classific-ation	Size Range	Compacted thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable Type such as Moorum or Gravel	
				Grading Classific-ation & size	For. WBM Sub-base/ base course (Loose quantity)	Grading Classification & size	Loose Qty.
Grading 1	90 mm to 45 mm	100 mm	1.21 to 1.43 m^3	Type A 13.2 mm	0.27 to 0.30 m^3	Not uniform	0.30 to 0.32 m^3
Grading 2	63 mm to 45 mm	75 mm	0.91 to 1.07 m^3	Type A 13.2 mm	0.12 to 0.15 m^3	-do-	0.22 to 0.24 m^3
-do-	-do-	-do-	-do-	Type B 11.2 mm	0.20 to 0.22 m^3	-do-	-do-
Grading 3	53 mm to 22.4 mm	75 mm	-do-	-do-	0.18 to 0.21 m^3	-do-	-do-

14.2.2.7 Binding material

14.2.2.7.1 Binding material to be used for water bound macadam as a filler material meant for preventing ravelling, shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS: 2720 (Part-5).

14.2.2.7.2 The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 $m^3/10m^2$ and 0.08-0.10$m^3/10m^2$ for 100 mm compacted thickness.

14.2.2.7.3 The above mentioned quantities should be taken as a guide only, for estimation of quantities of construction etc.

14.2.2.7.4 Application of binding materials may not be necessary when the screenings used are of crushable type such as moorum or gravel.

14.2.3 Construction Operations

14.2.3.1 Preparation of base

14.2.3.1.1 The surface of the subgrade/sub-base/base to receive the water bound macadam course shall be prepared to the specified lines and crossfall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water. Any sub-base/base/surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (leveling course) to **Clause 13.4** of these Specifications.

14.2.3.2 As far as possible, laying water bound macadam course over an existing thick bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous weaning course where water bound macadam is proposed to be laid over it. However, where the intensity of rain is low and the interface drainage facility is efficient, water bound macadam can be laid over the existing thin bituminous surface by cutting 50 mm x 50 mm furrows at an angle of 45 degrees to the centre line of the pavement at one m intervals in the existing road. The directions and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base course beneath the existing thin bituminous surface.

14.2.3.3 Inverted choke

14.2.3.3.1 If water bound macadam is to be laid directly over the subgrade, without any other intervening pavement course, a 25 mm course of screenings (Grading B) or coarse sand shall be spread on the prepared subgrade before application of the aggregates is taken up. In case of a fine sand or silty or clayey subgrade, it is advisable to lay 100 mm insulating layer of screening or coarse sand on top of fine grained soil, the gradation of which will depend upon whether it is intended to act as a drainage layer as well. As a preferred alternative to inverted choke, appropriate geosynthetics performing functions of separation and drainage may be used over the prepared subgrade as directed by the Engineer. **Section 700** of MoST specifications for Road and Bridge Works (IV Revision) shall be applicable for use of Geosynthetics.

14.2.3.4 Spreading coarse aggregates

14.2.3.4.1 The coarse aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/base to proper profile by using templates places across the road about 6m apart, in such quantities that the thickness of each compacted layer is not more than 100 mm for Grading 1 and 75 mm for Grading 2 and 3, as specified in **Clause 13.2.2.5**. Wherever possible, approved mechanical devices such as aggregate spreader shall be used to spread the aggregates uniformly so as to minimise the need for manual rectification afterwards. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any approved means so as to achieve the specified results.

14.2.3.4.2 The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be uniform gradation with no pockets of fine material.

14.2.3.4.3 The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved Drawings.

14.2.3.4.4 The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operations.

14.2.3.5 Rolling

14.2.3.5.1 Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

14.2.3.5.2 Except on superelevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

14.2.3.5.3 Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, where screenings are not to be applied, as in the case of crushed aggregates like brick metal, laterite and kankar, compaction shall be continued until the aggregates are thoroughly keyed. During rolling, slight sprinkling of water may be done, If necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or subbase course.

14.2.3.5.4 The rolled surface shall be checked transversely and longitudinally, with templates and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired crossfall (camber) and grade. In no case shall the use of screenings be permitted to make up depressions.

14.2.3.5.5 Material which gets crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates.

14.2.3.5.6 It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses as per **Clause13.9.4.1.**

14.2.3.6 Application of screenings

14.2.3.6.1 After the coarse aggregate has been rolled to **Clause 13.2.3.5**, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screening are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

14.2.3.6.2 The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

14.2.3.6.3 The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

14.2.3.7 Sprinkling of water and grouting

14.2.3.7.1 After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

14.2.3.7.2 In case of lime treated soil sub-base, construction of water bound macadam on top of it can cause excessive water to flow down to the lime treated sub-base before it has picked up enough strength (is still “green”) and thus cause damage to the sub-base layer. The laying of water bound macadam layer in such cases shall be done after the sub-base attains adequate strength, as directed by the Engineer.

14.2.3.8 Application of binding material

14.2.3.8.1 After the application of screenings in accordance with **Clauses 13.2.3.6 and 13.2.3.7** the binding material where it is required to be used (**Clause 13.2.2.7**) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

14.2.3.9 Setting and drying

14.2.3.9.1 After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

14.2.3.9.2 The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.

14.2.4 Surface Finish and Quality Control of work

14.2.4.1 The surface finish of construction shall conform to the requirements of **Section 902** of MoST Specifications for Road and Bridge Works (IV Revision).

14.2.4.2 Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

14.2.4.3 The water bound macadam work shall not be carried out when the atmospheric temperature is less than 0 degree centigrade in the shade.

14.2.4.4 Reconstruction of defective macadam

14.2.4.4.1 The finished surface of water bound macadam shall conform to the tolerance of surface regularity as prescribed in **Section 902** of MoST Specifications for Road and Bridge Works (IV Revision). However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to subgrade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and recompacted. In no case shall depressions be filled up with screenings or binding material.

14.2.5 Arrangement for Traffic

14.2.5.1 During the period of construction, the arrangement of traffic shall be done as per **Clause 1.9.2.**

14.2.6 Measurements for payment

14.2.6.1 Water bound macadam shall be measured as finished work in position in cubic metres.

14.2.7 Rate

14.2.7.1 The Contract unit rate for water bound macadam sub-base/base course shall be payable in full for carrying out the required operations including full compensation for all components listed in **Clause 13.1.8.1** (1) to (5) including arrangement of water used in the work as approved by the Engineer.

14.3 Wet Mix Macadam Sub-Base/Base

14.3.1 Scope

14.3.1.1 This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on prepared subgrade/sub-base/base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved Drawings or as directed by the Engineer.

14.3.1.2 The thickness of a single compacted Wet Mix Macadam Layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be increased to 200 mm upon approval of the Engineer.

14.3.2 Materials

14.3.2.1 Aggregates

14.3.2.1.1 Physical requirements

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less then 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 13-7 below.

Table 13-7 Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-Base/Base Courses

Sr	Test	Test Method	Requirements
1.	*Los Angeles Abrasion value or * Aggregate Impact value	IS: 2386 (Part-4) IS: 2386 (Part-4) or IS: 5640	40 per cent (Max.) 30 per cent (Max.)
2.	Combined Flakiness and Elongation Indices (Total)	IS: 2386 (Part-1)	30 per cent (Max.)

- Aggregate may satisfy requirements of either of the two tests.
- To determine this combined proportion, the flaky stone from a representative sample should first separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from remaining (Non-Flaky) stone metal. Elongation index is weight of elongation particles divided by total number of flaky particles. The value of flakiness index and elongation index so found are added up.

If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part-5).

14.3.2.1.2 Grading requirements

The aggregates shall conform to the grading given in Table 13-8.

Table 13-8. Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Per cent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

Materials finer than 425 micron shall have plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

14.3.3 Construction Operations

14.3.3.1 Preparation of base

14.3.3.1.1 Clause 13.2.3.1 shall apply.

14.3.3.2 Provision of lateral confinement of aggregates

14.3.3.2.1 While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in **Clause 13.9.4.1**.

14.3.3.3 Preparation of mix

14.3.3.3.1 Wet mix macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

14.3.3.3.2 Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size while adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

14.3.3.4 Spreading of mix

14.3.3.4.1 Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

14.3.3.4.2 The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

14.3.3.4.3 The paver finisher shall be self-propelled, having the following features:

1. Loading hoppers and suitable distribution mechanism
2. The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.
3. The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

14.3.3.4.4 The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

14.3.3.5 Compaction

14.3.3.5.1 After the mix has been laid for the required thickness, grade and crossfall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km/h.

14.3.3.5.2 In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least

one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

14.3.3.5.3 In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

14.3.3.5.4 Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

14.3.3.5.5 Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

14.3.3.5.6 Rolling should not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

14.3.3.5.7 Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8).

14.3.3.5.8 After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

14.3.3.6 Setting and drying

14.3.3.6.1 After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

14.3.4 Opening to Traffic

14.3.4.1.1 Preferably no vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

14.3.5 Surface Finish and Quality Control of Work

14.3.5.1 Surface evenness

14.3.5.1.1 The surface finish of construction shall conform to the requirements of **Section 902** of MoST Specifications for Road and Bridge Works (IV Revision).

14.3.5.2 Quality control

14.3.5.2.1 Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

14.3.6 Rectification of Surface Irregularity

14.3.6.1 Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to subgrade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, reshaped with added premixed material or removed and replaced with fresh premixed

material as applicable and recompacted in accordance with **Clause 13.3.3**. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

14.3.7 Arrangement for Traffic

14.3.7.1 During the period of construction, arrangement of traffic shall be done as per **Clause 1.9.2**.

14.3.8 Measurements for Payment

14.3.8.1 Wet mix macadam shall be measured as finished work in position in cubic metres.

14.3.9 Rates

14.3.9.1 The contract unit rate for wet mix macadam shall be payment in full for carrying out the required operations including full compensation for all components listed in **Clause 13.1.8.1**.

14.4 Preparation of Surface [Base and Surface Courses (Bituminous)]

14.4.1 Scope

14.4.1.1 This work shall consist of preparing an existing granular or black-topped surface bituminous course. The work shall be performed on such widths and lengths as shown on Drawings or as instructed by the Engineer. The existing surface shall be firm and clean and treated with Prime or Tack coat as shown on the drawings as otherwise stated in the contract.

14.4.2 Materials

14.4.2.1 For scarifying and re-laying the granular surface

14.4.2.1.1 The materials used shall be coarse aggregates salvaged from scarification of the existing granular base course supplemented by fresh coarse aggregates and screenings so that aggregates and screenings thus supplemented correspond to **Clause 13.2:** Water bound macadam or **Clause 13.3**: Wet mix macadam, as the case may be.

14.4.2.2 For patching potholes and sealing cracks

14.4.2.2.1 Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with **Clause 3004.2** and **3004.3** of MoST Specifications for Road and Bridge Works (IV Revision).

14.4.2.3 For profile corrective course

14.4.2.3.1 A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the drawings or as indicated in the contract documents. The profile corrective course shall be laid to tolerances and densities as specified for wearing course if a single layer, or base course, if it is to be covered with wearing course layer.

14.4.2.4 Profile corrective course and its application

14.4.2.4.1 The type of material for profile corrective course shall be as shown on the Drawing or as directed by the Engineer. Where it is to be laid as part of the overlay/strengthening course, the profile corrective course material shall be of the same Specification as that of the overlay/strengthening course. However, if provided as a separate layer, it shall be of the same Specifications and details given in the contract drawings.

(1) Any high spot in the existing surface shall be removed by a milling machine or other approved method, and all loose material shall be removed to the satisfaction of the Engineer.

(2) Where the maximum thickness of profile corrective course will be not more than 40 mm, the profile corrective course shall be constructed as an integral part of the over lay layer, adopting such construction procedures and using such equipment as approved by the Engineer, to lay the specified type of material, to thickness and tolerance as specified, for the course, to be provided.

14.4.3 Construction Operations

14.4.3.1 Preparing existing granular surface

14.4.3.1.1 Where the existing surface is granular, all loose and disintegrated materials shall be removed and the surface lightly watered if the profile corrective course to be provided as a separate layer is also granular. Where the profile corrective course of bituminous material is to be laid over the latter shall, after removal of all loose material, be primed in accordance with **Clause 13.19**.

14.4.3.1.2 The surface finish of all granular layers on which bituminous work are to be placed, shall, unless otherwise specifically instructed by the Engineer, be free from dust. All such layers must be capable of being swept, after the removal of any non-integral loose material, by means of mechanical broom, with out shedding significant quantities of material and dust removed by air jet, washing, or other means approved by the Engineer.

14.4.3.1.3 After cleaning the surface shall be correct to line and level, with tolerances specified for base courses.

14.4.3.2 Scarifying existing bituminous surface

14.4.3.2.1 Where specified or shown on drawings, the existing bituminous layer in the specified width shall be removed with care without causing undue disturbance to the underlying layer by suitable method approved by the Engineer. After removal, all loose and disintegrated material, the underlying layer which might have been disturbed should be suitably reworked and compacted to line and level. After supplementing the base material as necessary with suitable fresh stone, the compacted finished surface shall be primed in accordance with **Clause 13.19** on the process of removal shall, before laying of the overlay course, be reset properly by spreading/hand packing of aggregates and compacting with suitable roller/heavy hand rammers/approved mechanical temper so that the level of he top surface of such scarified area shall be even and properly graded with respect to adjoining surface. Where applicable, the granular surface, after removal of the existing bituminous layer, shall be primed as per **Clause 13.19**. Reusable materials shall be stacked as directed by the Engineer with all lift and lead of 1000m of their origin.

14.4.3.3 Patching of potholes and sealing of cracks

14.4.3.3.1 Where the existing surface to be overlaid is bituminous, any existing pot-holes and cracks shall be repaired and sealed in accordance with **Clauses 3004.2 and 3004.3** of MoST Specifications for Road and Bridge Works (IV Revision) or as directed by Engineer.

14.4.3.4 Laying the profile corrective course

14.4.3.4.1 Laying on granular base: After preparing the surface in accordance with **Clause 13.4.3.1** and **13.4.3.2** the profile corrective course shall be laid using material as described in **Clause 13.4.2.3** and **13.4.2.4** or as otherwise described in the contract and compacted to the the requirement of particular specification.

14.4.3.4.2 Laying on existing bituminous surface: The existing bituminous surface shall be prepare in accordance with **Clause 13.4.3.3** and after applying tack coat conforming to **Clause 13.5**, the bituminous profile corrective course shall be laid and compacted to the requirements of the particular Specifications.

14.4.3.4.3 Correction of local depressions: Where local sags or depressions occur in the existing pavement, a specific filling operation shall be instructed by the Engineer, which should be laid in accordance with **Figure 500-1** 0f MoST Specifications for Road and Bridge Works (IV Revision) Normally the maximum layer thickness at any point should not exceed 100mm. In placing multiple lifts, they should be arranged according to method as illustrated.

For correcting the camber or super elevation of the existing carriageway, the method shown in **Figure 500-2** 0f MoST Specifications for Road and Bridge Works (IV Revision) shall be adopted depending on the profile of the existing carriageway.

14.4.3.4.4 Covering the profile corrective course

Profile Corrective Course particularly shall be so planned that layer ishall be covered by the designed base / wearing course at the earliest opportunity.

14.4.4 Surface Finish and Quality Control of work

14.4.4.1 The relevant provisions of **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.4.5 Arrangement for Traffic

14.4.5.1 During the construction operations, arrangement of traffic shall be done to **Clause 1.9.2**.

14.4.6 Environmental Protection The provision of **Clause 111 and the provision of Annexure A to Clause 501** of MoST Specifications for Road and Bridge works (IV Revision) shall apply.

14.4.7 Measurements for Payment

14.4.7.1 Pot holes and cracks

14.4.7.1.1 The work of filling potholes shall be measured separately and be paid in square meters.

14.4.7.1.2 The work of filling cracks by applying fog spray or emulsion slurry seal shall be measured in square meter, for the area covered by spray.

14.4.7.1.3 The work of filling cracks larger than 3 mm in width shall be measured and paid on a linear meter basis.

14.4.7.2 Scarifying

14.4.7.2.1 Scarifying the existing bituminous surface shall be measured on a square meter basis.

14.4.7.3 Profile Corrective Course

14.4.7.3.1 Profile corrective course shall be measured as the volume instructed and compacted in position and measured in cubic meter or in tonnage as stipulated in the contract. The volume shall be calculated by plotting the exact profile of the profile corrective course as required, and laid, superimposed on the existing pavement profile. Cross-sectional areas of the profile corrective course shall be measured at intervals as used in the design, or as determined by the Engineer, and the volume shall be calculated using the method of end areas.

14.4.7.4 Prime Coat Prime Coat is to be measured and paid for on a square meter basis.

14.4.7.5 Tack Coat this is to be a provisional: item which may be used in-part or not at all, at the Engineer's directions, and is to be measured and paid for, if used, on a square meter basis.

14.4.8 Rates

14.4.8.1 Rate for scarifying: The contract unit rate for scarifying existing bituminous surfaces, including repairing/ reworking disturbed underlying layers and stacking reusable / unusable material shall include for but not necessarily be limited to, the cost of all labour, supply of materials needed for repair / reworking, hire charges of tools and plants, and transportation of scarified materials with in 1000 m of their origin.

14.4.8.2 Rate for premixed bituminous material: The contractor's unit rate for premixed bituminous material shall be payment in full for carrying out the required operations including full compensation for, but not necessarily limited to

(i) Making arrangements for traffic to **Clause 1.9.2** except for initial treatment to verge shoulders and construction of diversions
(ii) Preparation of the surface to receive the material.
(iii) Providing all materials to be incorporated in the work including arrangements in stock yards, all royalties, fees, rents where necessary and all leads and lifts.
(iv) Mixing, transport, laying and compacting the mix, as specified.
(v) All labour, tools, equipment, plant including installation hot mix plant, power supply units, and all machinery, incidental to complete the work to these specifications
(vi) Carrying out the work in part widths of the road where directed
(vii) Carrying out all tests for control of quality, and
(viii) The rate shall cover the provision of bitumen at the rate specified in the contract, with the provision that the variation in actual percentage of bitumen used will be assessed and the payment adjusted accordingly.
(ix) The rates for premixed material are to include for all wastage in cutting joints etc.
(x) The rates are to include for all necessary testing, mix design, transporting and testing of samples, and cores. If there is not a project specific laboratory, the contractor must arrange to carry out all necessary testing at an out side laboratory, approved by the Engineer, and all costs incurred are deemed to be included in the rate quoted for the material.
(xi) The cost of all plant and laying trials as specified to prove the mixing and laying methods is deemed to be included in the contractor's rate for the material.

14.4.8.3 Rate for pot holes and crack sealing

14.4.8.3.1 The rate for patching potholes shall include for breaking out, trimming edges, cleaning out, painting edges and bottom with bitumen, and filling and compacting the excavation with specified material. The rate should be inclusive of all plants, tool, labour and material, transport and disposal of surplus material.

14.4.8.3.2 The contract unit rate for sealing cracks by applying fog spray shall be inclusive of providing all materials, tools, labour plant and carrying out the work.. The contract unit rate for sealing cracks by providing emulsion slurry seal shall be set forth in **Clause 516.9** of MoST Specifications for Road and Bridge Works (IV Revision)

14.4.8.3.3 The contract unit rate for crack sealing 3 mm to 6 mm cracks with straight run or other specified bitumen, shall be based on either a square meter basis or linear meter of cracks as measured, as stipulated by the contract

14.4.8.3.4 The contract unit rate for cracks between 6mm to 15 mm is to be measured on a linear meter basis, and the rate is to include for materials, tools, plant, labour and transport

14.5 Tack Coat

14.5.1 Scope

14.5.1.1 This work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing bituminous road surface preparatory to superimposition of a bituminous mix, when specified in the contract or instructed by the Engineer.

14.5.2 Materials

14.5.2.1 Binder

14.5.2.1.1 The binder used for tack coat shall be a bituminous emulsion complying with **IS 8887** of a type and grade as specified in the contract or as directed by the Engineer. The use of cut back bitumen as per **IS 217** shall be restricted only for sites at sub-zero temperature or for emergency applications as directed by the Engineer.

14.5.3 Weather and Seasonal Limitations

14.5.3.1 Bituminous material shall not be applied to a wet surface or during a dust storm or when the weather is foggy, rainy, or windy or when the temperature in the shade is less than 10 degree C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cut back bitumen, the surface shall be dry.

14.5.4 Construction

14.5.4.1 Equipment: The tack coat distributor shall be self propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas in accessible to the distributor, or in narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer

14.5.4.2 Preparation of base

14.5.4.2.1 The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and and any extraneous material, and be other wise prepared in accordance with the requirement of **Clause 13.4 and Clause 902** of MoST Specifications for Road and Bridge Works (IV Revision) as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

14.5.4.3 Application of tack coat

The application of tack coat shall be at the rate specified in the contract, and shall be applied uniformly; if rate of application of tack coat is not specified in the contract then it shall be at the rate specified in **Table 13-9**

Table 13-9 Rate of Application of Tack Coat

Sr.	Type Surface	Quantity of Liquid Bituminous Material in kg Per sqm area
1.	Normal bituminous surfaces	0.20 to 0.25
2.	Dry and hungry bituminous surfaces	0.25 to 0.30
3.	Granular surfaces treated with primer	0.25 to 0.30
4.	Non bituminous surfaces	
(i)	Granular base (not primed)	0.35 to 0.40
(ii)	Cement concrete pavement	0.30 to 0.35

*The normal range of spraying temperature for a bituminous emulsion shall be 20 degree C to 70 degree C. and for a cutback,50 to 80 degree C if RC-70/MC-70 is used.Where a geosynthetic is proposed for use, provisions of **clauses 703.3.2 and 703.3.4** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply. The method of application of the will depend on the type of equipment used, size of nozzles, pressure at the spray bar,,and speed of forward movement. The contractor shall demonstrate at aspraying trial, that the equipment and method to be used is capable of producing a uniform spray, with in the tolerances specified.*

Where the material to receive an over lay is a freshly laid bituminous layer, that has not been subjected to traffic, or contaminated by dust, a tack coat is not mandatory where the overlay is completed with in two days.

14.5.4.4 Curing of tack coat: The tack coat shall be left to cure until all the volatiles have been evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

14.5.5 Quality control of Work

14.5.5.1 For control of the quantity of material supplied and the works carried out, the relevant provision of **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision). Shall apply.

14.5.6 Arrangements for Traffic

14.5.6.1 During the period of construction, the arrangement of traffic shall be done to **Clause 1.9.2**.

14.5.7 Measurement for Payment

14.5.7.1 Tack coat shall be measured in terms of surface area of application in square metres.

14.5.8 Rate

14.5.8.1 The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in **Clause 13.1.8.1** (1) to (5) as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat at 0.2 kg.

14.6 Dense Graded Bituminous Macadam

14.6.1 Scope

14.6.1.1 This clause specifies the construction of Dense Graded Bitumen Macadam, (DBM), for use mainly, but not exclusively, base, binder and profile corrective course. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub base. The thickness of a single layer shall be 50mm to 100 mm.

14.6.2 Materials

14.6.2.1 Bitumen

14.6.2.1.1 The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specification for “Paving Bitumen” IS 73, and of the penetration indicated in Table 13-11 for dense Bitumen or this Bitumen as modified by one of the methods specified in **Clause 521** of MoST Specifications for Road and Bridge Works (IV Revision) or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in the Manual for Construction and Supervision of Bituminous Works.

14.6.2.2 Coarse aggregates

14.6.2.2.1 The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. They shall be clean, hard, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti stripping agent, as per the manufacturer's recommendations, without additional payment. Before approval of source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in table 13.10 for dense bituminous macadam.

14.6.2.2.2 Where the crushed gravel is proposed for use as aggregates, not less than 90 % by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces.

14.6.2.2.3 The plasticity index of the fraction passing the 425 micron sieve shall not exceed 4.

14.6.2.3 Fine Aggregates

14.6.2.3.1 Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two passing the 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

14.6.2.3.2 The fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS 2720 (Part 37).

14.6.2.3.3 The plasticity index of the fraction passing the 0.425mm sieve shall not exceed 4. when tested in accordance with IS 2720 (Part 5)

Table 13-10 Physical Requirements for Coarse Aggregates for Dense Graded Bituminous Macadam

Property	Test	Specifications
Cleanliness (dust)	Grain size Analysis[1]	Max. 5% passing 0.075mm sieve
Particle Shape	Flakiness and elongation Index Combined[2]	Max. 30 %
Strength	Los Angeles Abrasion Value[3] Aggregate Impact Value[4]	Max. 35 % Max. 27 %
Durability	Soundness[5] Sodium Sulphate Magnesium Sulphate	 Max. 12 % Max. 18 %
Water Absorption	Water Absorption[6]	Max. 2%
Stripping	Coating and stripping of Bitumen Aggregate Mixture[7]	Minimum retained coating 95 %
Water Sensitivity**	Retained Tensile Strength [8]	Minimum 80 %

Notes 1. IS 2386 Part 1 5. IS 2386 Part 5
2. IS 2386 Part 1 6. IS 2386 Part 3
(the elongation test to be done only on non-flaky aggregate in the sample)
3. IS 2386 Part 4* 7. IS 6241
4. IS 2386 Part 4* 8. AASHTO T 283**
* Aggregates may satisfy requirement of either of two tests.
** The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95 %

14.6.2.4 Filler

14.6.2.4.1 Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer.

14.6.2.4.2 The filler shall be graded within the limits indicated in Table 13.10A:

Table 13-10A Grading Requirements for Mineral Filler

IS Sieve (mm)	Cumulative Per cent passing by weight of total aggregate
0.6	100
0.3	95-100
0.075	85-100

14.6.2.4.3 The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent of weight of total aggregate shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of water sensitivity test in Table 13.10, then 2 percent by total weight of aggregate, of hydrated lime shall be added without additional cost.

14.6.2.5 Aggregate grading and binder content

14.6.2.5.1 When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combind grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within limits shown in Table 13.11, for dense bituminous macadam grading 1 or 2 as specified in the contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

Table 13-11. Composition of Dense Graded Bituminous Macadam Pavement Layers

Grading	**1**	**2**
Nominal aggregate size	**40 mm**	**25 mm**
Layer Thickness	**80-100 mm**	**50-75 mm**
IS Sieve[1] (mm)	**Cumulative % by weight of total aggregate passing**	
45	**100**	
37.5	95-100	100
26.5	63.93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7-21
0.15	-	-
0.075	2-8	2-8
Bitumen content % by mass of total mix[2]	Min 4.0	Min 4.5
Bitumen grade (pen)	65 or 90	65 or 90

Note: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.

14.6.3 Mixture Design

14.6.3.1 Requirement for the mixture

14.6.3.1.1 Apart from conformity with grading and quality requirements of individual ingredients, the mixture shall meet the requirements set out in Table 13-12.

Table 13-12 Requirements for Dense Graded Bituminous Macadam

Minimum stability (kN at 60^{o}C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3-6
Per cent voids in mineral aggregate (VMA)	See table 13-12A below
Per cent filled with bitumen (VFB)	65-75

14.6.3.1.2 The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 13-12A.

Table 13-12A: Minimum Per Cent Voids in Mineral Aggregate (VMA)

Nominal Maximum Particle Size[1] (mm)	Minimum VMA, Per cent Related to Design Air Voids, Per cent[2]		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Note: 1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent
2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

14.6.3.2 Binder content

14.6.3.2.1 The binder content shall be optimized to achieve the requirements of the mixture set out in Table 13-12 and the traffic volume specifed in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer.

14.6.3.2.2 Where 40 mm dense bituminous macadam mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures; particularly the minimum stability values in Table 13-12 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

14.6.3.3 Job mix formula

14.6.3.3.1 The Contractor shall inform the Engineer in writing, at least 20 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details:

1. Source and location of all materials
2. Proportions of all materials expressed as follows where each is applicable:
   - Binder type, and percentage by weight of total mixture;
   - Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
3. A single definite percentage passing each sieve for the mixed aggregate;
4. The individual gradings of the individual aggregate fracations, and the proportions of the each in the combined grading;
5. The results of tests enumerated in Table 13-12 as obtained by the Contractor;
6. Where the mixture is a batch mixture, the individual weight of each type of aggregate and binder per batch;
7. Test results of physical characteristics of aggregates to be used;
8. Mixing temperature and compacting temperature.

14.6.3.3.2 While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

14.6.3.3.3 Approval of the job mix formula shall be based on independent testing by the Engineer for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

14.6.3.3.4 The approved job mix formula shall remain effective unless and until a revised job mix formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded to the Engineer fot approval before the placing of the material.

14.6.3.4 Plant Triral - Permissible variation in job mix formula

14.6.3.4.1 Once the laboratory job mix formula is approved, the contractor shall carry out plant trials at the mixture to establish that the plant can be setup to produce the uniform mix conforming to the approved job mix formula. The permissible various of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 13-13. These variations are intended to apply to individual specimens taken for quality control tests in accordance with **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

Table 13-13 Permissible Variations from the Job Mix Formula

Description	Permissible variation	
	Base/ binder course	Wearing course
Aggregate passing 19 mm sieve or larger	± 8 %	± 7 %
Aggregate passing 13.2 mm, 9.5 mm	± 7 %	± 6 %
Aggregate passing 4.75 mm	± 6 %	± 5 %
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5 %	± 4 %
Aggregate passing 0.3 m, 0.15 mm	± 4 %	± 3 %
Aggregate passing 0.075 mm	± 2 %	± 1.5 %
Binder Content	± 0.3 %	± 0.3 %
Mixing temperature	± 10^{o} C	± 10^{o} C

14.6.3.4.2 Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

14.6.3.5 Laying Trials

14.6.3.5.1 Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid, and compacted all in accordance with **Clause 501** of MoST specification for Road & Bridge Works (IV Revision). The laying trial shall be carried out on a suitable area which is mot to form part of the works, unless specifically approved in writing by the Engineer. The are of the laying trials shall be a minimum of 100 square meter of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

14.6.3.5.2 The Contractor shall previously inform the Engineer of the proposed method of laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layers shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

14.6.3.5.3 Once the laying have been approved, the same palnt and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

14.6.4 Construction Operations

14.6.4.1 Weather and Seasonal Limitations

14.6.4.1.1 The provisions of **Clause 501.5.1** of MoST specification for Road & Bridge Works (IV Revision) shall apply.

14.6.4.2 Preparation of base

14.6.4.2.1 The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with **Clauses 501 and 902** of MoST specification for Road & Bridge Works (IV Revision) as appropriate, or as directed by the Enginner. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot access, other approved method shall be used as directed by the Engineer.

14.6.4.3 Geosynthetics

14.6.4.3.1 Where Geosynthetics are specified in the Contract this shall be in accordance with requirements stated in **Clause 703** of MoST specification for Road & Bridge Works (IV Revision).

14.6.4.4 Stress absorbing layer

14.6.4.4.1 Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of **Clause 522** of MoST specification for Road & Bridge Works (IV Revision).

14.6.4.5 Prime coat

14.6.4.5.1 Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of **Clause 13.19**, or as directed by the Engineer.

14.6.4.6 Tack coat

14.6.4.6.1 Where the material on which the dense bituminous macadam is to be placed is bitumen bound surface, a tack coat shall be applied, as specified, in accordance with the provisions of **Clause 13.5**, or as directed by the Engineer.

14.6.4.7 Mixing and Transportation of the mixture

14.6.4.7.1 The provisions as specified in **Clause 501.3 and 501.1** of MoST specification for Road & Bridge Works (IV Revision) shall apply.

14.6.4.8 Spreading

14.6.4.8.1 The provisions of **Clauses 501.5.3 and 501.5.4** of MoST specification for Road & Bridge Works (IV Revision) shall apply.

14.6.4.9 Rolling

14.6.4.9.1 The general provsions of **Clauses 501.6 and 501.7** of MoST specification for Road & Bridge Works (IV Revision) shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same metod, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

14.6.5 Opening to Traffic

14.6.5.1 The newly laid surface shall not be open to traffic for at least 24 hrs after laying and completion of compaction, without the express approval of the Engineer in writing.

14.6.6 Surface Finish and Quality Control of Work

14.6.6.1 The surface finish of the completed construction shall conform to the requirements of **Clause 902** of MoST Specifications for Road and Bridge Works (IV Revision). All materials and workmanship shall comply with the provisions set out in **Section 900** of MoST specification for Road & Bridge Works (IV Revision).

14.6.7 Arrangements for Traffic

14.6.7.1 During the period of construction, arrangements for the traffic shall be made in accordance with the provisions of **Clause 1.9.2**.

14.6.8 Measurements for payment

14.6.8.1 Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tons or by the square meter at a specified thickness as detailed on the Contract drawings, or documents, or as directed by the Engineer.

14.6.9 Rate

14.6.9.1 The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out the required operations as specified, and shall include, but not necessarily limited to all components listed in **Clause 13.4.8.2 (i) to (xi)**. The rate shall include the provision of bitumen, at 4.25 per cent by weight of the total mixture.

The variance in actual percentage of bitumen used will be assessed and the payment adjusted, up or down, accordingly.

14.7 Bituminous Concrete

14.7.1 Scope

14.7.1.1 This clause specifies the construction Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layers of bituminous concrete on a previously prepared bituminous bound surface. A single layers shall be 25mm to 100mm in thickness.

14.7.2 Materials

14.7.2.1 Bitumen

14.7.2.1.1 The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 13-14, for bituminous concrete, or this bitumen as modified by one of the methods specified in **Clause 521** of MoST specification for Road & Bridge Works (IV Revision), or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bitumenous Works.

14.7.2.2 Coarse aggregates

14.7.2.2.1 The coarse aggregates shall be generally as specified in **Clause 13.6.2.2** shall apply, except that the aggregates shall satisfy the physical requirements of Tanle 13.14A.

14.7.2.3 Fine aggregates

14.7.2.3.1 The fine aggregates shall be all as specified in **Clause 13.6.2.3**.

14.7.2.4 Filler

14.7.2.4.1 Filler shall be generally as specified in **Clause 13.6.2.4.** Where the aggregates fail to meet the requirements of the water sensitivity test in Table 13.14A then 2 percent by total weight of aggregate, of hydrate lime shall be added without additional cost.

14.7.2.5 Aggregates grading and binder content

14.7.2.5.1 When tested in accordance with IS: 2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 13-14 for grading 1 or 2 as specifed in the Contract.

14.7.3 Mixture Design

14.7.3.1 Requirement for the mixture

14.7.3.1.1 Apart from conformity with the grading and quality requirements of individual ingredients, the mixture shall meet the requirements set out in Table 13-15.

14.7.3.1.2 The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 13-12A

14.7.3.2 Binder content

14.7.3.2.1 The binder content shall be optimized to achieve the requirements of the mix set out in Table 13-15 and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5mm sieve and retained on the 22.4mm sieve, where approved by the Engineer.

14.7.3.3 Job mix formula

14.7.3.3.1 The procedure for formulating the job mix formula shall be generally as specified in **Clause 13.6.3.3** and the results of the tests enumerated in Table 13-15.

Table 13-14A: Physical Requirements for Coarse Aggregates for Bituminous Concrete Pavement Layer

Property	Test	Specifications
Cleanliness (dust)	Grain size Analysis[1]	Max. 5% passing 0.075 mm sieve
Particle Shape	Flakiness and elongation Index	Max. 30 % (Combined)[2]
Strength*	Los Angeles Abrasion Value[3] Aggregate Impact Value[4]	Max. 30 % Max. 24 %
Polishing	Polished Stone Value[5]	Min 55
Durability	Soundness[6] Sodium Sulphate Magnesium Sulphate	 Max. 12 % Max. 18 %
Water Absorption	Water Absorption[7]	Max. 2%
Stripping	Coating and stripping of Bitumen Aggregate Mixtures[9]	Minimum retained coating 95 %
Water Sensitivity**	Retained Tensile Strength [8]	Minimum 80 %

Notes

1. IS 2386 Part 1
2. IS 2386 Part 1
(the elongation test to be done only on non-flaky aggregate in the sample)
3. IS 2386 Part 4*
4. IS 2386 Part 4*
5. BS:812 Part 114
6. IS 2386 Part 5
7. IS 2386 Part 3
8. AASHTO T 283**
9. IS 6241

* Aggregates may satisfy requirement of either of two tests.

** The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95 %

14.7.3.4 Plant trials - Permissible variations from the job mix formula

14.7.3.4.1 The requirements for plant trials shall be all as specified in **Clause 13.6.3.4**, and permissible limits for variation as shown in Table 13.13.

14.7.3.5 Laying trials

14.7.3.5.1 The requirements for laying trials shall be all as specified in **Clause 13.6.3.5.**

14.7.4 Construction Operations

14.7.4.1 Weather and seasonal limitations

14.7.4.1.1 The provisions of **Clause 501.5.1** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

Table 13-14: Composition of Bituminous Concrete Pavement Layers

Grading	**1**	**2**
Nominal aggregate size	**19 mm**	**13 mm**
Layer Thickness	**50-65 mm**	**30-45 mm**
IS Sieve[1] (mm)	**Cumulative % by weight of total aggregate passing**	
45		
37.5		
26.5	100	
19	79-100	100
13.2	59-79	79-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix[2]	5.0-6.0	5.0-7.0
Bitumen grade (pen)	65	65

Note: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.

Table 13-15 Requirements for Bituminous Pavement Layer

Minimum stability (kN at 60^{o}C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3-6
Per cent voids in mineral aggregate (VMA)	See table 13-12A
Per cent filled with bitumen (VFB)	65-75
Loss of stability on immersion in water at 60^{o}C (ASTM D 1075)	Min. 75 per cent retained strength

14.7.4.2 Preparation of base

14.7.4.2.1 The surface on which the bituminous concrete is to be laid shall be prepared in accordance with **Clause 501 and 902** of MoST Specifications for Road and Bridge Works (IV Revision) as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In location where mechanical broom cannot access, other approved method shall be used as directed by Engineer.

14.7.4.3 Geosynthetics

14.7.4.3.1 Where Geosyntheticsare specified in the contract this shall be in accordance with the requirements stated in **Clause 703** of MoST Specifications for Road and Bridge Works (IV Revision).

14.7.4.4 Stress absorbing layer

14.7.4.4.1 Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements stated in **Clause 522** of MoST Specifications for Road and Bridge Works (IV Revision).

14.7.4.5 Tack coat

14.7.4.5.1 Where specified in the Contract, or otherwise required by the Enginner, a A tack coat shall be applied in accordance with the requirements of **Clause 13.5**

14.7.4.6 Mixing and transportation of the mixture

14.7.4.6.1 The provisions as specified in **Clause 501.3 and 501.4** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.7.4.7 Spreading

14.7.4.7.1 The general provisions of **Clause 501.5.3 and 501.5.4** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.7.4.8 Rolling

14.7.4.8.1 The general provisions of **Clause 501.6 and 501.7** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply, as modified by the approved laying trials.

14.7.4.9 Opening to Traffic

14.7.4.9.1 The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the Engineer in writing.

14.7.4.10 Surface Finish and Quality Control of Work

14.7.4.10.1 The surface finish of the completed construction shall conform to the requirements of **Clause 902** of MoST Specifications for Road and Bridge Works (IV Revision). All materials and workmanship shall comply with the provisions set out in Section 9000 of this Specification.

14.7.4.11 Arrangements for Traffic

14.7.4.11.1 During the period of construction, arrangement of traffic shall be made in accordance with the provisions of **Clause 1.9.2**.

14.7.5 Measurements for Payment

14.7.5.1 The measurement shall be all as specified in **Clause 507.8** of MoST Specifications for Road and Bridge Works (IV Revision).

14.7.6 Rate

14.7.6.1 The contract unit rate shall be all as specified in **Clause 13.6.9**, except that the rate shall include the provision of bitumen at 5.0 per cent, by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

14.8 Cement Concrete Pavement

14.8.1 Scope

14.8.1.1 The work shall consist of construction of unreinforced, dowel jointed, plain cement concrete pavement in accordance with requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the Drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connecting with the work, as approved by the Engineer.

14.8.1.2 The design parameters, viz., thickness of pavement slab, grade of concrete, joint details etc., shall be stipulated in the Drawings.

14.8.2 Materials

14.8.2.1 Source of materials

14.8.2.1.1 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 aggregate 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.

14.8.2.2 Cement

14.8.2.2.1 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.

1. Ordinary Portland Cement, 33 Grade, IS: 269.
2. Ordinary Portland Cement, 43 Grade, IS: 8112.
3. Ordinary Portland Cement, 53 Grades, IS: 12269.

14.8.2.2.2 If the soil around has soluble salts like Sulphates in excess of 0.5 percent, the cement used shall be Sulphate resistant and shall conform to IS: 12330.

14.8.2.2.3 Guidance may be taken from IS: SP:23, Handbook for concrete mixes for ascertaining the minimum 7 days strength of cement required to match with design concrete strength. Cement to be used may preferably be obtained in bulk form. If cement in paper bags are proposed to be use, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them of suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in accordance with **Chapter 7**. The cement shall be subjected to acceptance test just prior to its use.

14.8.2.3 Admixtures

14.8.2.3.1 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 use, must be furnished to the Engineer in advance to obtain his approval

before used. 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 aggregate percentage of the column of the mix shall be 5 ± 1.5 percent for 25 mm nominal size aggregate.

14.8.2.4 Aggregate

14.8.2.4.1 Aggregates for pavement concrete shall be natural material complying with IS: 383 but with aggregate Los Angles Abrasion Test result not more than 35 percent. The limits of deleterious materials shall not exceed the requirements set out in IS: 383. The aggregate shall be free from chert, flint, chalcedony or other silica in aggregate form that can react with the alkalis 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.

14.8.2.4.2 Coarse aggregate

1. Coarse aggregate shall consist of clean, hard, strong, dens, 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 aggregate 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 per cent in magnesium Sulphate solution is used.
2. Dumping and stacking of aggregates shall be done in an approved manner. In case the Engineer considers that the aggregate are not free from dirt, the same may be washed and drained for at least 72 hours before batching as directed by the Engineer.

14.8.2.4.3 Fine aggregate

1. 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 per cent
    - Coal and lignite 1.0 per cent
    - Material passing IS Sieve No. 75 micron 4.0 per cent

14.8.2.5 Water

14.8.2.5.1 Water used for mixing and curing of concrete shall be clean and free from injurious amount of soil, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS: 456.

14.8.2.6 Mild Steel bars for Dowels and Tie Bars

14.8.2.6.1 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 IS.

14.8.2.7 Premoulded Joint filler

14.8.2.7.1 Joint filler board for expansion joints which are proposed for used 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 firm compressible material and complying with requirements of IS: 1838, or BS Specifications **Clause** No. 2630 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 less than one lane width. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

14.8.2.8 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).

14.8.2.9 Storage of materials

14.8.2.9.1 All materials shall be stored in accordance with the provisions of **Chapter 7** of the Specifications and other relevant IS Specifications. All efforts 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 leveled with 15 cm of watered, mixed and compacted granular sub-base material. The area shall have slope and drain to drain off rain water. 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 **Section 903** of MoST Specifications for Road and Bridge Works (IV Revision) immediately prior to their use.

14.8.3 Proportioning of Concrete

14.8.3.1 After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighted 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 **Section 903.5.2** of MoST Specifications for Road and Bridge Works (IV Revision). The mix design shall be based on the flexural strength of concrete.

14.8.3.2 Cement content

14.8.3.2.1 The cement content shall not be less than 350 kg per cum. 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 cum. of concrete.

14.8.3.3 Concrete strength

14.8.3.3.1 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 test 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.

14.8.3.3.2 The ratio between the 7 and 28 day strengths shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at lest 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.

14.8.3.3.3 If during the construction of the real length or during normal working, the average value of any four concessive 7 days 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 greed by the Engineer. The increased cement content shall be maintained at lest until the four corresponding 28 day strengths have been assessed for its conformity with the requirements as per **Clause 13.8.3**. whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

14.8.3.4 Workability

14.8.3.4.1 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.

14.8.3.4.2 The workability requirement at the Batching Plant and paving site shall be established by 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 $\pm$ 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.

14.8.3.5 Design mix

14.8.3.5.1 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 present of the Engineer or his representative and the design mix shall be subject to the approved 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 requirement of the design/Drawings have been determined.

14.8.3.5.2 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.

14.8.3.5.3 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.

14.8.4 Sub-base

14.8.4.1 The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant Drawings and Specifications contained in **Section 601** of MoST Specifications for Road and Bridge Works (IV Revision). If the sub-base is found damaged at some places of it has cracks wider than 10 mm., it shall be repaired with fine cement concrete or bituminous concrete before laying separation layer. Prior to laying of concrete it shall be ensured that the separation membrane as per **Clause 13.8.5** is placed in position and the same is clean of dirt or other extraneous materials and free from any damage.

14.8.5 Separation Membrane

14.8.5.1 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.

14.8.6 Joints

14.8.6.1 The location and type of joints shall be as shown in the Drawings. Joints shall be constructed depending upon their functional requirement as detailed in the following paragraphs. The location of the joints shall be transferred accurately at the site and mechanical saw cutting of joints done s 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 subbase 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.

14.8.6.2 Transverse joints

14.8.6.2.1 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:

1. Deviations of the filler board in the case of expansion joints from the intended line of the joint shall not be greater than $\pm$ 10 mm.
2. 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.
3. Deviations of the joint groove form the best fit straight line of the joint shall not be greater than 10 mm.
4. 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 13.8.11.**

14.8.6.2.2 Contraction joints

1. Contraction joints shall consist of 2 mechanical sawn joint groove, 3 to 5 mm wide and 1/4 and 1/3 depth of the slab $\pm$ 5 mm or as stipulated in the Drawings and dowel bars complying with **Clause 13.8.6.5** and as detailed in the Drawings.

2. 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 damages to the slab.

14.8.6.2.3 Expansion joints

The expansion joints shall consist of a joint filler board complying with **Clause 13.8.2.7** and dowel bars complying with **Clause 13.8.6.5** 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 13.8.6.2.1** 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 to 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.

14.8.6.3 Transverse construction joint

14.8.6.3.1 Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for fore 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.

14.8.6.4 Longitudinal joint

14.8.6.4.1 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.

14.8.6.4.2 Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the Drawing and in accordance with **Clause 13.8.6.6**.

14.8.6.5 Dowel bars

14.8.6.5.1 Dowel bars shall be mild steel rounds in accordance with **Clause 13.8.2.6** 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.

14.8.6.5.2 Unless shown otherwise on the Drawings, dowels bars shall be positioned at mid depth of the slab within a tolerance of $\pm$ 20 mm and centered equally about intended lines of the joint within a tolerance of $\pm$ 25 mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of carriageway and to each other within tolerances given thereunder, the compliance of which shall be checked as per **Clause 13.8.10.7**.

1. For bars supported on cradles prior to the laying of the slab:
   I. All bars in a joint shall be within $\pm$ 3 mm per 300 mm length of bar
   II. 2/3rd of the bars shall be within $\pm$ 2 mm per 300 mm length of bar
   III. 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
   IV. 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.
2. For all bars inserted after laying of the slab:
   I. Twice the tolerance for alignment as indicated in (I) above.

14.8.6.5.3 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:

1. Two thirds of the number of bars of any assembly tested shall not deflect more than 2 mm per 300 mm length of bar.
2. The remainder of the bars in that assembly shall not deflect more than 3 mm per 300 mm length of bar.

14.8.6.5.4 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:

1. For expansion joint, 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 continuos fixing is used. The residual deflection after removal of the load shall be not more than 3 mm.
2. The joint assembly fixing 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.
3. The fixings for contraction joint shall not fail under the 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.
4. Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3 mm 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 of timber packing.

14.8.6.5.5 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.

1. Four bars shall be taken at random from stock and without any special preparations 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.

14.8.6.5.6 For expansion joint, a closely fitting cap 100 mm long consisting of waterproofed cardboard or on 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.

14.8.6.6 Tie bars

14.8.6.6.1 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.

14.8.6.6.2 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.

14.8.6.6.3 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 joints 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.

14.8.6.6.4 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.

14.8.7 Weather and Seasonal limitations

14.8.7.1 Concreting 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 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.

14.8.7.2 Concreting in hot weather

14.8.7.2.1 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.

14.8.7.2.2 No concreting shall be done when the concrete temperature is below 5 degree Centigrade and the temperature is descending.

14.8.8 Side Forms, Rails and Guidewires

14.8.8.1 Side forms and rails

14.8.8.1.1 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. Sideforms 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 rails shall be firmly secured in position by not less than 3 stakes/pins per each 3 m length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3 m and when in place shall not settle in 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 not 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.

14.8.8.2 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 the anticipated length of pavement to be laid within the next 24 hrs whichever is more.

14.8.8.3 Use of guidewires

14.8.8.3.1 Where slip form paving is proposed, a guidewire shall be provided along both sides 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.

14.8.8.3.2 The guidewires shall be supported on stakes not more than 8 m apart by connectors capable of fine horizontal and vertical adjustment. The guidewire 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 guidewires shall be anchored to fixing point or winch and not on the stakes.

14.8.8.3.3 The stakes 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 an tensioned on the connectors at any section for at least 2 hours before concreting that section.

14.8.8.3.4 The Contractor shall submit to the Engineer for his approval of line and level, the stakes an connectors which are ready for used in the lengths 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.

14.8.9 Construction

14.8.9.1 General

14.8.9.1.1 A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying but 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 mm in one day.

14.8.9.2 Batching and mixing

14.8.9.2.1 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.

14.8.9.3 Equipment for proportioning of materials and paving

14.8.9.3.1 Proportioning of materials shall be done in the batching plant by weight, each type of material being weighted 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.

14.8.9.3.2 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 device 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 a 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 warning 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 cleaned 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 references 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 midpoint 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.

14.8.9.3.3 Paving equipment

1. The concrete shall be placed with an approved fixed form or slip paver with independent unit 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 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.

2. 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.

14.8.9.3.4 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 conditions.

14.8.9.4 Hauling and placing of concrete

14.8.9.4.1 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.

14.8.9.4.2 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.

14.8.9.4.3 Where fixed from pavers are to be used, forms shall fixed in advance as per **Clause 13.8.8** of the Specifications. 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 to permit proper finishing, protecting and curing of the pavement.

14.8.9.4.4 In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

14.8.9.4.5 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.

14.8.9.4.6 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.

14.8.9.4.7 While the concrete is still plastic, its surface shall be brush textured in compliance with **Clause 13.8.9.8** and the surface and edges of the slap cured by the application of a sprayed liquid curing membrane in compliance with **Clause 13.8.9.9**. 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.

14.8.9.4.8 As soon as side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by the using fine concrete composed 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.

14.8.9.4.9 If the requirement of **Section 902.4** of MoST Specifications for Road and Bridge Works (IV Revision). 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.

14.8.9.5 Construction by fixed form paver

14.8.9.5.1 The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

14.8.9.5.2 The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition onto 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 over working.

14.8.9.6 Construction by slip form paver

14.8.9.6.1 The slip form paving train shall consist of power machine which spreads, compacts and finishes the concrete in 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 crossfall.

14.8.9.6.2 The level of the conforming plate and finishing beams shall be controlled automatically from the guide wires installed as per **Clause 13.8.8** by sensors attached attached at four corners of the slip for paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least on 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.

14.8.9.6.3 Slip-form paving machine 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.

14.8.9.6.4 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 13.8.14**, 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.

14.8.9.7 Construction by hand-guided methods

14.8.9.7.1 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.

14.8.9.8 Surface texture

14.8.9.8.1 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 carriage way.

14.8.9.8.2 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 up 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.

14.8.9.8.3 The texture depth shall be determined by the Sand Patch Test as described in **Clause 13.8.12**. 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:

1. Five individual measurements of the texture depth shall be taken at least 2 mm 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.

14.8.9.8.4 Texture depths shall not be less than the minimum required when measurements are taken as given in Table 13-16 nor greater than a maximum average of 1.25 mm.

Table: 13-16 Texture Depth

Time of Test	**Number of Measurements**	**Required Texture Depth (mm)**	
		Specified Value	**Tolerance**
Between 24 hours and 7 days after the construction, of the slab or until the slab is first used by vehicles.	An average of 5 measurements	1.00	± 0.25
Not later than 6 weeks before the road is opened to public traffic	An average of 5 measurements	1.00	+ 0.25 - 0.35

14.8.9.8.5 After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

14.8.9.8.6 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.

14.8.9.9 Curing

14.8.9.9.1 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.

14.8.9.9.2 Curing compounds shall contain sufficient fluke 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.

14.8.9.9.3 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 manufacturers 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.

14.8.9.9.4 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 13.8.7.2**. 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.

14.8.9.9.5 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.

14.8.10 Trial Length

14.8.10.1 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 equipment 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 subbase layer below it.

14.8.10.2 The Contractor shall demonstrate the materials, plant, equipment and methods of construction that are proposed for concrete paving, by first construction 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.

14.8.10.3 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 1 m/hr) to that which is proposed for the main work.

14.8.10.4 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.

14.8.10.5 The trial length shall comply with the Specification in all respects, with the following additions and exceptions:

14.8.10.5.1 Surface levels and regularity

1. In checking for compliance with **Section 903.5** of MoST Specifications for Road and Bridge Works (IV Revision) 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.
2. The maximum number of permitted irregularities of pavement surface shall comply with the requirements of **Section 902.4** of MoST Specifications for Road and Bridge Works (IV

Revision). Shorter trial lengths shall be assessed prorata based on values for a 300 m length.

14.8.10.5.2 Joints

1. Alignment of dowel bars shall be inspected as described in **Clause 13.8.10.7** 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 13.8.6.5**, 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.
2. If there are deficiencies in the first expansion joint that is constructed as a trial, the next expansion joint shall be 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.

14.8.10.5.3 Density

1. Density shall be assessed as described in **Clause 13.8.3.3** from at least 3 cores drilled from each part of the trial length.

14.8.10.5.4 Position of tie bars

1. Compliance with **Clause 13.8.6.6** 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.

14.8.10.6 Approval and acceptance

14.8.10.6.1 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.

14.8.10.6.2 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 the Engineer. Any changes in materials, plant, equipment, and construct 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.

14.8.10.6.3 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 13.8.9.8.6** shall be removed immediately upon notification of deficiencies by the Engineer and the Contractor shall construct a further trial length.

14.8.10.7 Inspection of dowel bars

14.8.10.7.1 Compliance with **Clause 13.8.6.5** for the position and alignment of dowel bars at construction and expansion joints shall be checked by measurements relative to side forms for guide wires.

14.8.10.7.2 When the slab has been constructed, the position 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.

14.8.10.7.3 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 hacking shall be increased to 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.

14.8.10.7.4 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 13.8.6.5.5** shall be provided on dowels on one of the joints. The joint groove shall be widened and sealed as per **Clause 13.8.11**.

14.8.11 Preparation and Sealing of Joint Grooves

14.8.11.1 General

14.8.11.1.1 All transverse joints in surface slabs shall be sealed using sealants described in **Clause 13.8.2.8**. Joints shall not be sealed before 14 days after construction.

14.8.11.2 Preparation of joint grooves for sealing

14.8.11.2.1 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.

14.8.11.2.2 If rough arrises 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 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 arrises shall be repaired by an approved thin bonded arris repair using cementitious materials.

14.8.11.2.3 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 manufacturer, the sides of the groves may have to be sand blasted to increase the bondage between sealant and concrete.

14.8.11.2.4 The groove shall be cleaned and dried at the time of priming and sealing.

14.8.11.2.5 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.

14.8.11.3 Sealing with sealants

14.8.11.3.1 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.

14.8.11.3.2 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 manufacturer's recommendations and reheated material shall not be used.

14.8.11.3.3 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.

14.8.11.3.4 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.

14.8.11.3.5 Sealant shall be applied, slightly to a lower level than the slab with a tolerance of 5 ± 2 mm.

14.8.11.3.6 During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapours or by the sealing process.

14.8.11.4 Testing of applied sealants

14.8.11.4.1 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 13.8.2.8**. The samples shall meet the requirement of AASHTO M 282 for hot applied sealant or BS 5212: (Part - 2) for cold applied sealant.

14.8.12 Measurement of Texture Depth - Sand Patch Method

14.8.12.1 The following apparatus shall be used:

1. A cylindrical container of 25 ml internal capacity
2. 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
3. Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

14.8.12.1.1 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.

14.8.12.1.2 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.

14.8.13 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.

14.8.14 Tolerances for Surface Regularity, Level, Thickness and Strength

14.8.14.1 The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given the **Section 903.5** of MoST Specifications for Road and Bridge Works (IV Revision). Control of quality of materials and works shall be exercised by the Engineer in accordance with **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

14.8.15 Measurements for Payment

14.8.15.1 Cement concrete pavement shall be measured as a finished work in square metres with specified thickness. The volume to be paid for will be calculated on the basis of thickness and plans shown on the project Drawings and adjusted for the deficiency in thickness. No additional payment shall be made for extra thickness of the slab. The full payment will be made to this item after 28 days strength of the concrete is found to be satisfactory.

14.8.15.2 The unit for measurement for concrete pavement shall be the cubic metre of concrete placed, based on the net plan areas for the specified thickness shown on the Drawings or directed by the Engineer. The rate shall include all provisions of this Specification and shall include the provision of all materials including polythene film, concrete, stock piling, mixing, transport, placing, compacting, finishing, together with all formwork, and including testing and submission of test certificates and records. No deduction shall be made in measurement for opening provided that the area of each is less than 0.5 sqm. The unit rate as entered in the Bill of Quantities shall also include the full costs of contraction, expansion, construction, and longitudinal joints. It shall also include joint filler, keys, caulking rod, debonding strip., sealant primer, joint sealant, dowel bar and tie rod.

14.8.15.3 Pavement thickness

14.8.15.4 All precautions and care shall be taken to construct pavement having uniform thickness as called for on the plans.

14.8.15.5 Thickness of the cement concrete pavement shall be calculated on the basis of level data of the cement concrete pavement and the underlying sub-base taken on a grid of 5 m x 3.5 m or 6.25 m x 3.5 m, the former measurement being in longitudinal direction.

14.8.15.6 A day's work is considered as a 'lot' for calculating the average thickness of the slab. In calculating the average thickness, individual measurements which are in excess of the specified thickness by more than 10 mm shall be considered as the specified thickness plus 10 mm.

14.8.15.7 Individual areas deficient by more than 25 mm shall be verified by the Engineer by ordering core cutting and if in his opinion the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the plans.

14.8.15.8 When the average thickness for the lot is deficient by the extent shown in Table 13-17, the contract unit price will be adjusted as per this Table:

Table 13-17 Payment Adjustment for Deficiency in Thickness

Deficiency in average thickness of day's work	Per cent of Contract unit price payable
Upto to 5 mm	100
6 - 10 mm	87
11 - 15 mm	81
16 - 20 mm	75
21 - 25 mm	70

14.8.15.9 In the stretch where deficiency of average thickness is more than 25 mm, the section whose thickness is deficient by 26 mm or more is identified with the help of cores. Such slabs shall be removed and reconstructed at the cost of the Contractor. During such rectification work, care shall be taken to replace full slab be taken to replace full slab and to the full depth.

14.8.16 Rate

14.8.16.1 The Contract unit rate for the construction of the cement concrete shall be payment in full for carrying out the operations required for the different items of the work as per these Specifications including full compensation for all labour, tools, plant, equipment, testing and incidentals to complete the work as per Specifications, providing all materials to be incorporated in the work including all royalties, fees, storage, rents where necessary and all leads and lifts.

14.9 Shoulders, Islands and Median

14.9.1 Scope

The work shall consist of constructing shoulder (hard / paved / earthen with brick or stone block edging) on either side of the pavement, median in the road dividing the carriage way into separate lanes and islands for channelising the traffic at junctions in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the Drawings or as directed by the Engineer.

14.9.2 Materials

14.9.2.1 Shoulder on either side of the road may be of selected earth / granular material / paved conforming to the requirements of **Clause 5.20 / 13.1** and the median may be of selected earth conforming to the requirements of **Clause 5.20**.

14.9.2.2 Median/Traffic islands shall be raised and kerbed at the perimeter and the enclosed area filled with earth and suitably covered with grass turf / shrubs as per **Clause 5.22** and / or paved as per **Clause 13.11.3.4** or **13.11.3.5.**

14.9.2.3 Paved shoulders shall consist of sub-base, base and surfacing courses, as shown in the Drawings and materials for the same shall conform to relevant Specifications of the corresponding items. Where paved or hard shoulders are not provided, the pavement shall be provided with brick/stone block edgings as shown in the Drawings. The bricks shall conform to **Chapter 7** of these Specifications. Stone blocks shall confirm to **Chapter 7** of these Specifications and shall be of size 225 mm x 110 mm x 75 mm.

14.9.3 Size of Shoulders/Median/Islands

14.9.3.1 Shoulder (earthen/hard/paved) /median/traffic island dimensions shall be as shown on the Drawings or as directed by the Engineer.

14.9.4 Construction Operations

14.9.4.1 Shoulder

14.9.4.1.1 The sequence of operations shall be such that the construction of paved shoulder is done in layers each matching the thickness of adjoining pavement layer. Only after a layer of pavement and corresponding layers in paved and earth shoulder portion have been laid and compacted, the construction of next layer of pavement and shoulder shall be taken up.

14.9.4.1.2 Where the materials in adjacent layers are different, these shall be laid together and the pavement layer shall be compacted first. The corresponding layer is paved shoulder portion shall be compacted thereafter, which shall be followed by compaction of earth shoulder layer. The adjacent layers having same material shall be laid and compacted together.

14.9.4.1.3 In all cases where paved shoulders have to be provided along side of existing carriageway, the existing shoulders shall be excavated in full width and to the required depth as per **Clause 5.13.4**. Under no circumstances, box cutting shall be done for construction of shoulders.

14.9.4.1.4 Compaction requirement of earthen shoulder shall be as per Table 5-4. In the case of bituminous courses, work on shoulder (earthen / hard / paved), shall start only after the pavement course has been laid and compacted.

14.9.4.1.5 During all stages of shoulder (earthen / hard / paved) construction, the required crossfall shall be maintained to drain off surface water.

14.9.4.1.6 Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed, without damage to the pavement, and the area so affected thoroughly cleaned.

14.9.4.2 Median and Islands

14.9.4.2.1 Median and Islands shall be constructed in a manner similar to shoulder up to the road level. Thereafter the median and islands, if raised, shall be raised at least 300 mm by using kerb stones of approved material and dimensions and suitably finished and painted as directed by the Engineer. If not raised, the median and islands shall be differentiated from the shoulder/pavement as the case may be, directed by the Engineer. The confined area of the median and islands shall be filled with local earth or granular material or any other approved material and compacted by plate compactor / power rammer. The confined area after filling with earth shall be turfed with grass or planted with shrubs and in case of granular fill it can be finished with tiles/slabs as directed by the Engineer.

14.9.4.3 Brick / stone block edging

14.9.4.3.1 The brick/stone blocks shall be laid on edge, with the length parallel to the transverse direction of the road. They shall be laid on a bed of 25 mm sand, set carefully, rolled into position by a light roller and made flush with the finished level of the pavement.

14.9.5 Surface Finish and Quality Control of Works

14.9.5.1 The surface finish of construction shall conform to the requirements of **Section 902** of MoST Specifications for Road and Bridge Works (IV Revision). Control on the quality of materials and works shall be exercised by the Engineer in accordance with **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

14.9.6 Measurements for a Payment

14.9.6.1 Shoulder (earthen/hard/paved), island and median construction shall be measured as finished work in position as below:

1. For excavation in cum.
2. For earthwork/granular fill in cum.
3. For sub-base, base, surfacing courses in units as for respective items.
4. For kerb in running m.
5. For turfing and tile/slab finish in sqm.
6. For brick/stone block edging in sqm.

14.9.7 Rate

14.9.7.1 The Contract unit rate for shoulder (hard / paved / earthen with brick or stone block edging), island and median construction shall be payment in full for carrying out the required operations including full compensation for all components listed in **Clause 13.1.8** as applicable. The rate for brick / stone block edging shall include the cost of sand cushion.

14.10 Cement Concrete Kerb and Kerb with Channel

14.10.1 Scope

14.10.1.1 This work shall consist of constructing cement concrete kerbs and kerbs with channel in the central median and/or along the footpaths or separators in conformity with the lines, levels and dimensions as specified in the Drawings.

14.10.2 Materials

14.10.2.1 Kerbs and kerb with channel shall be provided in cement concrete of Grade M20 in accordance with **Chapter 9** of these Specifications.

14.10.3 Type of Construction;

14.10.3.1 These shall be cast-in-situ construction with suitable kerb casting machine in all situations except at locations where continuous casting with equipment is not practicable. In those situations, precast concrete blocks shall be used.

14.10.4 Equipment

14.10.4.1 A continuous kerb casting equipment of adequate capacity and controls, capable of laying the kerbs in required cross-sections and producing a well-compacted mass of concrete free of voids and honeycombs, shall be used.

14.10.5 Construction Operations

14.10.5.1 Kerbs shall be laid on firm foundation of minimum 150 mm thickness cement concrete of M 10 grade cast in situ or on extended width of pavement. The foundation shall have a projection of 50 mm beyond the kerb stone. Before laying the foundation of lean concrete, the base shall be levelled and slightly watered to make it damp.

14.10.5.2 In the median portions in the straight reaches, the kerb shall be cast in continuous lengths. In the portions where footpath is provided and/or the slope of the carriageway is towards median (as in case of superelevated portions). There shall be sufficient gap/recess left in the kerb to facilitate drainage openings.

14.10.5.3 After laying the kerbs and just prior to hardening of the concrete, saw-cut grooves shall be provided at 5 m intervals or as specified by the Engineer.

14.10.5.4 Kerbs on the drainage ends such as along the footpath or the median in superelevated portions, shall be cast with monolithic concrete channels as indicated in Drawings. The slope of the channel towards drainage pipes shall be ensured for efficient drainage of the road surface.

14.10.5.5 Vertical and horizontal tolerances with respect to true line and level shall be $\pm$ 6 mm.

14.10.6 Measurements for Payment

14.10.6.1 Cement concrete kerb / kerb with channel shall be measured in linear metre for the complete item of work.

14.10.6.2 Foundation of kerb, where separately provided shall be measured in linear meter for complete item of work.

14.10.7 Rates

14.10.7.1 The Contract unit rates for cement concrete kerb / kerb with channel and foundation for kerb shall be payment in full compensation for furnishing all materials, labour, tools, equipment for construction and other incidental cost necessary to complete the work.

14.11 Footpaths and Separators

14.11.1 Scope

14.11.1.1 The work shall consist of constructing footpaths and/or separators at locations as specified in the Drawings or as directed by the Engineer. The lines, levels and dimensions shall be as per the Drawings. The scope of the work shall include provision of all drainage arrangements as shown in the Drawings or as directed.

14.11.2 Materials

14.11.2.1 The footpaths and separators shall be constructed with any of the following types:

1. Cast-in-situ cement concrete of Grade M20 as per **Chapter 9** of these Specifications.
2. Precast cement concrete blocks/tiles of Grade M20 as per **Chapter 9** of the Specifications. The minimum thickness of the cement concrete block/tile shall be 25 mm and minimum size be 300 mm x 300 mm.
3. Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the Contractor and approved by the Engineer. The minimum thickness of the natural stone slab shall be 25 mm minimum shall be 300 mm x 300 mm.

14.11.3 Construction Operations

14.11.3.1 Drainage pipes below the footpath originating from the kerbs shall be first laid in the required slope and connected to the drains/sumps/storm water drain/drainage chutes as per provisions of the Drawings, or as specified.

14.11.3.2 Portion on back side of kerbs shall be filled and compacted with granular sub-base materials as per **Clause 13.1** of these Specifications in specified thickness.

14.11.3.3 The base shall be prepared and finished to the required lines, levels and dimensions as indicated in the Drawings with the following and over the prepared base, precast concrete blocks / tiles / natural stone slabs and / or cast-in-situ slab shall be set/laid as described in **Clause**s **13.11.3.4 and 13.11.3.5**.

1. Minimum 150 mm thick, compacted granular sub-base material as per **Clause 13.1** of the Specifications.
2. Minimum 25 mm thick cement concrete of Grade M 15.

14.11.3.4 Precast cement concrete blocks / tiles / natural stone slab

14.11.3.4.1 The block / tiles / slabs shall be set on a layer of average 12 mm thick cement-sand mortar (1:3) laid on prepared base in such a way that there is not rocking. The gaps between the blocks / tiles / slabs shall not be more than 12 mm and shall be filled with cement-sand mortar (1:3).

14.11.3.5 Cast-in-situ cement concrete

14.11.3.5.1 The minimum thickness of the cement concrete shall be 25 mm and it shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as per **Chapter 9** of the Specifications.

14.11.4 Measurements for Payment

14.11.4.1 Footpaths and separators shall be measured in sqm. between inside of kerbs.

14.11.5 Rates

14.11.5.1 Contract unit rates shall be inclusive of full compensation of all labour, materials, tools, equipment and incidentals to construction of footpaths. Cost of providing pipes and arrangement for their discharge into appropriate drainage channels shall be incidental to the construction if footpaths.

14.12 Traffic Signs

14.12.1 General

14.12.1.1 The colour, configuration, size and location of all traffic signs for highways other than Expressways shall be in accordance with the Code of Practice for Road signs, IRC: 67 or as shown on the Drawings. For Expressways, the size of the signs, letters and their placement shall be as specified in the Contract Drawings and relevant Specifications. In the absence of any details or for any missing details, the signs shall be provided as directed by the Engineer.

14.12.1.2 The signs shall be either reflectorised or non-reflectorised as shown on the Drawings or as directed by the Engineer. When they are of reflectorised type, they shall be of retro-reflectorised type and made of encapsulated lens type reflective sheeting vide **Clause 13.12.3**, fixed over aluminium sheeting as per these Specifications.

14.12.1.3 In general, cautionary and mandatory signs shall be fabricated through process of screen printing. In regard to informatory signs with inscriptions, either the message could be printed over the reflective sheeting, or cut letters of non-reflective black sheeting used for the purpose which must be bonded well on the base sheeting as directed by the Engineer.

14.12.2 Materials

14.12.2.1 The various materials and fabrication of the traffic signs shall conform to the following requirements:

14.12.2.1.1 Concrete shall be of the grade shown on the contract Drawings or otherwise as directed by the Engineer. The Specification for materials shall be as per **Chapter 7**.

14.12.2.1.2 Reinforcing steel shall conform to the requirement of IS: 1786 unless otherwise shown on the Drawing.

14.12.2.1.3 High strength bolts shall conform to IS: 1367 whereas precision bolts, nuts, etc., shall conform to IS: 1364.

14.12.2.1.4 Plates and support sections for the sign posts shall conform to IS: 226 and IS: 2062 or any other relevant IS Specifications.

14.12.2.1.5 Aluminium sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS: 736-Material designation 24345 or 1900.

14.12.2.1.6 Signs with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick. All other shall be at least 2 mm thick. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under the prevailing wind and other loads.

14.12.2.1.7 In respect of sign sizes not covered by IRC: 67, the structural details (thickness, etc) shall be as per the approved Drawings.

14.12.3 Traffic Signs Having Retro-reflective Sheeting

14.12.3.1 General requirements

14.12.3.1.1 The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface which has the property of retro-reflection over its entire surface. It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for these properties in an unprotected outdoor exposure facing the sun for two years and its having passed these tests shall be obtained from a reputed laboratory, by the manufacturer of the sheeting. The reflective sheeting shall be either of Engineering Grade material with enclosed lens or of High Intensity Grade with encapsulated lens. The type of the sheeting to be used would depend upon the type, functional hierarchy and importance of the road.

14.12.3.2 High intensity grade sheeting

14.12.3.2.1 This sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent water-proof plastic having a smooth surface. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM Standard E: 810) as indicated in Table 13-18.

Table 13-18: Acceptable Minimum Coefficient of Retro-Reflection for High Intensity Grade Sheeting (Candelas Per Lux Per Square Metre)

Observation Angle (in ^{o})	Entrance Angle (in ^{o})	White	Yellow	Orange	Green/Red	Blue
0.2	-4	250	170	100	45	20
0.2	+30	150	100	60	25	11
0.5	-4	95	62	30	15	7.5
0.5	+30	65	45	25	10	5.0

14.12.3.2.2 When totally wet, the sheeting shall not show less than 90 per cent of the values of retro-reflectance indicated in Table 13.18. At the end of 7 years, the sheeting shall retain at least 75 per cent of its original retro-reflectance.

14.12.3.3 Engineering grade sheeting

14.12.3.3.1 This sheeting shall be enclosed lens type consisting of microscope lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM Standard: E-810) as indicated in Table 13-19.

Table 13.19: Acceptable Minimum Coefficient of Retro-Reflection for Engineering Grade Sheeting (Candelas Per Lux Per Square Metre)

Observation Angle (in ^{o})	Entrance Angle (in ^{o})	White	Yellow	Orange	Green	Red	Blue
0.2	-4	70	50	25	9.0	14.5	4.0
0.2	+30	30	22	7.0	3.5	6.0	1.7
0.5	-4	30	25	13.5	4.5	7.5	2.0
0.5	+30	15	13	4.0	2.2	3.0	0.8

14.12.3.3.2 When totally wet, the sheeting shall not show less than 90 per cent of the values, of retro-reflection included in Table 13.19. At the end of 5 years, the sheeting shall retain at least 50 per cent of its original retro-reflectance.

14.12.3.4 Messages / borders

14.12.3.4.1 The messages (legends, letters, numerals etc.,) and borders shall either be screen-printed or of cut-outs. Screen printing shall be processed and finished with materials and in a manner specified by he sheeting manufacturer. Cut-outs shall be of materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer.

14.12.3.5 For screen-printed transparent coloured areas on white sheeting, the co-efficient of retro-reflection shall not be less than 50 percent of the values of corresponding colour in Tables 13-18 and 13-19, as applicable.

14.12.3.6 Cut-out messages and borders, wherever used, shall be made out of retro-reflective sheeting (as per **Clause 13.12.2 or 13.12.3.** as applicable), except those in black which shall be of non-reflective sheeting.

14.12.3.7 Colour

14.12.3.7.1 Unless otherwise specified, the general colour scheme shall be as stipulated in IS: 5 " Colour for Ready Mixed Paints", viz.,

Blue	-	IS	Colour	No.166: French Blue
Red	-	IS	Colour	No.537: Signal Red
Green	-	IS	Colour	No.284: India Green
Orange	-	IS	Colour	No.591: Deep Orange.

14.12.3.7.2 The Colours shall be durable and uniform in acceptable hue when viewed in day light or under normal headlights at night.

14.12.3.8 Adhesives

14.12.3.8.1 The sheeting shall either have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent or other preparation for adhesion to a smooth clean surface, or a tack free adhesive activated by heat, applied in a heat-vacuum applicator, in a manner recommended by the sheeting manufacturer. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheeting from the sign base in one piece by use of sharp instrument. In case of pressure-sensitive adhesive sheeting, the sheeting shall be applied in accordance with the manufacturer's Specifications. Sheeting with adhesives requiring use of solvents or other preparation for adhesive shall be applied strictly in accordance with the manufacturer's instructions.

14.12.3.9 Refurbishment

14.12.3.9.1 Where existing signs are specified for refurbishment, the sheeting shall have a semi-rigid aluminium backing pre-coated with aggressive-tack type pressure sensitive adhesive. The adhesive shall be suitable for the type of material used for the sign and should thoroughly bond with that material.

14.12.3.10 Fabrication

14.12.3.10.1 Surface to be reflectorised shall be effectively prepared to receive the retro-reflective sheeting. The aluminium sheeting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheeting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handed, except by suitable device or clean canvas gloves, between all cleaning and preparation operation and application of reflective sheeting/primer. There shall be no opportunity for metal to come in contact with grease, oil or other contaminants prior to the application of retro-reflective sheeting.

14.12.3.10.2 Complete sheets of the material shall be used on the signs except where it is unavoidable; at splices, sheeting with pressure sensitive adhesives shall be overlapped not less than 5 mm. Sheeting with heat-activated adhesives may be spliced with an overlap not less than 5 mm or butted with a gap not exceeding 0.75 mm. Where screen printing with transparent colours is proposed, only butt jointing shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

14.12.3.11 Warranty and durability

14.12.3.11.1 The Contractor shall obtain from the manufacturer a sever-year warranty for satisfactory field performance including stipulated retro-reflectance of the retro-reflective sheeting of high intensity grade and a five year warranty for the adhesive sheeting of engineering grade and submit the same to the Engineer. In addition, a seven year and a five year warranty for satisfactory in-field performance of the finished sign with retro-reflective sheeting of high intensity grade and engineering grade respectively, inclusive of the screen printed or cut out letters/legends and their bonding to the retro-reflective sheeting shall be obtained from the Contractor/supplier and passed on to the Engineer. The Contractor/supplier shall also furnish a certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty.

14.12.3.11.2 Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and, following cleaning, shall show no appreciable discolouration, cracking, blistering or dimensional change and shall not have less than 50 percent of the specified minimum reflective intensity values (Tables 13-18 and 13-19) when subjected to accelerated weathering for 1000 hours, using type E or EH Weatherometer (AASHTO Designation M 268).

14.12.4 Installation

14.12.4.1 Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind loads or displacement by vandalism. Normally, signs with an area upto 0.9 sqm. shall be mounted on a single post, and for greater area tow or more supports shall be provided. Sign supports may be of mild steel, reinforced concrete or galvanised iron (G.I.) Post-end(s) shall be firmly fixed to the ground by means of properly designed foundation. The work of foundation shall conform to relevant Specifications as specified.

14.12.4.2 All components of signs and supports, other than the reflective portion and G.I. posts below ground shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. Any part of mild steel (M.S.) post below ground shall be painted with three coats of red lead paint.

14.12.4.3 The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size in the case of reinforced concrete or G.I. posts. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

14.12.5 Measurements for Payment

14.12.5.1 The measurements of standard cautionary, mandatory and information signs shall be in numbers of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured by area in square metres.

14.12.6 Rate

14.12.6.1 The Contract unit rate shall be payment in full for the cost of making the road sign, including all materials, installing it at the site and incidentals to complete the work in accordance with the Specifications.

14.13 Overhead Signs

14.13.1 General

14.13.1.1 Overhead signs may be used in lieu of, or as an adjunct to, ground signs where the situation so warrants for proper information and guidance of the road user. The following conditions may be considered while deciding about the provision of overhead signs:

1. Traffic volume at or near capacity
2. Complex interchange design
3. Three or more lanes in each direction
4. Restricted sight distance
5. Closely spaced interchanges
6. Multi-lane exits
7. Large percentage of commercial vehicles
8. High speed traffic
9. Consistency of sign message location through a series of interchanges
10. Insufficient space for ground mounted sign
11. Background of street lighting
12. Distances of important places enroute highways at suitable intervals.

14.13.1.2 From safety and aesthetic standpoints, overhead signs shall be mounted on overhead bridge structures wherever possible. Where these are required to be provided at some other locations, the support system should be properly designed based on sound engineering principles, to safely sustain the dead load, live load and wind load on the completed sign system. For this purpose, the overhead signs shall be designed to withstand a wind loading of 150 kg/m^2 normal to the face of the sign and 30 kg/m^2 transverse to the face of the sign. In addition to the dead load of the structure, walkway loading of 250 kg concentrated live load shall also be considered for the design of the overhead sign structure.

14.13.2 Height

14.13.2.1 Overhead signs shall be provide a vertical clearance of not less than 5.5 m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater then 300 mm in excess of the minimum design clearance of other structures.

14.13.3 Lateral Clearance

14.13.3.1 The minimum clearance outside the usable roadway shoulder for expressway signs mounted at the road side or for overhead sign supports either to the right or left side of the roadway shall be 1.80 m. This minimum clearance of 1.80 m shall also apply outside of an unmountable kerb. Where practicable, a sign should not be less than 3 m from the edge of the nearest traffic lance. Large guide signs should farther removed preferably 9 m or more from the nearest traffic lane, unless otherwise specified. Lesser clearances, but not generally less than 1.80 m, may be used on connection roadways or ramps at inter-changes.

14.13.3.2 Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. When overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimise the impact forces or protect motorist adequately by a physical barrier or guard rail of suitable design.

14.13.4 Number of Signs At An Overhead Installation

14.13.4.1 In no case should there be more than three signs displayed at any one locations, including regulatory or warning signs, either on the overhead structure or on its support.

14.13.5 Materials For Overhead Sign and Support Structures

14.13.5.1 Aluminium alloy or galvanized steel to be used as truss design supports shall conform to relevant IS. These shall be of sections and type as per structural design requirements as shown on the plans

14.13.5.2 After steel trusses have been fabricated and all required holes punched or drilled on both the horizontal truss units and the vertical and support. Units. They shall be galvanised in accordance with IS Specifications.

14.13.5.3 Where aluminium sheets are used for road signs, they shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS 736- Material Designation 24345 or 1900. The thickness of sheet shall be related to the size of the sign with minimum thickness of sheet as 1.5 mm.

14.13.5.4 High strength bolts shall conform to IS: 1367 whereas precision bolts, nuts, etc. Shall conform to IS: 1364.

14.13.5.5 Plates and support sections for sign posts shall conform to IS: 226 and IS: 2062.

14.13.5.6 The overhead signs shall be reflectorised with high intensity retro-reflective sheeting preferably of encapsulated lens type.

14.13.6 Size, Locations, etc. of Signs

14.13.6.1 The size of the signs, letters and their placement shall be as specified in the Contract Drawings and Specifications.

14.13.6.2 In the absence of details or for any missing details in the Contract documents, the signs shall be provided as directed by the Engineer.

14.13.7 Installation

14.13.7.1 The supporting structure and signs shall be fabricated and erected as per details given in the plans.

14.13.7.2 Sign posts, their foundations and sign mountings shall be so constructed as to hold signs in a proper and permanent position to adequately resist swaying in the wind or displacement by vandalism.

14.13.7.3 The work of construction of foundation for sign supports including excavation and backfill, forms, steel reinforcement, concrete and its placement shall conform to the relevant Specifications given in these Specifications.

14.13.7.4 The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury and defacement.

14.13.7.5 Brackets shall be provided for mounting signs for the type to be supported by the structure. For better visibility, they shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degree from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward. All brackets shall be of a length equal to the heights of the signs being supported.

14.13.7.6 Before erecting support structures, the bottom of each base plate shall be protected with an approved material which will adequately prevent any harmful reaction between the plate and the concrete.

14.13.7.7 The end supports shall be plumbed by the use of levelling nuts and the space between the foundation and base plate shall be completely filled with an anti-shrink grout.

14.13.7.8 Anchor bolts for sign supports shall be set to proper locations and elevation with templates and carefully checked after construction of the sign foundation and before the concrete has set.

14.13.7.9 All nut on aluminium trusses, except those used on the flanges, shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminium nut.

14.13.7.10 All nuts on galvanized steel trusses, with the exception of high strength bolt connections, shall be tightened only to a snug condition.

14.13.7.11 Field welding shall not be permitted.

14.13.7.12 After installation of signs is complete, the sign shall be inspected by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor to eliminate or minimize this condition.

14.13.8 Measurements for Payment

14.13.8.1 Aluminium or steel over head sign structure will be measured for payment by the specific unit (each) complete in place or for each component of the overhead sign structure as indicated in the bill of Quantities and the detailed Drawings(s).

14.13.8.2 Flat sheet aluminium signs with retro-reflective sheeting thereon shall be measured for payment by the square metre for each thickness, complete in place.

14.13.9 Rate

14.13.9.1 The structural steel part of the overhead sign shall be measured in tonnes while the sign board shall be measured in sq. m. Other items like excavation for foundation and concrete in foundation to be measured and paid in cu. m. Separately. The Contract unit rate for overhead sign structure shall be payment in full compensation for furnishing all labour, materials, tools, equipment, excavation, fabrication and installation and all other incidental costs necessary to complete the work to the Specifications.

14.13.9.2 The Contract unit rate for aluminium sheet signs shall include the cost of making the sign including all materials and fixing the same in position and all other incidental costs necessary to complete the work to the Specifications.

14.14 Road Markings

14.14.1 General

14.14.1.1 The colour, width and layout of road marking shall be in accordance with the Code of Practice for Road Markings with paints, IRC:35, and as specified in the Drawings or as directed by the Engineer.

14.14.2 Materials

14.14.2.1 Road markings shall be of ordinary road marking paint, hot applied thermoplastic compound, or reflectorised paint as specified in the item and the material shall meet the requirements as specified below.

14.14.3 Ordinary Road Marking Paint

14.14.3.1 Ordinary paint used for road marking shall conform to Grade I as per IS: 164.

14.14.3.2 The road marking shall preferably be laid with appropriate road marking machinery.

14.14.3.3 Laying thickness of road marking paint shall be as specified by the Engineer.

14.14.4 Hot Applied Thermoplastic Road Marking

14.14.4.1 General

14.14.4.1.1 The work under this Clause consists of marking traffic stripes using a thermoplastic compound meeting the requirements specified herein.

14.14.4.1.2 The thermoplastic compound shall be screeded/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic.

14.14.4.1.3 The colour of the compound shall be white or yellow (IS colour No.356) as specified in the Drawings or as directed by the Engineer.

14.14.4.1.4 Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.

14.14.4.2 Thermoplastic Material

14.14.4.2.1 General

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads.

14.14.4.2.2 Requirements

1. Composition: The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 13-20.

Table 13-20. Proportions of Constituents of Marking Material (Percentage By Weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-40	30-40
Titanium Dioxide	10.0 min	-
Calcium Carbonate and Inert Fillers	42.0 max	See Note
Yellow Pigments	-	See Note

Note: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met.

2. Properties: The properties of thermoplastic material, when tested in accordance with ASTM D36/BS3262-(Part I), shall be as below:

   (a) Luminance:
   White: Daylight luminance at 45 degree-65 per cent min. As per AASHTO M 249.
   Yellow: Daylight luminance at 45 degree-45 per cent min. As per AASHTO M 249.
   (b) Drying time:
   When applied at a temperature specified by the manufacturing and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.
   (c) Skid resistance: not less than 45 as per BS 6044.
   (d) Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
   (e) Softening point: 102.5 ± 9.5^{o} C as per ASTM D 36.
   (f) Flow resistance: Not more than 25 per cent as per AASHTO M 249.
   (g) Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249.

3. Storage life: The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer / supplier / Contractor.

4. Reflectorisation: Shall be achieved by incorporation of beads, the grading and - other properties of the beads shall be specified in **Clause 13.14.4.3.**

5. Marking: Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
   - The Name, Trade Mark or other means of Identification of Manufacturer
   - Batch Number
   - Date of Manufacture
   - Colour (White or Yellow)
   - Maximum Application Temperature and Maximum Safe Heating Temperature.

6. Sampling and testing: The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

14.14.4.3 Reflectorising glass beads

14.14.4.3.1 General

This Specification covers two types of glass beads to be used for the production of reflectorised pavement markings. Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 13-20 and Type 2 beads are those which are to be sprayed on the surface vide **Clause 13.14.6.3.**

14.14.4.3.2 The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions. There shall conform to the requirements spelt out in **Clause 13.14.4.3.3.**

14.14.4.3.3 Specific requirements

1. Gradation: The glass beads shall meet the gradation requirements for the two types as given in Table 13-21.

Table 13-21. Gradation Requirements for Glass Beads

Sieve size	Percent retained	
	Type 1	Type 2
1.18 mm	0 to 3	-
850 micron	5 to 20	0 to 5
600 -do-	-	5 to 20
425 -do-	65 to 95	-
300 -do-	-	30 to 75
180 -do-	0 to 10	10 to 30
Below 180 micron	-	0 to 15

2. Roundness: The glass beads shall have a minimum of 70 per cent true spheres.

3. Refractive index: The glass beads shall have a minimum refractive index of 1.50.

4. Free flowing properties: The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

14.14.4.3.4 Test methods: The specific requirements shall be tested with the following methods:

1. Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter desiccator which is filled within 25 mm of the top of a desiccator plate with sulphuric acid water solution (specific gravity 1.10). Cover the desiccator and let it stand for 4 hours at 20 to 29 degree C. Remove sample from desiccator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be essentially free of lumps and clusters and shall flow freely through the funnel.
2. The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS 6088 and BS 3262 (Part-I).
3. The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification. However, if so required, these rates may be carried out as directed by the Engineer.

14.14.4.4 Application properties of thermoplastic material

14.14.4.4.1 The thermoplastic material shall readily get screeded/ extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

14.14.4.4.2 The material upon heating to application temperatures shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

14.14.4.5 Preparation:

14.14.4.5.1 The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

14.14.4.5.2 After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

14.14.4.6 Properties of finished road marking:

1. The stripe shall not be slippery when wet.
2. The marking shall not lift from the pavement in freezing weather.
3. After application and proper drying, the stripe shall show no appreciable deformation or discolouration under traffic and under road temperatures upto 60^{o}C.
4. The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil drippings from traffic.
5. The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
6. The colour of yellow marking shall conform to IS Colour No.356 as given in IS: 164.

14.14.5 Reflectorised Paint

14.14.5.1 Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirement of **Clause 13.14.4.3**.

14.14.6 Application

14.14.6.1 Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

14.14.6.2 The thermoplastic material shall be applied hot either by screening or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine.

14.14.6.3 The pavement temperature shall not be less than 10^{o}C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the plant.

14.14.6.4 The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over and old line of compatible material. Such new material shall so bond itself to the old line that no splitting or separation takes place.

14.14.6.5 Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square meter area.

14.14.6.6 The minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS - 3262 (Part-3).

14.14.6.7 The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

14.14.7 Measurements for Payment

14.14.7.1 The painted markings shall be measured in sq. Metres of actual area marked (excluding the gaps, if any).

14.14.7.2 In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers.

14.14.8 Rate

14.14.8.1 The Contract unit rate for road markings shall be payment in full compensation for furnishing all labour, materials, tools, equipment, including all incidental costs necessary for carrying out the work at the site conforming to these Specifications complete as per the approved Drawing(s) or as directed by the Engineer and all other incidental costs necessary to complete the work to these Specifications.

14.15 Hectometre / Kilometre Stones

14.15.1 General

14.15.1.1 The work covers the supply, painting, lettering and fixing of distance measurement stones and shall include:

1. Hectometre stones
2. Kilometre stones
3. 5th Kilometre stones

14.15.2 The dimensions of the stones and the size, colour, arrangement of letters and script shall be as per IRC: 26 “Type Designs for 200 Metre Stones” and IRC:8 “Type Designs for Highway Kilometre Stones”.

14.15.3 The hectometre/kilometre stones may be made of local stones, concrete or any other materiel available locally and approved by the Engineer. The stones shall be bedded into the ground with adequate foundations as indicated in the Drawings or in the relevant I.R.C. Specifications or as directed by the Engineer. The orientation and location of the stones shall be as indicated in the Drawings or in the relevant I.R.C. Specifications or as directed by the Engineer.

14.15.4 Measurements for Payment

14.15.4.1 The measurement will be in numbers of 200 metre, kilometre and 5th kilometre stones fixed at site.

14.15.5 Rate

14.15.5.1 The Contract unit rate for hectometre/kilometre/5th kilometre stones shall be payment in full compensation for furnishing all labour, materials, tools, equipment and making the stones, painting and lettering and fixing at site and all other incidental costs necessary to complete the work to these Specifications.

14.16 Road Delineators

14.16.1 General

14.16.1.1 The work covers supplying and fixing roadway indicators, hazard markers and object markers.

14.16.2 The design, materials to be used and the location of the road delineators shall conform to Recommended Practice for Road Delineators, IRC: 79, and to relevant Drawings or as otherwise directed by the Engineers.

14.16.3 Measurements for Payment

14.16.3.1 The measurement shall be made in numbers of delineators fixed at site.

14.16.4 Rate

14.16.4.1 The Contract unit rate Road Delineators shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and fixing at site and all other incidental costs necessary to complete the work to these Specifications.

14.17 Boundary Stones

14.17.1 General

14.17.1.1 The work comprises of supplying and fixing boundary stones as per designs and Specifications given in IRC:25 “Type Designs for Boundary Stones” and at locations indicated in the Drawings or as directed by the Engineer.

14.17.2 Measurements for payment

14.17.2.1 The measurement shall be made in numbers of boundary stones fixed at site.

14.17.3 Rate

14.17.3.1 The Contact unit rate for boundary stones shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and fixing and all other incidental costs necessary to complete the work to these Specifications.

14.18 Road Traffic Signals

14.18.1 General

14.18.1.1 The traffic signal, its configuration, size and location shall be in accordance with IRC: 93 and IS: 7537 and as shown in the Drawings or as directed by the Engineer. Prior to installation of signals, the Contractor shall submit to the Engineer, for approval, detailed proposals showing the signal type, sizes, paint and structural details of the signals posts including control system.

14.18.2 The traffic signals shall have a complete electronic mechanism for controlling the operation of traffic with an auxiliary manual controller. The time plan of signal shall be as per Drawing and shall be modified as directed by the Engineer.

14.18.3 Materials

14.18.3.1 The various materials and fabrication thereof shall conform to the following:

14.18.3.2 Signal foundation

14.18.3.2.1 The signal foundations shall be constructed as per Specifications given in **Clause** 13 of IRC:93 or as shown in the Drawings.

14.18.3.3 Constructional requirements

14.18.3.3.1 The constructional requirements for post, signal head assembly, signal head, optical system, lamp and holder, visor, post, supports for overhead mounted signals, equipment housing, locks, inter-connecting cables, earthing, mains termination, controller electrical components, etc., shall conform to IS: 7537 unless otherwise stated in IRC:93. The post shall be painted and protected as per **Clause** 3.7. of IS: 7537.

14.18.3.4 Optical requirements

14.18.3.4.1 The shape of all signal lenses shall be circular and shall be of specified colour and size and as shown in the Drawing. Quality of lenses, arrangement of lenses, illuminations, visibility and shielding of signals shall be as per relevant **Clauses of IRC: 93 and IS: 7537**.

14.18.4 Tests

14.18.4.1 Tests shall be carried out on all components of traffic signal including tests on complete system for its performance as per relevant **Clauses of IRC: 93 and IS: 7537**.

14.18.5 Maintenance of Traffic Signals

14.18.5.1 It shall be the responsibility of the Contractor to provide for maintenance of the signal section throughout the warranty period for at least five (5) years after installation and as per **Clause 18 of IRC: 93.**

14.18.6 Measurements for Payment

14.18.6.1 The measurement for the traffic signalisation system shall be by unit for complete work as specified and as per Drawing for complete road junction.

14.18.7 Rate

14.18.7.1 Contract unit rate for the traffic signalisation system as a whole shall be payment in full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying, fixing at site, testing and maintenance throughout warranty period and all other incidental costs necessary to complete and maintain the work to these Specifications.

14.19 Prime Coat over Granular Base

14.19.1 Scope

14.19.1.1 This work shall consist of application of single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix.

14.19.2 Materials

14.19.2.1 Primer

14.19.2.1.1 The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. These are:

1. Surfaces of low porosity; such as wet mix macadam and water bound macadam,
2. Surfaces of medium porosity; such as cement stabilized soil base,
3. Surfaces of high porosity; such as a gravel base.

14.19.2.2 Primer viscosity

14.19.2.2.1 The type and viscosity of the primer shall comply with the requirements of IS 8887, as sampled and tested for bituminous primer in accordance with these standards. Guidance on viscosity and rate of spray is given in Table 13-22.

Table 13-22 Viscosity Requirement and Quantity of Bituminous Primer

Type of surface	Kinematic Viscosity of Primer at 60° C (Centistokes)	Quantity of Liquid Bituminous Material per 10 sq. m. (Kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to -12
High porosity	250-500	12 to 15

14.19.2.3 Choice of primer

14.19.2.3.1 The primer shall be bitumen emulsion, complying with IS 8887 of a type and grade as specified in the contract or as directed by the Engineer. The use of medium curing cutback as per IS 217 shall be restricted only for sites at sub zero temperatures or for emergency as directed by the Engineer.

14.19.3 Weather and Seasonal Limitations

14.19.3.1 The bituminous primer shall not be applied on a wet surface (see 13.19.4.2) or during dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10° C. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present.

14.19.4 Construction

14.19.4.1 Equipment

14.19.4.1.1 The primer distributor shall be a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying of small areas inaccessible to the distributor, or in narrow strips shall be sprayed with a pressure hand sprayer, or as directed by the Engineer. By manual methods may be allowed for small areas at the discretion of the Engineer.

14.19.4.2 Preparation of road surface

14.19.4.2.1 The surface to be primed shall be prepared in accordance with **Clause 13.4 and Clause 902** of MoST Specifications for Road and Bridge Works (IV Revision) appropriate. Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

14.19.4.3 Application of bituminous primer

14.19.4.3.1 The viscosity and rate of application shall be as specified in the contract. or as determined by site trials carried out as directed by the Engineer. Where geosynthetic is proposed for use, the requirement of **Clauses 703.3.2 and 703.4** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply. The bituminous primer shall be sprayed uniformly in accordance with **Clause 501** of MoST Specifications for Road and Bridge Works (IV Revision). The method of application of the primer will depend on the type of equipment to be used, size of nozzle, pressure at the spray bar and speed of forward movement. The

contractor shall demonstrate at a spraying trial that the equipment and method to be used is capable of producing a uniform spray, with in the tolerance specified

14.19.4.4 Curing of primer and opening to traffic

14.19.4.4.1 A primed surface shall be allowed to cure for at least 24 hours or such other period as is found to be necessary to allow all the volatile to evaporate before any subsequent surface treatment or mix is laid. Any un absorbed primer shall first be blotted with an application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course. A very thin layer of clean sand may be applied to the surface of the primer, to prevent the primer picking up under the wheels of the paver and the trucks delivering bituminous material to the paver.

14.19.4.5 Tack Coat

14.19.4.5.1 Over the primed surface a tack coat should be applied in accordance with **Clause 13.5**.

14.19.5 Quality control of work

14.19.5.1 For control of the quality of materials supplied and the works carried out, the relevant provision of Section **900** of MoST Specifications for Road and Bridge Works (IV Revision) Shall apply.

14.19.6 Arrangement for Traffic

14.19.6.1 During the construction operations, arrangement of traffic shall be done as per **Clause 1.9.2**.

14.19.7 Measurements for Payment

14.19.7.1 Prime coat shall be measured in terms of surface area of application in sqm.

14.19.8 Rate

14.19.8.1 The contract unit rate for prime coat with adjustment as described in **Clause 13.19.7** shall be payment in full for carrying out the required operations including full compensation for all components listed in **Clause 13.1.8.1 (1) to (5)** as applicable to the work specified in these Specifications. Payments shall be on the basis of the provision of prime coat at an application rate of 0.6 kg. Per square meter, with adjustments, plus or minus, the variation between this amount and the actual amount approved by the Engineer after the preliminary trials referred to in **Clause 13.19.4.3.**

14.20 Bituminous Macadam

14.20.1 Scope

14.20.1.1 The work shall consist of construction, in a single course having 50mm to 100mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on apreviously prepared base to the requirements of these Specifications. Bituminous macadam is more open graded than the dense graded bituminous materials described in **Clauses 13.6 and 13.7 and 508** of MoST Specifications for Road and Bridge Works (IV Revision).

14.20.2 Materials

14.20.2.1 Bitumen

14.20.2.1.1 The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for “Paving Bitumen” IS: 73, and of the penetration indicated in Table 13-24.

14.20.2.2 Coarse aggregates

14.20.2.2.1 The coarse aggregates shall consist of crushed stone, crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft friable matter organic or other deleterious matter. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with anti-stripping agents, as per manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping.

14.20.2.2.2 The aggregates shall satisfy the physical requirements set forth in Table 13-23.

14.20.2.2.3 Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 m sieve shall have at least two fractured faces.

Table 13-23: Physical Requirements for Coarse Aggregates for Bituminous Macadam

Property	Test	Specifications
Cleanliness	Grain size Analysis[1]	Max. 5% passing 0.075mm sieve
Particle Shape	Flakiness and elongation Index (Combined)[2]	Max. 30 %
Strength*	Los Angeles Abrasion Value[3]	Max. 40 %
	Aggregate Impact Value[3]	Max. 30 %
Durability	Soundness[4]	
	Sodium Sulphate	Max. 12 %
	Magnesium Sulphate	Max. 18 %
Water Absorption	Water Absorption[5]	Max. 2%
Stripping	Coating and stripping of Bitumen Aggregate Mixtures[6]	Minimum retained coating 95 %
Water Sensitivity[7]	Retained Tensile Strength	Minimum 80 %

Notes 1. IS 2386 Part 1 4. IS 2386 Part 5
2. IS 2386 Part 1 5. IS 2386 Part 3
(the elongation test to be done only on non-flaky aggregate in the sample)
3. IS 2386 Part 4* 6. IS 6241
7. The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95 %
* Aggregates may satisfy requirement of either of these two tests.

14.20.2.3 Fine aggregates

14.20.2.3.1 Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

14.20.2.4 Aggregate grading and binder content

14.20.2.4.1 When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 13-24 for the grading specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

14.20.2.5 Proportioning of materials

14.20.2.5.1 The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 13-24. The binder content shall be within a tolerance of $\pm$ 0.3 per cent by weight of total mixture when individual specimens are taken for quality tests in

accordance with the provisions of **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

Table 13-24: Composition of Bituminous Macadam

Mix designation	**Grading 1**	**Grading 2**
Nominal aggregate size	**40 mm**	**25 mm**
Layer Thickness	**80-100 mm**	**50-75 mm**
IS Sieve[1] (mm)	**Cumulative % by weight of total aggregate passing**	
45	**100**	
37.5	90-100	
26.5	75-100	100
19	-	90-11
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content % by weight of total mixture[1]	3.1-3.4	3.3-3.5
Bitumen grade	35 or 90	35 or 90

Note: 1. Appropriate bitumen contents for conditions in the cooler areas of India may be up to 0.5% higher subject to the approval of Engineer.

14.20.3 Construction Operations

14.20.3.1 Weather and seasonal limitations

14.20.3.1.1 The provisions of **Clause 501.5.1** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.20.3.2 Preparation of the base

14.20.3.2.1 The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with **Clause 13.4 and Clause 902.3** of MoST Specifications for Road and Bridge Works (IV Revision) as appropriate, and a prime coat, shall be applied in accordance with **Clause 13.19** where specified, or as directed by the Engineer.

14.20.3.3 Tack coat

14.20.3.3.1 A tack coat in accordance with **Clause 13.5** shall be applied as required by the Contract documents, or as directed by the Engineer.

14.20.3.4 Preparation and transportation of mixture

14.20.3.4.1 The provisions of **Clause 501.3 and 501.4** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.20.3.5 Spreading

14.20.3.5.1 The provisions of **Clause 501.5.3** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

Table 13-24A: Manufacturing and Rolling Tempratures

Bitumen Penetration	Bitumen Mixing (^{o}C)	Aggregate Mixing (^{o}C)	Mixed Material (^{o}C)	Rolling (^{o}C)	Laying (^{o}C)
35	160-170	160-175	170 Maximum	100 Minimum	130 Minimum
65	150-165	150-170	165 Maximum	90 Minimum	125 Minimum
90	140-160	140-165	155 Maximum	80 Minimum	115 Minimum

14.20.4 Rolling

14.20.4.1.1 Compaction shall be carried out in accordance with the provisions of **Clause 501.6 nd 501.7** of MoST Specifications for Road and Bridge Works (IV Revision).

14.20.4.1.2 Rolling shall be continued until the specified density is achieved, or where no density is specified, unitl there is no further movement under the roller. The frequency of testing is defined in **Clause 903** of MoST Specifications for Road and Bridge Works (IV Revision).

14.20.5 Surface Finish and Quality Control of Work

14.20.5.1 The surface finish of completed construction shall conform to the requirements of **Clause 902** of MoST Specifications for Road and Bridge Works (IV Revision). For control of the quality of materials supplied and the works carried out, the relevant provisions of **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision).

14.20.6 Protection of the Layer

14.20.6.1 The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of **Section 513** of MoST Specifications for Road and Bridge Works (IV Revision) before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

14.20.7 Arrangements of Traffic

14.20.7.1 During the period of construction, arrangement of traffic shall be made in accordance with the provisions of **Clause 1.9.2**.

14.20.8 Measurements for Payment

14.20.8.1 Bituminous macadam shall be measured as finished work in cubic metres, or by weight in metric tones, where used as regulating course, or square meters at the specified thickness as indicated in the Contract or shown on the drawings, or as otherwise directed by the Engineer.

14.20.9 Rate

14.20.9.1 The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include for, all components listed in **Clause 13.4.8.2 (i) to (xi)**.

14.21 Close-Graded Premix Surfacing / Mixed Seal Surfacing

14.21.1 Scope

14.21.1.1 This work shall consist of the preparation, laying and compaction of a close-graded premix surfacing material of 20 mm thickness composed of graded aggregate premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

14.21.1.2 Close graded premix surfacing shall be of Type A or Type B as specified in the Contract document.

14.21.2 Materials

14.21.2.1 Binder

14.21.2.1.1 The provisions of **Clause 511.1.2.1** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.21.2.2 Course aggregates

14.21.2.2.1 The provisions of **Clause 511.1.2.2** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.21.2.3 Fine aggregates

14.21.2.3.1 The fine aggregates shall consist of crushed rock quarry sands, natural gravel/ sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particle, dry and free from injurious, soft or flaky particles and organic or deleterious substances.

14.21.2.4 Aggregate gradation

14.21.2.4.1 The coarse and fine aggregates shall be so graded or combined as to conform to one or the other grading shown in Table 13-25, as specified in the contract document.

Table 13-25: Aggregates Gradation

IS Sieve	Cumulative per cent by weight of total aggregate passing	
Designation	**Type A**	**Type B**
13.2 mm	-	100
11.2 mm	100	88-100
5.6 mm	52-88	31-52
2.8 mm	14-38	5-25
0.09 mm	0-5	0-5

14.21.2.5 Proportioning of materials

14.21.2.5.1 The total quantity of aggregates used for Type A or B close-graded premix surfacing shall be 0.27 cubic meter per 10 sqm area. The quantity of binder used for premixing in terms of straight-run bitumen shall be 22.0 kg and 19.0 kg per 10 square metres area for Type A and Type B surfacing respectively.

14.21.3 Construction Operations

14.21.3.1 The provisions of **Clause 511.1.3.1 through 511.1.3.5** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.21.4 Opening to Traffic

14.21.4.1 Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Excessive traffic speeds should not be permitted.

14.21.5 Surface Finish and Quality Control of Work

14.21.5.1 The surface finish of construction shall conform to the requirements of **Clause 902** of MoST Specifications for Road and Bridge Works (IV Revision). For control on the quality of materials supplied and the works carried out, the relevant provisions of **Section 900** of MoST Specifications for Road and Bridge Works (IV Revision) shall apply.

14.21.6 Arrangements for Traffic

14.21.6.1 During the period of construction, arrangement for traffic shall be in accordance with the provisions of **Clause 1.9.2**.

14.21.7 Measurements for Payment

14.21.7.1 Close-graded premix surfacing, Type A or B shall be measured as finished work, for the area specified to be covered, in square meters at a specified thickness. The area will be net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

14.21.8 Rate

14.21.8.1 The contract unit rate for close-graded premix surfacing, Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in **Clause 13.4.8.2 (i) to (xi).**

15 PIPE CULVERTS

15.1 Scope

15.1.1 This work shall consist of furnishing and installing reinforced cement concrete pipes, of the type, diameter and length required at the locations shown on the Drawings or as ordered by the Engineer and in accordance with the requirements of these Specifications.

15.2 Materials

15.2.1 All materials used in the construction of pipe culverts shall conform to the requirements of **Chapter 7**.

15.2.2 Each consignment of cement concrete pipes shall be inspected, tested, if necessary, and approved by the Engineer either at the place of manufacture or at the site before their incorporation in the works.

15.3 Excavation for Pipe

15.3.1 The foundation bed for pipe culverts shall be excavated true to the lines and grades shown on the Drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to levels as shown on the Drawings. In case of high embankments where the height of fill is more than three times the external diameter of the pipe, the embankment shall first be built to an elevation above the top of the pipe equal to the external diameter of the pipe, and to width on each side of the pipe of not less than five times the diameter of pipe, after which a trench shall be excavated and the pipe shall be laid.

15.3.2 Where trenching is involved, its width on either side of the pipe shall be a minimum of 150 mm or one-fourth of the diameter of the pipe whichever is more and shall not be more than one-third the diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

15.3.3 The pipe shall be placed where the ground for the foundation is reasonably firm. Installation of pipes under existing bridges or culverts shall be avoided as far as possible. When during excavation the material encountered is soft, spongy or other unstable soil, and unless other special construction methods are called for on the Drawings or in special provisions, such unsuitable material shall be removed to such depth, width and length as directed by the Engineer. The excavation shall then be backfilled with approved granular material which shall be properly shaped and thoroughly compacted upto the specified level.

15.3.4 Where bed-rock or boulder strata are encountered, excavation shall be taken down to atleast 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock / boulders in this area be removed and the space filled with approved earth, free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

15.3.5 Trenches shall be kept free of water until the pipes are installed and the joints have hardened.

15.4 Bedding for Pipe

15.4.1 The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert, shall conform to the specified levels and grade, and shall be one of the following two types ad specified on the Drawings:

15.4.1.1 First Class bedding

15.4.1.1.1 Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material, shaped concentrically to fit the lower part of the pipe exterior for atleast ten per cent, of its overall height or as otherwise shown on the Drawings.

The bedding material shall be well graded sand or another granular material passing 5.6 mm sieve suitably compacted / rammed. The compacted thickness of the bedding layer shall be as shown on the Drawings and in no case shall it be less than 75 mm.

15.4.1.2 Concrete cradle bedding

15.4.1.2.1 When indicated on the Drawings or directed by the Engineer, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner then M 15 conforming to **Chapter 9**. The shape and dimensions of the cradle shall be as indicated on the Drawings. The pipes shall be laid on the concrete bedding before the concrete has set.

15.5 Laying of Pipe

15.5.1 No pipe shall be laid in position until the foundation has been approved by the Engineer. Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

15.5.2 The arrangement for lifting, loading and unloading concrete pipes from factory / yard and at site shall be such that the pipes do not suffer any undue structural strain, any damage due to fall or impact. The arrangement may be got approved by the Engineer.

15.5.3 Similarly, the arrangement for lowering the pipe in the bed shall be got approved by the Engineer. It may be with tripod-pulley arrangement or simply by manual labour in a manner that the pipe is placed in the proper position without damage.

15.5.4 The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. In case of use of pipes with bell-mouth, the belled end shall face upstream. The pipes shall be fitted and matched so that when laid in work, they from a culvert with a smooth uniform invert.

15.5.5 Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

15.6 Jointing

15.6.1 The pipes shall be jointed either by collar joint or by flush joint. In the former case, the collars shall be of RCC 150 to 200 mm wide and having the same strength as the pipes to be jointed. Caulking space shall be between 13 and 20 mm according to the diameter of the pipe. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons. Before caulking, the collar shall be so placed that its centre coincides with the joint and an even annular space is left between the collar and the pipe.

15.6.2 Flush joint may be internal flush joint or external flush joint. In either case, the ends of the pipes shall be specially shaped to form a self centering joint with a jointing space 13 mm wide. The jointing space shall be filled with cement mortar, 1 cement to 2 sand, mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed.

15.6.3 For jointing pipe lines under light hydraulic pressure, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen of other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

15.6.4 All joints shall be made with care so that their interior surface is smooth and consistent with interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.

15.7 Backfilling

15.7.1 Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, excessive amounts of sods or other vegetable matter, and lumps and shall be approved by the Engineer. Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the launches of the pipe. Approved pneumatic or light mechanical tamping equipment can be used.

15.7.2 Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

15.7.3 In case of high embankment, after filling the trench upto the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compactor.

15.8 Headwalls and Other Ancillary Works

15.8.1 Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance, with the details shown on the Drawings or as directed by the Engineer. Masonry for the walls shall conform to **Chapter 10, 11 or 9** as applicable. Aprons shall conform to **Chapter 26**.

15.9 Opening to Traffic

15.9.1 No traffic shall be permitted to cross the pipe line unless height of filling above the top of the pipe line is atleast 600 mm.

15.10 Measurements for Payment

15.10.1 R.C.C. pipe culverts shall be measured along their centre between the inlet and outlet ends in linear metres.

15.10.2 Selected granular material and cement concrete for pipe bedding shall be measured as laid in cubic metres. Ancillary works like headwalls, etc., shall be measured as provided for under the respective Chapters.

15.11 Rate

15.11.1 The Contract unit rate for the pipes shall include the cost of pipes including loading, unloading, hauling, handling, storing, laying in position and jointing complete and all incidental costs to complete the work as per these Specifications.

15.11.2 Ancillary works such as excavation including backfilling, concrete and masonry shall be paid for separately, as provided under the respective Clauses.

16 MANUFACTURING / SUPPLYING LAYING AND JOINTING OF PIPES

16.1 Reinforced Cement Concrete (RCC) Pipes

16.1.1 Scope

16.1.1.1 This Specification covers the requirements for manufacturing, testing, supplying, jointing and, testing at work sites, of Reinforced Cement Concrete (RCC) pipes, of both pressure and non pressure varieties used for pumping mains, sewers and storm water drains.

16.1.2 Applicable Codes

16.1.2.1 The manufacturing, testing, supplying, jointing and testing at work sites of RCC pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern.

16.1.3 Materials

IS: 458	Specification for Concrete Pipes (with and Without Reinforcement).
IS: 3597	Method of Tests for Concrete Pipes.
IS: 5382	Specification for Rubber Sealing Rings for Gas Mains, Water Mains and Sewers.

16.1.3.1 Codes of practice

IS: 456	Code of Practice for Plain and Reinforced Concrete.
IS: 783	Code of Practice for Laying of Concrete Pipes.

16.1.4 Design

Design of RCC pipes shall be in accordance with the relevant clauses of IS: 454.
The details of reinforcement shall be as per Clause 5.2 of IS: 458.
The ends of pipes shall be in accordance with relevant clauses of IS: 458.

16.1.5 Manufacturing

16.1.5.1 General

1. The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

2. The RCC pipes and collars / rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

3. Engineer shall at all reasonable times have free access to the places where the pipes and collars / rubber rings are manufactured for the purpose of examining and testing the pipes and collars / rubber rings and of witnessing the test and manufacturing.

4. All tests specified either in this Specification or in the relevant Indian Standards shall be performed by Supplier / Contractor at his own cost and in presence of Engineer if desired. for this, sufficient notice before testing of the pipes shall be given to Engineer.

5. If the test is found unsatisfactory, Engineer may reject any or all pipes of that lot. The decision of Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

16.1.5.2 Materials

Materials should conform to the requirements given in **Chapter 7.**

16.1.5.3 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

16.1.5.4 Dimensions

1. The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS: 458 for different class of pipes.

2. The tolerances regarding overall length, internal diameter of pipes or socket and barrel wall thickness shall be as per relevant clauses of IS: 458.

16.1.5.5 Workmanship and finish

1. Pipes shall be straight and free from cracks except that craze cracks may be permitted. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600 mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

2. The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between Engineer and the manufacturer or supplier.

3. The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

4. The pipes shall be free from local dents or bulges greater than 3.00 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

5. The deviation from straight in any pipes throughout its effective length, tested by means of a rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters, 3 mm for every metre run.

16.1.6 Testing

16.1.6.1 All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.

16.1.6.2 During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by Engineer the results of compressive tests of concrete cylinders or cubes made from the concrete used for the pipes. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure.

16.1.6.3 The specimen of pipes for the following tests shall be selected in accordance with **Clause 9.1** of IS: 458 and tested in accordance with the methods described in IS: 3597:

1. Hydrostatic test.
2. Three edge bearing test or sand bearing test.
3. Absorption test.
4. Bursting test.

Note: Three edge bearing strength to produce 0.25 mm crack in case of special design of pipes shall be as follows:

300 mm Ø	*1200 kg/m*
350 mm Ø	*3040 kg/m*
400 mm Ø	*3460 kg/m*
450 mm Ø	*4160 kg/m*
500 mm Ø	*4160 kg/m*
600 mm Ø	*4720 kg/m*
700 mm Ø	*5320 kg/m*
800 mm Ø	*6060 kg/m*
900 mm Ø	*6760 kg/m*
1000 mm Ø	*7400 kg/m*
1100 mm Ø	*8200 kg/m*

16.1.7 Sampling and inspection

16.1.7.1 In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Specification shall be ascertained on the basis of tests on pipes selected from it.

16.1.7.2 The number of pipes to be selected from the lot shall be in accordance with column 1 and 2 of Table 9 of IS: 458.

16.1.7.3 Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every “r th” pipe be selected till the requisite number is obtained, “r” being the integral part of N/n where “N” is the lot size and “n” is the sample size.

16.1.7.4 All the pipes selected as per **Clause 15.1.7.3** shall be inspected for dimensional requirements, finish and deviation from straight.

16.1.7.5 The number of pipes to be tested for tests under **Clause 15.1.6.3** shall be in accordance with column of Table 9 of IS: 458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in **Clause 15.1.7.4**

16.1.7.6 A lot shall be considered as conforming to the requirements of IS: 458 if the following conditions are satisfied.

1. The number of defective pipes (those not satisfying one or more of the requirements for dimensions, finish and deviation from straight) shall not be more than the permissible number given in Column 3 of Table 9 of IS: 458.
2. All the pipes tested for various tests as per **Clause 15.1.6.3** shall satisfy corresponding requirements of the tests.
3. In case the number of pipes not satisfying requirements of any one or more tests, one or two further sample of same size shall be selected and tested for the test or tests in which failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

16.1.8 Marking

16.1.8.1 The following information shall be clearly marked on each pipe:

1. Internal diameter of pipe.
2. Class of pipe.
3. Date of manufacture, and
4. Name of manufacturer or his registered trademark or both.

16.1.9 Laying

16.1.9.1 Laying of pipe shall conform to **Clause 15.7**.

16.1.10 Jointing

16.1.10.1 Jointing of RCC pipes shall be done as per the requirements of following Specifications and as per the relevant IS. The type of joints shall be as specified in the Contract / Drawing. After jointing extraneous material if any, shall be removed from the inside of the pipe and newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

16.1.10.2 Spigot and Socket Joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar in the proportion of 1:1, which shall be rammed with caulking tool.

16.1.10.3 Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation. The collar shall then be placed symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand in the proportion of 1:1, tempered with just sufficient water to have a consistency of the semi dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a filled sloping at 45^{o} to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

16.1.10.4 Spigot and Socket Joint (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring, shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar in the proportion of 1:1, shall then be filled into the remaining annular space and rammed with a caulking tool.

16.1.10.5 Collar Joint (Semi-flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring, which when compressed between the spigot and collar, seal the joint. Stiff mixture of cement mortar in the proportion of 1:1, shall then be filled into the remaining annular space and rammed with a caulking tool.

16.1.10.6 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipes. The manufacturers instructions shall be used, and the manufacturers instructions shall be deemed to form a part of this Specifications. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

16.1.10.7 Flush Joint (Internal)

This joint shall be generally used for culvert pipe of 60 cm. diameter and over. The ends of the pipes are specially shaped to form a self-centering joint with an internal jointing spaces 1.3 cm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar in the proportion of 1:1, mixed sufficiently dry to remain in position when forced with a trowel or rammer.

16.1.10.8 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against the other and adjusted in correct position. The jointing space shall then be filled with cement mortar in the proportion of 1:1, sufficiently dried and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

16.1.11 Cleaning of pipes

16.1.11.1 As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by Engineer to prevent entry of mud or slit etc.

16.1.11.2 If as a result of the removal of any obstruction, Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory Contractor shall amend the work and carry out such further tests as are required by Engineer.

16.1.11.3 It shall also be ascertained by Contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably enlightened by projected sunlight or otherwise.

16.1.12 Testing at work site

16.1.12.1 After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Specifications and as directed by Engineer. All equipment for testing at work site shall be supplied and erected by the Contractor and shall be rectified by him / her to the full satisfaction of Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

16.1.12.2 After the joints have thoroughly set and have been checked by Engineer and before backfilling the trenches, the entire section of the sewer (or storm water drain) shall be proved by Contractor to be water tight by filling in pipes with water to the level of 1.50 m. above the top of the highest pipe in the stretch and heading the water up for the period of one hour. The apparatus used for the purpose of testing shall be approved by Engineer. Contractor if required by Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 litre / hour / 100 linear metres / 10 mm nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

16.1.12.3 In case of pressure pipeline the completed stretch of pipeline shall be tested for site test pressure of 0.15g/sq.cm. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure, as specified in IS: 458.

16.1.13 Measurement

16.1.13.1 All RCC pipes shall be measured according to the work actually done and no allowance will be made for any waste in cutting to the exact length required. The measurement for pipes shall be in running metres nearest to a cm. of length along the centre line of pipe as actually laid at work sites.

16.1.14 Rate

16.1.14.1 The rate for providing, laying and jointing of RCC pipes shall be deemed to include the cost of collars / rubber rings, jointing material, testing and the extra excavation required for ordinary bedding of pipes and also for collars and pipe sockets if any.

16.1.15 Notes

16.1.15.1 If any damage is caused to the pipeline during the execution of work or while cleaning / testing the pipeline as specified, Contractor shall be held responsible for the same and shall replace the damaged pipeline and retest the same at his own cost to the full satisfaction of Engineer.

16.1.15.2 Water for testing of pipeline shall be arranged by Contractor at his own cost.

16.2 Salt Glazed Spigot & Socket Stoneware (GSW) Pipes (A Class with 1.5 Kg/cm^2)

16.2.1 Scope

16.2.1.1 This Specification covers the requirements for manufacturing, testing, supplying, jointing and, testing at work sites, of salt glazed spigot and socket stoneware pipes.

16.2.2 Applicable Codes

The manufacturing, testing, supplying, jointing and testing at work sites of GSW pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of Codes and standards, this Specification shall govern.

16.2.2.1 Materials

IS: 651 and IS: 4127	Specification for GSW Pipes.
IS: 651 and IS: 4127	Method of Tests for GSW Pipes.

16.2.3 Design

16.2.3.1 Design of GSW pipes shall be in accordance with the relevant clauses of IS: 651 and IS: 4127.

16.2.4 Manufacturing

16.2.4.1 General

1. The stoneware pipe shall conform to IS: 651 and IS: 4127. The Contractor shall arrange to give at his own cost Hydraulic test, Absorption test, test for resistance to action of acid, test for crushing strength etc. in the manner described by the IS: 651 and IS: 4147. Number of pipes to be tested shall be as per relevant latest IS., separately for each diameter of pipe. All the above tests including the hydraulic test shall be carried out at the premises of manufacture of pipes and the necessary guages, apparatus and supply of labour etc. shall be arranged by the Contractor at his own cost. However, before delivery of pipes is made at the site, the Contractor shall arrange to give visual tests for damage or cracks etc. and the sound test, for whole of the lot received from time to time. The

pipes for all the above tests shall be selected at random by the Engineer from the stock of the manufacturer from time to time. The length of pipe shall be 60 cm / 75 cm / 90 cm. Necessary test results to be given for pipes as per IS: 651 and test certificate results to be given for records.

2. The method of making the test shall be to the entire satisfaction of the Engineer, and all the cost of the designing, purchasing, setting up and using the apparatus required to make the test shall be borne by the Contractor.

3. No pipe shall be dispatched from the place of manufacture until the approval of the Engineer has been given in writing.

16.2.5 Loading and Unloading

16.2.5.1 At every point of loading or unloading, pipes or castings must be handled by approved lifting tackles. Unloading by rolling down planks or any other form of inclined ramp will not be allowed unless the written consent of the Engineer to the method proposed has been obtained. Pipes are to be carefully stacked on site with timber packing under and between the pipes. The pipes are to be laid up at the gradients beginning at the lower end. No pipe is to be laid until the trench has been excavated to its required depth for a distance of 20m, in front of the pipe to be laid. (This distance may vary as directed by the Engineer).

16.2.6 Laying

16.2.6.1 Laying of GSW pipes shall conform to **Clause 15.7**.

16.2.7 Measurement

16.2.7.1 The mode of payment shall be as per the running meter of pipes provided, laid, lowered and jointed. Retention money for testing to be kept at 10% of value of item of work. On giving test of the complete sewerage system to the satisfaction of the Engineer the same shall be released.

16.3 Centrifugally Cast Iron Pipes

16.3.1 Scope

16.3.1.1 This Specification covers the requirements for manufacturing, supplying, laying, jointing and, testing at works site, of Centrifugally Cast Iron pipes (Spun Iron pipes) used for water supply, sewerage and storm water drains.

16.3.2 Applicable Codes

16.3.2.1 The laying of CI pipes and fittings / specials shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the standards / Codes shall be referred to. If requirements of this Specification conflicts with the requirements of the standards / Codes, this Specification shall govern.

IS: 1536	Specification for Centrifugally Cast (Spun) Iron Pressure Pipes for Water, Gas and Sewage
IS: 1538	Specification for Cast Iron Fittings for Pressure Pipes for Water, Gas and Sewage
IS: 11606	Methods for Sampling of Cast Iron Pipes and Fittings
IS: 3114	Code of Practice for Laying of CI Pipes

16.3.2.2 Others I.S. Codes not specifically mentioned here but pertaining to the use of CI pipes form part of these Specifications.

16.3.3 Manufacture

16.3.3.1 The spun iron pipes shall be of CI, casted centrifugally and shall be of class LA, A, B or as specified.

16.3.3.2 The metal used for the manufacture of pipes shall be of quality not less than that of grade 15 of IS: 210-1970

16.3.3.3 The pipes shall be stripped with all necessary precautions necessary to avoid warping or shrinking defects. The pipes shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not effect the use of the pipes.

16.3.3.4 All Cast Iron (spun) pipes and fittings shall be of approved brand conforming to IS: 1536 and IS: 1538 respectively and free from flaws, air bubbles, cracks, sand holes and other defects and truly cylindrical and of uniform thickness. These shall not be brittle but shall allow ready cutting, chipping and all joints shall be double flanged joints and shall be air and water tight.

16.3.4 Specials and fittings

16.3.4.1 CI specials and fittings used for CI pipes shall conform to IS: 1538. The methods for sampling of CI pipes and fittings shall conform to IS: 11606.

16.3.5 Dimensions and tolerances

16.3.5.1 The dimensions of pipes, sockets, spigots and flanges and their tolerances shall conform to the sizes specified in relevant clause of IS: 1536.

16.3.6 Inspection of pipes

16.3.6.1 The pipe and fittings shall be inspected for defects and be rung with a light hammer, preferably while suspended, to detect cracks. Smearing the outside with chalk dust helps the location of cracks. If doubt persists further confirmation may be obtained by pouring a little kerosene on the inside of the pipe at the suspected spot. If a crack is present the kerosene seeps through and shows on the outer surface.

16.3.6.2 Any pipe found unsuitable after inspection before laying shall be rejected.

16.3.7 Laying and Jointing of CI pipes and fittings

16.3.7.1 The laying of CI pipe lines shall, in general be in accordance with **Clause 15.7**. Specifications given in IS: 3114 shall also be followed as applicable.

16.3.7.2 Rubber ring Tyton joints shall be used for jointing of CI pipe lines outside the buildings and other external water supply installations. They shall be used strictly in accordance with the manufacturer's instructions. Wherever required, for internal water supply piping arrangements with CI pipes, pipes shall be connected by flanged joints.

16.3.8 Thrust Blocks

16.3.8.1 In case of bigger diameter pipes where the pressure is very high, thrust blocks of cement concrete (1 cement: 2 coarse sand: 4 graded stone aggregate of 20 mm nominal size) of adequate size and shape shall be provided on all bends / tees etc., to transmit the hydraulic thrust to the ground, spreading over a sufficient areas, depending upon the type of soil met with, as per the relevant Drawings or as directed by Engineer.

16.3.9 Testing

16.3.9.1 Mechanical Tests

Mechanical tests shall be carried out during the manufacture of the pipes as specified in IS: 1536.

16.3.9.2 Hydrostatic tests at works

1. For hydrostatic tests, the pipes shall be kept under pressure for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand pressure test without showing any leakage or any other defect of any kind. As far as possible the hydrostatic test shall be conducted before giving any coating to the pipes. These pipes shall be used upto half the hydraulic test pressure as given in the following table. The hydraulic test pressure for Centrifugally Cast Iron pipes as per IS: 1536, shall be as given below:

Type of pipes	**Test pressure in kg/cm^2 (meter head)**		
	Class LA	**Class A**	**Class B**
Spigot and socket pipes in all diameters	12 (120)	18 (180)	24 (240)
Flanged pipes upto 600 mm diameter	-	18 (180)	24 (240)

2. The specials shall conform to IS: 1538. The hydraulic test pressure of each class of specials shall be as follows:

Nominal diameter	**Test pressure in kg/cm^2 (meter head of water)**	
	Specials without branches or with branches not greater than half the principal diameter	**Specials with branches greater than half the principal diameter**
Upto and including 300 mm	25 (250)	25 (250)
Over 300 mm to 600 mm	20 (200)	20 (200)
Over 600 mm upto 1500 mm	15 (150)	15 (150)

3. Water of approved quality for testing shall be arranged by the Contractor.

16.3.10 Testing at site

The following tests are to be carried out after a new pipe is laid, jointed and partially back filled. Portions of the line shall be tested by subjecting the pressure test as the laying progresses before the entire line is completed (the test stretch should not generally exceed 500 m), to identify any error of workmanship which can be detected and corrected at minimum cost. For all these tests water of approved quality has to be arranged by the Contractor.

16.3.10.1 Pressure test

Pressure test at a pressure of atleast double the maximum working pressure shall be carried out. Pipes and joints shall be absolutely water tight under the test. The procedure for pressure testing shall be as follows:

1. Each valved section of the pipe shall be slowly filled with water and all air shall be expelled from the pipe through the hydrants and blowoffs. If these are not available at high places, necessary taping may be made at points of highest elevation before the test is made and plugs inserted after the tests have been completed.

2. Sufficient backfill shall be placed on the pipe to resist the movement due to pressure while testing. Trench shall be partially backfilled such that the joints, couplings, valves, hydrants or any other fittings shall be left exposed for observations during testing. The specified pressure based on the elevation of the lowest point of the line or section under

test and corrected to the elevation of the test guage, shall be applied by means of a pump connected to pipe in a manner satisfactory to the Engineer. The duration of the test shall not be less than 5 minutes.

3. During testing, all exposed pipes, fittings etc., should be carefully examined. When the joints are made with lead, all such joints showing visible leaks shall be recaulked until tight. When the joints are made with cement and show seepage or slight leakage, such joints shall be cut out and replaced as directed by the Engineer. Any cracked or defective pipes, fittings, valves or hydrants etc., discovered in consequence of this pressure test shall be removed and replaced by sound material and the test shall be repeated until satisfactory to the Engineer.

16.3.10.2 Leakage test

After the successful completion of the pressure test, Leakage test shall be conducted at a pressure to be specified by the Engineer for a duration of two hours. The procedure for Leakage test shall be as follows:

1. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled.

2. No pipe installation shall be accepted until the leakage is less than the number of cm^3/hr, as determined by the following formula:

   $ql = (ND\sqrt{P})/3.3$

   where
   ql = the allowable leakage in cm^3/hr
   N = number of joints in the length of the pipe line,
   D = diameter of pipe in mm, and
   P = average test pressure during the leakage testing kg/cm^2

3. Should any test of the pipe laid in position disclosed leakage greater than that obtained by the above formula, the defective joints shall be replaced until the leakage is within the specified allowance.

16.3.11 Markings

16.3.11.1 Each pipe shall have cast, stamped or indelibly painted on it the following appropriate marks.

1. Manufacturers name or identification mark
2. The nominal diameter
3. Class reference
4. Mass of pipe
5. The no. of the Indian standard and
6. The year of manufacture.

16.3.11.2 Marking may be done on the outsides of the sockets or towards the end of barrels of pipes.

16.3.12 Measurements

16.3.12.1 The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. Specials shall be excluded and enumerated and paid separately. The portion of the pipe within the collar at the joints shall not be included in the length of pipe work.

16.3.12.2 Excavation, refilling, shoring and timbering in trenches masonry or concrete pillars and thrust blocks wherever required shall be measured and paid for separately under relevant items of work.

16.3.12.3 Joints shall be measured and paid for separately.

16.3.13 Rate

16.3.13.1 The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured / enumerated separately under clause 'Measurements', which shall be paid for separately.

16.4 Galvanised Iron Pipes

16.4.1 Scope

16.4.1.1 This Specification covers the requirements for manufacturing, supplying, laying, jointing and testing at works and site of Galvanised Iron pipes used for water supply.

16.4.2 Applicable Codes

16.4.2.1 The laying GI pipes and fittings / specials shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the standards / Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern.

IS: 1239 (Part-I)	Specification for Medium Grade GI Pipes
IS: 1239 (Part-II)	MS Tubular or Wrought Steel Fittings for GI Pipes
IS: 4736	Specification for Galvanizing
IS: 554.	Specifications for Pipe Threads of Screwed Tubes and Sockets

16.4.2.2 Others I.S. Codes not specifically mentioned here but pertaining to the use of CI pipes form part of these Specifications.

16.4.3 Manufacture

16.4.3.1 The pipes shall be Galvanised mild steel hot finished seamless (HFS) or welded ERW, HRIWor HFW screwed and socketed conforming to IS: 1239 (Part-I) for medium grade. The zinc coating shall be uniform adherent, reasonably smooth and free from imperfections.

16.4.3.2 All screwed pipes and sockets shall have pipe threads conforming to the requirements of IS: 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

16.4.3.3 Where the pipes have to be cut or threaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The ends of the pipe shall then be carefully threaded conforming to the requirements of IS: 554 with pipe dies and tapes in such a manner that it will not result in slackness of joints when two pieces of pipes are screwed together. The taps and dies shall be used only for straightening screw threads which have become bent or damaged and shall not be used for turning of the threads as to make them slack, as the later procedure may not result in a water tight joint. The screw threads of the pipes and fittings shall be protected from damage until they are fitted.

16.4.4 Dimensions

16.4.4.1 The dimensions and weights of medium grade GI pipes and sockets and tolerances shall be as prescribed below:

Nominal bore (mm)	Dimension of pipes			Weight of pipe	
	Outside diameter (mm)		Thickness (mm)	Plain end Kg/m	Screwed end socket Kg/m
	Max.	Min.			
6	10.6	9.8	2.0	0.427	0.430
8	14.0	13.2	2.35	0.667	0.681
10	17.5	16.7	2.35	0.886	0.892
15	21.8	21.0	2.65	1.27	1.28
20	27.3	26.5	2.65	1.64	1.65
25	34.2	33.3	3.24	2.51	2.53
32	42.9	42.0	3.25	3.23	3.26
40	48.8	47.9	3.25	3.72	3.76
50	60.8	59.7	3.65	5.24	5.31
65	76.6	75.3	3.65	6.69	6.81
80	89.9	88.0	4.05	8.68	8.85
100	115.0	113.1	4.50	12.40	12.70
125	140.8	138.5	4.85	16.50	17.00
150	166.5	163.9	4.85	19.60	20.20

16.4.5 Tolerance

16.4.5.1 Tolerance in Thickness

Butt welded medium tubes	+ not limited	- 10.0 %
Seamless tubes	+ not limited	- 12.5 %

16.4.5.2 Tolerance in Weight

Single tube (irrespective of quantity)	+ 10 %	- 8 %
For quantities of less than 150 m of one size	+ 10 %	- 8 %
For quantities of 150 m and over of one size	+ 4 %	- 4 %

16.4.6 Specials and fittings

16.4.6.1 The fittings for GI pipes shall be of mild steel tubular or wrought steel fittings conforming to IS: 1239 (Part-II). The fittings shall be designated by the respective nominal bores of the pipes for which they are intended.

16.4.7 Jointing

16.4.7.1 The pipes shall be cleaned and cleared of all foreign matter before being laid. While jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. Care shall be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burr from the joint shall be removed after screwing. After laying, the open ends of the pipe shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

16.4.8 Laying of GI pipes and fittings

16.4.8.1 External work

1. GI pipes if used for external work, shall be laid according to **Clause 15.7**. If they are laid in trenches, the widths and depths, for different diameters of the pipes shall be as follows:

Dia. of Pipe (mm)	Width of Trench (cm)	Depth of Trench (cm)
15 to 50	30	60
65 to 100	45	75

2. At joints the trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with the Specifications on laying of pipes given in this chapter.

3. Pipes shall be laid on a cushion of sand minimum 7.5 cm deep and filled upto 15 cm above the pipes. The remaining portion of the trench shall then be backfilled as described in Chapter 5.

16.4.8.2 Internal work

1. For internal work, the Galvanised iron pipes and fittings shall run on the surface of the walls or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed on the ducts or recess etc., provided there is sufficient space to work on the pipes with the usual tools. The pipes shall not ordinarily be buried in walls or solid floors. Where unavoidable, pipes may be buried for short distances provided adequate protection is given against damage and where so required joints are not buried. Where directed by the Engineer, a MS tube sleeve shall be fixed at the place where the pipe is passing through a wall or floor, for reception of the pipe and to allow freedom for expansion and contraction and other movements. In case the pipe is embedded in walls or floors it should be painted with anticorrosive bitumastic paints of approved quality. The pipe shall not come in contact with lime mortar or lime concrete as the pipe is affected by lime. Under the floors the pipes shall be laid in layer of sand filling as done under concrete floors.

2. All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screwed bolts. These clamps shall be embedded in the brick work of the walls, and shall be spaced at regular intervals in straight lengths as shown in the table ahead:

Dia of Pipe (mm)	Horizontal length (m)	Vertical length (m)
15	2	2.5
20	2.5	3
25	2.5	3
32	2.5	3
40	3	3.5
50	3	3.5
65	3.5	5
80	3.5	5

3. The clamps shall be fixed at shorter lengths near the fittings as directed by the Engineer.

4. For G.I. pipes 15 mm diameter, the holes in the walls and floors shall be made by drilling with chisel or jumper and not by dismantling the brick work or concrete. However, for bigger dimension pipes the holes shall be carefully made of the smallest size as directed by the Engineer. After fixing the pipes the holes shall be made good with cement mortar 1:3 (1 cement: 3 coarse sand) and properly finished to match the adjacent surface.

5. Unions will be provided to facilitate connections, additions and alternations as well as for maintenance and for change of pipes. The locations where unions are to be provided will be decided with prior within approval of the Engineer.

16.4.9 Thrust Blocks

16.4.9.1 In case of bigger diameter pipes where the pressure is very high, thrust blocks of cement concrete (1 cement: 2 coarse sand: 4 graded stone aggregate of 20 mm nominal size) of adequate size and shape shall be provided on all bends / tees etc., to transmit the hydraulic thrust to the ground, spreading over a sufficient areas, depending upon the type of soil met with, as per the relevant Drawings or as directed by Engineer.

16.4.10 Paintings

16.4.10.1 The pipes shall be painted with two coats of anticorrosive bitumastic paint of approved quality.

16.4.11 Testing

16.4.11.1 The pipes and fittings after they are being laid and jointed shall be tested to a hydraulic test pressure of 60 kg/cm^2 (600 m). The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shocks or water hammer, which may develop otherwise. The draw off taps and stop cocks shall then be closed and specified hydraulic pressure shall be applied gradually. A calibrated and accurate pressure gauge shall be used for testing the pressure. The test pump having been stopped, the test pressure should be maintained for at least half an hour. The pipes and fittings shall be tested in sections as the work of laying proceeds, having the joints exposed for inspection during the testing. Pipes or fittings which are found defective shall be replaced and joints found leaking shall be redone, without any extra payment.

16.4.11.2 The water for testing shall be provided by the Contractor. The quality of water should be approved by the Engineer.

16.4.12 Measurements (External and Internal works)

16.4.12.1 The lengths shall be measured in running metre correct to a cm for the finished work which shall include G.I. pipe and G.I. fittings such as bends, tees, elbows, reducers, crosses, plugs, sockets, nipples and nuts, but exclude brass or gun metal taps (cocks), valves, unions, lead connection pipes and shower roses. All pipes and fittings shall be classified according to their diameters, method of jointing and fixing substance, quality and finish. In case of fittings of an equal bore the pipe shall be described as including all cuttings and waste. In case of fittings of unequal bore, the largest bore shall be measured. Pipes laid in trenches (or without supports) and pipes fixed to walls, ceilings, etc., with supports shall be measured separately.

16.4.12.2 Digging and refilling of trenches shall be measured separately as specified in the appropriate clauses of excavation.

16.4.13 Rates

16.4.13.1 External work

The rate shall included the cost of labour and materials involved in all the operations described above. The rates shall not include excavation in trenches, painting of pipes and sand filling all round the pipes, unless otherwise specified.

16.4.13.2 Internal work

The rate shall include the cost of labour and material involved in all the operations described above. The rate shall include the cost of cutting holes in walls and floors and making good the same. This shall not however, include concealed pipe work in which case cutting of chase and making good shall be paid separately. It shall not include painting of pipes and providing sleeves, unless specified otherwise. It will be also not include unions which shall be paid for separately.

16.5 Electrically Welded Steel Pipes

16.5.1 Scope

16.5.1.1 This Specification covers the requirements for manufacturing, supplying, laying, jointing and, testing at works, and site of Electrically Welded Steel pipes, internally lined with cement concrete and externally coated with cement mortar, used for water supply mains.

16.5.2 Applicable Codes

16.5.2.1 The laying of pipes and fittings / specials shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the standards / Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern.

IS: 3589	Seamless/Electrically Welded Steel Pipes for Water, Gas, Sewage-Specification
IS: 5822	Code of Practice for Laying of Electrically Welded Steel Pipes for Water Supply-
IS: 7322	Specification for Specials for Steel Cylinder Reinforced Concrete Pipes
IS: 432 Part I	Mild Steel and Medium Tensile Bars Reinforcement
IS: 432 Part II	Specifications for Mild Steel and Medium Tensile Bars and Hard Drawn Steel Wire (Third Revision)
IS: 2328	Flattening Test for Seamless Pipes
IS: 12269	Specification for 53 Grade Ordinary Portland Cement (OPC)
IS: 6452	Specification for High Alumina Cement for Structural Use (I Revision)
IS: 8112	Specifications for Curing of High Strength OPC
IS: 8041	Specifications for Curing of Rapid Hardening Cement
IS: 269	Specification for Ordinary Portland Cement (OPC)
IS: 455	Specification for Portland Slag Cement
IS: 1489	Specification for Portland Pozzolana Cement
IS: 8043	Specification for Hydrophobic Portland Cement
IS: 4853	Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes (First Revision)
IS: 4260	Recommended Practice for Ultrasonic Butt Welds in Ferritic Steel
IS: 3600 (Part I)	Methods of Testing Fusion Welded Joints and Weld Metal in Steel: Part I Cruciform Fillet Weld Tensile Test

16.5.2.2 Others I.S. Codes not specifically mentioned here but pertaining to the use of Electrically Welded Steel pipes shall form part of these Specifications.

16.5.3 Material

16.5.3.1 Steel

The steel used for manufacturing the pipes and specials shall conform to IS: 2062. The quality of steel, chemical composition and tensile strength of the steel plates shall be as specified in IS: 3589. The thickness of steel plates used for manufacturing pipes shall conform to IS: 3589 or as specified. The thickness of steel plates used shall in no case be less than that specified in IS: 3589.

16.5.3.2 Cement Mortar and Cement Concrete

The Cement Mortar and Cement Concrete used for pipes and specials, shall conform to the Specifications mentioned in **Chapter 9.** The maximum size of aggregate shall be one third the thickness of concrete cover inside the steel pipe or 10 mm, whichever is less. The concrete mix shall have a minimum cement content of 450 kg/m^3 and a characteristic compressive strength of 25 N/mm^2 at 28 days. The cement mortar shall have a minimum cement content of 600 kg/m^3 and a characteristic compressive strength of 25 N/mm^2 at 28 days.

16.5.3.3 Reinforcement

All cage reinforcement used in the pipes and specials shall conform to IS: 432 (Part-1) or IS: 432 (Part-2).

16.5.3.4 Welding Electrodes

All electrodes used for welding of steel plates shall conform to IS: 814.

16.5.4 Length

16.5.4.1 The pipes shall be manufactured in lengths of 5m, unless otherwise specified or agreed to between the purchaser and the manufacturer, for ease in handling.

16.5.5 Joints and Ends

16.5.5.1 Pipe sections shall be of swelled and plain ends suitable for sleeve jointing. The dimensions of sleeves shall be as specified in IS: 3589. Other relevant Specifications with respect to joints and ends, as per IS: 3589, shall also be applicable.

16.5.6 Tolerances

16.5.6.1 The tolerances over dimensions of pipes for different diameters of pipes shall be as specified in IS: 3589.

16.5.7 Manufacture

16.5.7.1 Pipes shall be made from steel plates or strips by butt welding spirally. Pipes shall be of specified nominal diameter after internal lining with 25 mm thick cement concrete as per Specifications.

16.5.7.2 Prior to welding, edges of plates or strips shall be prepared suitably. Prior to welding, the plates shall be fitted closely and during welding they shall be held firmly. Welding shall be done so that there shall be thorough fusion and complete penetration.

16.5.7.3 The ends of the steel pipes shall be square with its longitudinal axis.

16.5.8 Welding

16.5.8.1 For manufacturing of the steel pipes, any of the following types of welding shall be adopted as per IS: 3589.

1. Automatic submerged arc welding.
2. Automatic metal arc welding with covered electrodes.
3. Automatic metal arc welding with bare electrode and carbon dioxide.
4. Electric resistance welding.

16.5.8.2 The welding of pipes in the field and testing should comply with IS: 816.

16.5.8.3 Plates shall be held in the correct position. Abutting edges shall be properly squared. Each deposited layer of the welded metal in the fusion welding process shall be thoroughly cleaned

before additional weld metal is supplied to coincide with the centre line of joint and the finished joint shall be free from all defects.

16.5.8.4 All welds shall have complete fusion with the base metal and shall be free from cracks, oxides, slag inclusion and gas pockets.

16.5.8.5 If welding is stopped for any reason, special care shall be taken when welding is resumed to obtain complete penetration between weld metal, plate and weld metal previously deposited. Three percent of all seams of pipes welded in the fabrication shop shall be Radio graphed (as per IS: 4853) to render visible inspection of any internal defects such as blow holes, slag inclusion or cracks. If any defects are detected the metal at the location shall be chipped out and rewelded. In addition to Radiography of the joints, 100 percent testing by ultrasonic equipment (as per IS: 4260) shall also be included in welding tests. Any defects found out shall be rectified free of cost. Welds found deficient in quality shall be removed by chipping or melting and remade as per Specifications. Chipping or cutting the weld shall not extend to the base metal.

16.5.8.6 Sample welds shall be submitted for testing. The weld joints shall be tested in accordance with the procedure laid down in IS: 3600 (Part-I)-1985, as specified in IS: 5822. Approval of such tests shall be required prior to welding of the pipe.

16.5.8.7 Manual welding of special sections and fittings will be permitted when it is impracticable to use an automatic welding machine.

16.5.8.8 Final welding of closure gaps for buried pipes shall be done after intermediate pipes have been backfilled.

16.5.9 Fabrication of specials

16.5.9.1 Specials such as bends, tapers, tees shall conform to IS: 7322. Specials shall be fabricated by cutting plates of the specified thickness to the required shape obtained by developing the form of specials on ground. Stiffeners shall be provided wherever necessary. Abutting profiles shall be obtained using templates which guide the cutting torches as to obtain a uniform cut. No hand cutting shall be permitted. Specifications for the using and testing of the plates, electrodes, welding, cleaning etc., shall be the same as for the straight pipes.

1. Horizontal and vertical curves

Standard bends of deviations from 5 degree to 90 degrees shall be fabricated out of steel plates. The cut pieces shall as far as possible be placed at the end of pipes joined in the factory. The angle of the cut pieces shall be made so as to obtain the necessary curvature. In case of deviations differing from the standards, cut pieces shall be made to suit the particular site conditions. Length of the cut pieces shall be in line with standard specials. The vertical cuts, shall be so adjusted as to conform to the proposed longitudinal section. Distance pieces may be used to obtain the above conditions.

2. Tapers and Tees

Tapers and tees shall be fabricated with one or more stocks, each stock having a stiffening ring fixed circumferentially in the centre. The stiffener rings shall be made of M.S. Plate of approved thickness.

3. Provisions for valves

Provisions in the form of stubs of required diameter shall be fabricated by the Contractor and shall be fixed to the pipeline after cutting pipe with necessary pad plates.

16.5.10 Cement Concrete and Mortar Lining of Pipes and specials.

16.5.10.1 Preparation of surface before lining or coating.

The surface of pipe to be lined or coated with cement mortar or cement concrete shall be clean. Any loose rust, loose millscale, dirt, debris, oil, grease and other detrimental materials present shall be removed by mechanical means.

16.5.10.2 Cement Concrete lining for inside of steel pipes and specials and mortar coating outside

Cement Concrete shall be composed of cement, coarse and fine aggregates and water well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface. Thickness of cement concrete lining inside the pipe shell shall be of 25 mm and that of the mortar lining outside the pipe shell shall be 25 mm thick.

16.5.10.3 Mixing

The concrete for internal lining shall be mixed as per provisions in **Chapter 9.**

16.5.10.4 Cover

The clear cover to the reinforcement whether steel cylinder or cage shall not be less than 9 mm for lining and 12 mm for coating.

16.5.10.5 Reinforcement

Wire fabric shall be used for external reinforcement. It shall be 50 x 50 mm steel wire mesh, 13 gauge each way, and conform to IS: 432 (Part-1) or IS: 432 (Part-2). The reinforcement cage for the pipes shall extend throughout the pipe barrel and shall consist of spirals or rings and straights. The spirals or rings shall be circular in shape and shall be either wound round the steel pipe shell itself or wound round collapsible frame or drums and then slipped on the steel pipe shell. The fabric shall be wrapped on the shell by tack welding. The outer cage reinforcement for swelled end portions of the pipe shall be wound on them at the time of laying. Minimum reinforcement in the lining shall not be less than three percent of the quantity of steel pipe shell. Splices shall be made by welding or other suitable means. The fabric shall be wrapped on the shell by tack welding.

16.5.10.6 Equipment for lining of Pipes

1. Straight sections of pipe shall be lined by use of a spinning machine specifically designed to suit for the purpose of rotating the section and centrifugally applying cement concrete lining to the interior of steel pipe. Mechanical feeding is preferable.
2. The Contractor shall plan for installation of sufficient number of spinning machines/equipment for inside lining and outside coating of pipes, and the proposed factories. If during the progress of works, it becomes necessary for transporting of plates/pipes from one factory to the other for fabrication/lining and or coating due to inadequate number of machines or breakdowns or to meet progress targets, the Contractor should arrange for such transportation of pipes from one factory to the other at his own cost.

16.5.10.7 Concreting lining and mortar coating of pipes

1. This shall be done generally in two stages to give the required thickness of the barrel.
2. In the first stage concreting shall be done inside the pipe shell and in the second stage placing of the mortar is done outside the pipe shell. Placing of concrete inside the steel pipe shell shall always be done at the manufacturer's works and consolidated by spinning, vibrating, spinning combined with vibrations or other appropriate mechanical means whilst the placing of mortar outside the steel pipe shell shall be done later either at the manufacturer's works or at site.

3. Mortar coating outside the steel pipe shell shall not commence before the expiry of three days after the completion of concreting inside, unless otherwise it is established that the concrete lining inside has attained a works cube strength of not less than 110 kg/cm^2, earlier than this period. During this entire period the concrete inside the steel pipe shell shall be under curing. The mortar outside the steel pipe shell shall be either vibrated or applied under pressure.

4. In the case of pipes with plain ends or slip-in type ends, the portions that should be left exposed without concreting or mortar lining shall be mutually agreed to between the purchaser and the manufacturer.

16.5.10.8 Lining of specials

1. Whenever practicable, specials shall be made form cut lengths of matured lined straight pipes. The lining shall be cut back from the end to ends to be bevelled and welded for a sufficient distance to ensure that any of the concrete lining which is intended to remain as part of lining shall not suffer damage by the cutting or welding process. The concrete lining shall be made good by rendering by hand.

2. Hand rendering of specials shall consist of freshly mixed concrete of a mixture equivalent to that of the lining being repaired, and shall be thoroughly compacted and finished to a smooth surface of the correct form.

   Cement concrete shall be used both for lining and coating of specials. The thickness of lining and coating shall be 25 mm. Specials shall have the nominal dia as that of the connecting pipe after lining. Specifications for lining and coating of specials shall be as that of the straight pipes.

3. The application of cement concrete lining to bends, or specials sections whose shapes preclude other process of lining shall be by mechanical placement, pneumatic placement or hand trowelling finished to produce a smooth dense surface. Debris shall be removed as necessary, permitting the application of the lining to a clear surface.

4. Thickness shall be as required for spun lining of straight sections except that it may be varied by feathering or filleting to affect system lining with adjoining sections of pipe and thickness of lining.

16.5.10.9 Determination of thickness of lining

Lining thickness shall be determined on the freshly lined pipes, at intervals frequent enough to assure compliance. Thickness of lining may be determined by means of a steel pin not larger than 1.5 mm in diameter or on a hardened concrete or mortar by means of a non-destructive measurement process. The lining shall be measured at four equidistant points on two cross sections of the barrel at each end of the pipe or fittings. The first set shall be atleast 200 mm from the respective ends of the pipe or fitting. The second set shall be made as far into the interior of the pipe or fitting as can be readily reached without injuring the lining.

16.5.10.10 Curing

1. After completion of concreting or mortar lining, the concrete or mortar shall be kept wet by any suitable means such as immersion in water, covering by wet gunny bags, or by mechanical sprinklers, for a period of not less than 14 days when cement conforming to IS: 269 or IS: 455 or IS: 1489 or IS: 8043 or IS: 6909 is used; not less than 7 days when cement conforming to IS: 8041 or IS: 8112 is used; not less than 3 days when cement conforming to IS: 6452 or IS: 12269 is used; and not less than 21 days when cement conforming to IS: 12330 is used.

2. Non-pressure steam curing may be permitted provided the requirement of non-pressure steam curing are fulfilled. For non pressure steam curing, the pipe shall be subjected to the action of thoroughly saturated steam at a temperature of 38 to 54 degree C for a

period of not less than 24 hours or for such additional time as may be necessary to enable the pipe to meet the strength requirements.

16.5.10.11 Repair of defective or Damaged Areas of lining

Defective or damaged areas of linings may be patched by cutting out the defective or damaged lining to the metal so that the edges of lining not removed are perpendicular or slightly undercut. A fresh mix of concrete or mortar equivalent to that of the lining being repaired shall be prepared. The cut-out area and the adjoining lining shall be thoroughly wetted, and the concrete or mortar applied to the inside or outside respectively, and trowelled smooth with the adjoining lining. After any surface water has evaporated, but while the patch is still moist, it shall be cured as specified.

16.5.10.12 Protection of work

The lined pipe and fittings shall be protected from extreme heat due to direct sun rays, from impact of rainfall, and from freezing temperatures until the linings have cured sufficiently to withstand these conditions.

16.5.11 Workmanship

16.5.11.1 All pipes shall be cleanly finished free of cracks, surface flaws, laminations and all other defects. They shall be cylindrical, concentric and straight in axis. The ends shall be accurately cut and shaped for welds. The ends shall be square with the axis of the pipe. The repair of minor defects by welding or otherwise shall be permitted only after obtaining the prior permission from the Engineer in writing. No heating shall be permitted.

16.5.12 Handling of pipes and specials.

16.5.12.1 During manufacturing and during the entire period of the application of concrete or mortar lining protection and the curing thereof, the section shall be carefully supported and handled so as to avoid injury to the fresh lining. If a pipe section must be rolled or otherwise moved, such operation shall be done slowly and with every reasonable precaution against damage. Any portion of the lining, coating that may become damaged shall be cut and replaced.

16.5.12.2 During delivery, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the protection or to the section as a whole.

16.5.13 Laying of pipes

16.5.13.1 Pipes shall be laid in accordance with **Clause 15.7**.

16.5.13.2 All pipes shall be laid true to line and level and on pedestals wherever required, the joints strictly conforming to welding Specifications. Joints shall be finished in a workman like manner and shall prove to be sound and water tight. The field welding shall be carefully carried out so as to induce the minimum heat distortion and local hardness in steel.

16.5.13.3 In addition, the provisions of IS: 5822 shall also be applicable.

16.5.14 Field Jointing of Insides and outsides of Concrete lined pipes

16.5.14.1 Cement mortar shall be used for lining of inside and outside lining of joints. It shall be of the same Specifications as those of outside mortar coating of pipes, cement mortar lining for inside and outside of field joints shall be done only after testing the pipe line as per Clause 15.5.17.3.

16.5.14.2 Jointing Inside

For the inside lining of field joints, wire fabric of 50 x 50 mm steel mesh, 13 gauge each way, shall be provided. Inside joints of mortar lined pipe shall be plastered with cement mortar and

finished off smooth with the inside surface of the pipe by trowelling or by other equipment means. Before placing the joint mortar material against the surface of the lining, these surfaces shall be carefully cleaned and wetted to ensure good bond between the lining and joint mortar. The field joint shall be cured for a minimum of 14 days. In any case the pipe line shall not be put into serve until the mortar has cured for a minimum of 24 days. The joints shall be finished off smooth with the inside surface of the lining by trowelling.

16.5.14.3 Jointing Outside

1. For this item, the joints have been classified into two groups:

   - Those coming under water logged area
   - Those coming in other area.

2. Joints under waterlogged areas: These joints shall be done with Cement Mortar 1:2 with two layers of M.S. 50 mm x 50 mm x 13 gauge weld mesh and the thickness of mortar shall be 50 mm thick and a suitable water proofing compound shall also be used.

3. Joints coming in other areas: This shall be done with Cement mortar 1:2, 25 mm thick with one layer of 50 mm x 50 mm x 13 gauge wire fabric reinforcement.

4. Outside field joints shall be coated with cement mortar retained by suitable forms so as to bridge the joints. The mortar shall be compacted within the form to produce a dense coating without voids. The joint coating shall be kept moist for a minimum or 14 days.

16.5.15 Fixing of fixtures

16.5.15.1 Contractor has to fix the required number of fixtures at proper locations as per the approved Drawings and the instructions of Engineer. The fixtures shall be fixed to the flanges by bolts, nuts and washers with necessary fireplay insertions etc. All types of fixtures and necessary equipment required for fixing these fixtures shall be arranged by the Contractor at his own cost.

16.5.16 Testing of Pipe line

16.5.16.1 Mechanical Test (Tensile Test)

Tensile test shall be carried out as specified in IS: 1894:1972. The tensile strength and percentage elongation of pipes shall not be less than the values specified in the table below. The percentage elongation shall be determined on a guage length of 5.65 times of square root of original cross sectional area of the specimen (So).

Steel grade	Tensile strength Mpa (min)	Percentage elongation (min)
Fe 330	330	20
Fe 410	410	18
Fe 450	450	12

16.5.16.2 Hydrostatic Testing at Works

1. Each straight pipe section whose ends are in plane at right angle to the pipe axis shall be tested hydrostatically before the pipe is coated, wrapped or lined, as per IS: 3589. The pipes shall withstand the test pressure without showing any signs of weakness, leak or sweating. The test shall be carried out in the presence of the Engineer and as per Specifications. The required pressure should be maintained for at least 2 minutes for inspection purposes. The pipes shall be fitted with an accurate pressure gauge approved by the Engineer.

2. The hydraulic test pressure shall be the pressure calculated from the formula P=2St/D except that the maximum test pressure shall not exceed 5 Mpa.

Where
P = Test pressure in Mpa
S = Stress in Mpa which shall be taken as 40 % of specified minimum tensile strength
t = Specified thickness in mm
D = Specified outside diameter in mm

3. In this test, no hammering shall be permitted. Any section showing more than one leak for each 1.5 metres of welded seam or more than 2.5 percent of the total lengths of welded seam will be rejected. Stopping leaks by means of caulking tools shall not be permitted. In sections showing less than one leak for each 1.5 meters of welded seam and not more than 2.5 percent of the total lengths of welded seam, the leaks shall be repaired by chipping the weld and rewelding, after obtaining the permission of the Engineer in writing. All such sections shall be clearly be indicated in the logbook for reference. The repaired pipe should be retested hydrostatically for specified pressures. If on retest a pipe shows any leak in the welded seams it will be rejected. Accepted pipe sections shall be marked with legible marks of identification. This test is compulsory on all straight pipes.

16.5.16.3 Testing at site

1. After completing the installation of pipe line, or a section of the line and welding of joints, a hydrostatic pressure test of the line shall be made before giving the lining and coating to the exposed joints. The hydrostatic pressure shall be maintained as per **Clause 11.2.1** of IS: 5822:1994, during which time the pipe shall not show any sign of sweating or oozing or spotting of water at the joints or any part. If a drop in pressure occurs the quality of water added in order to re-establish the test pressure, should be carefully measured. This should not exceed 0.1 litre per mm of pipe diameter per km of pipe line per day for each 30 m head of pressure applied.

2. If the pressure measurements are not made at the lowest section, an allowance should be made for the static head between the lowest point and the point of measurement to ensure that the maximum pressure is not exceeded at the lowest point. Any defective joint or part shall be repaired and retested in the presence of the Engineer. The Contractor shall make his own arrangements for water for field testing. Water if supplied by department will be charged at non-domestic rates prevalent at the time of supply. The pipe line shall be tested in stretches of not exceeding 2 km in length. This field hydraulic test is mandatory. This clause is not negotiable.

16.5.17 Measurements

16.5.17.1 The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. Specials shall be excluded and measured in running meters and paid for separately under the relevant item. The portion of the pipe at the joints shall not be included in the length of pipe work.

16.5.17.2 Excavation, refilling, shoring and timbering in trenches masonry or concrete pillars and thrust blocks wherever required shall be measured and paid for separately under relevant items of work.

16.5.18 Rate

16.5.18.1 The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured/enumerated separately under clause ‘Measurements’, which shall be paid for separately.

16.6 Prestressed Concrete (PSC) Pipes

16.6.1 Scope

16.6.1.1 This Specification covers the requirements for design, manufacturing, testing, supplying, laying, jointing and testing at works and site of Prestressed Concrete (PSC) pipes used for water supply mains, sewers and storm water drains.

16.6.2 Applicable Codes

16.6.2.1 The manufacturing, testing, supplying, jointing and testing at work sites of PSC pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern.

S:784	Specifications for Prestressed Concrete Pipes (Including Fittings)
IS: 783	Code of Practice for Laying of Concrete Pipes
IS: 1343	Code of Practice for Prestressed Concrete
IS: 7322	Specifications for Specials for Steel Cylinder Reinforced Concrete Pipes
IS: 3597	Methods of Test for Concrete Pipes
IS: 5382	Specifications for Rubber Sealing Rings for Gas Mains, Water Mains and Sewers
IS: 226	Specifications for Structural Steel (Standard Quality)

16.6.2.2 Others I.S. Codes not specifically mentioned here but pertaining to the use of PSC pipes form part of these Specifications.

16.6.3 Design

16.6.3.1 The Contractor shall design PSC pipes as per the Specifications for PSC pipes, to withstand the likely extreme conditions of stresses that may arise during all stages of manufacturing, handling and service. The designs shall be submitted to the Engineer for approval. Only on written approval of the designs by the Engineer, the Contractor has to start manufacturing the pipes. Any alterations / additions suggested by the Engineer are to be carried out by the Contractor without any extra cost.

16.6.3.2 All pipes shall be designed to withstand the combined effects of internal water pressure and the external loads. The design of prestressed concrete pipes shall be in accordance with the basic assumptions and general requirements stipulated in IS: 1343.

16.6.3.3 The design of PSC pipes shall take into consideration all such stages which may cause stress in any section of the pipe. For investigation of these design stages, the likely extreme conditions of stresses shall be considered in the order of their occurrence, during the process of manufacture, handling, erection and under service, giving due regards to the worst accompanying conditions.

16.6.3.4 The wall of PSC pipes shall be sufficiently thick to ensure that during and immediately upon completion of the prestressing operation, the stress in the concrete shall not exceed the limit specified in relevant clauses of IS: 1343 and IS: 784. The maximum permissible stress due to all forces, after deducting full losses, shall confirm to relevant clauses of IS: 1343 and IS: 784, under combined conditions of full prestress with or without hydrostatic pressure and stresses due to erection or handling. All combination of direct forces in any plane section of the pipe shall remain always compressive. The values of this compressive stresses shall not be less than 10 kg/cm^2.

16.6.3.5 No weightage on the difference in the concrete core thickness as well as the reinforcement schedule provided from one tender to another shall he considered for evaluation. This is entirely for the test pressure indicated in the schedule.

16.6.3.6 For any other details in the design of the pipe, Specifications in IS: 1343 and IS: 784 are binding.

16.6.4 Material

16.6.5 Cement

16.6.5.1 The cement used in the manufacture of PSC pipes shall conform to one of the following:

1. Ordinary Portland cement conforming to IS: 269
2. Rapid Hardening Portland Cement conforming to IS: 8041
3. Slag cement (with not more than 50 % slag) conforming to IS: 455

16.6.6 Aggregate

16.6.6.1 The coarse and fine aggregates shall conform to I.S.383. The maximum size of aggregate shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller.

16.6.7 Water

16.6.7.1 The water used in the preparation of concrete mix shall be clean and free from harmful or injurious compounds such as acids, alkali, oil, organic material or other substances and shall conform to the requirements of mixing water as per IS: 456.

16.6.8 Admixtures

16.6.8.1 No admixtures shall be used in the preparation of concrete mix.

16.6.9 Concrete

16.6.9.1 Suitable mix of concrete shall be proportioned such that the pipes and fittings made from it shall conform to all the requirements of the Specifications for PSC pipes and the Specifications laid down for design mix concrete as per IS: 1343. The quality control of the concrete shall be exercised in accordance with IS: 456.

16.6.10 Steel reinforcement

16.6.10.1 The reinforcement steel used for manufacturing PSC pipes shall conform to the Specifications of IS: 784.

16.6.11 Rubber gaskets

16.6.11.1 Rubber gaskets used for joints shall comply with IS: 5382. The pipe manufacturer shall test each gasket by stretching it to 33.3 % in excess of its original length and examining it visually for defects, particularly at any joint.

16.6.11.2 Gaskets shall be clearly labelled in bundles. The label shall indicate the type of gasket, the type of joint and the diameter of the pipe with which they are to be used, and that they have been tested.

16.6.12 Dimensions and Tolerances

16.6.12.1 The internal diameter of the pipes shall be as per Specifications in IS: 784.

16.6.12.2 Pipe sections shall be manufactured in lengths of 5 m unless otherwise specified or approved by Engineer.

16.6.12.3 The tolerances over length, diameter and thickness of pipes shall be as per IS: 784.

16.6.13 Manufacture

16.6.13.1 Moulds

The Moulds and method of manufacture shall be such that the form and dimensions of the finished pipe conform to the requirements of Specifications of dimensions and tolerances and workmanship. The surface and edges of the pipes are clean and true to the dimensions.

16.6.13.2 Concrete Core

Unless the design calls for higher concrete strength, the minimum compressive strength of concrete shall not be less than 45 N/mm^2 at 28 days.

16.6.13.3 Clear cover

The clear cover of concrete over all steel reinforcement including the ends of the longitudinal prestressing wires shall not be less than 12 mm.

16.6.13.4 Prestressing

1. Pretensioning and release of Longitudinal wires

    - The concrete core shall be longitudinally prestressed throughout its length, including the socket, by means of high tensile steel wires, which shall be provided with permanent anchorages embedded within the joint portion at each end.

    - The centre line spacing between the longitudinal wires measured along the arc shall not exceed twice the core thickness or 150 mm, whichever is greater. Where reinforcement is used, the pretension stress shall be maintained by suitable supports, during the placing and curing of the pipe core until the concrete in the core has attained a strength equal to 1.8 times the longitudinal induced compression in the concrete.

    - The longitudinal wires shall be stressed to the design tension, taking into account the yield of slip of the temporary anchorages on the pipe moulds, and the tension shall be maintained by positive means during the curing of the concrete.

    - The tensioned wires shall not be released until the concrete in the core has attained a compressive strength of concrete in compression at 28 days as mentioned in **Clause 15.6.13.2**.

2. Circumferential Prestressing

    - Circumferential prestressing shall not take place until the concrete in the core has reached a sufficient compressive strength to resist without damage the force acting upon it, nor until the concrete in the core has reached a minimum cube strength of 32 N/mm^2.

    - The initial compressive stress induced in the concrete core shall not exceed 55 % of the compressive strength of the concrete in the pipe at the time of transfer.

    - Methods and equipment for applying the wire shall be such that wire shall be wound around the core in a helical form at the predetermined design spacing and capable of controlling the tension. Splicing or jointing (not welding), developing the full strength of the wire, may be permitted.

- The clear spacing between successive turns of the circumferential prestressing wire shall not be less than the greatest of the following:

  I. Diameter of the prestressing wire,
  II. One and half times the maximum nominal size of the aggregate used for the outer coat concrete, and
  III. 5 mm.

16.6.13.5 Cement mortar cover coating

1. After circumferential prestressing wire is wound on the pipes, it shall be given a coating of cement mortar, to protect it from corrosion. The cover coating shall preferably be applied within 16 hours after the prestressing wire has been wound. Minimum cement content in coating mortar shall be 600 Kg/m^3. The thickness of this coating shall not be less than 25 mm, over the circumferential reinforcement.

2. Cement mortar coating shall be done by rotary brushes or belts or by other approved means. The sand and cement shall be thoroughly mixed before being fed into the cover coating machine. Pneumatic process in which mixing of all ingredients is carried out at the nozzles or gun, shall not be permitted.

16.6.14 Handling and Transportation of pipes

16.6.14.1 Pipes shall be handled and transported to the site carefully as per the general Specifications for Laying of Pipes and Fittings given in this chapter, as per IS: 783.

16.6.14.2 Pipes manufactured at factory are to be carried to the site of work directly or stacked suitably and neatly along the alignment / road side / elsewhere near by the work site, as directed by the Engineer.

16.6.14.3 All pipes shall be loaded in trucks by mechanical crane / tripod and unloaded carefully using crane / tripod. No unloading using crow bars or on tyres will be allowed in any case. Rubber belt may be used instead of crow bars or chains.

16.6.14.4 Extreme care shall be taken while handling the pipes. Damages during transit will be to the Contractor's account and replacement for such pipes has to be made by the Contractor without any extra cost.

16.6.14.5 The rates should be inclusive of payment of entry tax, octroi, work contract tax and all other statutory taxes prevailing at the time of tendering. All such taxes are to be paid by the Contractor at no extra cost to the Engineer. This does not include any increase of slabs of levy due to turn over.

16.6.15 Lowering, Laying and Jointing of Pipes

16.6.15.1 Pipes shall be lowered, laid and jointed carefully as per the general Specifications for Laying of Pipes and Fittings given in this chapter, as per IS: 783.

16.6.15.2 Each pipe shall be thoroughly checked for any damages before laying. and only the pipes which are approved by the Engineer shall be laid.

16.6.15.3 As directed by the Engineer, moorum / sand bedding has to be done at the places shown. At other places, consolidation of bottom depth to the required grade will be done, as far as possible.

16.6.15.4 The trench shall be kept free of water till the jointing material is properly set.

16.6.15.5 Walking on completed line shall not be permitted until trenches are back filled.

16.6.16 Jointing of Pipes

16.6.16.1 Pipes shall be provided with Flexible Joints unless otherwise specified. Joining shall be done in accordance with the Specifications of IS: 783, the general Specifications of Laying of Pipes and Fittings given in this chapter.

16.6.16.2 The sections of the pipe should be joined together in such a manner that there shall be as little unevenness as possible along the inside of the pipe. The basic requirements for jointing are:

1. Cleanliness of all parts, particularly joint surface,
2. Correct location of components,
3. Centralisation of spigot within socket,
4. Provision of correct gap between one end of the spigot and the back of the socket (for rubber ring joint) to ensure flexibility at each end, and
5. any lubricant used shall be approved as to composition and method of application.

16.6.16.3 The following Specifications for jointing of PSC pipes are to be considered in addition to the above:

1. The joints shall be Confined Joints as per the approved Design and Drawing, with a continuous rubber ring made of a special composition rubber of such size and cross section as to fill completely the recess provided for it, over the spigot portion of the pipes. The gasket shall be the sole element to make the joint water tight and shall have smooth surface free from pits, blisters, porosity and other imperfections. The rubber compound shall contain not less than 5% by volume of first grade natural crude or synthetic rubber. The remainder of the compound shall consist of pulverised fillers free from rubber substitutes, reclaimed rubber and other deleterious substances.

2. Rubber ring used for jointing shall comply with IS: 5382. The manufacturer shall test each ring by stretching it to 33.3 % in excess of its original length.

3. Every rubber ring shall be visually checked particularly at joints, for any defects.

4. No jointing shall be made under water. The jointing surfaces shall be dried and cleaned before the joint and the prepared joint shall be kept clean.

5. All jointing work shall be done in an approved manner by skilled workmen so that complete pipeline shall have a continuous, smooth and uniform interior surface. Extended joint materials shall be removed from the inside of the pipes.

16.6.17 Specials and Fittings

16.6.17.1 Specials and fittings for PSC pipes shall be made out of steel plate fabricated to the required dimensions and given a coating of cement mortar inside and outside and shall be as per the Specifications below:

1. These specials shall be suitable for fixing prestressed concrete pipeline and shall conform to the requirements of IS: 784 and IS: 7322.

2. The special such as bends, tapers, tees, and branches shall be fabricated by cutting steel plates of 10 mm thickness and shall be manufactured with spigot and socket type joints with rubber gasket, suitable for jointing with a prestressed pipe, as per Specifications.

3. The steel for fabricated steel plate fittings is cut, shaped and welded so that the finished fitting has the required shape and interior dimensions. Adjacent segments shall be jointed by means of lap or butt welding.

4. The steel used for manufacturing of specials shall conform to IS: 226.

5. The specials shall be lined inside and outside with 25 mm thick cement mortar, reinforced with 50 x 50 mm weld mesh of specified guage. The cement mortar inside shall be 1:1.5 (1 part cement:1.5 part sand) and cement mortar outside shall be 1:2 (1 part cement:2 part sand).

6. All specials shall be hydrostatically tested before using as per **Clause 8** of IS: 7322. In case of specials manufactured at site, they shall be tested by penetration oil or other approved means.

7. All the specials shall be tested for hydrostatic pressure as specified for PSC pipes and to the pressure specified for pipes in the reaches where the specials are fitted.

8. All fittings shall be inspected by the Engineer at the place of manufacture, either at site or at factory. Engineer must have free access to the place of manufacture for the purpose of examining, testing and marking of the fittings.

9. The Contractor is fully responsible for any defects in manufacturing not conforming to IS Specifications. All defective specials shall be replaced by the Contractor free of cost.

10. Extreme care shall be taken while carting the specials to site, so that inside or outside coating is not damaged. If damages are observed the Contractor shall have to make it good at his cost.

11. For all other Specifications, the IS. 7322 or relevant amendments are binding.

12. Payment shall be done on per meter basis measured along the central line of the special/fittings. The quantity is as mentioned in Bills of quantities.

13. The valves like sluice valves, non return valves, scour valves, air valves shall be arranged by the Contractor as per the quoted rates and as per Bill of Quantities.

14. The quantity of specials shown in Bill of Quantities is tentative and the Contractor is required to supply and fix the specials as per actual requirement on site, as per quoted rates.

16.6.18 Testing

16.6.18.1 Pipes shall be given different tests for ensuring quality of manufacture as per IS: 784 and quality of laying as per IS: 783.

16.6.18.2 Hydraulic testing

1. In case of Hydraulic testing, the pipe line shall be filled completely with water for the length laid and kept for a week. The testing of pipe will be done in sections as directed by the Engineer. The pressure in the pipe shall be increased gradually to the fullest pressure i.e., two times the working pressure for pumping mains and 1½ times the working pressure for gravity mains in respective reaches and this pressure is maintained for one hour. Seepage allowance shall be allowed.

2. If the section length of pipeline fails in hydraulic testing, Contractor has to locate the leakages and remove them and retest the sectional length. No section will be accepted unless it is water tight except for seepage allowance as per IS: 783.

3. The Contractor has to make his own arrangements for water of approved quality, required for testing pipeline.

16.6.19 Measurement

16.6.19.1 The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. Specials shall be excluded and measured in running meters and paid for separately under the relevant item. The portion of the pipe at the joints shall not be included in the length of pipe work.

16.6.19.2 Excavation, refilling, shoring and timbering in trenches masonry or concrete pillars and thrust blocks wherever required shall be measured and paid for separately under relevant items of work.

16.6.20 Rate

16.6.20.1 The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured/enumerated separately under clause 'Measurements', which shall be paid for separately.

16.7 Laying of Pipes and Fittings / Specials

16.7.1 Scope

16.7.1.1 This Specification covers the requirements for laying of pipes and fittings / specials below ground for water supply / sewerage / storm water drainage works.

16.7.2 Applicable Codes

16.7.2.1 The laying of pipes and fittings / specials shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the standards / Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern.

16.7.2.2 Codes of practice

IS: 783	Code of Practice for Laying of Concrete Pipes.
IS: 311	Code of Practice for Laying of Cast Iron Pipes.
IS: 376	Safety Code for Excavation Work.
IS: 127	Code of Practice for Laying of Glazed Stoneware Pipes.
IS: 5822	Code of Practice for Laying of Welded Steel Pipes for Water Supply.
IS: 6530	Code of Practice for Laying of Asbestos Cement Pressure Pipes.

16.7.3 Carting and Handling

16.7.3.1 Pipes and fittings / specials shall be transported from the factory to the work sites, at places along the alignment of pipe line as directed by Engineer. Contractor shall be responsible for the safety of pipes and fittings / specials in transit, loading / unloading. Every care shall be exercised in handling pipes and fittings / specials to avoid damage. While unloading, the pipes and fittings / specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber with steadying ropes or by any other approved means.

16.7.3.2 Padding shall be provided between coated pipes, fittings / specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to the other. In case of spigot socket pipes while unloading, as far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or splaying of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings / specials along concrete and similar pavement with hard surfaces shall be prohibited.

16.7.3.3 Wherever a section of pipe, or a fitting is to be lifted or moved, it shall be handled carefully with belt slings. The belts shall be constructed so that no metal bears against the pipe and so that the bearing is uniform. The width of the belts shall be adequate to prevent any damage to the pipe coating. The pipe section may at no time be dropped but shall be lowered carefully into position and may not be slided along the ground. If it is to be rolled, it may be done only on slides or ground specially prepared so as to prevent any damage to the coating.

16.7.3.4 All State and local laws be observed during transportation. The Contractor shall secure permits and licences and provide all signals, guards and lights that may be required. Upon delivery the pipe sections and fittings shall be placed on specially prepared ground to protect them from distortion and damage. The ground shall be prepared so that they will rest evenly and will have uniform bearing throughout their lengths. Valve and sluice gates shall be placed on blockings.

16.7.4 Storage

16.7.4.1 Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stack shall not exceed 1.5m.

16.7.4.2 Fittings / specials shall be stacked under cover and separated from pipes. Valves and sluice gates shall be placed on blockings.

16.7.4.3 Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they should not be left out on the ground in the sun or overnight under heavy frost or snow conditions.

16.7.5 Laying

16.7.5.1 Excavation

1. Before excavating the trench the alignment of pipeline shall be approved by Engineer. The excavation of trenches and pits for manholes / chambers shall be carried out in accordance with the Specification and shall be done such that it does not get far ahead of the laying operation as approved by Engineer.

2. To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work until it is safe for the traffic to use the roadways. The Contractor shall provide sign boards at salient points in streets and keep men to guide the traffic at his own cost. The relevant Indian Standards and the rules and regulations of local authorities in regard to safety provisions shall be observed.

3. Trial pits may be dug by the Contractor, without being directed to do so, along the lines of the trenches as shown on the drawings in advance of the excavations for the purpose of satisfying himself as to the location of under ground obstructions or conditions. The Contractor shall proceed with caution, in any excavation and shall use every means to determine the exact location of underground structures, pipelines, conduits etc., prior to excavation in the immediate vicinity thereof. The Contractor shall be solely responsible for the cost of protection or repair or replacement of any structure, pipeline, conduit etc., above or below ground which may be broken or otherwise damaged by his operations.

4. Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2 m above the surface of the ground. There shall be two rails, one near the top of the posts and the other about 50 mm

above the ground and each shall be of 50 mm to 70 mm in diameter and sufficiently long to run from post to post to which it shall be bound with strong rope. The method of projecting rails beyond the posts and tying them together where they meet will not be allowed on any account. All along the edges of the excavated trenches a bank of earth about 1.2 m high shall be formed where required by Engineer for further protection..

5. The lighting, barricading, guarding of the trenches and the maintenance of watchman shall be done by the Contractor at his cost. At every 30 meters interval and at every change in the gradient, sight rails shall be provided and fixed by the Contractor at his own cost. The sight rails and boning rods for checking the excavation and inverts of the pipes shall be of the quality approved by the Engineer. In all streets in the City/Town at every 15 meters interval, blank board shall be provided by the Contractor at his own cost, to facilitate crossing of the trench by the Public residing on the either side.

6. The road metal and also the rubble packing shall first be stripped off for the whole width of the trench / pit and separately deposited in such place or places as may be determined by Engineer.

7. During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit or as may be necessary to prevent the sides of the trench / pit to slip or fall or at such a distance and in such a manner so as to avoid covering fire hydrants, sluice values, manhole covers, etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organization or otherwise as Engineer may direct.

8. Contractor shall take into account additional excavation if any as Engineer may require in order to locate the position of water pipes, drains, sewers, etc. or any other works which may be met with, in or about the excavation of trenches / pits while quoting the rates for excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as Engineer may direct, and shall be protected by Contractor from damage during the progress of the work.

9. Wherever extra width of excavation shall be necessary for shoring and strutting, of the trenches on account of the nature of the soil, such extra width required to accommodate the shoring boards shall not be paid for separately and the rates quoted for trench work are deemed to be inclusive of all such incidental work.

10. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structures/pipelines of water, gas, sewage etc..

11. If the work for which the excavation has been made is not complete by the expected date of the setting in of monsoon which is **First week of June** or the setting in of rain whichever is earlier, or before the day fixed by Engineer for filling in any excavation on account of any festival or special occasion, Contractor shall backfill such excavation and consolidate the filling.

12. Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than [External diameter of pipe in mm + 600 mm] + [400 mm for every 1500 mm Depth of cutting] or as specified in the Cross Section Drawing (in case there is any difference, the latter shall prevail). In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the crown of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry or otherwise at the discretion and to the satisfaction of Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings / specials and the space resulting shall be refilled with lean cement concrete of adequate depth, properly consolidated to give the curved seating. The bottom of the trench shall be properly trimmed to permit even

bedding of the pipeline. Bottom of trenches / pits shall be saturated with water and well rammed wherever Engineer may consider it necessary to do so. For laying of pipes larger than 1200 mm in diameter, in earth and moorum, the curvature of the bottom of the trench should match the curvature of the pipe as far as possible, subtending an angle of 120 degrees at the centre of the pipe.

13. Wherever a socket or collar of pipe or fitting / special occurs a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand, all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by Engineer.

14. When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60 cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

15. The excess excavated material shall be carried away from site of works to a place upto to a distance as directed by Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to cart the materials and to clear the site, the same shall be carried out by Engineer at Contractor's risk and cost and any claim or dispute shall not be entertained in this respect.

16. Refilling of trenches, where the excavation is in rock shall be with the surplus soft soil from pits located within 200meters from the reach in question.

17. It is to be distinctly understood that no extra payment shall be made for the excavation from borrow pits located within 200 metres for obtaining earth for refilling, any instructions of the Engineer to bring earth from beyond 200 metres for refilling shall be detailed in writing and a separate extra payment shall be made for the additional conveyance. No payment shall be made for disposal of soil for excavation, surplus to or unsuitable for filling.

16.7.6 Work included in Excavation

16.7.6.1 Unless otherwise directed on the project Specifications, all of the following items are included in the excavation:

1. Removing all surface obstructions including shrubs, jungle etc.,
2. Making all necessary excavations true to line and grade,
3. Furnishing and installing all shoring and bracing as necessary or as directed,
4. Pumping and bailing out water to keep trenches free of water during pipe laying and jointing and thereafter until joints mature,
5. Providing for uninterrupted surface water flow during work in progress,
6. Providing for disposing off water flows from storm, drains, nallas or other sources, suitably,
7. Protecting all pipes, conduits, culverts, railway tracks, utility poles, wire fences, buildings, and other public and private property adjacent to or in the line of work,
8. Removing all shoring and bracing which is not ordered to be left in place or not required by the project plans or Specifications to remain in place,
9. Hauling away and disposing of excavated materials not necessary or else unsuitable for back filling purposes. The extra excavated soil will have to be properly dressed in soil banks along with the trench as directed,
10. Back filling the trenches as directed or as per Specifications,
11. Restoring all property injured or disturbed by these construction activities to the condition as near its original condition as possible,
12. Restoring the surfaces and repairing of all roads, streets, alleys, walks, drives, working spaces, and rights of way to a condition as good as prior to excavation

16.7.7 Change of Trench Location

16.7.7.1 In case the Engineer orders that the location of trench be moved a reasonable distance, on account of the presence of an obstruction or due to such other cause or if a changed location is authorized at the Contractor's request, the Contractor shall not be entitled to extra compensation or to a claim for damage. If however such change is made at the orders of the Engineer, which involves abandonment of excavation together with the necessary back fill, will be measured, classified and paid for in the same manner as for other trench excavation and back fill of the same character. In case the trench is abandoned in favour of new location at the Contractor's request, after its approval, the abandoned excavation and back fill shall be at Contractor's expense.

16.7.8 Minimum earth cover

16.7.8.1 If a profile is not furnished for a pipeline, the main will be constructed with a minimum earth cover of 1000 mm from the top of the pipeline, unless otherwise indicated on plans and ordered by the Engineer.

16.7.9 Dewatering

16.7.9.1 During the excavation, if subsoil water is met with, Contractor shall provide necessary equipment and labourers for dewatering the trenches / pits by bailing out water or water mixed with clay. If pumping out subsoil water is found to be necessary, Contractor shall provide sufficient number of pumps for the same. In both the above cases the excavation shall be done to the required level and the pipes shall be laid to proper alignment and gradient. Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer / drain, Contractor shall take necessary permission from the local authorities.

16.7.9.2 The Contractor shall be responsible for the adequate pumping, drainage and bailing out of water from the excavation. Failure to make such provisions which results in unsuitable subgrade conditions, and which will require any special foundations as directed by the Engineer, such foundations shall be placed at the entire cost of the Contractor and will not be measured or paid for as separate pay items. If the Contractor selects to under cut the trench and use gravel or tile bailing, drainage of well pointing, the additional work will be considered as incidental work and additional compensation will not be allowed

16.7.10 Special foundation in poor soil

16.7.10.1 Where the bottom of the trench at subgrade is found to consist of material which is unstable to such a degree that in the opinion of Engineer, it cannot be removed and replaced with approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant Drawings and as instructed by Engineer shall be constructed.

16.7.10.2 During the progress of the work, should the foundation for the pipeline be in soft, yielding or spongy materials which are unsuitable for the subgrade of the pipeline and which is not the result of the Contractor's negligence, to make proper provisions for adequate drainage of the excavation, the Contractor shall remove such unsuitable subgrade materials to the depth directed by the Engineer. The Contractor shall fill the excavated depth in the manner hereinafter described or as directed by the Engineer.

16.7.10.3 The Contract unit for foundation shall be one cubic metre. The foundations will be measured for payment complete in place. The contract unit unit price shall be the total compensation for furnishing all labour, tools, materials, equipment and incidentals necessary to complete the work, including all excavation and disposal of surplus material.

16.7.10.4 Rock Foundations

16.7.10.4.1 The space resulting from the removal of unsuitable materials shall be filled with crushed stone, local lime stone rock, free from loamy soil, clay and vegetable matter, graded in size from 25mm to 30mm in general.

16.7.10.5 Gravel Foundations

16.7.10.5.1 The space resulting from removal of unsuitable material shall be filled with gravel. No extra payments will be made on this account, except for lead charges if any beyond 50m.

16.7.10.6 Concrete Foundations

16.7.10.7 The space resulting from removal of unsuitable materials shall be filled with a concrete foundation and the concrete shall conform to relevant provisions of **Chapter 9** of these Specifications.

16.7.11 Wooden shoring

16.7.11.1 Contractor shall suitably design polling boards, walling and struts to meet different soil conditions that might be encountered in excavating trenches / pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and / or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

16.7.11.2 Engineer may order portions of shoring to be left in the trenches / pits at such places, where it is found absolutely necessary to do so as to avoid any damage which may be caused to buildings, cables, gas- mains, water-mains, sewers, etc. in close proximity of the excavation, by pulling out the shoring from the excavations. Contractor shall not claim, on any reason, whatsoever for the shoring which may have been left in.

16.7.12 Steel plate shoring

16.7.12.1 Where the subsoil conditions are expected to be of a soft and unstable character in trench / pit excavation the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, walling, etc., as per the instructions, manner and method directed by Engineer. Contractor shall supply, pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Specification.

16.7.13 Boning staves and sight rails

16.7.13.1 In laying the pipes and fittings / specials the centre for each manhole / chamber or pipe line shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 mm X 100 mm X 1800 mm) at each manhole / chamber or junction of pipe lines at nearly equal distance from the peg and at sufficient equal distance therefrom to be well clear of all intended excavation, so arranged that a sight rail when fixed against the post will cross the centre of the manhole / chamber or pipe lines. The sight rail shall not in any case be more than 30m apart. Intermediate rails shall be put up if directed by Engineer.

16.7.13.2 Boning staves of 75 mm X 50 mm size shall be prepared by Contractor of various lengths, each length being of a certain whole number of metres and with a fixed tee-head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of this tee-head, at a distance equal to as the case may be, the outside diameter of the pipe or the thickness of the concrete bed to be laid. The top of cross

pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of pipe, etc. as the case may be.

16.7.13.3 The sight rail of size 250 mm X 40 mm shall be screwed with the top edge resting against the level marks. The centre line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the centre lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of the sight from rail to rail.

16.7.13.4 The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee hands and cross piece of the boning staves shall be painted black.

16.7.13.5 For the pipes converging to a manhole / chamber at various levels, there shall be rail fixed for every different level. When a rail comes within 0.60 m of the surface of the ground, higher sight-rail shall be fixed for use with the rail over the next point.

16.7.13.6 The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and Engineer gives permission to proceed with the backfilling.

16.7.14 Bedding

16.7.14.1 The bedding for pipe shall be provided as specified in the Drawings or as per direction of Engineer.

16.7.15 Concrete cushion, embedment and encasement

16.7.15.1 Concrete embedment and encasement wherever required, shall be constructed as per the details given in approved Drawings or as directed by the Engineer. Where concrete bedding is to be placed beneath the pipeline, the sub-grade shall be prepared to dimensions as shown in the Drawings. The bottom of the trench may be sloped on the sides or kerbed, but the thickness of concrete shall be as specified in the Drawings or as directed by the Engineer. Dry mix will not be permitted.

16.7.15.2 For earth, granular material or concrete embedment,each pipe section shall have uniform bearing on the subgrade for the full length of the pipe barrel, suitable excavation shall be made to receive the pipe, bell or collar and allow adequate room for proper workmanship in making the joint. Adjustment to line and grade shall be made by scraping away or filling in with gravel or concrete and not by wedging or blocking up the bell. Pipe sockets and barrels shall be clean and free from dirt at the time of jointing.

16.7.15.3 The concrete for bedding portion will be mixed moist or damp to give a slump of not more than 25 mm and for sides and top portions of encasement, if specified, will be mixed to obtain a slump between 25 mm and 80 mm. All water in the trench must be disposed off prior to placing of concrete. There should be no cleavage line between the bedding concrete and the side embedment concrete. Clear out space shall be left for jointing and lowering pipe in place and bringing to grade by tamping under pipe or removing excess concrete under pipe. After the joint is made, the remainder of the concrete embedment may then be poured and thoroughly tamped to make bond with original concrete. Care must be exercised in tamping to prevent lifting of the pipe out of alignment or grade. Back filling shall be done in a careful manner and such time after the concrete cushion, embedment or encasement is placed, as not to damage the concrete in any way.

16.7.15.4 All pipes shall be so laid that the contact in the joint between the two lengths of pipe shall be uniform throughout the circumference of the joint. Where curves in the alignment are indicated on the Drawing, and the curves are flat, standard pipe will be used with the outside edge of the joint pulled away from the seat to make a smooth joint. Where curves are sharp, standard or specially made bends will be used. Openings at end of day's work openings in tees, deep cut connections, shall be capped and sealed.

16.7.16 Laying of pipes and fittings / specials

16.7.16.1 All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure / pipe line of water, gas, sewage, etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Engineer. Pipes and fittings / specials shall be carefully lowered in the trenches.

16.7.16.2 The pipes and specials shall be stacked along the alignment in advance with utmost care during the transit so that they are not damaged. Any damage due to these reasons shall be Contractor's liability. The pipe shall be lowered and laid only after the trenches are finally ready and levels duly checked by the Engineer. It shall be seen that no damaged pipe is lowered in the trench. Every precaution shall be taken to prevent foreign materials from entering the pipes when they are being placed in the line. Normally the socket ends shall face the upstream. When any portion of the excavation shall have been carried down to the necessary depth, the Contractors shall obtain permission from the Engineer before commencing the laying of pipes or concrete or the construction of masonry.

16.7.16.3 Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings / specials shall be made by Contractor. In no case pipes and fittings / specials shall be dropped. Slings of canvas or equally non abrasive material of suitable width or special attachment to fit the ends of pipes and fittings / specials shall be used to lift and lower the coated pipes and fittings / specials. The pipes and fittings / specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect crack, wherever applicable. If doubt persists, further confirmation shall be done by pouring a little paraffin on the inside of the pipe at the suspected spot. No sign of paraffin should appear on the outside surface. Pipes and fittings / specials damaged during lowering or aligning shall be rejected by Engineer.

16.7.16.4 All the pipes are to be laid perfectly true both in alignment and to gradient specified. Pipes in a trench shall be laid and fitted previous to the jointing being commenced. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipe line runs uphill in which case the socket ends should face the upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings / specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings / specials of proper dimensions to ensure such uniform space. Precaution shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by Engineer. during the period that plug is on, the Contractor shall take proper precautions against floatation of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted, the deflection allowed at joints shall not exceed $2\frac{1}{2}^{o}$. In the case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

16.7.16.5 Properly fitted temporary wooden stoppers shall be provided to close the ends of all incomplete pipe lines. The stoppers are only to be removed when pipes are being laid and jointed. Pipe laying and jointing shall be started and completed only section wise as per the instruction of the Engineer. During the progress of pipe laying the open ends of pipe shall be closed and water tight. Sight rails shall be provided at all change of direction or gradients at distance of @ 30 m along straight lengths. All the invert levels shall be confirmed from the sight rails with the help of proper boning rods as per the standard practice. The pipe shall be jointed with cement mortar 1:1 and proper caulking shall be done. After a particular section of the pipe is laid and jointed hydraulic testing shall be done section wise.

16.7.16.6 Just prior to placing each pipe section in the line, damaged coating shall be repaired and the interior shall be cleaned off all foreign materials. Cleaning shall be accomplished by brushing, blowing with compressed air and washing with water or as specified by the Engineer.

16.7.16.7 The item for laying of pipe line also includes labour work for lowering, laying and jointing various pipes including jointing with specials, levelling, etc. The Contractors shall transport pipes and specials from stores, for their various sections in such quantities as may be required for laying. Ordinarily no surplus stock shall remain on completion of any section. In case however, such pipe etc. become surplus in any sections, the Contractor shall remove the same to the next section for use in the work. It is likely that on completion of the whole work, some pipes and specials etc. may become surplus at the site and the Contractors shall arrange to hand over the same in good condition to the Engineer at the Owner's store as may be directed if required by Owner. The Contractor shall supply a list of stock so returned to the Engineer. No extra payment shall be made to the Contractors for these works. The rates for laying the pipes shall cover the cost of loading, transporting and unloading as may be required. The fortnight report for pipes collected and laid should be sent to the Engineer.

16.7.16.8 The cutting of pipe for inserting valves, fittings or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

16.7.17 Jointing

16.7.17.1 Pipes shall be laid to the lines and grades given in the plans, with the ends abutting to form a even joint without shoulders or unevenness of any kind along the invert of the pipes. No joint shall be made under water. The ends of the pipes shall be dry and kept clean before and during laying and jointing operations.

16.7.17.2 All joint work shall be done in an approved manner by skilled workmen so that the completed pipeline shall have a continuous, smooth and uniform interior surface. Extruded joint material shall be removed from the interior of the pipe. In cold weather protective measures must be taken to ensure a satisfactory joint.

16.7.17.3 Jointing for pipes and fittings / specials shall be done in accordance with the relevant Specifications depending on type of pipes being used.

16.7.18 Valve Rooms, Manholes, Head Walls, Thrust Blocks, Anchor Blocks, Saddle supports etc.

16.7.18.1 The Contractor shall build manholes, inlet manholes, inlets, junction chambers, headwalls, culverts, anchor blocks, thrust blocks and such other miscellaneous structures that may be required at the locations shown by the Engineer and of such forms, dimensions and materials as are shown in the standard details or as may be specified or directed. These structures shall also include the installation of such specials and connections to pipes and other structures as may be required to complete the constructions as shown in the Drawings.

16.7.19 Closure sections and connections to structures

16.7.19.1 Closure sections shall be constructed where required by the Contractor's operations. Connections to pipe specials shall be made as approved by the Engineer. Lining and coating of the pipe lines, which must be cut to provide for closure pieces or to permit the proper location of valves structure shall be repaired by the Contractor. No separate payment will be made for closure pieces installed, but the same will be measured as it is a pipe in place and along the pipeline.

16.7.19.2 The cutting of pipe for inserting valves, fittings or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

16.7.20 Temporary stoppages of work

16.7.20.1 At times when pipe laying is not in progress, or at the end of the day's work, the open ends of pipe shall be closed by a watertight plug or other means approved by Engineer. During the period that plug is on, the Contractor shall take proper precautions against floatation of the pipe owing to entry of water into the trench.

16.7.21 Testing and commissioning

16.7.21.1 Testing and Commissioning of pipes shall be done in accordance with the relevant Specifications.

16.7.22 Water Tightness test

16.7.22.1 All hydraulic structures, either water supply or drainage etc., such as sewer lines, joints etc., or any other liquid containers shall have to be tested for water tightness. The Contractor shall give all such hydraulic tests by making his own arrangements for water filling and disposal of water after the test and shall repeat this test, if necessary, until the requisite test results are obtained without any claim for extra cost or compensation. The water tightness test shall be conducted as specified in IS: 4127- 1967. The tendered rates for hydraulic structures shall include all costs incurred by the Contractor for water tightness test. If any such hydraulic structure or fixture is found to be unsatisfactory at the time of giving this test the Contractor shall either repair or demolish and construct the same as directed such that the structure is made absolutely water tight and declared as satisfactory by the Engineer. The decision of the Engineer will be taken as final. The Contractor may use at the time of construction, for increasing the water tightness, approved proprietary chemicals only with the express permission of the Engineer to serve the purpose of the Contractor to facilitate such type of work for his own convenience and advantage. But in all such cases, the Contractor will not be entitled to any extra rate. The Contractor shall see that every effort is made to make structures and fixtures water tight, by resorting to such chemicals and making efficient use of proportion and grading of materials etc., as provided originally in the Specifications.

16.7.23 Backfilling

16.7.23.1 Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipe line. The tamping around the pipe shall be done by hand or other hand operated mechanical means. The water content of the soil shall be as near to the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Back filling shall be consolidated by watering, ramming, care being taken to avoid damage to the pipe line. In case of mild steel pipes / specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipe line to aid alignment, these timbers shall be removed before backfilling.

16.7.24 Reinstatement of road / footpath

Reinstatement of road / footpath shall be done as per the requirements of local authorities and the relevant Specifications after the completion of work.

16.7.24.1 Clearing of site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by Engineer and the construction site left clean to the satisfaction of Engineer.

16.7.25 Disinfection of water mains

16.7.25.1 The mains intended for potable water supplies should be disinfected before commissioning them for use.

16.7.25.2 The mains shall be chlorinated with a liquid chlorine solution (that is liquid chlorine gas and water mixture). The disinfection shall be considered to have been achieved if a chlorine residual of not less than 10 ppm remains in the water after 24 hours standing in the pipe. If this requirement is met with, the main should be thoroughly flushed with clean water.

16.7.25.3 If the treatment specified in **Clause 15.7.25.2** is not possible, enough chlorinate lime, calcium or sodium hypochlorite should be introduced to produce the required concentration of chlorine in the solution. The solution should then be allowed to stand for not less than 24 hours, after which it should be tested for residual chlorine, which should not be less than 10 ppm. If found satisfactory, the mains should be thoroughly flushed with clean water.

16.7.26 Measurement

16.7.26.1 The measurements for excavation in trenches shall be done in following manner and will be paid accordingly.

Length	As per actual length of pipe and fittings / specials laid at work site.
Width & cross Section	As per Drawing.
Depth	Average depth of trench from ground level to invert of pipe plus thickness of bedding.

16.7.26.2 Excavation of asphalt road and reinstatement of road shall be measured on per square metre basis and the length and width at top of trench shall be considered same as those mentioned for excavation of trench.

16.7.26.3 The measurement for removal of excess excavated material upto a specified distance shall be as per the relevant item(s) in the schedule of Quantities and Rates and shall be measured on cubic metre basis. In case of soil 30% deduction shall be done to take account for voids where as it will be 40% in case of rubble.

16.7.26.4 Measurement for pipes and fittings / specials shall be in accordance with the relevant clause(s) of Specification for particular types of pipes.

16.7.27 Notes

16.7.27.1 Fencing provided along the sides of trenches and pits shall not be paid for separately and Contractor shall take into account the costs of such works and quote accordingly.

16.7.27.2 In case of the metal packing or dressed stones not being deposited as specified or being mixed up with excavated materials and not available for the reinstatement of road / pavement, the cost of the new metal packing or dressed stones required shall be charges to Contractor by Engineer.

16.7.27.3 Service lines if damaged during excavation shall be made good either by Contractor or by other agency as Engineer may decide and the cost of the same shall be borne by the Contractor wholly in either case.

16.7.27.4 Contractor shall not be paid any additional compensation for excess excavation over what is specified as well as for any remedial measures that are specified.

16.7.27.5 The excess excavated material shall be carried away from site of works as specified, failing which in view of public safety and traffic convenience Engineer may carry out the work by any other agency at Contractor's risk and cost.

17 SUPPLY OF UPVC AND DUCTILE IRON PIPES, SPECIALS, VALVES AND LAYING OF PIPES FOR WATER SUPPLY

17.1 General

17.1.1 Standards

17.1.1.1 Except as otherwise specified in this technical specification, the Indian/International Standards and Codes of Practice in their latest version shall be adhered to for the design, manufacturing, inspection, factory testing, packing, handling and transportation of product. Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Engineer in Charge.

17.1.1.2 This specification requires a reference to the following standard specifications

IS: 4985	Unplasticized PVC pipes for potable water supplies
IS: 10151	PVC and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals, and drinking water
IS: 10500	Drinking water specification
IS: 12235	Methods of test for unplasticized PVC pipes for potable water supplies
IS: 4669	Methods of test for PVC resin
IS: 12818	Unplasticized PVC screen and casing pipes for bore/tubewell
IS: 3400	Methods of test for vulcanised rubber (part-1 to 22)
IS: 1387	General requirements for the supply of metallurgical material
IS: 210	Grey iron casting
IS: 1536	Centrifugally cast (spun) iron pressure pipe for water, gas and sewage
IS: 1537	Vertically cast iron pressure pipe for water, gas and sewage
IS: 1538	Cast iron fittings for pressure pipes for water, gas and sewage
IS: 5531	CI specials for Asbestos cement pressure pipes for water gas & sewage
IS: 1363	Hexagon head bolts, screws and nuts of product grade A and B (part:1-5)
IS: 1367	Technical supply conditions for threaded steel fasteners
IS: 780	Sluice valve for water works purposes
IS: 2906	Specifications for sluice valves for water works purposes
IS: 318	Leaded tin bronze ingots and casting
IS: 8543	Methods of testing plastics: Determination of density of solid plastics
IS: 7181	Horizontally cast iron double flanged pipes for water, gas and sewage.
IS: 8794	CI detachable joints for use with Asbestos cement pressure pipes
IS: 5382	Rubber sealing rings for gas mains, water mains and sewers
IS: 5531	Cast iron specials for asbestos cement pressure pipes for water, gas and sewage
IS: 779	Water meters
IS: 3624	Pressure and vacuum gauges
IS: 341	Black japan, types A, B and C
IS: 9862	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
IS: 1239	Mild steel tubes, tubular and other wrought steel fittings
IS: 7328	High density polyethylene materials for moulding and extrusion
IS: 4984	Specification for high density polyethylene pipes for potable water supplies; sewage and industrial effluents
IS: 554	Dimensions for pipe threads where pressure tight joints are required on the threads
IS: 1592	Asbestos cement pressure pipes - Specifications
IS: 778	Specifications for copper alloy gate, globe and check valves for water works purposes
IS: 12820	Dimensional requirements for rubber gaskets for mechanical joints and push on joint for use with cast iron pies and fittings for carrying water, gas and sewage.
IS: 9523	Specification for DI fittings for pressure pipes for water, gas, and sewage.

ISO: 2045	Single socket for uPVC and uPVC pressure pipes with elastic sealing ring type joints - Minimum depth of engagement
ISO: 2507	PVC pipes and fittings- Vicat softening temperature - Test method and specification
ISO: 3603	Fittings for PVC pipe with elastic sealing ring joints pressure test for leakproofness
ISO: 1167	Thermoplastics pipes for the transport of fluids - Resistance to internal pressure - Test method and basic specification
ISO 3451-5	Determination of Ash: Part-5 - Poly vinyl chloride
ASTM: D 2152	Standard test method for degree of fusion of extruded PVC pipe and moulded fittings by Acetone immersion
MTNL	Mahanagar Telephone Nigam Limited; Technical specifications for cable ducts.
BS: 4772	Specification for DI fittings
IS: 7634-Parts 1-3	Code of practice for plastic pipe works for potable water supplies
IS: 8329	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage.
IS: 12288	Code of practice for use and laying of ductile iron pipes
CPHEEO	Manual on Water Supply and Treatment, III edition, Ministry of Urban Development, New Delhi- May 1999.

17.2 UPVC Pipes

17.2.1 Scope

17.2.1.1 This section of the document specifies the required properties of the pipes made of unplasticized polyvinyl chloride (uPVC) with socket(s) suitable for elastomeric sealing ring type joints for conveyance of water under pressure for supply of drinking water. The pipes are intended to be used for buried water mains with ambient atmospheric temperature reaching up to 50°C and soil surface temperature rising more than 65°C. The stipulations given in this document for uPVC pipe which are not covered by any other code/standard, shall be governed by the provisions of IS 4985

17.2.1.2 The pipes will be supplied with one end plain with chamfer and other end socket suitable for elastomeric sealing ring type joints in accordance with IS: 4985.

17.2.1.3 Each pipe shall be supplied along with a rubber ring suitable for the socket for elastomeric sealing ring type joints.

17.2.2 Material

17.2.2.1 The material from which the pipes are made shall consist substantially of unplasticized polyvinyl chloride conforming to IS: 10151, to which may be added only those additives that are absolutely needed to facilitate the manufacture of the polymer, and the production of sound, durable pipes of good surface, finish, mechanical strength and opacity.

17.2.2.2 The total quantity of additives like plasticizers, stabilisers, lubricants and fillers shall not exceed more than 7.0%.

17.2.2.3 The bulk density of uPVC pipe shall be 1.39 to 1.44 g/ cm^3.

17.2.2.4 PVC resin of suspension grade K-66/K-67 shall be used for extrusion of uPVC pipe.

17.2.3 Classification

17.2.3.1 The pressure rating of pipes shall be of class-3 and class-4 in accordance with IS: 4985 with a maximum continuous working pressure at 27 ^{0} C of 6 and 10 kg/cm^2

17.2.4 Dimensions of the pipes and the sockets

17.2.4.1 The dimensions and tolerances of pipes shall comply to clauses of IS: 4985.

17.2.4.2 The tolerance on outside diameter and wall thickness of pipe shall be as per Table-1 given in IS: 4985.

17.2.4.3 The dimensions of the socket for elastomeric sealing ring type joint shall be in accordance with **Clause 7.2.1.2** and Tables 4 and 5 of the IS 4985

17.2.4.4 The pipe shall be supplied in straight lengths of 6 m with tolerance of + 20 mm and -0 mm. The effective length of socket pipe shall be considered as shown in Figure-3 of IS: 4985.

17.2.5 Physical & chemical properties

17.2.5.1 The pipe shall confirm to the **Clause 10** of IS 4985-2000 for its physical and chemical properties except for the density and ash content provisions which shall be as per the stipulations of **Clause 16.2.2** of this chapter.

17.2.5.2 The colour of the pipes shall be dark grey.

17.2.5.3 Influence on water intended for human consumption shall be governed by IS: 12235.

17.2.5.4 All plastic and non plastic material for components of the uPVC piping system e. g. Elastomeric sealing ring, lubricants, when in permanent or in temporary contact with water which is intended for human consumption, shall not adversely affect the quality of the drinking water.

17.2.6 Mechanical properties

17.2.6.1 Hydrostatic strength of the pipes

17.2.6.2 The pipes and integral sealing ring will confirm to internal hydrostatic pressure in accordance with **Clause 11.1** and sampling as per annex D of IS 4985

17.2.7 Tests and conformity criteria

17.2.7.1 quality assurance from the manufacturer

The following in house tests shall be carried out on the raw material:

- grade (K-value)
- particle size distribution
- bulk density of resin
- bulk density of compound

The manufacturer will also have the following tests conducted from Standard Test Laboratry

- Effect on water quality
- Internal Hydrostatic Test (Type)

17.2.7.2 Acceptance Test

17.2.7.2.1 All uPVC pipes of the same size and class manufactured on a particular machine shall be considered as a lot for quality control inspection. However, the maximum size of a lot shall not be more than 1000 pipes.

17.2.7.2.2 The sampling procedure and scale of sampling for visual inspection and dimensional requirements shall be as per given in Annexe-D of IS: 4985.

17.2.7.2.3 The pipes shall be tested for lot acceptance.

17.2.7.2.4 The following acceptance tests shall be conducted in accordance with IS: 4985 and IS: 12235.

- Visual and dimensional check
- Reversion test.
- Vicat Softening test
- Ash Content
- Bulk density
- Resistance to external blows
- Internal hydrostatic pressure test for pipes and joints
- Opacity

17.2.8 Markings

17.2.8.1 Each pipe shall be clearly marked as indicated below:

- Manufacturers name and trademark
- Outside diameter in mm.
- Class of pipe and pressure rating
- Month and year of manufacturing
- Length of pipe
- Marking of insert depth of spigot

17.2.8.2 Each pipe shall also be marked in centre strip as circumference 1" wide at intervals not more than 3 meters to show the class of pipe.

- Class 3 – Green
- Class 4 – Brown

17.2.9 Packing and transport

17.2.9.1 The socket and spigot end of all the pipes shall be provided with tightly fitted end caps, protecting the inside of the pipes effectively against dirt etc. The end caps shall be of suitable high density (HD) plastic material in any colour other than black. They shall be fitted to the pipes prior to packing and transportation.

17.2.9.2 The pipes shall be transported to the store and site by trucks in pre packed bundles to ensure adequate protection during transport. At the time of packing and stacking of pipes the sockets shall be alternated within the pile and shall project sufficiently for the pipes to be correctly supported along their whole length. The pipes shall rest uniformly on the vehicle bed over their whole length during transport, carefully placed and firmly secured against unwarranted movement during transportation to the satisfaction of Engineer Incharge.

17.3 Rubber Rings for PVC Pipes and Specials

17.3.1 Scope

17.3.1.1 This section prescribes the requirements for materials used for vulcanised solid rubber sealing rings for water supply at ambient temperature. It covers rubber rings for uPVC pipes.

17.3.2 Material

17.3.2.1 The rubber shall be free from extractable substances which impart taste, odour or toxicity to water. The rubber or it's compound shall not content toxic materials, such as compounds of mercury, antimony, manganese, lead or copper.

17.3.2.2 The rubber rings shall be vulcanised from Butadiene-styrene rubber (SBR) or Ethylene propylene (EPDM). The colour of material shall be black.

17.3.2.3 The rubber ring shall be long term termite resistant.

17.3.2.4 The sealing ring shall have no detrimental effect on the properties of the pipe and shall not cause the test assembly to fail the functional requirements of Clause 16.2.7.2.4.

17.3.3 Appearance and homogeneity

17.3.3.1 The rings shall be homogeneous, free from porosity, grit, excessive blooms, blisters, or other visible surface imperfections. The fin or flash shall not exceed 0.4 mm and width 0.8 mm.

17.3.3.2 Rubber rings shall be made of a properly vulcanised virgin rubber compound containing no scrap or reclaim.

17.3.3.3 The surface of the rubber rings shall be smooth, free from pitting cracks, blisters, air marks, and any other imperfection that may affect its behaviour in service. The body of the rubber ring shall be free from porosity and air pockets.

17.3.4 Dimensions and tolerances.

17.3.4.1 The profile and dimensions of the rubber ring shall be such that under normal circumstances efficient sealing can be expected for the socket dimensions.

17.3.4.2 The nominal measurements and the tolerances shall be in accordance with the figures stated by the manufacturer and they shall be laid down in a drawing.

17.3.5 Physical requirements.

17.3.5.1 The rubber ring shall have the ISI mark and will confirm to IS: 5382 and comply with the following physical properties when tested in accordance with IS: 3400

Properties	SBR rings	EPDM
Tensile Strength	13 MPa	11 MPa
Hardness	50, +5, -4 IRHD	50, +5, -4 IRHD
Elongation at break	Min. 400%	Min. 400%
Compression Set Test condition 27degree C., 72h, Max. permanent deformation	12%	12%
Water absorption Test	Max. 10%	Max. 10%
Accelerated ageing Test Hardness Tensile Strength Elongation at break	 -5 to +8 IRHD ± 20% -30% to +10%	 -5 to +8 IRHD ± 20% -30% to +10%

17.3.6 Marking

17.3.6.1 Each sealing ring shall be permanently marked with:

- The Manufacturer's name or trade mark.
- The month and year of manufacture
- Diameter of pipe for which the ring is suitable.
- Type of rubber material

17.3.7 Testing

17.3.7.1 The scale of sampling and criteria for conformity shall be in accordance with IS: 5382. The following tests shall be conducted for conformity.

- Hardness
- Tensile strength
- Elongation at break
- Compression set
- Accelerated ageing
- Water absorption
- Stress relaxation

17.3.7.2 The test pieces shall be cut from the finished product. Where this is not possible because the sample would be too small, the manufacturer shall provide test slabs from the same batch of rubber and vulcanised to the same degree and in the same manner as that of the rubber from which the rubber rings have been manufactured.

17.3.7.3 Wherever it is not possible to cut standard test piece from the rings, for determination of tensile strength and elongation at break, test piece in the shape of dumb bell as shown in Figure - 2 of IS: 5382 shall be used with the rate of traverse of moving grip as 15 cm/min.

17.3.8 Packing

17.3.8.1 Maximum 10 pieces of rubber ring shall be packed in one polyethylene bag. The colour of the polyethylene bags shall be preferably black or dark grey. The rubber rings packed in polyethylene bags shall be supplied in bituminised polyethylene lined jute bags to protect them from undue exposure to light and heat.

17.3.9 The rubber rings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under it's own supervision and have it tested at his/sub contractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

17.4 Specials for uPVC Pipe System

17.4.1 uPVC specials

17.4.1.1 Manufacturing and type of sealing joint

17.4.1.1.1 All the uPVC fittings shall be fabricated from class-4 uPVC pipes only.

17.4.1.1.2 The socket dimensions shall be in accordance with the pipe sockets. The rubber sealing rings for pipe/specials shall be in accordance with the specifications as stated in **Clause 16.3**.

17.4.2 Type of specials

17.4.2.1 Double sockets

17.4.2.1.1 The double socket special shall be suitable for elastomeric sealing ring type joint as per the enclosed drawing. The dimensions of the fitting shall be as given in Table below.

Table for dimensions of Double Sockets

S No.	Suitable for pipe OD (mm)	Min. length of fitting (h) mm	Min. spacer (l) mm
1	63	235	20
2	90	266	20
3	110	288	20
4	140	314	20
5	160	334	20
6	225	404	30
7	280	460	30
8	315	485	30

17.4.2.2 Double Socket Bends:

17.4.2.2.1 The fabricated bends shall be suitable for elastromeric sealing ring type joint as per the enclosed drawing. The dimensions of the double socket bends shall be as given below:

S.No.	Outside diameter in mm	Radius (r) mm	Angle of bend in degrees	L1 = L2
1	63	221 221	90 45	359 230
2	90	315 315	90 45	469 285
3	110	385 385	90 45	551 326
4	140	490 490	90 45	674 387
5	160	560 560	90 45	756 428
6	225	788 788	90 45	1023 562
7	280	980 980	90 45	1268 674
8	315	1100 1100	90 45	1410 746

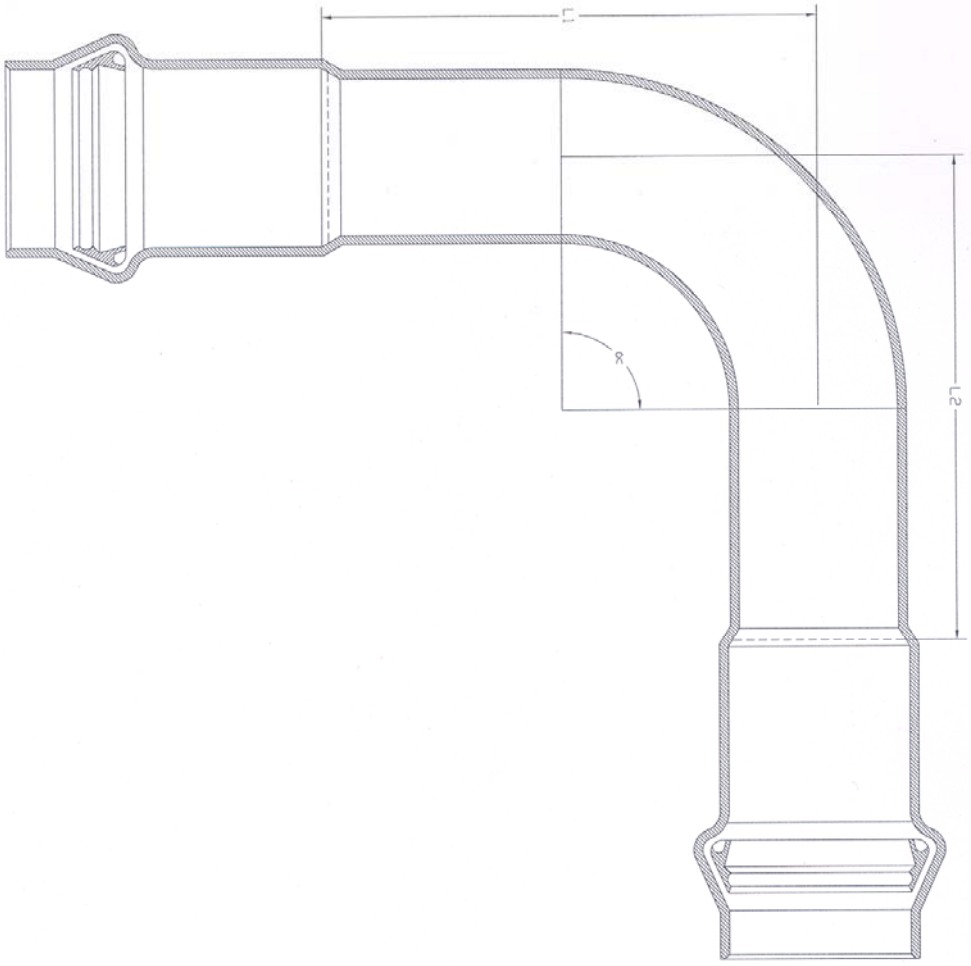
17.4.3 Quality control tests

17.4.3.1 All the fitting shall be tested for socket dimension, workmanship/surface finish and leak tightness in accordance with for uPVC pipes.

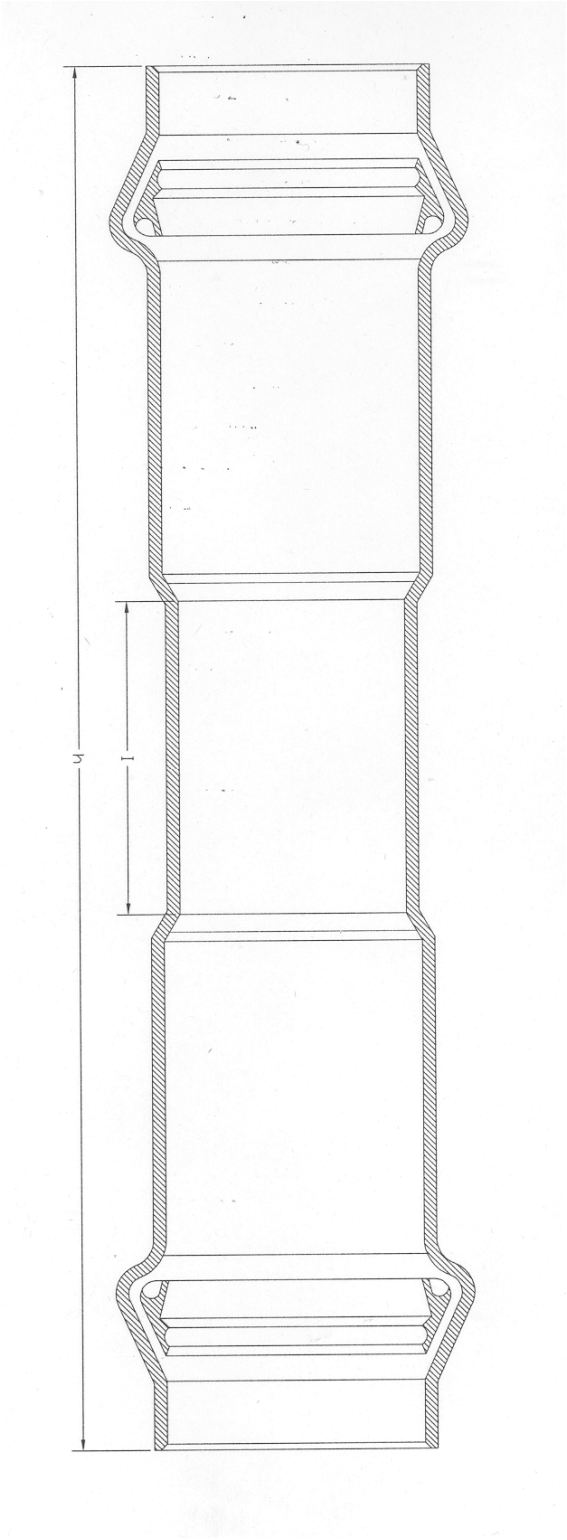
17.4.4 Supply of specials

17.4.4.1 All the PVC fittings shall be supplied along with necessary rubber rings. The rubber rings shall be supplied in black coloured polyethylene bags. The fittings shall be packed and supplied in jute bags or in cardboard or wooden boxes according to their size.

17.4.5 The fittings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under it's own supervision and have it tested at his/sub contractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.



Double Socket Bend for PVC Pipes



Double Socket Special for PVC Pipes

17.5 Ductile Iron Pipes

17.5.1 Ductile Iron Pipes:

The pipes will be centrifugally cast (spun) Ductile Iron pipes for Water and Sewage confirming to the IS 8329: 2000. The pipes used will be either with push on joints (Rubber Gasket Joints) or Flanged joints. The class of pipe to be used shall be of the class K-9.

The pipes shall be coated with bitumen as per appendix C and have factory provided cement mortar lining in the inside as per the provisions of Appendix B of the IS 8329: 2000.

The pipes will be supplied in standard length of 4.00, 5.00, 5.50 and 6.00 meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety will also be supplied with a rubber EPDM/(SBR) gasket. Any change in the stipulated lengths will be approved by the Engineer – in charge. The gaskets will confirm to the IS 5382:1985.
The gaskets should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under it's own supervision and have it tested at his/sub contractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

The flanged joints will confirm to the **Clause 6.2** of IS 8329. The pipe supply will also include one rubber gaskets for each flange.

17.5.1.1 Inspection and Testing:

The pipes will be subjected to following tests for acceptance:

- Visual and dimensional check as per Clause 13 and 15 of IS 8329
- Mechanical Test as per Clause 10 of IS 8329
- Hydrostatic Test as per Clause 11 of IS 8329
- The test reports for the rubber gaskets shall be as per acceptance tests of the IS 5832 and will be in accordance to **Clause 3.8**

The sampling shall be as per the provisions of the IS 8329

17.5.1.2 Marking

- All pipes will be marked as per Clause 18 of IS 8329 and show as below:
- Manufacturer name/ stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end

17.5.1.3 Packing and Transport:

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage.

17.6 Specials for Ductile Iron Pipes

17.6.1.1 General

This section covers the general requirements for Ductile Iron (DI) fittings suitable for Tyton joints to be used with Ductile Iron pipes with flanged and Tyton jointing system.

17.6.1.2 Types of specials

The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523 or BS: 4772.

- flanged socket
- flanged spigot
- double socket bends (90^0, 45^0, 22 1/2 ^{0}, 11 1/4 ^{0})
- double socket branch flanged tee
- all socket tee
- double socket taper
- All the fittings shall be of class K-12.

17.6.2 Supply

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382 as described in the preceding chapter. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

17.6.3 Lubricant for ductile iron pipes and specials

17.6.3.1 General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-in rubber ring joints

17.6.3.2 Specification

The lubricant has to have the following characteristics:

- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings
- to be applied in hot and cold weather; ambient temperature 0 - 50 °C, temperature of exposed pipes up to 70 °C
- must be non toxic
- must be water soluble
- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf live not less than 2 years

Acceptance tests

- They shall be conducted in line with the provisions of the IS 9523

17.6.4 Packing

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

17.6.5 The fittings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under it's own supervision and have it tested at his/sub contractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

17.7 Valves

17.7.1 General

The sluice valve will confirm to IS: 780/ IS: 2906.

The material to be supplied under this sub-section shall include but not be limited to the following:

All necessary fittings including bolts, nuts, gaskets, backing rings, counter flanges, jointing material, strainers etc. as required.

17.8 Sluice Valves

17.8.1 Scope

This section covers the requirements for non rising stem type sluice valve from 50 mm to 600 mm size. The valves will be used for water supply on line installations in upright positions, up to 45^0 C working temperature, with double flange and cap or hand wheel, for manual operation.

17.8.2 Nominal pressure and dimensions

The working pressure of the valves shall be 10 kg/cm^2 (1 Mpa)

The dimension and mass of the sluice valves shall be in accordance with IS: 780 for sizes from 50 to 300 mm and IS: 2906 for sizes 350 to 600 mm.

The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII).

17.8.3 Material

The material for different components parts of sluice valve shall conform to requirements given below:

S No.	Component	Material	Ref. to IS	Grade / designation
1	Body, bonnet, wedge, stuffing box, gland, thrust plate, hand wheel cap. etc.	Grey cast iron	210	FG 200
2	Stem	Stainless steel	6603	AISI 431, AISI 410
3	Wedge nut	Leaded tin bronze	318	LTB 2
4	Body seat ring, wedge facing ring	Leaded tin bronze	318	LTB 2
5	Bolt	Carbon steel	1363	Class 4.6
6	Nut	Carbon steel	1363	Class 4
7	Bonnet gasket	Compressed fibre board	2712	C
8	Gland packing	Asbestos	4687	nil

17.8.4 Coating

All sluice valves shall be coated by dipping in a bath of tar base composition as given in Clause 7 of IS: 780 for sizes from 50 mm to 300 mm and Clause 8 of IS: 2906 for sizes from 350 mm to 600.

All components susceptible to corrosion attack shall be coated internally and externally. Protective coating shall always be applied to the individual components before they are assembled, following shot blasting to give good adhesion.

17.8.5 Marking, testing and inspection

The standard marking and packing of the valves shall be done as per Clause 10 and 11 of IS: 780. The direction of rotation for OPEN, CLOSE position shall be marked on the hand wheel and on the bonnet of the valve.

Testing of sluice valve shall be done for close end in accordance with IS: 780 for sizes from 50 mm to 300 mm and IS: 2906 for sizes from 350 mm to 600.

All the valves shall be inspected for flaw detection test in accordance with IS: 780. for sizes from 50 mm to 300 mm and IS: 2906 for sizes from 350 mm to 600.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

17.8.6 Air valves

17.8.6.1 Scope and general design feature

This section covers the requirements of automatic double ball air valves to be used for evacuation of accumulation of air in water mains under pressure, for the exhaust of air when such mains are being charged with water and for inlet of air when they are emptied of water.

The design shall be such that higher the rate of flow the greater the resultant down thrust keeping the ball 'glued' to its seat until the last drop of air is expelled from the pipe system.

The valves shall have an integrated sluice valve. If required, they shall be installed on a flange welded on the MS pipe / special. The possible air velocity (inflow and outflow) must be at least 10 m/s. The working pressure of the air valves shall be 10 kg/cm^2 (1 Mpa).

17.8.7 Construction feature

The flow of air should be as unobstructed as possible. The low pressure orifice shall be in the same axis as the main discharge/incoming air flow and must have a diameter sufficiently large.

The cone angle in the low pressure (large orifice) chamber should be carefully calculated and there should be adequate height to allow for free movement of the vulcanite ball in the low chamber. The annulus around the low pressure vulcanite covered ball is to be generously proportioned for discharge of air under various differential pressure.

The orifice shall be carefully profiled to allow the requisite flow of air under varying differential pressure. It shall be in moulded synthetic rubber such that even after extended contact the vulcanite covered ball does not stick to it when the line pressure becomes zero.

In the high pressure chamber the orifice shall be in profiled in such a manner that the rubber covered ball is not damaged even after extended contact. There should be machined guide in the chamber which ensures that the ball travels vertically and makes contact with the nipple and seals off the orifice without fail.

17.8.8 Material

The material for different components parts of the air valve shall conform to requirements given below:

S No.	Component	Specifications
1	Body	Cast Iron conforming to IS: 210 GR FG 200
2	High Pressure Cover	Cast Iron confirming to IS 210 GR FG 200
3	Low Pressure Cover	Cast Iron confirming to IS 210 GR FG 200
4	Cowl	Cast iron confirming to !S 210 GR FG
5	High Pressure Orifice Plug	Stain less steel conforming to AISI 410
6	Low pressure ball	Vulcanite covered seasoned timber
7	High pressure ball	Rubber covered seasoned timber
8	Lower pressure seat ring	Dexine (Nitrile rubber)
9	Isolating sluice valve	Conforming to IS: 780 - 1984
10	Spindle for sluice valve	Stainless steel conforming to AISI 410
11	Bolts and nuts	Mild steel

The body and seat of the valve shall withstand a working pressure of 10 kg/cm^2 for at least 15 minutes.

17.9 Specifications for Laying and Jointing of Pipe Line System for Water Supply

17.9.1 Preparatory work

The contractor will inspect the route along which the pipe line is proposed to be laid. He should observe/ findout the existing underground utilities/ construction and propose an alignment along which the pipeline is to be laid. He should make all efforts to keep the pipe as straight as possible with the help of ranging rods. Whereever there is need for deviation, it should be dione with the use of necessary specials or by deflection in pipe joints (limited to 75% of permissible deflection as per manufacturer). The alignment as proposed should be marked on ground with a line of white chalk and got approved from Engineer Incharge. The Contractor will than prepare an L-Section along this alignment showing the location of proposed pipe line. The L-section should be got approved from the site Engineer. The position of fittings, valves, should be shown on the plan.

17.9.2 Alignment and the L-Sections

The alignments, L-section (depth of laying) and location of specials, valves and chambers may be changed at site in co-operation with and after approval of the Engineer in Charge.

17.9.3 Standards

Except as otherwise specified in this technical specification, the Indian Standards and Codes of Practice in their latest version, National Building code, PWD specification of the state of Rajasthan and Manual of water supply of GOI shall be adhered to for the supply, handling, laying, installation, and site testing of all material and works.

17.9.4 Tools and equipment

The contractor has to provide all the tools and equipment required for the timely, efficient and professional implementation of the work as specified in the various sections of the contract and as specified by the instructions of manufacturers of the pipes and other material to be handled under this contract. On demand he shall provide to the Engineer in Charge a detailed list of tools and equipment available. If in the opinion of the Engineer in Charge the progress or the quality of the work cannot be guaranteed by the available quantity and type of tools and equipment the contractor has to provide additional ones to the satisfaction of the Engineer in Charge. The Contractor will always have a leveling instrument on site.

17.9.5 Handling and laying of pipes

17.9.5.1 Transportation of pipes and specials

The Contractor has to transport the pipes and other materials from manufacturer to the site of laying as indicated by the Engineer in Charge. Pipes should be handled with care to avoid damage to the surface and the socket and spigot ends, deformation or bending. Pipes shall not be dragged along the ground or the loading bed of a vehicle. Pipes shall be transported on flat bed vehicles/trailers. The bed shall be smooth and free from any sharp objects. The pipes shall rests uniformly on the vehicle bed in their entire length during transporatation. Pipes shall be loaded and un-loaded manually or by suitable mechanical means without causing any damage to the stacked pipes.

The transportation and handling of pipes shall be made as per IS 12288. Handling instructions of the manufacturers of the pipes shall be followed. All precautions set out shall be taken to prevent damage to the protective coating, damage of the jointing surfaces or the ends of the pipes.

Whatever method and means of transportation is used, it is essential that the pipes are carefully placed and firmly secured against uncontrolled movement during transportation to the satisfaction of engineer in charge.

Cranes or chain pulley block or other suitable handling and lifting equipment shall be used for loading and un-loading of heavy pipes. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used. Where using crane hooks at sockets and spigot ends hooks shall be broad and protected by rubber or similar material, in order to avoid damage to pipe ends and lining. Damage to lining must be repaired before pipe laying according to the instructions of the pipe manufacturer. Pipes shall not be thrown directly on the ground.

When using mechanical handling equipment, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

Rolling or dragging pipes along the ground or over other pipes already stacked shall be avoided too.

17.9.5.2 Stringing of pipes along the alignment

The pipes shall be laid out properly along the proposed alignment in a manner that they do not create any significant hindrance to the public and that they are not damaged.

Stringing of the pipes end to end along the working width should be done in such a manner that the least interference is caused in the land crossed. Gaps should be left at intervals to permit the passing of equipment across the working area. Pipes shall be laid out that they remain safe where placed and that no damage can occur to the pipes and the coating until incorporated in the pipeline. If necessary, pipes shall be wedged to prevent accidental movement. Precautions shall be made to prevent excessive soil, mud etc. entering the pipe.

Generally, the pipes shall be laid within two weeks from the date of their dispatch from the manufacturer/store.

The joint gaskets shall be kept in wooden boxes or their original packing and stored in cool conditions and not exposed to direct sunlight. Gaskets must not be deformed. They shall be taken out only shortly before they are needed. All PVC pipes when stored shall be protected from sunlight and heat at all stages.

17.9.5.3 Pipe trench

17.9.5.3.1 Trench excavation

The trench excavation of pipe line shall be in accordance with IS 12288. Pipe trenches shall be excavated to the lines and levels shown on the drawings or as directed by the Engineer in Charge. The depth of the excavated trench shall be as given in the drawings or as directed by the Engineer in Charge. The width of the trench at bottom between the faces of sheeting shall be such as to provide 200/150 mm clearance on either side of the DI CI / PVC pipe except where rock excavation is involved. No pipe shall be laid in a trench until the section of trench in which the pipe is to be laid has been approved by the Engineer in Charge.

In agricultural land the depth should be sufficient to provide a cover not less than 900 mm so that the pipe line will not interfere with the cultivation of land. It may be necessary to increase the depth of pipeline to avoid land drains or in the vicinity of roads, railways or other crossings. Care should be taken to avoid the spoil bank causing an accumulation of rainwater.

The bottom of the trench shall be trimmed and levelled to permit even bedding of the pipes. It should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation shall be made at the joints of the pipes, so that the pipe is supported along its entire length.

All excavated material shall be stacked in such a distance from the trench edge that it will not endanger the work or workmen and it will avoid obstructing footpaths, roads and drive ways. Hydrants under pressure, surface boxes, fire or other utility controls shall be left unobstructed and accessible during the construction work. Gutters shall be kept clear or other satisfactory provisions made for street drainage, and natural water-courses shall not be obstructed.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards, as required, shall be placed and maintained during the progress of the work and until it is safe for traffic to use the roadways. All materials, piles equipment and pipes which may serve as obstruction to traffic shall be enclosed by fences or barricades and shall be protected by illuminating proper lights when the visibility is poor.

As far as possible, the pipe line shall be laid below existing services, like water and gas pipes, cables, cable ducts and drains but not below sewers, which are usually laid at greater depth. Where it is unavoidable, pipe line should be suitably protected. A minimum clearance of 150 mm shall be provided between the pipe line and such other services.

Trees, shrubbery fences, poles, and all other property and surface structures shall be protected. Tree roots shall be cut within a distance of 50 cm from pipe joints in order to prevent roots from entering them. Temporary support, adequate protection and maintenance of all under ground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be provided. The structures, which will be disturbed shall be restored after completion of the work.

Where water forms or accumulates in any trench the Contractor shall maintain the trench free of water during pipe laying.

Wherever necessary to prevent caving, trench excavations in soils such as sand, gravel and sandy soil shall be adequately sheeted and braced. Where sheeting and bracing are used, the net trench width after sheeting shall not be less than that specified above. The sides of the excavation shall be adequately supported at all times and, except where described as permitted under the Contract, shall be not battered.

The Engineer in Charge in co-operation with the Contractor shall decide about the sheeting/ bracing of the trench according to the soil conditions in a particular stretch and taking into account the safety requirements of the Contractor’s and ENGINEER- IN- CHARGE’s staff.

Generally, safety measures against caving have to be provided for trenches with vertical walls if they are deeper than 2.0 m.

17.9.5.3.2 Trench excavation to commensurate with the laying progress

The work of trench excavation should be commensurate with laying and jointing of the pipe line. It should not be dug in advance for a length greater than 500 m ahead of work of laying and jointing of pipeline unless otherwise defined by the Engineer in Charge. The Contractor has to ensure the following:

- safety protections as mentioned above have to be incorporated in the work process
- hindrances to the public have to be minimised
- the trench must not be eroded before the pipes are laid
- the trench must not be filled with water when the pipes are laid
- the trench must not be refilled before laying of the pipes

The bed for the laying of the pipes has to be prepared according to the L-Section immediately before laying of the pipes.

17.9.5.3.3 Bedding of the pipes

The trench bottom shall be even and smooth so as to provide a proper support for the pipe over its entire length, and shall be free from stones, lumps, roots and other hard objects that may injure the pipe or coating. Holes shall be dug in the trench bottom to accommodate sockets so as to ensure continuous contact between the trench and the entire pipe barrel between socket holes.

17.9.5.4 Laying and jointing of pipes

17.9.5.4.1 General

The pipes will be cleaned in the whole length with special care of the spigot and sockets on the inside/ outside to ensure that they are free from dirt and unwarranted projections. The whole of the pipes shall be placed in position singly and shall be laid true to profile and direction of slope indicated on longitudinal sections. The pipes shall be laid without deflection in a straight alignment between bends and between high and low points. Vertical and horizontal deflections between individual pipes need the approval of the Engineer in Charge. In no case the deflection shall be more than 75 % of those recommended by the manufacturer.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes, particularly the spigot end and the socket including the groove for the rubber ring.

Pipes and the related specials shall be laid according to the instructions of the manufacturers and using the tools recommended by them.

Cutting of pipes shall be reduced to a minimum required to conform with the drawings. Cutting has to be made with suitable tools and according to the recommendations of the manufacturer. The spigot end has to be chamfered again at the same angle as the original chamfered end. Cutting shall be perpendicular to the centre line of the pipe. In case of ductile iron pipes the cut and chamfered end shall be painted with two coats of epoxy paint. If there is no mark for the insertion depth on the spigot end of the (cut) pipe it shall be marked again according to the instructions of the manufacturer.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes, particularly the spigot end and the socket including the groove for the rubber ring. End caps are removed only just before laying and jointing

All specials like bends, tees etc. and appurtenances like sluice or butterfly valves etc. shall be laid in synchronisation with the pipes. The Contractor has to ensure that the specials and accessories are ready in time to be installed together with the pipes.

At the end of each working day and whenever work is interrupted for any period of time, the free ends of laid pipes shall be protected against the entry of dirt or other foreign matter by means of approved plugs or end caps.

When pipe laying is not in progress, the open ends of installed pipe shall be closed by approved means to prevent entrance of trench water and dirt into the line.

No pipe shall be laid in wet trench conditions that preclude proper bedding, or when, in the opinion of the Engineer in Charge, the trench conditions or the weather are unsuitable for proper installation.

The pipe line laid should be absolutely straight unless planned otherwise. The accuracy of alignment should be tested before starting refilling with the help of stretching a string between two ends of the straight stretch of pipes to rectify possible small klinks in laying.

17.9.5.4.2 Laying and jointing of DI pipes

Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 200 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes suitable mechanical equipment have to be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. All persons should vacate any section of trench into which the pipe is being lowered

On gradients of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is back filled over the barrel of the pipe.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.
Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc. which affect the design and laying of pipeline.

The assembly of the pipes shall be made as recommended by the pipe manufacturer and using the suitable tools.

The socket and spigot ends of the pipes shall be brushed and cleaned. The chamfered surface and the end of the spigot end has to be coated with a suitable lubricant recommended by the manufacturer of the pipes. Oil, petroleum bound oils, grease or other material which may damage the rubber gasket shall not be used as lubricant. The rubber gasket shall be inserted into the cleaned groove of the socket. It has to be checked for correct positioning.

The two pipes shall be aligned properly in the pipe trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot. After insertion, the correct position of the socket has to be tested with a feeler blade

Deflection of the pipes -if any- shall be made only after they have fully been assembled. The deflection shall not exceed 75 % of the values indicated by the pipe manufacturer.

17.9.5.5 Anchoring of the pipeline

Thrust blocks shall be provided at each bend, tee, taper, end piece to prevent undue movements of the pipeline under pressure. They shall be constructed as per design of ENGINEER- IN- CHARGE according to the highest pressure during operation or testing of the pipes, the safe bearing pressure of the surrounding soil and the friction coefficient of the soil.

17.9.5.6 Testing of the pipelines

17.9.5.6.1 Sectional tests

After laying and jointing the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Engineer in Charge. The length of the sections depends on the topographical conditions. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, other chamber).At the beginning, the Contractor shall test stretches not exceeding 2 km. After successful organization and execution of tests the length may be extended to more than 2 km after approval of the Engineer in Charge.

The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol if required:

- complete setting of the thrust blocks.
- partial backfilling and compaction to hold the pipes in position while leaving the joints exposed for leakage control
- opening of all intermediate valves (if any)
- fixing the end pieces for tests and after temporarily anchoring them against the soil (not against the preceding pipe stretch)
    - at the lower end with a precision pressure gauge and the connection to the pump for establishing the test pressure
    - at the higher end with a valve for air outlet
- If the pressure gauge cannot be installed at the lowest point of the pipeline, an allowance in the test pressure to be read at the position of the gauge has to be made accordingly
- slowly filling the pipe from the lowest point(s).
- the water for this purpose shall be reasonably clear and free of solids and suspended matter
- complete removal of air through air valves along the line.
- closing all air valves and scour valves.
- slowly rising the pressure to the test pressure while inspecting the thrust blocks and the temporary anchoring.
- keeping the pipeline under pressure for the duration of the pre-test / saturation of the lining by adding make-up water to maintain the pressure at the desired test level. Make up water to be arranged by Contractor himself at his own cost.
- start the test by maintaining the test pressure at the desired level by adding more make-up water; record the water added and the pressure in intervals of 15 minutes at the beginning and 30 minutes at the end of the test period.
- Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches.
- The testing conditions for the pipelines shall be as per the test pressures and condition laid out in IS 8329 for DI pipes and IS 4985 for uPVC pipes.

The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipework shall be accepted by the Engineer in Charge until all requirements of the test have been obtained.

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

17.9.5.6.2 Leakage Test

The testing conditions for the pipelines are summarized as follows:

- Maximum hydrostatic test pressure for DI K-9 pipes shall be hydrostatic working pressure of DI pipe i.e. 18.0 kg/cm^2 or 1.5 times of pressure in the pipeline, whichever is more.

- Pre test and saturation period with addition of make-up water
  Pressure: Test pressure
  Duration: 3 hrs for DI pipes without cement mortar lining / 24 hrs for DI pipes with cement mortat lining

- Pressure test with addition of make-up water
  Pressure: Test pressure
  Duration: 3 hrs

- Test criteria for DI pipes: Q = llitre per km per 10mm of pipe pe 30 m test pressure per 24 hrs.

- Test criteria for uPVC pipes: Q= 4.5 litre per 1.6 km of pipe per 25 mm nominal bore per 30 m head of test pressure per 24 hrs.

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount 'Q', calculated by the above formula.

The table, hereunder, gives recommended test pressure for uPVC pipes.

Maximum continuous working pressures and recommended test pressures				
Class of pipe	Working pressure		Recommended site/ field Test Pressure	
	Kg/ sq cm	Bar	Kg/ sq cm	Bar
3	6.0	6.0	9.0	9.0
4	10.0	10.0	15.0	15.0

Due to the elastic characteristics and relatively high thermal expansion and contraction of uPVC, it is advisable to avoid prolonged pressure tests.

If it is required to test a section of a pipe line with a free end, it is necessary to provide temporary support against the considerable end thrust developed by the application of the test pressure. The end support can be provided by inserting a wooden beam or similar strong material in a short trench excavated at right angle to the main trench and inserting suitable packing between the support and pipe end.

The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipework shall be accepted by the Engineer in charge until all requirements of the test have been obtained.

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

17.9.5.6.3 Failure to pass the test

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to the unsatisfactory in any way shall be redone by the Contractor.

17.9.5.7 Flushing and disinfecting of pipelines

After testing and commissioning the contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Engineer in Charge. Disinfection of drinking water pipelines shall be made by engineer- in charge.

17.9.5.8 Backfilling of the pipe trench

For the purpose of back-filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

Zone A: From the bottom of the trench to the level of the centre line of the pipe	Back-filling by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width of each side of the pipe, specials and appurtenances simultaneously. Special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.
Zone B: From the level of the centre line of the pipe to a level 300 mm above the top of the pipe	Back-filling and compaction shall be done by hand or approved mechanical methods in layers of 150 mm, special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.
Zone C: From a level 300 mm above the top of the pipe to the top of the trench.	Back-filling shall be done by hand or approved mechanical methods in 15 cm layers after compacting and carried to the level necessary to allow for the temporary restoration of road and path surfaces, and also for hard-core (if and where ordered) on roads or to such level as will leave the requisite space for the top soil, road surface etc. to be reinstated as directed by the Engineer in Charge. In case of agricultural or waste land and after approval by the Engineer in Charge back-filling may be made in thicker layers and with less compaction up to 200 - 300 mm above the initial ground level.

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the subgrade of the structures shall be made with sand in accordance with IS 12288.

The excavated material may be used for back-fill in the following cases, provided it complies with IS 12288 Clause 4.11.1:

a) In Zone C: In cases where settlement is unimportant the back-fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.

b) In any zone, when the type of back-fill material is not indicated or specified, provided that such material consists of loam, clay, sand, fine gravel or other materials which are suitable for back-filling in the opinion of the Engineer In Charge.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer in Charge, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer in Charge, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

Trenches crossing a road shall be backfilled with selected material placed in layers not exceeding 15 cm in thickness after compacting, wetted and compacted to a density of not

less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal of refuse or unsuitable soil.

17.9.6 sequence of works for ensuring good pipe laying

17.9.6.1 The required fittings, valves and jointing material should be carefully worked out in beginning. This material should be received in full first of all on site and stored as predirections of manufacturer or as directions given elsewhere in this manual on Standards.

17.9.6.2 The pipes should be received on site only after the above fittings, valves and material for joints has been received and all necessary preparation for laying has been made.

17.9.6.3 The material received should be checked for inspection certification as per contract and damage during transportation. All damaged material should be separated and not used.

17.9.6.4 The pipes received should be stored strictly as per directions of the manufacturer or as mentioned elsewhere in this manual or standards.

17.9.6.5 The pipes and other material should be again inspected for any damage before use in the trench.

17.9.6.6 The fittings and valves should be installed in sequence with the laying of pipes without leaving any gaps.

17.9.6.7 It is desirable to lay the pipe lines from the end from where it can be connected to the water source to enable regular flushing of laid pipes.

17.9.6.8 The entry of dirt or any foreign material in the pipe should be religiously prevented.

17.9.6.9 Each joint should be carefully checked for its completeness before covering up.

17.9.6.10 There should be a commensurate progress in trench excavation, laying and jointing of pipes, fittings, valves etc. and testing of laid pipes in sections so as to complete testing of all pipes laid in quick follow up of completing laying and jointing.

17.9.6.11 Disinfection of pipe lines should be carried out before commissioning.

17.9.7 Installation of valves

17.9.7.1 General

The installation of valves shall be made according to the instructions of the manufacturer and the Engineer in Charge.

17.9.7.2 Installation of valves

Sluice or butterfly valves shall be installed between flanges according to the instructions of the manufacturer.

Valves shall be placed on a support of concrete so that no shear stress is in the flanges. In case of axial thrust due to closure of a valve against pressure the valve shall be anchored in the support in a suitable manner to transfer the thrust into the floor slab of the chamber.

Air valves shall be installed on top of air valve tees.

17.9.8 Chambers for valves

17.9.8.1 Valve chambers

Valve chambers shall be constructed according to the typical drawings suitable for the respective valve and special arrangement to be given by ENGINEER- IN- CHARGE.. They shall be constructed in reinforced cement concrete M15 in situ. The top slab cover shall be cast in situ or made by precast RCC or Ferrocement slabs. Above big valves prefabricated slabs shall be provided for a length and width which allows dismantling of the valve without problems. The roof and the slabs have to be designed for a live load of IRC appropriate for the location.

The chambers shall be constructed after the laying of the pipes and the assembly of specials and valves. The size of the chambers shall be according to the following criteria as per direction of engineer in charge.

- distance of flanges from walls: 30 cm
- distance of sockets from walls: 30 cm
- distance between highest point of equipment and roof slab: 30 cm

Pipes passing through walls should be coated by two layer of soft material (hessian felt) to allow for differential settling and longitudinal expansion if directed by engineer in charge. Only metallic pipes may be cast into the walls for anchoring purposes.

A suitable locking device may be got constructed by Engineer In Charge,if required at site.

In case of chambers deeper than 120 cm MS iron ladder of 60 cm wide, cast iron steps or rungs shall be provided at the inner side wall with a vertical spacing as per arrangement shown in drawing.

The work shall include excavation, consolidation, levelling, 10 cm of lean concrete, foundations, finishing, refilling. It shall include all labour and material required for the complete chamber.

17.9.8.2 Scour valve chambers

Scour valve chambers shall be constructed according to the typical drawings enclosed suitable for the respective scour valve and special arrangement The chambers for scour valves shall be off-line and placed on the scour pipe. There is a closed chamber containing the scour valve, according to the chambers for sluice valves.

All specifications and constructional details for the valve chambers apply for the scour chambers accordingly.

17.9.8.3 Pillars for ductile iron pipes

In case of unstable subsoil or in case of ductile iron pipes laid above ground they shall be laid on pillars. Each pipe is supported at the plain end and behind the socket. One pillar shall support the socket end of one and the plain end of the other pipe. The pillars shall be of RCC and shall be founded on solid soil, not subject to erosion by wind or water. The foundation of the pillars has to be calculated according to the soil conditions.

The top of the pillar shall form two saddles for the pipe having the same radius as the pipe. The socket will be lying free between the two saddles. The pipes shall be laid on a coat of

polyethylene of 2 mm thickness, put on mortar. It has to be ensured that the spigot end of the pipe is supported by the saddle and does not unduly compress the rubber ring in the lower part. Each pipe is fixed by one adjustable galvanised steel spanner, fixed to the pillar with anchor bolts.

In case of vertical deviations the pipes shall be protected against uplift by additional reinforced clamps of mild steel. In this case, the design of the pillar has to be made taking in account these uplift forces. and design will be given by ENGINEER- IN- CHARGE.

17.9.8.4 Thrust blocks

The thrust blocks shall be of concrete M15 cast on site with/without proper reinforcement as per design and drawings to be given by ENGINEER- IN- CHARGE. The thrust blocks shall be cast directly against the undisturbed soil. If this is not possible, the backfilled soil at the contact surface shall be compacted well to full satisfaction of Engineer In Charge so that anchor block is not displaced during operation and testing.

17.9.8.5 Backfilling around chambers and thrust blocks

After the completion of chambers and thrust blocks the space between the structure and the excavation shall be backfilled with compacted material. Such backfill shall be placed in layers of 15 cm measured before compaction, wetted, if necessary, to optimum moisture and compacted well as per instruction of engineer in charge

Embankment around structures shall be done at levels and with slopes as shown in the drawings.

17.9.9 Other civil and related works

17.9.9.1 Crossing of existing Distribution Pipes and connecting pipes

Existing transmission and distribution pipes and connecting pipes of standpipes have to be protected during the laying of the pipes. In case of impossibility of deviation, the pipes have to be replaced according to the instructions of the Engineer in Charge and in co-operation with the local representative (for eg. Assistant Engineer) of PHED. The Contractor has the full responsibility in case of destruction of pipes due to inattention of his staff. All costs for the reinstatement of the original status of the pipes in case of damage have to be borne by him.

17.9.9.2 Poles of electrical or telephone lines

In case of impossibility of deviation of pipeline, poles of electricity lines (33, 11, 0.4 KV), telephone lines or anchor cables of poles have to be relocated. These works have to be executed by the respective department or according to its instructions. The Contractor has the full responsibility in case of destruction of lines or poles due to inattention of his staff. All costs for the reinstatement to the original status of the lines have to be borne by contractor.

17.9.10 Testing and commissioning

17.9.10.1 Commissioning general

After successful sectional tests after pipe laying and other pre-commissioning tests after physical completion, the pipeline shall be commissioned by the Contractor. Dynamic commissioning shall be made in conjunction with or after the commissioning of the respective system.

During testing/commissioning, the Contractor shall supply all material and labour to supervise, adjust, test, repair and do all things necessary to maintain the testing/ commissioning. This shall include labour on a 24 hour-a-day basis during the test period and for such other period of continuous operation as the Engineer in Charge may consider necessary to establish the efficient operation of the cluster distribution system.

If any test result shows noticeable variation from the specification requirements for the system the Contractor shall immediately take steps to rectify the deficiency without any extra cost to ENGINEER- IN- CHARGE.

The Contractor shall test and commission the system for 7 days at a stretch, from the date of commissioning. On expiry of this period the system shall be taken over by the ENGINEER-IN- CHARGE and a taking-over certificate shall be issued by the Engineer in Charge, provided all defects and/or deficiencies noticed are rectified to the satisfaction of the ENGINEER- IN- CHARGE.

Generally, the timing of most of the commissioning tests will depend on the availability of the respective pumps, the water and power availability at the pumping station and the completion of the reservoir.

Should the supply of water from the pumping station fail or should any other event beyond the Contractor's control interfere, the commissioning shall be during such a number of operational periods as the Engineer in Charge may consider equivalent. Any repairs or replacement required during this period shall be done by the Contractor at his own cost.

The Contractor shall allow for commissioning to be conducted at any time during the commissioning period without extra charges under the Contract.

The main indicators for the successful commissioning are:

- no leaks in pipes, joints, specials and valves
- all valves are properly installed and operational
- execution of the entire work including finishing according to the drawings and the specifications
- submission of as built drawings

17.9.10.2 Dynamic commissioning

- The dynamic commissioning shall commence after the work has been physically completed to the satisfaction of the Engineer in Charge. It shall simulate the design and operation conditions which are as follows:
- All branches into existing lines (if already in position) to be shut off.
- Pump in operation, pump discharging into the transmission main. This is for the commissioning of the transmission pipe only.
- Water being put into the system through overhead tank or direct pumping as the case maybe.
- Closing of the valves against full static or dynamic pressure.
- Operation of all valves including scour valves (open-close-open).
- Operation of all air valves.
- Operation of all locking arrangements of valve chambers.

18 MANHOLES AND VENT SHAFTS

18.1 Scope

18.1.1 This Specification covers the requirements for providing and construction ancillary works such as manholes, scraper manholes, vent shafts, etc.

18.2 Applicable Codes

18.2.1 The following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern.

IS: 111	Code of Practice for Ancillary Structures (Part I) - Manholes.
IS: 555	Cast Iron Steps for Manhole.
IS: 1077	Common Burnt Clay Building Bricks
IS: 3102	Classification of Burnt Clay Bricks.
IS: 395	Method of Sampling and Testing Clay Building Bricks.
IS: 2212	Code of Practice for Brick Work.

18.3 Manholes

18.3.1 Location

18.3.1.1 Manholes shall be constructed at places as shown on Layout Plan Drawings and as directed by Engineer.

18.3.2 Excavation

18.3.2.1 Excavation shall be done in accordance with **Chapter 5 and Chapter 15** of this Specification.. The rate quoted for manhole shall be inclusive of excavation and backfilling, bailing or pumping out water and shoring.

18.3.3 Bed concrete

18.3.3.1 The bed concrete shall be done in accordance with **Chapter 9** of this Specification.

18.3.4 Brickwork

18.3.4.1 The brickwork shall be done in accordance with **Chapter 10** of this Specification.

18.3.4.2 Bricks used in works shall conform to the relevant Indian Standards. They shall be sound, hard, homogeneous in texture, well burnt in kiln without being vitrified, table moulded, deep red cherry or copper coloured, of regular shape and size and shall have sharp and square and parallel faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing ingrained particles and / or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Overburnt or underburnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 50 kg/sqcm. unless otherwise noted in Drawings. The class and quality requirements of bricks shall be as laid down in IS: 3102.

18.3.4.3 The size of the brick shall be 23.0 X 11.5 X 7.5 cm unless otherwise specified; but tolerance upto $\pm$ 3 mm in each direction shall be permitted. Only full size brick shall be used for masonry work. Brick bats shall be used only with the permission of Engineer to make up required wall length or for bending. Sample bricks shall be submitted to Engineer for approval and bricks supplied shall conform to approval samples. If demanded by Engineer brick sample shall be got tested as per IS: 395 by Contarctor at no extra cost to Engineer. Bricks rejected by Engineer shall be removed from the site of works within 2 hours.

18.3.5 Cement mortar

18.3.5.1 Mortar for brick masonry shall be prepared as per IS: 2250. In ordinary manholes, brickwork shall have cement mortar (1:5); in scraper manholes, brickwork shall have cement mortar (1:2). Gauge boxes for sand shall be of such dimensions that one bag containing 50 kg. of cement forms one unit. The sand shall be, free from clay, shale, loan, alkali organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer sand shall be thoroughly washed till it is free of any contamination.

18.3.5.2 For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry conditions. Water shall then be added and mixing continued to give a uniform mix of required consistency. Cement mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

18.3.6 Workmanship

18.3.6.1 All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work of manholes shall be in the proportion specified. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 115 mm thick brick work shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

18.3.6.2 All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be leveled. The thickness of brick courses shall be kept uniform. For walls of thickness greater than 230 mm both faces shall be kept in vertical planes. All interconnected brickwork shall be carried out at nearly one level (so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed at an angle not exceeding 5^{o}. But in no case the level difference between adjoining walls shall exceed 1.25 m. Workmanship shall conform to IS: 2212.

18.3.6.3 Brick shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 12 mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plaster or pointing to be done. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top. If mortar in the lower courses has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid. No extra payment will be made for raking joints.

18.3.7 Cement plaster work

18.3.7.1 All joints in masonry shall be raked to a depth of 12 mm with a hooked tool made for the purpose when the mortar is still green and in any case within 8 hours of its laying. The surface to be rendered shall be washed with fresh clean water to make it free from all dirt, loose material, grease, etc. and thoroughly wetted for 6 hours before plastering work is commenced.

18.3.7.2 Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.

18.3.7.3 The proportion of the cement mortar shall be as specified on relevant Drawings. Cement shall be mixed thoroughly in dry condition and then just enough water added to obtain workable consistency. The quality of water, sand and cement shall be as per relevant I.S. The mortar

thus mixed shall be used immediately and in no case shall the mortar be allowed to stand for more than 25 minutes after mixing with water.

18.3.7.4 Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. The decision as to when the plaster has hardened, will be given by Engineer. Curing shall be done by continuous applying water in a fine spray and shall be carried out for at least 7 days.

18.3.7.5 Plastering shall be done on inside / both faces of brick masonry, as directed by the Engineer, in CM 1:3 and 15 mm thick for ordinary manholes and in CM 1:2 and 20 mm thick for scraper manholes.

18.3.7.6 20 mm plastering work shall be carried out in 2 layers, the first layer being 10 mm (1:3) thick and the second layer being 10 mm (1:1) thick. The first layer shall be dashed against the prepared surfaces with a trowel to obtain an even surfaces. The second layer shall then be applied and finished leaving an even and uniform surfaces, trowel finished unless otherwise directed by Engineer.

18.3.8 C.C.Channel

18.3.8.1 Cement concrete channel be constructed in C.C. of M150 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete and rendered in cement mortar (1:1) 20 mm. thick and formed to a slope of not flatter than 1 in 12 to the channel.

18.3.9 Pipe entering or leaving manhole

18.3.9.1 Whenever a pipe enters or leaves a manhole, bricks on edge must be out to a proper form and laid around the upper end of the pipe so as to form an arch. All around the pipes, there shall be a joint of cement mortar 1:2 13 mm thick between it and the bricks.

18.3.10 C.I. Frame and cover

18.3.10.1 Cast Iron frame and cover shall be as per IS: 1726. The frame shall be fixed in cement concrete of M150 grade all around and finished with neat cement.

18.3.10.2 The manhole frame shall have 560 mm Ø clear opening and shall weigh not less than 208 kg. including cover. In case of rectangular C.I. frame and cover of 900 mm X 600 mm clear opening, the total weight shall not be less than 275 kg. C.I. cover shall be marked with year, sewer, **KUWS&DB** and arrow showing direction of flow or as specified in the Drawings. The manhole cover and frame shall be painted with 3 coats of anticorrosive paint after fixing in position. In case of scraper manhole the frame shall have clear opening of 1200 mm X 900 mm and shall weigh not less than 900 kg. including covers.

18.3.11 Fibre reinforced frame and cover

18.3.11.1 Heavy duty fibre reinforced concrete manhole covers and frames shall be provided capable of withstanding loads of 35 tones. The frame shall be fixed in cement concrete of M150 grade all around and finished with neat cement. The fibre reinforced frame shall have a clear opening 102 kg. The cover will have a minimum thickness of 100 mm and an approximate weight of 78 kg. The fibres shall constitute 1% of the weight of the concrete in the form of 50 mm to 100 mm metallic threads. For the cover sheet lapping is provided by M.S. Flat of 18 gauge to avoid damage to the edge and is painted with black paint.

18.3.12 C.I. Steps

18.3.12.1 Cast iron steps shall be as per IS: 555. Where the depth of invert of manhole exceeds 800 mm, cast iron steps of approved pattern shall be built in the brick work at the interval of 30 cm vertically and 38 cm horizontally. C.I. steps shall weigh not less than 4.5 kg each and shall be

of 150 mm X 375 mm overall dimensions. In case of pipe diameter greater than 600 mm box type C.I. steps weighing 19 kg. each shall be provided in channel of the manhole as per Drawing.

18.3.13 Measurement for manhole

18.3.13.1 The depth of manhole shall be measured from the top of cover to the invert level of the deepest outgoing sewer from the manhole. The rate quoted in schedule of Quantities and Rates for manhole shall include all items such as brick masonry, plastering on both sides, bed concrete and channel, concrete at top, fibre reinforced or C.I. frame and cover, C.I. steps, etc. inclusive of excavation and backfilling, bailing and pumping out water and shoring. The measurement shall be as per number basis and as per the actual depth of manhole constructed.

18.4 Vent Shafts

18.4.1 General

18.4.1.1 Vent shafts shall be erected at places shown on the Drawings of longitudinal sections of the sewers or as directed by Engineer.

18.4.2 RCC Vent Shafts

18.4.2.1 RCC vent shaft shall be of 100 mm Ø and 6.0 m height from ground level with inside core 150 X 150 at top & 200 X 200 at bottom in PCC M150 foundation including flue chamber in brick masonry CM 1:4 with 20 mm thick cement plastering CM 1:3. This shall be connected to the nearest manhole shaft by 150 mm diameter GSW pipe or as directed by Engineer.

18.4.3 Jointing of Stoneware Pipes

18.4.3.1 The spigot and socket joints of stoneware pipes shall be of rigid type and shall be caulked with tarred gasket (prepared ready for use before being brought on the work in one length for each joint and sufficiently long to entirely surround the spigot end of the pipe. The gasket to be driven as far as possible by means of a suitable instruments. After the pipes area thoroughly cleaned and moistened, mixture of one part of cement and one part of clean fine sand tempered with just sufficient water to have a consistency of semi-dry condition should be forced into the joint and well rammed with caulking tools, so that whole space around the spigot and socket is completely filled with lightly chalked mortar and the joints shall be finished off with a splayed fillet sloping at 5 degrees to the side of the pipe.

18.4.4 Measurement for Vent Shaft

18.4.4.1 The rate quoted in Schedule of Quantities and Rates for Vent shaft shall be deemed to include the cost of RCC vent shaft, necessary excavation to manhole inclusive of concrete encasement, erecting, etc. complete. The measurement for vent shaft shall be on per number basis.

19 PIPELINE APPURTENANCES

19.1 Scope

19.1.1 This Specification covers the requirements for various pipeline appurtenances like Public Stand Posts, Fire Hydrants, Valve Chambers, Anchor Blocks, Thrust Blocks, Pipe Supports, etc., required to be provided for various water supply pipelines.

19.2 Public Stand Post

19.2.1 Public Stand Post shall be of the following Specifications:

19.2.2 It shall consist of RCC Kerb Platform, RCC fountain slab and Pot rest. The concrete used shall be of mix as specified in the Drawing. GI Pipe of medium class conforming to IS: 1239 shall be used for the Public Stand Post unless otherwise specified. GI Pipe of specified size and rating shall be provided during casting of Stand Post, slab and drain. It shall be fixed with brass bib cock. Public Stand Post shall be constructed as per approved Drawings, and all items of work shall be carried out as per respective Specifications for the items given under respective heads.

19.3 Fire Hydrant

19.3.1 The fire hydrants shall be of spindle type with 65 mm outlet combined with sluice valve, unless otherwise specified. The hydrant shall conform to IS: 909 and shall consist of the following components:

1. One Sluice Valve of Class 1 type conforming to IS: 780;
2. A duck foot bend;
3. A 65 mm male coupling instantaneous pattern; and
4. Cast iron cap permanently secured to the duck foot bend by means of a chain. Where the fire service requirement of coupling differs from the above, the requisite coupling as shown on the Drawing shall be provided at no extra cost.

19.3.2 The body and cover shall be of good quality Cast Iron, spindle of Bronze and the nut and valve seat of Leaded Tin Bronze. The body, spindle and other parts shall be truly machined with its surface smoothly finished.

19.4 Valve Chambers

19.4.1 Valve chambers shall be provided for valves such as Sluice valves, Scour valves etc., at the places shown in the Drawings, with 0.6 m minimum clear space on all sides of the valves.

19.4.2 Base course for foundations for valve chambers shall be in Cement Concrete (1:3:6) using 40 mm and down size metal, with hard broken granite, trap, basalt or with any other approved grade as per the Specifications. Base coarse shall be 150 mm thick, laid at a level not less than 1 m below the natural ground level.

19.4.3 Over the base coarse, foundation for the walls of the valve chamber shall be constructed in stone masonry, in cement mortar 1:6, as per the Specifications in **Chapter 9**. The stones for the stone masonry in foundation shall be hammer dressed. The courses shall be not less than 20 cm high with bond stones 2 m apart in each course.

19.4.4 Over the foundation courses, a Damp Proof Course (DPC) in Cement Concrete (1:3:6), using 20 mm and down size granite or basalt or trap jelly, in 100 mm thickness shall be provided.

19.4.5 Over the DPC, walls of the valve chambers (superstructure) shall be constructed in stone masonry, in Cement Mortar 1:6, as per the Specifications in Chapter 11. The stones for the stone masonry in superstructure shall be chisel dressed and all quoins 2 line dressed, 5 cm wide on each face. The courses shall be not less than 15 cm high with bond stones 2 m apart in each course.

19.4.6 For the walls of the valve chambers, cement pointing in cement mortar 1:3, with 2 coats of water proof cement paint of approved colour over one coat of primer coat shall be provided. Pointing shall be 20 mm to 25 mm deep.

19.4.7 Roof shall be constructed in RCC, M150 grade (1:2:4) and provided with projections over all sides. Roof shall be plastered with cement mortar 1:3, in 12 mm thickness. RCC perforated ventilators and door openings with rolling shutters as per Specifications shall be provided as per the Drawings, in such chambers.

19.4.8 Hand railing as per Specifications shall be provided to get down into the valve chambers from door level.

19.4.9 Cement concreting and cement mortar shall be done as per the Specifications in Chapter 9.

19.4.10 Necessary earth work in excavation and backfilling etc. complete, as per the requirements shall be done as per the Specifications in Chapter 5.

19.5 Anchor Blocks and Thrust Blocks

19.5.1 Anchor Blocks and Thrust blocks in Reinforced Cement Concrete (1 cement: 3 coarse sand: 6 graded stone aggregate of 20 mm to 25 mm nominal size) of adequate size and shape shall be provided at all places shown in the Drawings, to transmit the hydraulic thrust / force to the ground, spreading over a sufficient area, depending upon the type of soil met with, shall be provided. These shall be provided as per the relevant Drawings or as directed by Engineer. The exposed surfaces shall be finished in cement mortar 1:4, 12 mm thick.

19.5.2 Cement concreting and cement mortar shall be done as per the Specifications in Chapter 9.

19.5.3 Necessary earth work in excavation and backfilling etc. complete, as per the requirements shall be done as per the Specifications in Chapter 5.

19.6 Pipe Supports

19.6.1 Pipe supports shall be provided wherever required, in cement concrete (1:2:4), using granite or trap jelly of 20 mm and down size and of approved gradation, for the required dimensions and as per the approved Drawings. These shall be finished with cement mortar 1:3.

19.6.2 A base coarse in cement concrete 1:3:6, 150 mm thick, using 40 mm and down size aggregate of approved gradation shall be provided for the pipe supports, at a level not less than 1 m below natural ground level.

19.6.3 Necessary earth work in excavation and backfilling etc. complete, as per the requirements shall be done as per the Specifications in Chapter 5.

20 WOOD WORK AND JOINERY

20.1 Scope

20.1.1 These specifications refer to wood work in general including carpentry and joinery work in the buildings.

20.2 Applicable Codes

20.2.1 The provision of the latest revisions of the following IS. codes shall form a part of these specifications. Other I.S. codes not specifically mentioned here, but pertaining to wood work and joinery form part of these specifications.

IS: 205	Specifications for non-ferrous metal butt hinges
IS: 287	Recommendation for maximum permissible moisture content of timber used for different purposes.
IS: 303	Specification for plywood for general purpose
IS: 362	Specification for parliament hinges
IS: 419	Specification for putty for the use on window frames
IS: 883	Code of practice for design of structural timber in building.
IS: 1003	Specification for Timber paneled and glazed shutters Part II - Window and ventilator shutters
IS: 1200	Method of measurement of building and Civil Engineering Works - Wood Work and Joinery
IS: 1341	Specification for steel butt hinges
IS: 1658	Specification for Fiber Hard Boards
IS: 1761	Specification for transparent sheet glass for glazing and framing purposes.
IS: 3087	Specification for wood particle boards (medium density for structural timber building)

20.3 Materials

20.3.1 Sawn Timber

20.3.1.1 First class Indian teak wood shall be used. The timber shall be of high quality and well seasoned. It shall have uniform color free from defects such as cracks, dead knots, shakes, sapwood etc. No individual hard and wound knot shall be more than 6 sq. Cm in size and the aggregate age of such knots shall not be more than 1% of the area of the piece. The timber shall be close grained having not less than 2 growth rings per cm. Width in cross section. The maximum permissible percentage of moisture content for well seasoned timber used in building work shall be as specified in the IS: 287.

20.3.2 Glazing Materials

20.3.2.1 Glass Panels:

20.3.2.1.1 Unless otherwise specified, glass panes used in glazed or paneled and glazed shutters, shall be of good quality glass of thickness not less than 2 mm for panes upto 0.1 sqm in area and not less than 3 mm for glass panes of area larger than 0.1 sqm with a tolerance of 0.2 mm in both cases. The glass shall be free from flaws such as specks, bubbles, smoke waves, air holes, etc. and shall conform to IS: 1761.

20.3.2.1.2 Unless otherwise specified, glass panes used in shutters of bath room and lavatories shall be frosted and of thickness as mentioned above and shall be free from any flaws.

20.3.2.1.3 Where so specified, special quality glass such as plate glass, pin heads glass, wired glass etc. shall be used. They shall conform to relevant IS standards.

20.3.3 Putty for glazing in wooden frames of doors and windows

20.3.3.1 Putty shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil and mixing the whole thing into a homogeneous stiff paste. It shall be free from impurities like dust, grit, etc. and shall conform to IS: 419

20.3.4 Fittings

20.3.4.1 The item of wood work of joinery generally includes fittings such as hinges and screws for fixing of door shutters and is explicitly so mentioned in the item.

20.3.4.2 Hinges

20.3.4.2.1 Hinges shall be of iron, brass, aluminium or any other material as specified. They shall present a neat appearance and shall operate smoothly, and their riveted heads shall be well formed and smooth. Hinges shall be of the type specified and shall confirm to the relevant Indian Standard Specifications.

20.4 Workmanship

20.4.1 Wood work, wrought, framed and fixed

20.4.1.1 General

20.4.1.1.1 The work shall be carried out as per detailed drawings and/or as directed by the Engineer. The wooden members of the frame shall be planned smooth and accurate to the full dimensions. Rebates, roundings, mouldings, etc. As shown in the Drawing shall be done before the members are joined into frames. Where wood work is not exposed to view as in the case of frames for false ceiling, however, no planning is required to be done unless specified expressly as wrought timber work.

Note: The work wrought shall mean 'planed'.

20.4.1.1.2 Jointing in timber frames must be made carefully and accurately. They shall be strong, neat and shall fit without wedging or filling. The joints shall be pinned with hard wood or bamboo pins of 10 to 15 mm diameter after the members of the frame are pressed together in a suitable vice-mechanism.

20.4.1.1.3 The door and window frame shall have rebate to house the shutters and the depth of such rebate shall be 1.25 cm.

20.4.1.1.4 Wood work shall be painted, oiled, polished or otherwise treated as specified. All portions of timber abutting against masonry or concrete portion of building shall be coated with boiling coal tar or other type of approved wood preservatives primer, before placing them in final position.

20.4.1.1.5 Before any surface treatment is applied in the wood, work shall be got approved by the Engineer.

20.4.1.2 Fixing in position

20.4.1.2.1 The forms shall be fixed only after acceptance by the Engineer. In case of door frames without stills, the vertical members shall be buried in floor for the full thickness of the floor and the door frame shall be temporarily braced at the still level so as to prevent warping or distortion of frame during construction.

20.4.2 Paneled, glazed or paneled and glazed shutters:

20.4.2.1 General

20.4.2.1.1 The work shall be carried out as per detailed Drawing. The wooden members shall be planed smooth and accurate. They shall be cut to the exact shape and sizes without patching or plugging of any kind. Mouldings, rebates, roundings, etc. Shall be done, as shown in the Drawing, before the pieces are assembled into the shutter.

20.4.2.2 Joinery work

20.4.2.2.1 The thickness of the styles and rails shall be as specified in the item of work. The minimum thickness of panels shall normally be 15 mm where the clear width of panel is not more than 300 mm and 20 mm where the clear width of panel is not more than 300 mm. However, where the Engineer so considers, lesser thickness upto 12 mm and 15 mm respectively may be allowed by him instead of 15 mm and 20 mm specified above. Solid wood panel for door and window shutters be made out of one or more strips of timber planks of not less than 125 mm width. It is preferable to use strips of not more than 200 mm width to reduce chances of warping, splitting or other defects. The timber strips shall be joined together with continuous tongued and grooved joints, glued together and reinforced with metal dowels. The groovings of the solid panel shall normally run along the longer dimensions of the panel unless otherwise directed. The corners and edges of panels shall be finished as shown in the Drawing and these shall be feather tongued into styles and rails. Sash bars shall have mitres joints with the styles.

20.4.2.2.2 Styles and rails of shutters shall be made out of single piece. Lock and intermediate rails exceeding 200 mm in width if permitted by the Engineer may be made out of one or more pieces of timber but the width of each pieces shall not be less than 125 mm. Where more than one piece of timber is used, they shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels (rust proof) at regular intervals of 20 cm or pinned with not less than three 40 mm rust proof pins of the lost head type.

20.4.2.2.3 The tenons shall pass clear through styles. The styles and rails shall have a 12 mm groove to receive the panel.

20.4.2.2.4 In case the double shutters the rebate at the closing junction of the two shutters shall be of depth not less then 2 cm.

20.4.2.2.5 Shutters shall not be painted or otherwise treated before these are passed by the Engineer and fixed in position.

20.4.3 Glazing:

20.4.3.1 The glazing work shall be done in accordance with the specification given separately elsewhere.

20.4.4 Hold Fasts:

20.4.4.1 Hold fasts used for fixing doors and window frames shall be made of 40 x 3 mm flat iron and 40 cm long. It shall have two holes on one end for fixing to frame with long screws at the other end. The flat iron shall be split and bent at right angles in the opposite direction. The hold fast shall be tightly fixed to the frame by means of bolts, the bolt hole in frame being plugged suitably and finished neat. The hold fast shall be embedded into masonry by concrete block of 200 x 250 x 400 mm size.

20.5 Measurements

20.5.1 Woodwork and joinery work shall be measured in square meters. Length and width of unfinished opening shall be measured to the nearest 0.01 m.

20.5.2 Areas shall be worked out correct upto 3rd place of decimal of a sqm All work shall be measured net as fixed, that is, no extra allowance in measurement shall be made for shape, joints, etc. However, where the dimensions as fixed exceeds the specified dimension (as per Drawing, etc.) only the specified dimension(s) shall be measured and where one or more dimension of the piece as fixed is less than the fixed dimension the actual dimension shall measured without prejudice to the right of Engineer to reject the piece and order replacement of such pieces.

20.6 Rate

It should include

1. Supply of specified species of timber sawn to requisite size without any defect, wrought, framed and fixed in position with the required standard of workmanship including supply and fixing of fixtures, straps, bolts, holdfasts, spikes, nails, screws, etc., applying contractors glue or other joining materials, coal tarring embedded pasts, glazing and supplying and fixing of all specified fittings.

2. All material, labour, scaffolding, use of equipment etc., for framing, fixing and completing the item as specified.

20.7 Flush Door Shutters

20.7.1 General

20.7.1.1 The door shall be of flush type solid core with single or double shutter as the case may be.

20.7.2 Shutters

20.7.2.1 The shutters shall be decorative or non-decorative type of the exterior or interior grade as described in the item and as shown in the drawings. It shall conform to the relevant specifications for the type and grade in I.S. 2202/1983, Specifications of wooden Flush door shutters (solid core type). The finished thickness shall be as mentioned in the item. Face veneers used shall be of the pattern and color approved by the Engineer.

20.7.3 Fixtures and Fastenings

20.7.3.1 These shall be as shown on the drawings or as indicated in the specifications. Where it is not specified they shall be of oxidised brass and shall be of good quality and workmanship. All fixtures and fastenings shall be sound and strong. They shall be sectional and of the best quality. The size, shape, design and finish shall be as shown on the drawings and approved by the Engineer.

20.7.3.2 Unless otherwise specified each leaf shall be hung with three brass butt hinges for back flap with brass screws. Each door shall be furnished with aldrop and latch, brass flush bolts, etc. The fixtures shall comply with the relevant Indian Standards. Samples of all fixtures and fastening shall be got approved by the Engineer and deposited in his office for reference.

20.7.3.3 All the fixtures shall be fixed to the joinery in a secure and efficient manner. Metal sockets shall be provided to all bolts where the shoots enter, stone, concrete, etc.

20.7.4 Measurement

20.7.4.1 Flush door shutters shall be measured in square metres. Length and width of unfinished opening shall be measured to the nearest 0.01 m.

20.7.4.2 For further details of measurement of flush door shutters see **Clause 18.5.**

21 HOLLOW CONCRETE BLOCKS

21.1 Scope

This section covers the requirements for hollow concrete block masonry work in walls, partitions, parapets and any such work covered in general building work.

21.2 Applicable Codes

21.2.1 The provisions of the following Indian Standard Specification shall form a part of this specification to the extent they have been referred to and are applicable with:

IS: 269	Specifications for ordinary rapid hardening and low heat Portland cement.
IS: 2116	Specifications for sand for masonry mortar
IS: 2250	Code of Practice for preparation and use of masonry mortars
IS: 2185 (Part - 1)	Specifications for concrete masonry units
IS: 2572	Code of Practice for construction of hollow concrete block masonry
IS: 1905	Code of Practice for structural safety of buildings - masonry walls

21.3 Materials

21.3.1 Masonry Units:

21.3.1.1 Hollow concrete blocks used as masonry units shall conform to IS: 2185. Grade A and B units shall be used in load bearing structures and Grade C in non-load bearing structures. The Contractor shall submit samples and have these tested and submit the test results for approval prior to the commencement of work.

21.3.2 Cement

21.3.2.1 Cement for mortar shall conform to IS: 269 generally.

21.3.3 Sand

21.3.3.1 Sand shall conform o IS: 2116

21.3.4 Water

21.3.4.1 Water shall conform to the requirements given in C. 3.2.5 of IS: 2116

21.3.5 Mortar

21.3.5.1 Mortar shall be composed of cement and sand unless otherwise specified in the Bill of quantities.

21.3.5.2 All mortar shall be prepared in accordance with IS: 2250 and shall have a slump of 75 mm when tested as per IS: 1199.

21.4 Preparatory Work

21.4.1 The blocks need not be wetted before or during laying in the walls. In case the climatic conditions so require, the top and the sides of the blocks may only be slightly moistured so as to prevent absorption of water from the mortar and ensure the development of the required bond with the mortar.

21.5 Laying

21.5.1 Only skilled and experienced masons shall be employed for laying the block masonry. The first course shall be laid with great care, making sure that it is properly aligned, levelled and

plumped, as this will assist the mason in laying in succeeding courses to obtain straight and truly vertical wall.

21.5.2 Before laying the first course, the alignment of the wall shall be marked on the footings. A string shall be stretched tightly along the faces of the two corner blocks and the intermediate blocks adjusted to be in the same line. Then each of the intermediate blocks shall be laid over a bed of mortar. After every three of four blocks have been laid, their correct level, alignment and vertically shall be checked.

21.5.3 The construction of walls may be started either at the corners first of from one end proceeding in the other direction. If the corners are build first, they shall be four or five courses higher then the center of the wall. The blocks at corners shall be checked for true alignment, level and being in plumb. A storey rod, course pole and masons level shall be used to check the top of masonry in each course.

21.5.4 All the mortar joints shall be 10 mm thick. Mortar shall not be spread too far ahead of the actual laying of the block. After laying each block, the excess mortar extruding from the joints shall be out-off with the trowel and thrown back on the mortar board to be re-worked into fresh mortar. Dead mortar that has been picked up from the scaffold or from the floor shall not be used.

21.5.5 Special provisions:

21.5.5.1 Closure blocks

When installing closure block, all edges of the opening and all four vertical edges of the closure block shall be buttered with mortar. The closure block shall be carefully block shall be buttered with mortar. The closure block shall be carefully lowered into place if any of the mortar falls out leaving an open joint, the closure block shall be removed, fresh mortar applied and the operation repeated.

21.5.5.2 Sills

A course of solid concrete block masonry or 100 mm thick precast concrete sill blocks extending 200 mm beyond the end of opening shall be provided under door, window and ventilator openings.

21.5.5.3 Wall crossings

When two walls meet or interact shall be bonded or tied securely. When both the walls are laid at a time, true masonry bond between atleast 50 % of units shall be ensured. When they are laid separately, pockets with 200 mm maximum vertical spacing shall be left in the wall which is laid first.

21.6 Curing

Green work shall be protected from rain by suitable covering masonry work, as it progresses shall face for atleast 14 days after completion. Proper watering cans with nozzles shall be used for the purpose.

21.7 Scaffolding:

21.7.1 Double scaffolding sufficiently strong to withstand all the likely loads to come upon it and having two sets of vertical supports shall be provided. Where two sets of supports are not possible the inner end of the horizontal scaffolding pole shall rest in a hole provided in the wall. Such pole shall rest in a hole provided in the wall. Such holes however shall not be allowed in pillars under one meter in width or immediately near the skew backs of arches. Such holes shall be filled immediately after removal of scaffolding with 1:4:8 concrete.

21.8 Measurements and Payment:

21.8.1 The quoted rate shall be per cum of masonry, the thickness bedding specified.

21.8.2 Measurement shall be based on he actual quantities at the site limited however by the Drawings and directions of the Engineer.

21.8.3 The quoted rate shall cover the supply of all materials, labour, tools, plant and equipment, scaffolding and temporary works and all other incidental work required to complete the work in accordance with the above specifications.

21.8.4 No deductions shall be made for openings less then 01. Sqm in area. The quoted rate is deemed to include all such work including fine, projections, etc. Shown in the Drawings.

22 METAL DOORS, WINDOWS AND VENTILATORS

22.1 Scope

22.1.1 This specifications the requirements of metal doors, windows and ventilators.

22.2 Applicable Codes:

22.2.1 The provisions of the latest Indian Standards mentioned below shall form a part of these specifications. Other IS Codes not specifically mentioned here but pertaining to Metal Doors, Windows & Ventilators form part of these specifications.

IS: 1956	Glossary of terms relating to iron and steel
IS: 814 (Part I)	Specifications for covered electrodes for metal are welding of structural steel.
IS: 814 (Part II)	1.For welding products other than sheets, Specifications for covered electrodes for metal are welding of structural steel. 2.For welding sheets
IS: 815	Classification and coding of covered electrodes for metal are welding and cutting operation.
IS: 1948	Aluminium doors, windows & ventilators.
IS: 6227	Code of Practice for use of metal are welding in tubular structure
IS: 6248	Specifications for metal rolling shutters and rolling grill
IS: 1081	Code of Practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
IS: 2062	Weldable Structural Steel
IS: 1361	Specifications for steel windows for Industrial Buildings
IS: : 1200 (Part VIII)	Measurements for steel work and iron work
IS: 1038	Specifications for steel doors, windows, and ventilators.
IS: 226	Specifications for structural steel (Standard quality)
IS: 823	Code of procedure for manual metal arc welding of metal steel
IS: 102	Ready mixed paint, brushing, red lead non sitting, priming.
IS: 1363	For black hexagon bolts, nut and lock nuts (dia 6 to 39 mm) and black hexagon screws (dia 6 to 24 mm)
IS: 813	Scheme of symbols for welding.

22.3 Materials

22.3.1 Structural Steel

22.3.1.1 Standard quality mild steel of various varieties and designations shall be used for different works as mentioned below:

22.3.1.2 St. 42 - S.: This variety of steel (standard quality) shall conform to specifications given in IS: 2062 (latest) and shall be used for (i) Reveted steel work (ii) bolted steel work (iii) steel work where welding is employed for fabrication provided that the thickness of material does not exceed 20 mm. When material conforming to this standard is over 20 mm thick special precautions may be required in case the material is to be welded (see IS; 823 - latest).

22.3.1.3 St. 30 - 0: This variety of steel (ordinary quality) shall conform to specifications given in IS: 1977 and is intended for general purposes such as door and window frames, window bars, grills steel gates, hand railing, builder's hardware, fencing post, tie bars, etc. All finished steel material shall be properly and neatly rolled to dimensions, sections and weights as specified. The finished material shall be free from visible as well as hidden defects and excessive rusting. The ends of the tubes shall be cut square, unless otherwise specified.

22.3.1.4 Steel sections and tubes shall be well protected and kept free from excessive rust and scaling. In this regard, decision of Engineer shall be final and binding on the Contractor.

22.3.2 Black Bolts:

22.3.2.1 Also known as machine bolts, these bolts shall be made from rods and they come from the rolling mills and are not finished to exact size. A lower working stress is taken for these types of bolts then those of rivets and 'turned fitted bolts'.

22.3.3 Rolling Grills:

22.3.3.1 The grills shall conform to specifications given in IS: 6248. Rolling grills shall be supplied in the following alternative types as specified. The grills shall be complete with accessories. The fixing arrangement shall be as per the Drawing with regard to whether it shall be fixed on the inside or outside between jamb of opening on or below the lintel etc.

1. Gear operated type (push and pull type or manually operated type): It shall be used upto a maximum of about 8 sqm. clear area without ball bearings and upto a clear area of about 12 sq. m with ball bearings.
2. Gear Operated Type (Mechanical Type): It shall be fitted with ball bearings. It shall be used upto a maximum of about 25 sq. M. Clear area, if the rolling grill is operated by a bevel gear box and crank handle upto a maximum of about 35 sqm. clear area, if the rolling grill is operated by chair wheel and hand chain, mounted directly on the work shaft.

22.3.3.2 Grills shall be manufactured out of 8 mm dia. Mild steel round bars. Rolling grills shall be of mid bar type or of any other approved design.

22.3.3.3 The guide channels shall be of mild steel deep channel section and of rolled pressed or built up (fabricated) jointless construction. The thickness of sheet used shall not be less than 3.15 mm. Hood covers shall be made of mild steel sheet not less than 0.90 mm thick. For grills having width 3.5 mm and above thickness of M.S. sheet for the hood cover shall be not less than 1.25 mm.

22.3.4 Steel Doors, Windows and Ventilators:

22.3.4.1 Steel doors, windows and ventilators and sashes shall be manufactured from fusion welding quality steel (St. 42 W) sections conforming to specifications given in IS: 2062.

22.3.4.2 In case of composite units consisting of a combination of two or more units of doors, windows and ventilators, etc. As the case may be, different shall be coupled by using coupling sections made from M S sheet 3.15 mm thick as per IS: 1038 para 5.2. the weight of different rolled steel sections use for manufacture of doors, windows and ventilators shall be as per those specified in IS: 1038, unless other wise specified.

22.3.5 Painting

22.3.5.1 Where a coat of red lead paint is specified approved quality of red lead paint conforming to IS: 102 shall be used.

22.3.6 Welding Equipment:

22.3.6.1 The welding plant and equipment shall be of modern design and shall be got approved by the Engineer.

22.3.6.2 The electrodes required for metal arc welding shall be 'covered electrodes' and shall conform to IS: 814 (Part I) for welding products other than sheets and IS: 814 (Part II) for welding sheets.

22.3.6.3 The type of covering shall be as per IS: 815 for classification and coding of covered electrodes for metal welding of structural sheets.

22.4 Workmanship

22.4.1 Structural Steel Work

22.4.1.1 The steel sections as specified or required shall be out, square and to correct lengths, as per Drawing and design. The cuts ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member, except as indicated in the Drawings or directed by the Engineer. All straightening and shaping to form shall be done by application of pressure and not by hammering. Any bending or cutting shall be carried out in such a manner as not to impair the strength of the metal. All operations shall be done in cold state unless otherwise directed/permitted.

22.4.1.2 All holes shall be generally drilled to the required size and at the required position. Sub-punching shall be permitted, provided it is done 3 mm less in diameter and reared thereafter to the required size.

22.4.1.3 Holes for rivets and black bolts shall be larger by 0.4 to 0.6 mm than the nominal diameter of the rivets of black-bolts depending upon the dia of rivets.

22.4.1.4 Holes for counter-sunk bolts shall be made in such manner that their heads fit flush with the surface after fixing.

22.4.1.5 All bolt heads and nuts shall be hexagonal and of equal size, unless specified otherwise. The screwed threads shall conform to IS: 1363 and the threaded surface shall not be tapered. The bolts shall be of such length as to project two clear threads beyond the nuts when fixed in position and these shall fit in the bolts without any shake. The nuts shall fit in the threaded ends of bolts properly. Tapered washers shall be provided for all heads and nuts bearing the leveled surfaces. The threaded portion of the bolt shall not be within the thickness of the parts bolted together. The faces of bolt needs and nuts shutting against steel members shall be machine finished.

22.4.2 Welding

22.4.2.1 Welding shall generally be done by electric process. The electric arc method being economical, is usually adopted. Where public electricity is not available a suitable generator shall be arranged. Gas welding shall be resorted to suing oxyacetylene flame with specific prior approval of the Engineer.

22.4.2.2 Types of welding

22.4.2.2.1 Welds used for joining structural members are generally of the following two types as under:

1. Fillet weld: The cross section of fillet weld is triangular and it is used to join two surfaces normally at right angles to each other. This type of weld is used more frequently in structural connections then any other type, and is usually in the form of isosceles triangle. The fillet welds shall be continuous or in intermittent as specified in the design.

2. Butt welds: These are classified according to the method of grooving or preparing of the base metal. The metal pieces shall be filled or obisolled to the required shape for butt welding at the throat for which no extra payment shall be made.

22.4.2.3 Fillet and Butt welds shall confirm to IS: 816. Special type of welds as slot-welds shall be used where so specified. Either direct or alternating current (but not both types) may be used throughout the whole work. An ammeter shall be provided to each arc and so situated that the Engineer can easily check the current being used by the operator. Each welder shall be surprised with a portable current regulator to enable him to adjust the welding current within the approved limits without leaving his work. Only qualified operators shall be employed for welding and they shall have been trained and shall be tested after every three months as per provisions of IS: 817 for “Code of Practice for training and testing of Metal Arc Welders”.

22.4.2.4 In welded structure holes are necessary for service bolts required during erection. These holes shall be made as specified above. The holes in the various sections shall be filled with punches and welded properly to form a composite section.

22.4.2.5 Surfaces which are to be welded together, shall be free from loose mill-scale, rust, paint, grease or other foreign matter. A coating of boiled linseed oil shall be permitted.

22.4.2.6 Before welding is commenced, the plates shall first be brought together and firmly clamped or spot welded at specified distance. This temporary connection has to be strong enough to hold the parts accurately in place without displacement.

22.4.2.7 All operators connected with welding and cutting equipment conform to the safety requirement given in IS: 818 for “Safety and health requirements in Electric and Gas welding and cutting operations”.

22.4.2.8 The following points shall be borne in mind during the process of welding:

1. Welds shall be made in the flat position, wherever applicable.
2. Arc length, voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work.
3. The sequence of welding shall be such that where possible the members which offers the least resistance to compression are welded first.

22.4.2.9 Process of Welding:

22.4.2.9.1 The electrode manipulation during welding shall be such as to ensure that:

1. The base metal is in a fused state when the filler metal makes contact with it
2. The filler metal does not overflow upon any unfused based metal
3. The base metal is not under-cut along the weld edges.
4. The flowing metal floats the slags, the oxides, and the gas bubbles to the surface behind the advancing pool.

   In case any of these requirements is unattainable by manipulation, the current shall be adjusted or the electrode size changed. Each time the arc is started, the electrode shall be moved in such a way that the fusion of base metal at the starting point is assured. At the completion of a run the movement of electrode shall be slowed down to fill the arc crater. After every interruption of the arc except at completion of a run the arc shall be restarted ahead of the previous deposit and then moved back to fill the crater, or such alternative technique shall be used as will ensure complete filling of the crater or complete fusion between the new and old deposits and the base metal at the point of junction and result in continuity of weld. Before welding operation is completed, all traces of slag shall be removed from the deposit, by chipping if necessary and the deposited and adjoining base metal be wire brushed and cleaned at all points. The requirements shall apply not only to successive layers but also to successive beats, and to the overlapping area whatever a junction is made on starting a new electrode:

5. The welds shall be free from cracks, discontinuity is welding and other defects such as

   I. under size
   II. over size
   III. undercutting
   IV. overcutting

   in case of fillet welds and defects (II), (III) and (IV) in the case of butt welds.,

22.4.2.10 All defective welds which shall be considered harmful to the structural strength shall be cut out and re-welded.

22.4.2.11 Finished welds and adjacent parts shall be protected with clean boiled linseed oil and after all slag has been removed, welds and adjacent parts shall be painted after the same are approved by the Engineer.

22.4.2.12 Inspection and testing of welds:

22.4.2.12.1 The method of inspection and testing shall be as under:

1. Dimensions of weld deposit: The size of the weld shall be as specified and it may be slightly over but not under.
2. Shape of profile: The profile of the weld is affected by the position of the joint, but it shall be uniform. In the case of butt and corner welds, the profile shall be slightly convex and in the case fillet welds it shall be usually slightly concave.
3. Uniformity of Surface: The height and spacing of the ripple shall be uniform; these being indicative of workmanship.
4. Degree of under cut: Undercutting is undesirable. The weld joint shall be free from undercut but slight intermittent occurrences may be disregarded.
5. Smoothness of joints: The joints in the weld run where welding has been adopted, shall be as uniform and smooth as possible and shall show no pronounced bump or crater in the weld surface.
6. Freedom from surface defects: The surface of the weld shall be free from porosity, cavities and burnt on scale.
7. Penetration bead in Butt welds: A slight penetration bead shall be present and it should be reasonably uniform in width and appearance. Intermittent occurrences of lack of penetration bead may be disregarded.
8. Degree of fusion: Fusion shall be complete over the whole area of the joint surface.
9. Degree of Root Penetration: These defects are most likely to occur at the root of the weld and in this position they are liable to have the maximum effects in reducing the strength of the weld. A close examination of the root shall, therefore, be made. In butt-welds, the penetration should extend to the underside of the plates producing a penetration bead of the right size. In fillet welds with good root penetration, the weld metal should reach the corner.

Note:

1. *In case of fusion welding or non-fusion weld and fillet welds will appear in joint, fillets being at the cretches.*
2. *In case of non-fusion welding of cast iron the joints shall show satisfactory penetration and adhesion.*
3. *Gas Cavities and Flux Entrapments: Unless they are caused by the use of unsuitable material, they are attributable to the quality of workmanship, the desired result being to achieve uniform appearance and freedom from cavities and flux entrapments (where flux is used). In fusion welding of mild-steel, cast iron and aluminium where neutral flame is used, and is fusion welding of brass or braze welding of cast iron where oxidising flame is used in current welding technique may result in rough, porous, discolored and lusterless appearance in the fracture.*
4. *In case of fusion welding or non-fusion welding of cast iron isolated blow holes or concentration of pinholes in the weld metal shall be regarded as grounds for rejection but isolated pinholes shall not be so regarded.*
5. *Bending Testing (for ductility): The elongation shall be not less than 30 percent for stress relieved welds and not less than 25 percent for non-stress relieve welds.*
6. *Tensile Testing: (Reduced Section Tensile Testing): The tensile strength shall be not less then minimum of the specified tensile range of the parent metal.*
7. *Radiographic Examination: This shall be done as given in IS: 6227.*

22.4.3 Rolling Grills:

22.4.3.1 The springs shall be of best quality and shall be manufactured from tested high tensile spring steel wire or strip of adequate strength to balance the shutters in all positions. The spring pipe shaft etc. shall be supported on strong mild steel or malleable cast iron brackets. Brackets shall be fixed on the or under the lintel as specified with rawl plugs, and screw bolts, etc.

22.4.3.2 Both the side guides and bottom rail shall be jointless and of single piece of a pressed steel.

22.4.3.3 Grill shall be laid on ground and the side-guide channels shall be bound with it with ropes, etc. The shutter shall then be placed in position and top fixed with suspension shaft with bolts and nuts. The side guide channels and the cover frame shall then be fixed by means of screw bolts, end rawl plugs drilled in the wall. The plates and screw bolts shall be concealed in plaster to make their location invisible. Fixing shall be done accurately in a workmen like manner so as to ensure easy and smooth operation of the grill.

22.4.4 Rolling Shutter

22.4.4.1 Same as above for Rolling Grills but with 18 gauge x 65 mm steel laths of deep convex corrugation. The rolling steel shutters shall be of approved make and design.

22.4.5 Steel Doors, Windows and Ventilators ;

22.4.5.1 General

22.4.5.1.1 The type, over all sizes, side opening position of steel doors, Windows and ventilators, shall be specified as per details given in IS: 1038, specifications for steel doors, windows and ventilators.

22.4.5.2 Fabrication

22.4.5.2.1 Both the fixed and opening frame shall be constructed of sections which have been cut to length and mitered. The corners of fixed and opening frames shall be electrically flash butt welded to form a solid and true right angle and all frames shall square and flat.

22.4.5.2.2 Sub-dividing bars of the units shall be tensioned and riveted into the frame. No face welding at the joint of sub-dividing bars and frame is required. The horizontal glazing bars shall pass through the vertical bars and the joints closed by hydraulic pressure.

22.4.5.2.3 The sizes of door, windows or ventilators frames shall not be more than + 1.3 mm.

22.4.5.2.4 The size of opening of steel doors, windows, and ventilators will be on a 10 mm module, i.e. the width as well as height will be in multiple to 10 cm.

22.4.5.3 Side-hung shutter windows

22.4.5.3.1 Window shutters shall be hung on projecting type hinges (not less then 65 mm and not more than 75 mm wide). One leaf of the hinge shall be welded into a slot in the outer frame and the other leaf of the hinge riveted to the opening shutters. Friction hinges may be provided for side-hung shutter windows in which case peg-stay may not be required. In cases where non-friction type hinges are provided, the windows shall be fitted with per-stays which shall be either of hot pressed brass, aluminium or steel protected against rusting and shall be 100 mm long with steel peg and locking bracket. The peg stay shall have three holes to open the side hung casements in three different angles.

22.4.5.3.2 The handle for side hung shutters shall be of hot pressed brass, aluminium or steel protected against rusting and shall be mounted on a steel or aluminium handle plate molded, screwed or riveted to the opening frame in such a manner that it could be fixed before the shutter in glazed and may not be removed after glazing. The handle shall have a two point nose, which shall engage with a brass or aluminium striking plate on the fixed frame in a slightly open position as well as in a fast position.

22.4.6 Ventilator

22.4.6.1 A brass or aluminium spring catch shall be fitted in the center of the top bar of the ventilator. A brass or aluminium cord pulley wheel in galvanised mild steel on malleable iron bracket shall

be fitted at the sill of the ventilator with mild steel screws or alternatively welded together with a mild steel or malleable iron cord eye riveted or welded to the bottom inner frame bar of the ventilator in a position corresponding to that of the pulley.

22.4.6.2 Top Hung Ventilator

22.4.6.2.1 The steel butt hinges for top hung ventilators shall be riveted to the fixed frame or welded to it after cutting a slot in it. Hinges to the opening frame shall be riveted or welded and cleaned off. Top hung casements shall be provided with a peg stay three holes which when closed shall tightly by the locking bracket. The locking bracket shall either be fitted to the fixed frames or to the window.

22.4.6.3 Center Hung Ventilator

22.4.6.3.1 This shall be hung on two pairs of brass or aluminium cup pivots riveted to the inner and outer frames of the ventilator to permit it to swing to an angle of approximately 85 Degree. The opening portion of the ventilator shall be so balanced that it remains open at any desired angle under normal weather conditions.

22.4.6.4 Position of Holes, fixing Screws and Lugs:

22.4.6.4.1 Outer frames shall be provided with fixing holes, screws and lugs centrally in the web of the section as directed.

22.4.6.5 Fixing of Steel Doors, Windows and Ventilators:

22.4.6.5.1 General Steel doors and windows shall be stacked in upright position on level ground, preferably on wooden battens to keep them in true shape without damage.

22.4.6.5.2 Steel work opening shall be so designed that the outer flange of the door, window or ventilator from section overlaps the steel surface by 10 mm.

22.5 Fixing Procedure (Masonry Opening)

22.5.1.1 Where large units shall be bound by coupling individual units together (with coupling sections) the mullions and transoms shall be bedded in mastic to ensure water tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembling and other coupling. All oozing mastic shall be trimmed out neatly.

22.5.1.2 MULLIONS normally project 2.5 cm at head and sills are fixed in pockets made into the masonry timber or steel with opening. But where it is at cross joint with a transom the shorter coupling unit shall run through unbroken and other coupling until shall be cut square to form a butt joint with other members.

22.6 Finish

22.6.1 Door and windows

22.6.1.1 Doors, windows or composite units shall be either hot dip galvanised or painted. All the steel surfaces shall be thoroughly cleaned free of rust, mill-scale, dirt, oil, etc., either by mechanical means e.g. sand of shot blasting or by chemical means e.g. pickling and then painted or hot-dip galvanised as given in IS: 1038. Final finishing coats shall be given after the doors, windows and ventilators are erected and fixed in final position. Non-ferrous parts and working parts such as handles, stays, catches handle pins, hinge-pins, etc. Shall not be painted.

22.6.2 Precautions

22.6.2.1 Steel doors, windows, etc. shall not be used for centering or scaffolding and shall not be rested on the steel door and window frames or glazing bars.

22.6.2.2 All fitting and hinges shall be covered with Hessain cloth so that these may not be damaged during construction.

22.6.2.3 The doors, windows and ventilators shall be measured in square meters of finished opening and item shall include painting, glazing and all necessary fixtures and fittings.

22.6.3 Weld Mesh

22.6.3.1 The welded mesh shall be of 10 gauge of standard wire products or equivalent. The measurements of weld mesh shall be taken from inside of MS angle and shall be in square meters. The method of fixing will be either by tack welding or by using a MS strip which shall then be welded. The weight of MS strip/angle etc. used shall be measured and paid for separately in the MS structural item.

22.6.4 M S Fabricated Gates and Wicket Gate

22.6.4.1 M S Fabricates gates etc. will be as per the design and Drawings and shall include all hold fasts, hinges (either roller bearing or otherwise) of any type, locking arrangements as specified, strap and stoppers, guide wheels and embedded runners for guide wheels all as specified. It shall include all necessary costs for fixing in position to RCC columns including all necessary temporary supports etc. and involve for one coat of primer and two coats of synthetic enamel paint of approved makes quality and shade.

22.6.5 Heavy Duty Sliding Windows

22.6.5.1 Aluminium windows and doors to be used in the work shall be manufactured using suitable heavy gauge (3.2 mm) Aluminium extruded sections of Indal or Jindal anodised to natural satin finish for 18 to 20 micron. For any work whose purpose made steel windows are specified., the same shall be obtained from Alumilite or Jindal or any other approved manufacturer. The Engineers and the Architect's approval for windows to be supplied by non-specified manufacturer shall be obtained in writing on the Contractor furnishing him at his own cost a sample of each window or door type., Only then a firm order shall be placed with the approved manufacturer. All windows and doors shall conform to the samples so approved.

22.6.5.2 Materials

22.6.5.2.1 Windows

Heavy duty sliding windows shall be made from extruded aluminium sections of alloy HF: 9-WF of IS: 733 - 1956. Height of the windows shall not be more than 1900 mm.

22.6.5.2.2 Frames

Frames shall be 2 or 3 track as required having in-built grooves to accept weather strip for weather sealing.

22.6.5.2.3 Shutters

The shutter vertical, interlock sections shall be hollow sections and horizontal sections shall be non-hollow and suitable for glazing with PVC gaskets. Interlock section shall have in-built grooves for weather stripping.

22.6.5.2.4 Gutter and valves

In heavy rainfall areas, the sill member shall be hollow section with special gutter section clipped on to the bottom track so as to have hollow chamber of minimum cross-sectional area of 1000 sqm. for 2 track and 1500 sq. Mm. For 3 track. The slots of size 75 x 5 mm shall be provided in the bottom track and gutter sections for vertical drainage of rain water. PVC valves shall be provided in the gutter sections acting as pressure equalization cum non-return valves.

22.7 Section Sizes and Other Requirements

22.7.1 Doors and windows

Item	Size
Frame - 2 track on the slides, top and bottom	63.5 x 34.4 x 1.4 mm
Frame - 3 track on the sides, top and bottom	94.6 x 34.4 x 1.5 mm
Shutter - vertical, interlock and horizontals	43 x 20 x 1.4 mm

Glazing gaskets: Soft PVC glazing gaskets shall be used for glazing the shutters. Rubber gaskets shall not be allowed.

Weather strips: Soft PVC weather strips shall be provided in the in-built grooves of the sections and rubber weather strips shall not be allowed. Use of pile weather strips in lieu of PVC is optional.

Hardware: The sliding shutters shall be provided with:

(a) Needle bearing nylon rollers, encased in plated MS brackets.
(b) Flush type handle-cum-lock having aluminium body and stainless steel spring/receiving latch.
(c) Nylon and cover-cum-guide on the top and bottom of the shutters.
(d) Nylon anti-lift with pile insert to prevent lifting and tilting of the shutters.

Construction: The frames shall be mechanically jointed with 3 mm thick aluminium angle cleats. The shutters shall be mechanically jointed with plated self tapping screws and aluminium safely plate or aluminium alloy blind rivets and nickel placed self tapping.... two shall be used for the joints and fittings.

Anodising: The aluminium sections shall be brushed and anodised to natural matte finish or electro colour anodised to any shade of bronze as per IS: 1868 - 1968. For general interior and exterior use the anodising shall be average 18 to 20 microns. For highly corrosive environment, anodising shall be average 18 to 20 microns. Gummed paper tapes shall be provided on the exposed surface of the sections as protective coating.

22.7.2 Openable Louvered Windows

Material	:	Heavy duty made from Aluminium extruded section HE-9-WP of I.S. 733
Frame	:	40 x 23 x 1.4 MM in-built top and bottom repeated sections 40 x 23 x 1.2 mm.
Coupling	:	Coupling bar panel shape 12.5 x 6 x 2 mm Bar
Louvers blade clip	:	One piece 18 gauge above sheets riveted to jambs by 89 mm c/c, after fixing the blade from inside and attached to coupling bart.
Ground Glass	:	4 mm thick for louver upto width of 760 mm and 5.5 mm thick for louvers above 760 mm.
Weather Strip	:	Soft P.V.C. Weather strip
Hardware	:	Louvers window with self locking type handle.
Construction & Anodising	:	Shall be average 18 to 20 micron and gum paper tape provided to sections as protective coating.

22.7.3 Medium Range Openable and Fixed Windows

Material	:	Heavy duty made from Aluminium extruded section He-9-WP of I.S. 733	
Frame	:	Frames shall have in-built grooves to accept the weather strip for weather sealing.	
Shutters	:	Vertical interlock will be hollow section Horizontal shall non-hollow suitable for glazing with suitable gaskets.	
Sections:	:		
Frame	:	Equal Log	63.5 x 43.0 x 1.6 mm
Shutter	:	Hollow section	57.4 x 40.0 x 1.6 mm
Mullion	:	Hollow section	62.0 x 40.0 x 1.6 mm
Glazing	:	Beading	30.0 x 19.0 x 1.1 mm 4 mm thick clear glass
Hardware		(Openable Shutter)	
a)		Heavy duty alum butt hinges having stainless steel pins, dowels and P.C. Washers.	
b)		Peg Stay - Aluminium extruded section.	
c)		Aluminium fasteners angle with nylons striking plate.	
Construction & Anodising		Same as General Specifications for Sliding Windows	

22.7.4 Doors

Material	:	Heavy duty made from Aluminium extruded section HE-9-WP of I.S. 733	
Frame	:	Outer frame including intermediate vertical and horizontal members shall be rectangular extruded section for weather shipping.	
Shutter	:	Shutter horizontal and vertical section provision for snap on glazing. Vertical section have mullion groove beading shipping.	
Glazing	:	Screwless snap on square aluminium above beading with PVC glazing gasket, - 5.5 mm thick clear glass.	
Section	:	Outer frames including intermediate, horizontal and vertical members - Size 101.6 x 44.5 x 2 mm.	
		Shutter Vertical	57 x 44.5 x 2.2 mm
		Shutter Top	48 x 44.5 x 2.2 mm
		Shutter Bottom	100 x 44.5 x 2.2 mm
		Square above beading	16 x 15.5 x 1.2 mm
Hardware	:		
a)		Lever lock, brass body, key operating from both sides.	
b)		Standard push and pull horizontal full length.	
c)		Double action hydraulic floor spring of approved make and quality with G.I. top and bottom pivots.	
Construction			
Frame	:	Frame shall be mechanically jointed with 3 mm thick aluminium cleat.	
Shutters	:	Mechanically jointed with plated self tapping screws and aluminium safety plates, blind rivets and nickel plated self tapping for joints and fittings.	
Anodising	:	Shall be average 18 to 20 micron and gumbed paper tape provided opt sections as protective coating.	

23 ALUMINUM SHEET IN ROOFING / SIDE CLADDING

23.1 Scope

23.1.1 These specifications cover the use of Industrial Troughed Aluminum sheets in roofing and side cladding.

23.2 Materials

23.2.1 The thickness of sheets shall be mentioned items. The sheet shall be free from all defects such as cracks, holes, cents, deformities, crippled edges, or otherwise damaged.

23.2.2 Accessories:-

23.2.2.1 All metal accessories or flashings shall be of the same material as the covering sheets. Flashing will be performed to suit, but performed north light pieces, corner pieces shall be procured from the manufacturer or alternatively shall be performed in the workshop.

23.2.3 Fastening

23.2.3.1 Aluminum alloy fastenings should be used to secure aluminum sheets. This will preclude any possibility of the sheets being weakened at the attachment point by bimetallic corrosion and will also ensure that the fittings themselves do not deteriorate. In the absence of aluminum fittings, hot-dip galvanized steel fittings may be used. Aluminum curved washers and bituminous felt washers should be used for all fastenings to ensure protection from galvanic corrosion and leakage. Hook bolts and Aluminum washers shall be 8 mm dia and 8 mm thick respectively.

23.2.4 Gutters

23.2.4.1 The eaves and valley gutters shall be suitable for the location and of the sizes as mentioned in the items.

23.3 Laying and Fixing of Sheets

23.3.1 General

23.3.1.1 In general the installation of aluminum sheets shall follow the conventional practice as established for steel sheeting.

23.3.1.2 Preparation of the roof/sides where aluminum sheets are to be laid on steel purlins/side girths, the steel should be thoroughly wire brushed and painted, preferably with two coats of red oxide zinc chromate primer and two coats of aluminum resin:

23.3.2 Method of Laying

23.3.2.1 Sheets should be laid, from the end of the building away from the prevailing wind so that exposed edges face down wind. The side laps should minimum one-and-a-half corrugations on roofs and one corrugation on siding. End lap shall be minimum 15 Degree on roofs and 100 mm on sides. If the roof slope is less than 15 Degree it is advisable to provide 225 mm to 300 mm end lap, especially if the roof is as a large one where wind pressure is likely to cause a build-up of pressure on the lower windward slopes.

23.3.2.2 The number of fastenings required will depend upon the conditions of use. Attachments to each purlins/side girt shall be made on every third corrugation at least. Additionally the laps shall be sealed by seam bolts of 6.25 mm diameter at a pitch of 300 mm on the side laps. Holes shall be made only by drilling and not by punching and all burrs shall be carefully removed. All attachments should pass through the crown of corrugations ridges for roots whereas for the siding, the attachments should pass through the troughs.

23.3.2.3 The lap shall occur always over purlins or side girths.

23.4 Measurements

23.4.1 the measurement shall be taken in sqm for the finished work in superficial area in the general plane (not girthed) of the roof/wall. The laps shall not be measured. The overlaps of sheets over the valley pieces and their underlay under the ridge, hip and flashing piece shall be included in the measurement length and breadth shall be measured correct to the centimeter. No deduction shall be made for holes cut for extractor or cowl type ventilators.

23.4.2 Measurements of ridges, lips, and other accessories and those of gutters shall be for the finished work and the length shall be taken along the center line correct to 10 mm. The laps shall not be measured.

24 FLOORING

24.1 Scope

24.1.1 These Specifications cover the general requirements of different kinds of floor finishes.

24.2 Applicable Codes

24.2.1 The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

IS: 210-1978 (210-1993*)	Grey Iron Castings (4th Revision)
IS: 269-1989	Specification for 33 Grade Ordinary Portland Cement (4th Revision) (Amendments 3)
IS: 401-1982	Code of Practice for Preservation of Timber (3rd Revision) (Amendments 2) (Reaffirmed 1990)
IS: 451-1972	Technical Supply Conditions for Wood Screws (2nd Revision) (Amendments 1) (Reaffirmed 1991)
IS: 455-1989	Specification for Portland Slag Cement (4th Revision) (Amendments 3)
IS: 653-1992	Specification for Linoleum Sheets and Tiles (3rd Revision)
IS: 661-1972 (661-1974)*	Code of Practice for Thermal Insulation of Cold Storage's (2nd Revision) (Amendments 2)
IS: 702-1988	Specification for Industrial Bitumen (2nd Revision)(Amendment 1)
IS: 777-1988	Specification for Glazed Earthenware Wall Tiles (2nd Revision) (Superseded By IS: 13753, 13754, 13755, 13756)
IS: 809-1992	Specification for Rubber Flooring Materials for General Purposes (2nd Revision)
IS: 1124-1974	Method of Test of Determination of Water Absorption, Apparent Specific Gravity and Porosity of Natural Building Stones (1st Revision) (Reaffirmed 1990)
IS: 1130-1969	Specification for Marble (Blocks, Slabs and Tiles) (Reaffirmed 1993)
IS: 1141-1973 (1141-1993)*	Code of Practice - Seasoning of Timber (2nd Revision)
IS: 1197-1970	Code of Practice for Laying Rubber Floors (1st Revision(Reaffirmed 1990)
IS: 1198-1982	Code of Practice for Laying, Fixing Ad Maintenance of Linoleum Floor (1st Revision)(Reaffirmed 1990)
IS: 1200 (Part XI) 1977	Method of Measurement of Building and Civil Engineering Work (Part XI) Paving, Floor Finishes, Dado and Skirting)(3rd Revision) (Amendment 1) (Reaffirmed 1992)
IS: 1237-1980	Specification for Cement Concrete Flooring Tiles (1st Revision)(Reaffirmed 1990)
IS: 1322-1982 (1322-1993)	Specification for Bitumen Felts for Water Proofing and Damp-Proofing (4th Revision)
IS: 1443-1972	Code or Practice for Laying and Finishing of Cement Concrete Flooring Tiles (1st Revision)(Reaffirmed 1991)
IS: 1489 (Part-1) 1991	Specification for Portland Pozzolana Cement (Part - 1) Flyash Based (3rd Revision)
IS: 1489- (Part II) 1991	Specification for Portland Pozzolana Cement (Part II) Calcined Clay Based (3rd Revision)(Amendment 1)
IS: 1580-1991	Specification for Bituminous Compounds of Water Proofing and Caulking Purpose (3rd Revision)
IS: 2078-1979	Method of Tensile Testing of Grey Cast Iron (1st Revision)(Reaffirmed 1991)
IS: 2114-1984	Code of Practice for Laying In-Situ Terrazzo Floor Finish (2nd Revision)(Amendment 1)(Reaffirmed 1990)
IS: 2571-1970	Code of Practice for Laying In-Situ Cement Concrete Flooring (1st Revision) (Reaffirmed 1991)
IS: 3400 (Part.1	Method of Test for Vulcanized Rubbers

to 22)	
IS: 3400-(Part III) 1980	Methods of Test for Vulcanized Rubbers (Part Iii) Hardness (1st Revision) (Reaffirmed 1991)
IS: 3400 - (Part X) 1977	Method of Test for Vulcanized Rubbers (Part X) Compression Set At Constant Strain (1st Revision)(Reaffirmed 1990)
IS: 3461-1980	Specification for PVC-Asbestos Floor Tiles (1st Revision)(Amendments 2) (Reaffirmed 1990)
IS: 3462-1986	Specification for Unbaked Flexible PVC Flooring (2nd Revision)(Amendment 1)(Reaffirmed 1991)
IS: 3622-1977	Specification for Sand Stone (Slab & Tiles)(1st Revision)(Reaffirmed 1993)
IS: 3670-1989	Code of Practice for Construction of Timber Floors (1st Revision)
IS: 5318-1969	Code of Practice for Laying of Flexible PVC Sheet and Tile Flooring (Reaffirmed 1990)
IS: 5766-1970	Code of Practice for Laying of Burnt Clay Brick Flooring (Reaffirmed 1991)
IS: 8041-1990	Specification Rapid Hardening Portland Cement (2nd Revision)(Amendments 2)
IS: 8042-1989	Specification for White Portland Cement (2nd Revision)(Amendments 4)
IS: 8043-1991	Specification for Hydrophobic Portland Cement (2nd Revision) (Amendment 2)
IS: 8112-1989	Specification for 43 Grade Ordinary Portland Cement (1st Revision(Amendments 3)
IS: 12330-1988	Specification for Sulphate Resisting Portland Cement. (Amendments 3)
IS: 1195	Bitumen Mastic for Flooring
IS: 3384	Bitumen Primer for Use in Waterproofing and Damp Proofing
IS: 4832 (Part - 1)	Acid Resistant Mortars - Silicate Type
IS: 4832 (Part - 2)	Acid Resistant Mortars - Resin Type
IS: 4457	Ceramic Unglazed Vitreous Acid Resisting Tiles

24.3 List of Mandatory Tests

Material	Clause	Test	Field/ Labora-tory	Test Proce-dure	Min. Quantity of material for carrying out the test	Frequency of testing
Terrazzo Tiles	22.14.1	1. Transverse strength 2. Water absorption 3. Abrasion test	IS: 1237-1980 Laboratory	IS: 1237-1980	5000 Nos. (no testing need be done if total number tiles of all types of all sizes form all manufacturers used in a work is less than 5000 Nos.)	One test for every 10,000 Nos. or part thereof for each type and size from a single manufacturer. (One test to be done even if the number of terrazzo tiles of any type and size from a single manufacturers is less than 50,000 Nos. provided the number of terrazzo tiles of all types and sizes from all manufacturers used in work exceed 5000 Nos.
White Glazed tiles (for floor & wall)	22.18.1	1. Water absorption 2. Crazing test 3. Impact strength test 4. Chemical resistant test	Laboratory	IS: 777-1988	3000 Nos.	3000 Nos. or part thereof

24.4 Brick on Edge Flooring

24.4.1 Bricks

24.4.1.1 Bricks of Specified dimensions and designations shall be used. These shall conform to the Specifications described in **Chapter 7.** Broken bricks shall not be used in flooring except for closing the line. The bricks shall be laid on edge.

24.4.2 Mortar

24.4.2.1 The mortar used shall be as specified (in case of dry bricks flooring fine sand shall be filled in the joints).

24.4.3 Base Concrete

24.4.3.1 Flooring shall be laid on base concrete where so provided. The base concrete shall be provided with the slope required for the flooring. Floors in verandah, courtyard kitchens, baths shall have slope ranging from 1:36 to 1: 48 depending upon locations as decided by the Engineer. Floors in water closet portion shall have slope of 1:30 or as decided by the Engineer to drain off washing water. Plinth masonry off-set shall be depressed so as to allow the base concrete to rest on it.

24.4.3.2 If the base consists of lime concrete, it shall be allowed to set for seven days and the flooring shall be laid in the next three days.

24.4.3.3 If the base is of lean cement concrete, the flooring shall commence within 48 hours of the laying of base, failing which, the surface of base shall be roughened with steel wire brushes without disturbing the concrete. Before laying the flooring the base shall be wetted and smeared with a coat of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between sub-grade and flooring.

24.4.3.4 Where base concrete is not provided, the earth below shall be properly sloped, watered, rammed and consolidated. Before laying the flooring it shall be moistened.

24.4.4 Soaking of Bricks

24.4.4.1 Bricks required for flooring shall be adequately soaked in stacks before use, by profusely spraying with clean water at regular intervals for a period of not less than six hours as to keep them wet to the satisfaction of the Engineer (In case the joints are to be filled with sand, the bricks need not be soaked).

24.4.5 Laying

24.4.5.1 The bricks shall be laid on the edge in plain, diagonal herring bone bond, or other pattern as specified or directed by the Engineer.

24.4.5.2 Bricks shall be laid on edge on 12 mm thick mortar bed and each brick shall be properly bedded and set home by gentle tapping with trowel handle or wooden mallet. Its inside face shall be buttered with mortar, before the next brick is laid and pressed against it.

24.4.5.3 On completion of a portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface of the flooring during laying, shall be frequently checked with a straight edge at least 2 m long, so as to obtain a true plain surface with the required slope.

24.4.6 Joints

24.4.6.1 Bricks shall be so laid that all joints are full or mortar. The thickness of joints shall not exceed 1.0 cm for brick work with bricks of any class designation. All face joints shall be raked to a minimum depth of 15 mm by raking tool during the progress of work when the mortar is still green so as to provide proper key for the plaster or pointing to be done. Where plastering or

pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of brick work shall be cleaned on the same day on which brick work is laid and all mortar droppings removed promptly.

24.4.7 Curing

24.4.7.1 Brick work shall be protected from rain by suitable covering when the mortar is green. Masonry work in cement mortar, composite lime mortar, lime mortar (lime of category other then C & D) shall be kept constantly moist on all faces for a minimum period of seven days. Brick work carried out during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period. In case of masonry with fat lime mortar, curing shall commence two days after laying of masonry and shall continue for at least seven days thereafter.

24.4.8 Measurements

24.4.8.1 Length and breadth shall be measured correct to a cm and area as laid shall be calculated in square metres correct to two places of decimal. Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

24.4.8.2 Brick flooring when laid in diagonal herring bone bond or other pattern as specified or directed by the Engineer shall be measured separately.

24.4.9 Rate

24.4.9.1 The rate shall include the cost of all materials and labour involved in all the operations described above, including application of cement slurry on base concrete or RCC slab and cleaning of base. Base concrete shall be paid for separately.

24.4.10 Dry Brick Flooring

24.4.10.1 All provisions in **Clause 22.4.1 to 22.4.8** will be applicable subject to following modifications, Bricks need not be soaked. Bricks will be laid on a bed of 12 mm thick mud mortar laid to required slope. The joints shall be as fine as possible and not exceeding 5 mm which will be filled with fine sand. No curing is to be done. The rate shall include the cost of all materials and labour involved in all the operations described above.

24.5 Cement Concrete Flooring

24.5.1 Cement Concrete

24.5.1.1 Cement concrete of specified mix shall be used and it shall generally conform to the Specifications described **Chapter 9**.

24.5.2 Base Concrete

24.5.2.1 Flooring shall be laid on base concrete where so provided. The base concrete shall be provided with the slopes required for the flooring. Flooring in verandah Courtyard kitchens & baths shall have slope ranging from 1:48 to 1:60 depending upon location and as decided by the Engineer. Floors in water closet portion shall have slope of 1:30 or as decided by the Engineer to drain off washing water. Plinth masonry off set shall be depressed so as to allow the base concrete to rest on it.

24.5.2.2 If the base consists of lime concrete, it shall be allowed to set for seven days and the flooring shall be laid within the next three days.

24.5.2.3 If the base is of lean cement concrete, the flooring shall be commenced preferably within 48 hours of the laying of base concrete. The surface of the base shall be roughened with steel

wire brushes without disturbing the concrete. Immediately before laying the flooring, the base shall be wetted and a coat of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between the base and concrete floor.

24.5.2.4 If the cement concrete flooring is to be laid directly on the RCC slab, the top surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between the base and concrete floor.

24.5.3 Thickness

24.5.3.1 The thickness of floor shall be as specified in the description of the item.

24.5.4 Laying

24.5.4.1 Panels

Flooring specified thickness shall be laid in the pattern including the border/or as given in the Drawings or as directed by the Engineer. The border panels shall not exceed 450 mm in width and the joints in the border in line with panel joints. The panels shall be of uniform size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sqm.

24.5.4.2 Laying of flooring with strips

1. Normally cement concrete flooring shall be laid in one operation using glass/plain asbestos/aluminium/PVC/brass strips or any other strips as required as per Drawing or instructions of the Engineer, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4 mm thick glass strips or 5 mm thick plain asbestos sheet, 2 mm PVC strips or 2 mm aluminium or brass strips shall be fixed with their tops at proper level, giving required slopes. Cost of providing and fixing strips shall be paid for separately.

2. Concreting

   Cement concrete shall be placed in the panels and be levelled with the help of straight edge and trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with a thin layer of cream of mortar. The evenness of the surface shall be tested with straight edge and made true to required slopes. While laying concrete, care shall be taken to see that the strips are not damages/distributed by the labourers. The tops of strips shall be visible clearly after finishing with cement slurry.

24.5.4.3 Laying of flooring without Strips

Laying of cement concrete flooring in alternate panels may be allowed by the Engineer in case strips are not to be provided.

1. Shuttering

   The panels shall be bounded by angle iron or flats. The angle iron/flat shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level giving required slopes. The surface of the angle iron or flats, to come in contact with concrete shall be smeared with soap solution or non-sticking oil (Form oil or raw linseed oil) before concreting. The flooring shall butt against the unplastered masonry wall.

2. Concreting

   The concreting shall be done in the manner described under **Clause 22.5.4.2**. The angle iron/flats used for shuttering, shall be removed on the next day of the laying of cement

concrete. The ends thus exposed shall be repaired, if damaged with cement mortar 1:2 (1 cement: 2 coarse sand) and allowed to set for minimum period of 24 hours. The alternate panels shall then be cleaned of dust, mortar, droppings etc. and concrete laid. While laying concrete, care shall be taken to see that the edges of the previously laid panels are not damaged and fresh mortar is not splashed over them. The joints between the panels should come out as fine straight lines.

24.5.5 Finishing

24.5.5.1 The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time, till moisture disappears from it or surplus water can be mopped up. Use of dry cement or cement and sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided.

24.5.5.2 Fresh cement shall be mixed with water to form a thick slurry and spread at the rate of 2 kg of cement over an area of one sqm of flooring while the flooring concrete is still green. The cement slurry shall then be properly processed and finished smooth.

24.5.5.3 The edges of sunk floors shall be finished and rounded with cement with a floating coat of neat cement

24.5.5.4 The junctions of floor with wall plaster, dado or skirting shall be rounded off where so specified.

24.5.5.5 The men engaged on finishing operations shall be provided with raised wooden platform to sit on so as to prevent damage to new work.

24.5.6 Curing

24.5.6.1 The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty gunnies shall be avoided as the colour of the flooring is likely to be bleached due to the remnants of cement dust from the bags.

24.5.7 Precautions

24.5.7.1 Flooring in lavatories and bath room shall be laid only after fixing of water closet and squatting pans and floor traps. Traps shall plugged while laying the floors and opened after the floors are cured and cleaned. Any damage done to W.C.'s squatting pans and floor traps during the execution of work shall be made good.

24.5.7.2 During cold weather, concreting shall not be done when the temperature falls below 4 degree Centigrade. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38 degree Centigrade. No concreting shall be laid within half a hour of the closing time of the day, unless permitted by the Engineer. To facilitate rounding of junction of skirting, dado and floor, the skirting/dado shall be laid along with the border or adjacent panels of floor.

24.5.8 Measurement

24.5.8.1 Length and breadth shall be measured before laying skirting dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

24.5.8.2 The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

24.5.9 Rate

24.5.9.1 The rate shall include the cost of all materials and labour involved in all the operations described above including application of cement slurry on RCC slab or on base concrete including roughening and cleaning the surface but excluding the cost of strips which shall be paid separately under relevant item. Nosing of steps where provided shall be paid for separately in running metre. Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard and rounding off edges of sunk floors. In case the flooring is laid in alternate panels, nothing extra shall be paid towards the cost of shuttering used for this purpose.

24.6 Cement Concrete Flooring with Topping of Red Oxide of Iron

24.6.1 Cement Concrete

24.6.1.1 Cement concrete of specified mix shall be used and it shall generally conform to the Specification described in **Chapter 9.**

24.6.2 Base Concrete

24.6.2.1 It shall be as specified in **Clause 22.4.3**.

24.6.3 Under Layer

24.6.3.1 The under layer of flooring shall be of cement concrete of specified thickness. The mix shall be 1:2:4 (1 Cement: 2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) by volume otherwise described in the item (See 4.2). As regards laying, the work shall be carried out in the manner specified in **Clause 22.5..4** except that:

1. Angle or flat iron used for shuttering shall be to the height of both the under and top layers of the floor.

2. The under layer shall not be left smooth but roughened with 2 mm deep diagonal lines at 7.5 cm centres both ways with a scratching tool to form a key for the finishing coat of red oxide of iron. No cement slurry be added to the concrete surface, and

3. The angle or flat shall removed only 24 hours after the top layer has been laid. The surface of under layer shall be left even and true to slope.

24.6.4 Top Layer

24.6.4.1 This shall consist of uniform and smooth layer of plaster of 10 mm thickness unless otherwise specified and of mix 1:3 (1 Cement: 3 coarse sand) unless otherwise specified, finished with a floating coat the ratio of cement to red oxide of iron specified in the description of item shall be adopted. Normally 3.5 kg, of red oxide of approved quality to 50 kg of cement shall be mixed. This ratio may, however, be adjusted to the tinge ordered by the Engineer. The red oxide shall be dry mixed thoroughly with the cement and then sand added and mixed. The full quantity of dry mortar required for a room shall be prepared in one lot in order to ensure uniform colour. Wet mortar shall be prepared in the usual manner as and when required.

1. Laying: The top layer shall be laid, the following day after the under layer has been laid. The plaster shall be done to a uniform thickness of 10 mm and finished smooth with cement slurry (2.0 kg of cement, red oxide used) for the plaster. The surface shall then be brought to a fine polish by use of polishing stones.

2. The angle or flats used for shuttering of panels shall be removed the next day, after the laying of the top layer and broken edges repaired with the same coloured mortar as in plaster.

3. The under layers of the alternate panels and the coloured plaster on top shall then be laid as described above. In laying such alternate panels care shall be taken that concrete and coloured mortar droppings do not disfigure the coloured topping previously finished.

4. The junction of floor with wall plaster, dado or skirting shall be rounded off neatly where so required, upto 25 mm radius. Men engages on the finishing operations shall be provided with raised wooden platforms to sit on, so as to prevent damage to new work.

24.6.5 Thickness

24.6.5.1 The thickness of the under layer panels shall be as specified in the description of the item and shall be measured correct to 1 cm. The thickness of the top layer shall not be less than that specified.

24.6.6 Curing

24.6.6.1 The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty cement gunnies shall be avoided as the colour is likely to be bleached with the remnants of cement matter from the bags.

24.6.7 Precautions

24.6.7.1 These shall be as specified in **Clause 22.5.7.**

24.6.8 Measurements

24.6.8.1 These shall be as specified in **Clause 22.5.8**.

24.6.9 Rate

24.6.9.1 The rate shall include the cost of all materials and labour involved in all the operations described above including application of cement slurry on base concrete including roughening and cleaning shall be paid for separately. Strips and noising of steps where provided shall be paid for separately in running metre.

24.6.9.2 Where the quantity of red oxide used is different from what is described in the item to get the tinge required by the Engineer. The difference in quantity shall be subject to corresponding adjustment in the rate for the item.

24.7 Cement Concrete Flooring with Metallic Hardener Topping

Wherever floors are required to withstand heavy wear and tear, use of floor hardener shall be avoided as far as possible by using richer mixes of concrete, unless the use of a metallic hardener is justified on the basis of cost. Where metallic hardener topping is used, it shall be 12 mm thick.

24.7.1 Metallic Hardening Compound

24.7.1.1 The compound shall be approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease sand, soluble alkaline compounds. Where so directed by the Engineer it shall be tested as described; in **Appendix A of Chapter 22**.

24.7.2 Base Concrete

24.7.2.1 It shall be as specified in **Clause 22.5.2**.

24.7.3 Under Layer

24.7.3.1 Cement concrete flooring of specified thickness and mix shall be laid as under layer **(Clause 22.6.1 and 22.6.3).** The top surface shall be roughened with brushes while the concrete is still

green and the forms shall be kept projecting up 12 mm over the concrete surface, to receive the metallic hardening compound topping.

24.7.4 Topping

24.7.4.1 This shall consist of 12 mm thick layer of mix 1:2 (1 cement: 2 stone aggregate 6 mm nominal size) by volume or as otherwise specified with which metallic hardening compound is mixed in the ratio of 1:4 (1 metallic concrete hardener: 4 cement) by weight. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry pucca platform. The dry mixture shall be mixed with stone aggregate 6 mm nominal size or as otherwise specified in the ratio of 1:2 (1 cement: 2 stone aggregate) by volume, and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete.

24.7.4.2 The mixture so obtained shall be laid in 12 mm thickness, on cement concrete floor within 2 to 4 hours of its laying. The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete so as to have good bond with it. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats.

24.7.4.3 The junction of floor with wall plaster, dado or skirting and finishing operations shall be dealt with as described in **Clause 22.5.4**.

24.7.4.4 The men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as to prevent damage to new work.

24.7.5 Measurements and Rates

24.7.5.1 The Specifications for curing, precautions to be taken, “Measurements” and “Rates” shall be as specified in **Clause 22.5.**

24.8 Cement Plaster in Risers of Steps, Skirting, Dado

A band of plaster at the bottom of wall not exceeding 30 cm in height above the floor shall be classified as skirting. It shall be flush with wall plaster as specified. The work shall be preferably carried out simultaneously with the laying of floor. It’s corners and junctions with floor shall be finished neatly as specified.

24.8.1 Thickness

24.8.1.1 The thickness of the plaster specified shall be measured exclusive of the thickness of key i.e., grooves or open joints in brick work. The average thickness should be regulated at the time of plastering by keeping suitable thickness of the guages. Extra thickness required in rounding of corners at junctions of wall shall be ignored.

24.8.2 Preparation of Wall Surface

24.8.2.1 The joints shall be raked out to depth of at least 15 mm in masonry walls. In case of concrete walls, the surfaces shall be roughened by hackings. The surface shall be cleaned thoroughly, washed with water and kept we before skirting is commenced.

24.8.3 Application

24.8.3.1 Skirting with specified mortar and to specified thickness shall be laid immediately after the surface is prepared. It shall be laid along with the border or adjacent panels of floor. The joints in skirting shall be kept true and straight in continuation of the line of joints in borders or adjacent panels. The skirting shall be finished smooth and true, with top truly horizontal and joints truly vertical except where otherwise indicated.

24.8.4 Finishing

24.8.4.1 The finishing of surface shall be done simultaneously with the borders of the adjacent panels of floor. The cement to be applied in the form of slurry for smooth finishing shall be at the rate of 2 kg of cement per litre of water applied over an area of 1 sqm.

24.8.4.2 Where skirting is flush with plaster, a groove 10 mm wide and upto 5 mm deep shall provided in plaster at the junction of skirting with plaster.

24.8.5 Curing

24.8.5.1 Curing shall be commenced on the next day of plastering when the plaster bas hardened sufficiently and shall be continued for a minimum period of 7 days.

24.8.6 Measurements

24.8.6.1 Length and height shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimals stating the thickness. Length shall be measured as the finished length of skirting. Height shall be measure from the finished level of floor correct to 5 mm.

24.8.7 Rate

24.8.7.1 Rate shall include the cost of all materials and labour involved in all the operations described above.

24.9 Cement Plaster Skirting Finished with Red Oxide of Iron.

24.9.1 Under Coat

24.9.1.1 The undercoat of skirting shall be of cement plaster of the thickness and mix described in the item. Specifications given under **Clause 22.8, 22.8.1. and 22.8.2** shall apply. As regards application, the work shall be carried out in a manner described in **Clause 22.8.3** except that the under coat shall be finished rough with a scratching tool to form a key for to the top coat.

24.9.2 Top Coat

24.9.2.1 Mortar

This shall consist of uniform and smooth layer of plaster of specified thickness and of mix 1:3 (1 Cement: 3 coarse sand) unless otherwise specified, finished with a floating coat of neat cement. In both plaster and floating coat the ratio specified in the description of item shall be adopted. Normally 3.5 kg of red oxide of approved quality to 50 kg of cement shall be mixed. This ratio may however, be adjusted to the tinge order by the Engineer. The red oxide shall be mixed with the cement and then sand added and mixed. The full quantity of dry mortar required for a room shall be prepared in one lot in order to ensure uniform colour. Wet mortar shall be prepared in the usual manner as and when required.

24.9.2.2 Application

The top coat shall be done the next day after the under coat has been applied. The plaster shall be done with the thickness specified and finished smooth, by application of cement-red oxide mix, at the rate of 1.0 kg. Per square metre of surface. The ratio adopted for the mix being the same as that of the plaster. When the surface has hardened sufficiently it shall be brought to a fine polish by use of polishing stones.

24.9.3 Thickness

24.9.3.1 The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of total thickness of skirting specified is of total thickness of plaster as measured from the unplastered face of the masonry. Average thickness of the under coat shall not be less than 6 mm and minimum thickness over any portion of the surface shall not be less than 4 mm. The thickness of top coat shall not be less than the thickness specified.

24.9.4 Curing

24.9.4.1 Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently and shall be continued for a minimum period of 7 days.

24.9.5 Measurements

24.9.5.1 Length and height shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimal stating the thickness. Length shall be measured as the finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm.

24.9.6 Rate

24.9.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

24.9.6.2 Where the quantity of red oxide used is different from what is described in the item to get the tinge required by the Engineer, the difference is quantity used will be subject to corresponding adjustment in the rate for the item.

24.10 Cement Concrete Pavement in Courtyard and Terrace Etc.

24.10.1 Specifications described in **Clause 22.5.1, 22.5.2.1, 22.5.3, 22.5.4, 22.5.6 and 22.5.7** shall hold good as far as applicable except that:

1. The panels shall be of uniform size and no dimension of a panel shall exceed 1.25 m and the area of panel should not exceed 1.25 sqm for the thickness of panels upto 50 mm.
2. Concrete shall be done in alternate panels only and no glass/asbestos strips shall be provided.

24.10.2 Finishing

24.10.2.1 The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some-time, till moisture disappears from it or surplus water can be mopped up.

24.10.2.2 Use of dry cement or cement and sand mix sprinkled on the surface to stiffen the concrete or to absorb excessive moisture shall not be permitted. Excessive troweling shall be avoided. When surface becomes fairly stiff, it shall be finished rough with wooden floats or where so specified chequered uniformly by pressing a piece of expanded metal of approved size.

24.10.3 Measurements

24.10.3.1 Same as **Clause 22.5.8** except that the volume will be calculated in cum nearest to two decimal places.

24.10.4 Rate

24.10.4.1 The rate shall include the cost of all materials and labour involved in all the operations described above except the base concrete below flooring which shall be paid for separately. Chequering to pattern shall be paid for separately unless otherwise specified.

24.11 Terrazzo (Marble Chips) Flooring Laid In Situ

24.11.1 Under layers

24.11.1.1 Cement concrete of specified mix shall be used and the Specifications given under **Chapter 9** shall apply. The panels shall be of uniform size, not exceeding 2 sqm in area or 2 m in length for inside situations. In exposed situations, the length of any side of the panel shall not be more than 1.25 metre. Cement slurry (a) 2.00 kg per sqm shall be applied before laying of under layer over the cement concrete / RCC base.

24.11.2 Fixing of Strips

24.11.2.1 4 mm thick glass strips or 5 mm thick plain asbestos sheet or 2 mm thick PVC strips/aluminium strips/brass strips unless otherwise specified shall be fixed with their top at proper level to required slope. Strips of stone or marble or of any other material of specified thickness can also be used if specifically required. The fixing and laying shall be as specified in **Clause 22.5.4.2**.

24.11.3 Top layer

24.11.3.1 Mortar

1. The mix for terrazzo topping shall consist of cement with or without pigment, marble powder, marble aggregate (marble chips) and water. The Cement and marble powder shall be mixed in the proportion of three parts of cement to one part marble powder by weight. For every part of cement marble powder mix, the proportion of aggregate by volume shall be as shown in Table 22-1 below.

2. The marble chips shall be white or pink Makrana, black Bhainslana, Chittoor black, Jaisalmer Yellow, Baroda Green, Dehradun white, Chittoor pink, yellow Patam cherala (Madras), grey Gadu (Surat), Chittoor green and yellow and Alwar black or as specified. It shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. The maximum thickness of the top layer for various sizes of marble aggregates (marble chips) shall be as shown in Table 22-1 below:

TABLE 22-1

Grade No.	Size of aggregates in (mm)	Proportion of aggregates to binder mix	Minimum thickness of top layer (mm)
00	1-2	1.75: 1	6
0	2-4	1.75: 1	9
1	4-7	1.25: 1	9
2	7-10	1.50: 1	12

3. Where aggregate of size larger than 10 mm are used, the minimum thickness of topping shall not be less than 1-1/2 times the maximum size of the chips. Where large size chips such as 20 mm or 25 mm are used, they shall be used only with a flat shape and bedded on the flat face so as to keep the minimum thickness of wearing layer.

4. Before starting the work, the Contractor shall get the sample of marble chips approved by the Engineer. The cement to be used shall be ordinary grey cement, white cement, coloured cement with admixture of colouring matter of approved quality in the ratio specified in the description of the item in the ratio to get the required shade as ordered by the Engineer., Colouring materials where specified shall be mixed dry thoroughly with the cement and marble powder and then marble chips added and mixed as specified above. The full quantity of dry mixture of mortar required for a room shall be prepared in a lot in order to ensure a uniform colour. This mixture shall be stored in a dry place and well

covered and protected from moisture. The dry mortar shall be mixed with water in the usual way as and when required. The mixed mortar shall be homogenous and stiff and to contain just sufficient water to make it workable.

5. The terrazzo topping shall be laid while the under layer is still plastic, but has hardened sufficiently to prevent cement from rising to the surface. This is normally achieved between 18 to 24 hours after under layer has been laid. A cement slurry preferably of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. It shall be laid to a uniform thickness slightly more than that specified in order to get the specified finished thickness after rubbing. The surface of the top layer shall be trowelled over, pressed and brought true to required level by a straight edge and steel floats in such a manner that the maximum amount of marble chips come and are spread uniformly over the surface.

24.11.3.2 Polishing, Curing and Finishing

1. Polishing shall be done by machine. About 36 hours after laying the top layer, the surface shall be watered and ground evenly with machine fitted with special rapid cutting grit blocks (carborundum stone) of coarse grade (no.60) till the marble chips are evenly exposed and the floor is smooth. After the first grinding, the surface shall be thoroughly washed to remove all grinding mud and covered with a grout of cement and colouring matter in same mix proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to cure for 5 to 7 days and then rubbed with machine fitted with fine grit blocks (No.120)./ The surface is cleaned and repaired as before and allowed to cure again for 3 to 5 days. Finally the third grinding shall be done with machine fitted with fine grade grit blocks (No.320) to get even and smooth surface without pin holes. The finished surface should show the marble chips evenly exposed.

2. Where use of machine for polishing is not feasible or possible, rubbing and polishing shall done by hand, in the same manner as specified for machine polishing except that carborundum stone of coarse grade (No.60) shall be used for the 1st rubbing, stone of medium grade (No.80) for second rubbing and stone of fine grade (No.120) for final rubbing and polishing.

3. After the final polish either by machine or by hand, oxalic acid shall be dusted over the surface @ 33 gm per square metre sprinkled with water and rubbed hard with a nemdah block (Pad of Woolen rags). The following day, floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

4. Curing shall be done by suitable means such as laying moist sawdust or ponding water.

24.11.4 Precautions

24.11.4.1 Flooring in lavatories and bathrooms shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned. Any damage done to WC's squatting pans and floor traps during the execution of work shall be made good.

24.11.4.2 During cold weather, concreting shall not be done when the temperature fails below 4 degree Centigrade. The concrete packed shall be protected against frost by suitable coverings. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not 38 degree Centigrade. No concreting shall laid within half an hour of the closing time of the day, unless permitted by the Engineer.

24.11.5 Measurements

24.11.5.1 Length and breadth shall be measured correct to a cm before lying skirting, dado or wall plaster. The area as laid shall be calculated in sqm correct to two decimal places.

24.11.5.2 Thickness of the under layer shall be measured correct to a cm. The thickness of top layer shall not be less than that specified.

24.11.5.3 No deduction shall be made, nor extra paid for voids not exceeding 0.20 square metre. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 01.0 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard.

24.11.5.4 Terrazzo (Marble Chips) flooring laid as floor borders, margins and similar bands upto 30 cm width on staircase treads shall be measured under the item of terrazzo flooring but extra shall be paid for such work. This extra in the case of staircase treads shall include the cost of forming the nosing also. However, moulded nosing shall be paid extra in running metres except where otherwise stated, returned moulded ends and angles to mouldings shall be included in the description. Extra shall also be paid for laying flooring in narrow bands not exceeding 7.5 cm in width and such bands shall be measured in running mteres for this purpose.

24.11.5.5 Dividing strips inserted in terrazzo to form bays, patterns shall be described stating the materials, it width and thickness and measured in running metres.

24.11.5.6 Special surface finishes to treads, risers and the ends of concrete steps and the like shall be measured separately and given in square metres and shall include form work, if required.

24.11.6 Rate

24.11.6.1 The rate shall include the cost of the material and labour involved in all the operations described above including cleaning of surface of RCC slab or base concrete and application of cement slurry but shall not include the cost of base concrete and cost of providing and fixing strips of glass or aluminium, or of any other material used for making panels., which shall paid for separately

24.12 Terrazzo (Marble Chips) Skirting In Situ

24.12.1 Under coat

24.12.1.1 The under coat of skirting shall be of cement plaster of the thickness and mix described in the item. Specifications given under **Clause 22.8, 22.8.1 and 22.8..2.** shall apply. As regards application, the work shall be carried out in the manner described in **Clause 22.8.3**. shall except that the under coat shall be finished rough with a scratching tool to form a key for the top coat.

24.12.2 Top Coat

24.12.2.1 The Specifications as in **Clause 22.11.3**. shall hold good as far applicable and shall include cutting to line and fair finish to top edges of terrazzo and polishing.

24.12.3 Thickness

24.12.3.1 The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of the thickness of plaster including top coat as measured from the unplastered face of the masonry. Average thickness of the under coat shall not be less than 6 mm and minimum thickness over any portion of the surface shall not be less than 4 mm. The thickness of top coat shall not be less than the thickness specified.

24.12.4 Measurements

24.12.4.1 Length and straight shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimal. Length shall be measured as finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm where the height level of floor correct to 5 mm where the height of skirting does not exceed 30 cm and when the height exceeds 30 cm it shall be measured correct to a cm.

24.12.5 Rates

24.12.5.1 The rate shall cost of all materials and labour involved in all the operations described above.

24.13 Crazy Marble Flooring

24.13.1 Base Concrete

24.13.1.1 Crazy marble stone flooring shall be laid on cement or lime concrete base. The base concrete shall be provided with slope required for the flooring in verandahs and courtyards to drain off washing and rain water. The surface of base shall be roughened with steel wire brushes, without disturbing the concrete, wetted and smeared with a floating cost of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between base and flooring.

24.13.1.2 Before laying the flooring on RCC slabs, the laitance shall be removed., the surface of slab hacked and a coat of cement slurry at 2 kg of cement spread over an area of one sqm shall be applied so as to get a good bond between RCC slab and floor.

24.13.2 Under Layer

24.13.2.1 The Under layer of crazy marble flooring shall be of cement concrete of thickness 25 mm or as specified. The mix shall normally be 1:2:4 (1 cement:2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) by volume unless otherwise specified. It shall conform to the Specifications given under **Chapter 9** of sub-head 'Cement Concrete'.

24.13.3 Top Layer

24.13.3.1 The mix of crazy marble stone flooring with or without pigment, marble powder, marble chips of 00 Nos. and marble stone pieces and water. The marble stone pieces shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. Before starting the work the Contarctor shall get the sample of marble stone approved by the Engineer. The marble stone pieces shall be of sizes as approved by the Engineer but the thickness shall be according to the overall thickness specified which could be achieved when laid over the under layer as specified. Thus for 50 mm thick floor, the thickness of marble pieces will be 25 mm while for 40 mm thick floor, the thickness will be 15 mm.

24.13.3.2 The white cement and marble powder shall be mixed in proportion of three parts of cement and one part of marble powder by weight, and the proportion of marble chips to binder mix by volume shall be 7 parts of marble chips to 4 parts of binder mix. The marble chips shall be as specified. It shall be hard, sound, dense and homogeneous in texture. It shall be uniform in colour and free from satins, cracks decay and weathering.

24.13.4 Laying

24.13.4.1 A cost of cement slurry at the rate of 2 kg of cement per sqm of area shall be spread and then the marble stone pieces shall be set by hand in such a manner that the top surface of all the set marble stones shall be true to the required level and slopes. After fixing the stones, the cement marble chips mixture shall be filled in between the gaps of laid marble stone pieces. The filled surface then shall be trowelled over, pressed brought to the level of the laid marble stone pieces.

24.13.5 Polishing

24.13.5.1 Curing and Finishing shall be as described in **Clause 22.11.3.2**.

24.13.6 Precautions

24.13.6.1 Flooring in lavatories and bathrooms shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned.

24.13.7 Measurements

24.13.7.1 Length and breadth shall be measured correct to a cm before skirting, dado or wall plaster and it shall be calculated in sqm correct to two decimal places. No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying floor at different levels in the same room or courtyards.

24.13.8 Rate

24.13.8.1 The rates shall include the cost of all materials and labour involved in all the operations described above including the cost of cleaning of RCC slab surface and applying the cement slurry, but it shall not include the cost of base concrete.

24.14 Terrazzo Tile Flooring

24.14.1 Terrazzo Tiles

24.14.1.1 Terrazzo tiles shall generally conform to IS: 1237-1980. Requirements and methods of testing of tiles are described in **Appendix B of Chapter 22**. Unless otherwise specified, the tiles shall be supplied initial grinding and grouting wearing layer.

24.14.1.2 The size of tiles shall be as given in Table 22-2 or as shown in the Drawings or as required by the Engineer. Half tiles for use with the full tiles shall be such as to make two half tiles when jointed together, match with dimensions of one full tile.

TABLE 22-2

Length Nominal	Breadth Nominal	Thickness not less than
200 mm	200 mm	20 mm
250 mm	250 mm	22 mm
300 mm	300 mm	25 mm

24.14.2 Tolerance

1. Tolerances on length and breadth shall be plus or minus one millimeter, and tolerance on thickness shall be plus 5 mm. The range of dimensions in any one delivery of tiles shall not exceed 1 mm on length and breadth and 3 mm on thickness.

2. The tiles shall be manufactured in a factory under pressure process subjected to hydraulic pressure of not less than 140 kg per square centimeter and shall be given the initial grinding with machine and grouting of the wearing layer before delivery to site. The wearing layer shall be free from projections, depressions, depressions, cracks, holes, cavities and other blemishes. The edges of wearing layer may be rounded.

3. The proportion of cement to aggregate in the backing of tiles shall be not leaner then 1:3 by weight. Where colouring material is used in the wearing layer, it shall not exceed 10 per cent by weight of cement used in the mix.

4. The finished thickness of the upper layer shall not be less than 5 mm for size of marble chips from the smallest upto 6 mm and also, not less than 5 mm for size of marble chips ranging from the smallest upto 12 mm, and not less than 6 mm for size of marble chips varying from the smallest upto 20 mm.

24.14.3 Laying

24.14.3.1 Base concrete of RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with lime mortar of any of the following Specifications prepared in conformity with provisions in relevant **Clauses of 'Mortar'.**

1. 1:1:2 (1 lime putty: 1 surkhi: 2 coarse sand), or
2. 1:3 (1 lime putty: 3 surkhi), or
3. 1:3 (1 lime putty: 3 coarse sand)

24.14.3.2 The ingredients shall be thoroughly mixed by volume in dry form. Care shall be taken to ensure that there are no hard lumps present. Water shall then be added and the ingredients thoroughly mixed.

24.14.3.3 Where lime putty of proper quality is not available, cement mortar 1:4 (1 cement: 4 coarse sand) bedding may also be used with prior approval of the Engineer.

24.14.3.4 The average thickness of the bedding mortar shall be 30 mm and the thickness at any place shall not be less than 10 mm.

24.14.3.5 Lime mortar bedding shall be spread, tamped and corrected to proper levels and allowed to harden for a day before the tiles are set. If cement mortar is laid in bedding the terrazzo tiles, these shall be set immediately after laying the mortar. Over this bedding neat grey cement slurry of honey like consistency shall be metre over such an area as would accommodate about twenty tiles. Tiles shall be washed clean and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till it is properly bedded, and in level with the adjoining tiles. The joints shall be kept as thin as possible not exceeding 1.5 mm and in straight lines or to suit the required pattern.

24.14.3.6 The surface of the flooring during laying shall be frequently checked with a straight edge atleast 2 metre long, so as to obtain a true surface with the required slope.

24.14.3.7 Where full tiles of half tiles cannot be fixed, tiles shall be cut (sawn) from full tiles to the required size and their edges rubbed smooth to ensure a straight and true joint;

24.14.3.8 Tiles which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plaster and tile work shall be finished neatly and without waviness.

24.14.3.9 After the tiles have been laid, surplus cement grout that may have come out of the joints shall be cleared off.

24.14.4 Curing, Polishing and Finishing

24.14.4.1 The day after the tiles are laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall than be grouted with grey or white cement mixed with or without pigment to match the shape of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

24.14.4.2 The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit block (No 60). Water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to

remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pinhole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No.120).

24.14.4.3 The final grinding with machine fitted with the finest grade grit blocks (No.320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Engineer.

24.14.4.4 For small areas or where circumstances so require, hand polishing may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1. 1st grinding - coarse grade stone (No.60)
2. Second Grinding - medium grade (No.80)
3. Final grinding - fine grade (No.120)

In all other respects, the process shall be similar as for machine polishing.

24.14.4.5 After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square meter sprinkled with water and rubbed hard with a 'namdah' block (pad of woollen rags). The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

24.14.4.6 If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished.

24.14.4.7 The finished floor shall not sound hollow when topped with a wooden mallet.

24.14.5 Measurements

24.14.5.1 Terrazzo tiles flooring with tiles manufactured from ordinary grey cement without pigment and coloured terrazzo tile flooring shall be measured separately and classified as in **Clause 22.11.5**. Terrazzo tile flooring shall be measured as laid in square meter correct to two places of decimal. For length and breadth dimensions correct to a cm before laying skirting, dado or wall plaster shall be taken. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for use of cut tiles not for laying the floor at different levels in the same room or courtyard.

24.14.5.2 Terrazzo tile flooring laid in floor borders and similar band shall be measured under the item of terrazzo tile flooring. Nothing extra shall be paid in respect of these and similar bands formed of half size of multiplies of half size standard tiles or other uncut tiles.

24.14.5.3 Treads of stairs and steps paved with tiles without nosing, shall also be measured under flooring. Moulded nosing shall be paid in running metre except where otherwise stated, returned moulded ends and angles to mouldings shall be included in the description. Extra shall, however, be paid for such areas where the width of treads does not exceed 30 cm.

24.14.6 Rate

24.14.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above. Where cement mortar bedding is used in place of lime mortar the rate will be adjusted accordingly.

24.15 Terrazzo Tiles in Risers of Steps, Skirting and Dado

24.15.1 The terrazzo tiles shall be as specified in **Clause 22.14.1**, as far as applicable. The minimum finished thickness of tiles shall, however, be 12 mm. The finished thickness of the upper layer

shall be not less than 5 mm for size of marble chips from the smallest upto 12 mm and not less than 6 mm for size of chips varying from the smallest upto 20 mm. Where the bigger sized chips are used the tiles shall be not less than 290 mm thick. The requirements of transverse strength tests specified in Appendix B, shall not apply when the tiles used are less than 20 mm thick.

24.15.2 Preparation of Surface

24.15.2.1 The Specification for this shall be same as specified in **Clause 22.9.2**

24.15.3 Laying

24.15.3.1 12 mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) or mix as specified, shall then be applied and allowed to harden. The plaster shall than be roughened with wire brushes or by scratching diagonal lines 2 mm deep at approximately 7.5 cm centres both ways, The back of tiles shall be buttered with a coat of grey cement slurry and edges with grey or white cement slurry with or without pigments to match the shade of tiles, and set in the bedding mortar. These shall be tamped and corrected to proper planes and lines. The tiles shall be set in the required pattern and butt jointed. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated.

24.15.3.2 The risers of steps, skirting or dado shall rest on the top of the tread or flooring. Where full size tiles cannot be fixed, the tiles shall be cut (swan) to the required size and their edges rubbed smooth.

24.15.4 Curing, Polishing and Finishing

24.15.4.1 The Specifications as in **Clause 22.14.3** shall hold good as far as applicable. Polishing shall be done only with hand.

24.15.5 Measurements

24.15.5.1 The thickness of the skirting shall be as stated. Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread or floor to the top (the underside of tread in the case of steps). This shall be measured correct to 5 mm in case of risers and skirting (not exceeding 30 cm in height). In case of heights more than 30 cms, as in the case of dado and on walls, the height shall be measured correct to a cm and such work shall be paid for separately. The area shall be calculated in square metre, correct to two places of decimal.

24.15.5.2 Where the height of risers, skirting or dado does not admit of full size or other finished size tiles and the tiles are to be cut (sawn), nothing extra shall be paid for the same.

24.15.6 Rate

24.15.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

24.15.6.2 Nothing extra shall be payable for use of cut (sawn) tiles to suit the size of risers, skirting, portions of dado etc.

24.16 Chequered Tile Flooring

24.16.1 Chequered Tiles

24.16.1.1 The tiles shall be of nominal sizes such as 20 x 20 cm 25 x 25 cm and 30 x 30 cm or of standard sizes with equal sides. The size of tiles to be used shall be as shown in Drawings or as required by the Engineer. The centre to centre distance of chequers shall not be less then 2.5 cm and not more than 5 cm.

24.16.1.2 The overall thickness of the tiles shall not be less than 22 mm. The grooves in the chequers shall be uniform and straight. The depth of the grooves shall not be less than 3 mm. The chequered tiles shall be cement tiles, or terrazzo tiles as specified in the description of the item. The thickness of the upper layer, measured from the top of the chequers shall not be less than 6 mm.

24.16.1.3 The terrazzo tiles shall be given the first grinding with machine before delivery to site.

24.16.1.4 The tiles shall conform to the Specifications for plain cement concrete or terrazzo tiles in respect of method of manufacture and the mix of the backing and wearing layers.

24.16.2 Laying, curing, Polishing and Finishing

24.16.2.1 These shall be as specified in **Clause 22.14.2 and 22.14.3** except that the polishing of the tiles and the chequer grooves, after laying, may be done by hand. Special care shall be taken to polish the grooves in such a manner as to get a uniform section and that their finish shall match with the finish of flat portion of the tiles. Cement concrete files normally do not require polishing concrete tiles normally do not require polishing but where polishing is required the same shall be done as described above.

24.16.3 Measurement and Rate

24.16.3.1 Measurement and Rate shall be as specified in **Clause 22.14.4 and 22.14.5**

24.17 Chequered Tiles in Stair Treads

24.17.1 Chequered Tiles

24.17.1.1 The Specifications for tiles shall be as specified in **Clause 22.16.1** except in the following respects:

1. The length of the tiles including nosing shall be as specified.
2. The nosing edge of the tile shall be rounded.
3. The minimum thickness of the tile shall be 30 min.
4. The front portion of the tile for a minimum length of 75 mm from and including the nosing shall have grooves running to the nosing and at centres not exceeding 25 mm. Beyond that the tiles shall have the normal chequer pattern.
5. The nosing shall also have the same wearing layer as the top.

24.17.2 Preparation of Surface and Laying

24.17.2.1 RCC or brick work in treads on which the tiles are to be laid shall be cleaned wetted and mopped. The bedding for tiles shall be with lime mortar of either 1:1:1 (1 lime putty: 1 surkhi: 1 coarse sand) or 1:4 (1 cement: 4 course sand) or of specified mix. The minimum thickness of bedding mortar at any place shall be 10 min. Bedding mortar shall be spread, tamped and corrected to proper levels. After laying bedding mortar, neat grey cement slurry of honey like consistency shall be spread over the mortar at the rate of 4.4 kg of cement per square metre over each tread. Tiles shall be washed cleaned and shall be fixed in this grout one at another. Each tile being gently tapped with a wooden mallet till it is properly bedded, and is in level and line with the adjoining tiles. The joints shall be kept ass thin as possible and in straight lines. The surface shall be checked with a straight edge during laying to obtain a true surface.

24.17.2.2 The square end of the tile shall, as far as possible butt against the riser face of the concrete or brick tread and in any case shall be embedded under the side wall plaster, skirting or dado and under the riser tile or other finish to a depth of not less than 10 min.

24.17.2.3 Where full size tiles cannot be fixed, these shall be cut (sawn) to the required size (along the groove of the chequers where the cut edge is exposed) and used. The cut in the case of embedded edges will be neat and true while the cut in the case of exposed edges shall in addition be rubbed smooth to ensure a straight and true joints.

24.17.2.4 After the tiles have been laid surplus cement grout shall be cleaned off.

24.17.3 Curing, Polishing and Finishing

24.17.3.1 The Specifications shall be as described in **Clause 22.14.3** except that polishing of the treads nosing and chequered grooves, after laying, may b done by hand in the same manner as specified under terrazzo the flooring. Special care shall be taken to polish the nosing and the grooves in such a manner as to get a uniform, section for the grooves and the nosing and their finish shall match with the finish of the flat portion of the tiles.

24.17.4 Measurements

24.17.4.1 Chequered tiles on stair treads shall be measured in square metre correct to two places of decimal. Length shall be measured correct to a cm before laying skirting, dado or wall plaster. Width shall be measured correct to a cm from the outer edge of the nosing, as laid, before providing the riser. In the case of the edge tiles of the landing and wide steps, width shall be measured upto the near edge of the chequered stair tread tiles. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas exceeding 0.10 square metre.

24.17.5 Rate

24.17.5.1 The rate shall include the cost of all materials and labour involved in the all the operations described above.

24.17.5.2 Nothing extra shall be payable for cutting the tiles to suit the size of treads and also for nosing.

24.18 Glazed Tile Flooring

24.18.1 White glazed tiles

24.18.1.1 The tiles shall be of approved make and shall generally conform to IS: 777-1988. They shall be flat, and true to shape sand free from blisters crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tiles shall be tested as indicated in Appendix of IS: 777-1988.

24.18.1.2 The tiles shall be square or rectangular of nominal size as 150 X 150 mm, 100 x 100 mm, 100 x 200 mm or as directed by the Engineer. The thickness of the tiles shall be 5 mm, or 6 mm as specified. The length of all four sides shall be measured correct to 0.1 mm and average length breadth shall not vary more than $\pm$ 0.8 mm from specified dimension. The variation of individual dimension from average value of length/breadth shall not exceed $\pm$ 0.5 mm. Tolerance in thickness shall be $\pm$ 0.4 mm.

Note (1): Where tiles of nominal sizes of 150 x 150 mm or 100x100 mm are not available tiles of nominal sizes 152 mm x 152 mm or 108 mm x 108 mm may be allowed to be used with prior approval of the Engineer.

Note (2): The actual size of tiles supplied shall be 1 mm less so that with 1 mm joint, the tile when laid shall conform to the nominal size.

24.18.1.3 The top surface of the tiles shall be glazed and glaze shall be either glossy or matt as specified. The underside of the tiles shall not have glaze on more than 5 percent of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be preferably to the base. The edges of the tiles shall be preferably free from glaze. However, any glaze if unavoidable, shall be permissible on only upto 50 per cent of the surface area of the edges.

24.18.2 Coloured Tiles

24.18.2.1 Only the glaze shall be coloured as specified. The sizes and Specifications shall be the same as for the white glazed tiles.

24.18.3 Preparation of Surface and Laying

24.18.3.1 Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:3 (1 cement: 3 coarse sand) or as specified. The average thickness of the bedding shall be 10 mm while the thickness under any portion of the tiles shall not be less than 5 mm.

24.18.3.2 Mortar shall be spread, tamped and corrected to proper levels and allowed to harden and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

24.18.3.3 Over this mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

24.18.3.4 The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope.

24.18.3.5 Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

24.18.3.6 Tiles which are fixed in the floor adjoining the wall shall enter not less than 10 mm under the plaster, skirting shall be cleaned off.

24.18.3.7 After tiles have been laid surplus cement slurry shall be cleaned off.

24.18.4 Pointing and Finishing

24.18.4.1 The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

24.18.5 Measurements

24.18.5.1 Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where covers are used at the junctions, the length and breadth shall be measured between the lower edges of the cover.

24.18.5.2 No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall hot be made for areas not exceeding 0.10 square metre.

24.18.6 Rate

24.18.6.1 The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be paid for the use of cut (sawn) tiles in the work.

24.18.6.2 Extra over and above the normal rate for white tiles shall be paid where coloured or any other type of decorative tiles have been used.

24.19 Glazed Tiles in Skirting and Dado

24.19.1 The tiles shall be of approved make and shall generally conform to IS: 777-1988. The tiles shall of earthenware covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound., true to shape, flat and free form flaws and other manufacturing defects affecting their utility. The top surface of the tiles shall be glazed. The underside of the ties shall not have glaze on more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze, however, any glaze if unavoidable shall be permissible on only upto 50 percent of the surface area of edges. The glaze shall be free from welts, chips, craze, specks, crawlings or other imperfections detracting from the appearance when viewed from a distance of one metre. The glaze shall be either glossy or matt as specified. The glaze shall be white in colour except in the case of coloured tiles when colours shall be specified by the Engineer. There may be more than one colour on a tile.

24.19.1.1 Dimensions and Tolerances

1. Glazed earthenware tiles shall be made square or rectangular in sizes such 149 x 149 mm and 99 x 99 mm or 99 x 199 mm or as specified and shall be straight of cushion edge type.

2. Half tiles for use as full tiles shall be dimensions which shall be such as to make the half tiles when jointed together (with 1mm joint) match with dimensions of full tiles. Tiles may be manufactured in sizes other then those specified. Above.

   Note: Commonly manufactured sizes include 108 x 108 mm, 152 x 152 mm, 200 x 200 mm, 200 x 150 mm and 200 x 100 mm.

3. The thickness of the tiles shall be 5 mm or 6 mm as specified.

4. The dimensions of fittings associated with the glazed tiles namely cove base, round edge tile, angles corner cups, ridge and legs, cornices and capping beads shall be of the shape and dimensions as required and the thickness of fittings shall be the same as the thickness of tiles given above.

24.19.1.2 Tolerances

1. Facial dimensions - The lengths of all the four sides of the tile shall be measured to the nearest 0.1 mm. The average value of lengths/breadth shall not vary more than $\pm$ 0.8 mm from the above specified dimension.

2. The variation of individual dimensions from average value of length/breadth shall not exceed $\pm$ 0.56 mm Tolerances on thickness shall be $\pm$ 0.4 mm.

3. Tiles shall be checked for squareness and warpage as described thereafter.

24.19.1.3 Trueness of shape (squareness)

Any variation from a right angle in the angle contained by any two adjoining sides shall be limited so that if a builder's steel square is placed against the angle, the distance between the inner edge of the square and the adjacent side of the tile or fitting shall not be more than 0.5 mm per 100 mm run.

24.19.1.4 Warpage

The tiles when tested for warpage on the edges and on the diagonal as per Appendix - A - IS: 777-1988 shall not have warpage exceeding the value as specified below:

Size of tile (mm)	Warpage (mm)
149 x 149	-0.4
	+0.7
99 x 99	-0.3
	+1.5

24.19.1.5 Performance Requirements Water absorption

The average water absorption of the tiles when tested and evaluated in accordance with IS 777-1988 shall not exceed 20 per cent.

Crazing: Tiles subjected to two cycles of crazing test as per IS: 777-1988 shall not show any sign of crazing.

Impact Resistance: tiles when tested for impact resistance as per IS: 77-1988 shall remain intact, apart from surface marking.

Chemical Resistance: when tested as per IS: 777-1988 the glazed surface of tiles and /or the fittings having a white or cream coloured glossy glaze shall show no modification.

24.19.2 Preparation of Surfaces

24.19.2.1 The joints shall be raked out to a depth of atleast 15 mm in masonry walls.

24.19.2.2 In case of concrete walls, the surface shall hacked and roughened with wire brushes. The surface be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

24.19.3 Laying

24.19.3.1 12 mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) mix of as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals.

24.19.3.2 The tiles should be soaked in water, washed clean, and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and jointed. The joints shall be as fine as possible. Top of skirting or dado shall truly horizontal and joints truly vertical except where otherwise indicated. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edges rubbed smooth.

24.19.4 Curing and finishing

24.19.4.1 The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days.

24.19.4.2 After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

24.19.5 Measurements

24.19.5.1 Length shall be measured correct to a cm. Height shall be measured correct to a cm in the case of dado and 5 mm in the case of riser and skirting. The area shall be calculated in square metre, correct to two places of decimal. Length and height shall be measured along the finished face of the skirting or dado including curves where specials such a coves, internal and external angles and beads are used. Where cornices are used the area of dado shall be measured excluding the cornices. Nothing extra will be paid for cutting (sawn) the tiles to sizes.

24.19.5.2 In addition to payment for areas of skirting and dado, specials such as coves, internal and external angles and beads shall be measured separately and paid for in running metres. Cornices shall also be similarly measured for payment in running metres. Areas where coloured tiles or different types of decorative tiles used will be measured separately to be paid extra over and above the normal rate of white tiles.

24.19.6 Rates

The rate shall include the cost of all material and labour involved in all the operations described above. The specials such as coves, internal and external angles and beading shall be measured and paid for separately. The rate shall not include cost of cornices which shall be measured and paid for in running meters separately.

24.20 Marble Flooring

24.20.1 Dressing of slabs

24.20.1.1 Every stone shall be cut to the required size and shape, fine chisel dressed on all sides to the full depth so that a straight edge lain along the side of the stone shall be fully in contact with it. The top surface shall also be fine chisel dressed to remove all waviness. In case machine cut slab are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid any where along the machine cut surfaces is in contact with every point on it. The sides and top surface of slab shall be machine rubbed or table rubbed with coarse sand before paving. All angles and edges of the marble slabs shall be true, square and free from chippings and the surface shall be true and plane.

24.20.1.2 The thickness of the slabs shall be 20,30 or 40 mm as specified in the description of the item. Tolerance of + 3 % shall be allowed for the thickness. In respect of length and breadth of slabs a tolerance of + 2 % shall be allowed.

24.20.2 Laying

24.20.2.1 Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 Cement: 4 coarse sand) or with lime mortar (1 lime putty: 1 surkhi: 1 coarse sand) as given in the description of the item.

24.20.2.2 The average thickness of the bedding mortar under the slab shall be 20 mm and the thickness at any place under the slab shall be not less than 12 mm.

24.20.2.3 The slabs shall be laid in the following manner:

1. Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per sqm. The edges of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the marble slabs as given in the description of the item.

2. The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels, and, slopes as instructed by the Engineer.

3. Due care shall be taken to match the grains of slabs which shall be selected judiciously having uniform pattern of Veins/streaks or as directed by the Engineer.

4. The slabs shall be matched as shown in Drawings or as instructed by the Engineer.

5. Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster and floor shall be finished neatly and without waviness.

24.20.3 Polishing and Finishing

24.20.3.1 Slight unevenness at the meeting edges of slabs shall then be removed by fine chiselling and finished in the same manners as specified in **Clause 22.14.3**. except that cement slurry with or without pigments shall not be applied on the surface before each polishing.

24.20.4 Measurements

24.20.4.1 Marble stone flooring with different kind of marble shall be measured separately and in square metre correct to two places of decimal. Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. No deduction shall be made nor extra. Paid for voids not exceeding 0.20 square metre. Deductions for ends of similar materials or other articles embedded shall no be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room. Steps and treads of stairs paved with marble stone slabs shall also be measured under the item of Marble Stone flooring. Extra shall, however, be paid for. Such areas where the width of treads does not exceed 30 cm. Nosing for treads shall be measured in running metre and paid for extra. The width of treads shall be measured from the outer edge of the nosing, as laid, before providing the riser.

24.20.5 Rate

24.20.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

24.21 Marble Stone in Risers of Steps and Skirting

24.21.1 Dressing of Slabs shall be as specified in **Clause 22.20.1** except that the thickness of slabs shall be 30 mm. A tolerance of $\pm$ 3 mm shall be allowed unless otherwise specified in the description of the item.

24.21.2 Preparation of Surface

24.21.2.1 It shall be as specified in **Clause 22.19.2** where necessary, the wall surface shall be cut uniformly to the requisite depth so that the skirting face shall have the projection from the finished face of wall as shown in Drawings or as required by the Engineer.

24.21.3 Laying

24.21.3.1 The risers of steps and skirting shall be in grey or white cement admixed with or without pigment to match the shade of the stone, as specified in the description of the item, with the line of the slab at such a distance from the wall that the average width of the gap shall be 12 mm and at no place the width shall be less then 10 mm, if necessary, the slabs shall be held

in position by temporary MS hooks fixed into the wall at suitable intervals. The skirting or riser face shall be checked for plane and plumb and corrected. The joints shall thus be left to harden then the rear of the skirting or riser slab shall be packed with cement mortar 1:3 (1 cement: 3 coarse sand) or other mix as specified in the description of the item. The fixing hooks shall be removed after the mortar filling the gap has acquired sufficient strength.

24.21.3.2 The joints shall be as fine as possible. The top line of skirting and riser shall be truly horizontal and joints truly vertical, except where otherwise indicated

24.21.3.3 The risers and skirting slab shall be matched as shown in Drawings or as instructed by the Engineer-in Charge.

24.21.4 Curing, Polishing and Finishing

24.21.4.1 It shall be as specified in **Clause 22.14.3** as far as applicable, except that cement slurry with or without pigment shall not be applied on the surface and polishing shall be done only with hand. The face and top of skirting shall be polished.

24.21.5 Measurements

24.21.5.1 Length shall be measured along the finished face of riser or skirting, correct to a cm. Height shall be measured from the finished level of tread or floor, to the top (the underside of tread, in the case of steps) correct to 1 mm. The areas shall be calculated in square metre correct to two places of decimal.

24.21.5.2 Dado and lining of pillars etc. Shall be measured as ‘Marble work in wall lining’. If the thickness it upto 25 mm or as “Marble Work” in Jambs, walls, columns and other plain work’ if the thickness is more.

24.21.6 Rate

24.21.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

24.22 Kota Stone Flooring

24.22.1 Kota Stone Slabs

24.22.1.1 The slabs shall be of selected quality, hard, sound, dense and homogenous in texture free from cracks, decay, weathering and flaws, The shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the Drawings or as instructed by the Engineer.

24.22.1.2 The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work the Contarctor shall get samples of slabs approved by the Engineer.

24.22.2 Dressing

24.22.2.1 Every slap shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.

24.22.2.2 The thickness of the slab after it is dressed shall be 20,25, 30 or 40 mm as specified in the description of the item. Tolerance of $\pm$ 2 mm shall be allowed for the thickness. In respect of length and breadth of slabs Tolerance of $\pm$ 5 mm for hand cut slabs and $\pm$ 2 mm for machine cut slabs shall be allowed.

24.22.3 Preparation of Surface and Laying

24.22.3.1 The Specification shall be as described in **Clause 22.20.2** except that the edges of the slabs to be jointed shall be buttered with grey cement, with admixture of pigment to match the shade of the slab.

24.22.4 Polishing and Finishing

24.22.4.1 The Specifications shall be as described in **Clause 22.14.3** except that (a) first polishing with coarse grade carborundum stone shall not be done, (b) cement slurry with or without pigment shall not be applied on the surface before polishing.

24.22.5 Measurements and Rates

24.22.5.1 These shall be as described in **Clause 22.20.4 and 22.20.5**.

24.23 Kota Stone in Risers of Steps, Skirting and Dado

24.23.1 Kota Stone Slabs and Dressing shall be as specified in **Clause 22.22.1 and 22.22.2** except that the thickness of the slabs shall be 25 mm or as specified in the description of the item. The slabs may be of uniform size if required.

24.23.2 Preparation of surface shall be as specified in **Clause 22.21.2**

24.23.3 Laying shall be as specified in **Clause 22.21.3** except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

24.23.4 Curing, Polishing and Finishing shall be as specified in **Clause 22.21.4** except that first polishing with coarse grade carborundum stone shall not be done.

24.23.5 Measurements

24.23.5.1 Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread of floor at the top (the underside of tread in the case of steps). This shall be measured correct to a mm in the case of risers of steps and skirting and correct to a cm in the case of dado. The area shall be calculated in square metre correct to two places of decimal.

24.23.5.2 Lining of pillars etc. Shall also be measured under this item.

24.23.6 Rate

24.23.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

24.24 Red or White Rough Dressed Sand Stone Flooring

24.24.1 Stone Slabs

24.24.1.1 The slabs shall be red or white as specified in the description of the item. The stone slabs shall be hard, sound, durable and tough, free from cracks, decay and weathering. In case of red sand stone, white patches or streaks shall not be allowed. However, scattered spots upto 10 mm diameter will be permitted. Before starting the work the Contarctor shall get samples of slabs approved by the Engineer.

24.24.1.2 The slabs shall be hand or machine cut to the requisite thickness along planes parallel to the natural bed of stone and should be of uniform size if required.

24.24.2 Dressing of Slabs

24.24.2.1 Every slab shall be cut to the required size and shape, and rough chisel dressed on the top, so that the dressed surface shall not be more than 6 mm from a straight edge when placed on it. The edge of depressions or projections shall be chisel dressed in a slant so that the surface does not have sharp unevenness. The sides shall also be chisel dressed to a minimum depth of 20 mm so that the dressed edge shall at no place be more than 30 mm from a straight edge butted against it. Beyond this depth the sides may be dressed slightly splayed so as to form inverted 'V' shaped joint with adjoining slabs. All angles and edges of the slabs shall be true, square and free from chippings and the surface reasonably true and plane.

24.24.2.2 Where slabs are used for treads without nosing, the exposed edges shall be rough chisel dressed to full depth and cut to uniform thickness.

24.24.2.3 The thickness of the slabs after it is dressed shall be 40 mm or as specified in the description of the item with a permissible tolerance of $\pm$2 mm.

24.24.3 Laying

24.24.3.1 Base concrete on which the slabs are to be laid shall be cleaned, wetted and moped. The bedding for the slabs shall be with cement mortar 1:5 (1 cement: 5 coarse sand) or with the lime mortar 1:1:1 (1 lime putty: 1 surkhi: 1 coarse sand) or as given in the description of the item.

24.24.3.2 The average thickness of the bedding mortar under the slabs shall be 20 mm and the thickness at any place under the slabs shall not be less than 12 mm.

24.24.3.3 The slab shall be laid in the following manner:

24.24.3.4 Mortar of specified mix shall be spread under each slab. The slab shall be washed clean before laying. It shall then be laid on top, pressed and larried, so that all hollows underneath get filled and surplus mortar works up through the joints. The top shall be tapped with a wooden mallet and brought to level and close to the adjoining slabs, with thickness of joint not exceeding 5 mm. Subsequent slabs shall be laid in the same manner. After laying each slab surplus mortar on the surface of slabs shall be cleaned off and joint finished flush.

24.24.3.5 In case pointing with other mortar mix is specified, the joint shall be left raked out uniformly and to a depth of not less than 12 mm when the mortar is still green The pointing shall be cured for a minimum period of 7 days. The surface of the flooring as laid shall be true to levels and slopes as instructed by the Engineer.

24.24.3.6 Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plaster skirting and floor shall be finished neatly and without waviness.

24.24.3.7 The finished floor shall not sound hollow when tapped with wooden mallet.

24.24.4 Finishing

24.24.4.1 Any unevenness existing between the edges of slabs at joints shall be removed by chiselling in a slant.

24.24.5 Measurements

24.24.5.1 These shall be as specified in **Clause 22.20.4**.

24.24.6 Rate

24.24.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above. Where pointing is to be done, this will be paid extra unless specifically included in the description of the item.

24.25 Red or White Fine Dressed Sand Stone Flooring

24.25.1 Stone slab shall be as specified in **Clause 22.24.1**.

24.25.2 Dressing

24.25.2.1 Every slab shall be cut to the required size and shape and chisel dressed on all sides to a minimum depth of 20 mm. The top and the joints shall be fine tooled so that straight edge laid along the face is fully in contact with. In case machine cut stones are used, chisel dressing and fine tooling of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surface is in contact with every point on it.

24.25.2.2 The thickness of the slabs after dressing shall be 40 mm or as specified in the description of item with a permissible tolerance of $\pm$ 2 mm.

24.25.3 Laying

24.25.3.1 Shall be as specified in **Clause 22.24.3**.

24.25.4 Finishing

24.25.4.1 In case of chisel dressed stone flooring slight unevenness, if any existing between the edges of slabs at joints shall then be removed by chiselling in a slant.

24.25.5 Measurement and Rate

24.25.5.1 Measurement and Rate shall be as specified in **Clause 22.24.5 and 22.24.6**

24.26 Red or White Fine Dressed and Rubbed Sand Stone Flooring

24.26.1 Stone slabs shall be as specified in **Clause 22.24.1**.

24.26.2 Dressing

24.26.2.1 The Specifications for dressing the top surface and the sides shall be as described in **Clause 22.24.2** In addition the dressed top and sides shall be table rubbed with coarse grade carborundum stone before paving, to obtain a perfectly true and smooth surface free from chisel marks.

24.26.2.2 The thickness of the slabs after dressing shall as specified with a permissible tolerance of $\pm$ 2 mm

24.26.3 Laying

24.26.3.1 The slab shall be laid with 3mm/5mm thick joint or as specified in the item.

24.26.3.2 Where the joints are to be limited to 5 mm thickness, the slabs shall be laid as specified in **Clause 22.20.3** except that the bedding mortar shall be as specified in **Clause 22.24.3** and sides of the slabs to be jointed shall be buttered with cement mortar 1:2 (1 cement: 2 stone dust) admixed with pigment to match the shade of the slab.

24.26.3.3 Where the slabs are to be laid with 5 mm thick joints, the Specifications for laying shall be as described in **Clause 22.24.3**.

24.26.4 Finishing

24.26.4.1 Finishing shall be specified in **Clause 22.24.4** except that chisel marks and unevenness shall be removed by rubbing with coarse grade carborundum stone.

24.26.5 Measurement and Rate

24.26.5.1 Measurement and Rate shall be as specified in **Clause 22.24.5 and 22.24.5**.

24.27 Cast Iron Grid Tiles Flooring

24.27.1 Cast Iron Grid tiles flooring shall consist of cast iron grids to give design, laid on a strong, with the hollows filled with cementing materials. This type of flooring is suitable in factories bakeries, dairies and similar structures where resistance to abrasion from iron tyred trolleys is a prime consideration

24.27.2 Cast Iron Grid Tiles

24.27.2.1 Tiles shall be manufactures from cast iron conforming to IS: 210-1978. The tile shall be of the dimensions and weight per square metre specified in the description of the item. Variation in weight to the extent of 5% on either side shall be permissible. The ribs of the tiles shall be tapering down with the thicker end at top so that the cementing materials filling the hollows between them is held fast and prevented from getting loose on the top. The tiles shall be of size such 20 x 20 cm, 30 x 30 cm or 38 x 38 cm as shown in the Drawings or as directed by the Engineer. Where the room lengths and widths are not exact multiples of the size of the tiles, the end rows shall be laid with fractional tiles. The top surface of the tiles shall be ground smooth while sides of the hollows shall be left in the rough cast state.

24.27.3 Base concrete

24.27.3.1 The cast iron grid flooring shall be laid on a base which shall conform to the Specifications given in **Clause 22.5.2** of cement concrete flooring. The base shall designed to withstand the load coming on the floor.

24.27.4 Laying

24.27.4.1 The base concrete or the RCC slab on which the grid tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the grid tiles shall consist of 1:2 cement and concrete (1 cement: 2 stone aggregate 6 mm nominal size) laid to 12 mm thickness tamped and corrected to proper levels. The bedding concrete shall be laid each time, over such an area as would accommodate about 8 to 10 tiles. The grid tiles shall be laid one by one pressed into the bedding tapped with a wooden mallet so that the concrete works up into the hollows of the grid tiles about 3 mm and the top face of the tile as at the correct finished level and plans.

24.27.4.2 The hollow shall be immediately filled in with cement concrete of the same mix tamped with 10 mm dia iron bars and the entire surface including width of joints finished 6 mm below the top. Subsequent tiles shall be laid in the same manner, the joints between adjacent tiles being not more than 3 mm wide. The joints and top 6 mm of the hollows shall then be grouted with neat cement slurry. The surface of the flooring shall be frequently checked with a straight edge at least 2 metre long during laying, so as to obtain a true surface, The surface shall then be cleaned of all mortar droppings. The finished surface shall have no raised edges. The surface of the flooring shall made smooth where necessary.

24.27.4.3 Tiles which are fixed adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado.

24.27.4.4 The surface shall be kept wet for a period of not less then seven days.

24.27.4.5 In special cases it may be required that the concrete bedding and the filling of the hollows and joints shall be acid or alkali resistant, in which case special type of cement to meet the

particular requirements shall have to be used instead of ordinary grey cement. In such cases., the types of special cement shall be specified in the description of the item.

24.27.5 Measurements

24.27.5.1 Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster, The area shall be calculated in square metre correct to two places of decimal. No deduction shall be made nor extra paid for void not exceeding 0.20 square metre. Deductions for ends of dissimilar material or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

24.27.6 Rate

24.27.6.1 The rate shall include the cost of all materials and labour involved in all the operations described above except the cost of base concrete. Nothing extra shall be paid for use of fractional tiles.

24.28 Acid Proof Flooring

24.28.1 General

24.28.1.1 The finishing as specified below shall be applied on the surface to be finished, i.e., RCC floor slab, PCC layer in ground floor or masonry wall, depending on the conditions.

24.28.2 Materials

24.28.2.1 The following materials shall be used.

1. BITROK Primer or equivalent conforming to IS: 3384
2. BITROK Mastic or equivalent conforming to IS: 1195
3. KERA SINTERED acid-proof tiles or equivalent conforming to IS: 4457
4. VICRON silicate based acid-proof cement mortar or equivalent conforming to IS: 4832 (Part-1).
5. RESILAX acid-proof cement mortar or equivalent conforming to IS: 4382 (Part -2).

24.28.3 Laying the flooring:

24.28.3.1 The flooring shall be laid over the clean, green surface. Before laying the primer coats, the sub-base shall be cleaned off all dirt, scum or laitance, and of loose materials. The surface shall be left rough by suitable means.

24.28.3.2 Above the prepared surface, two coats of bitrok primer as specified shall be applied. Above it a layer of acid resistant Bikrock mastic shall be laid. The thickness shall be 6 mm. This layer shall be allowed to dry for sufficient time. A bed of silicate based acid proof cement mortar 6 mm shall then be laid.

24.28.3.3 Over this surface 100 mm x 200 mm size acid-proof tiles shall be laid correct to line and alignment. The thickness of tiles shall be 20 mm. The dimensions shall be varied if so required in the Bill of Quantities.

24.28.3.4 The joints of the tiles thus laid shall be pointed using acid-proof mortar. The surface shall be rendered smooth to suit the best serviceable conditions.

24.28.3.5 Similar operations shall be carried out in skirting and dadoing.

24.28.3.6 The surface shall be kept wet for 7 days.

24.28.4 Measurement of Payment

24.28.4.1 The floor area shall be worked out correct to a sqm from the lengths measured correct to 10 mm for flooring and dadoing. For skirting, the length shall be measured correct to 10 mm. The payment for skirting will be for length only, the width being specified. The quoted rate is deemed to include all the materials and workmanship required for the execution of the work as specified above.

24.28.5 Rate

24.28.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above except the cost of base concrete. Nothing extra shall be paid for use of fractional tiles.

APPENDIX - A

ABRASION TEST FOR CONCRETE HARDENING COMPOUNDS (Clause 22.7.1.)

A-1. Preparation of Sample

25 mm cylinder shall be prepared in ratio 1:2 (1 cement: 2 graded stone) aggregate 6 mm nominal size by weight one each with and without the admixture of concrete hardening compound. The concrete hardening compound shall be used in the proportion by weight of cement as recommended by the firm. The cylinder shall be placed inside a damp box for 24 hours and then cured in water for 27 days. After that, they shall be subject to abrasion test on 'Dorry Type Avery Abrasion Testing Machine, using Emery Powder No.80 as the abrasing medium under the condition given in A2 below:

A-2. Conditions of Test

Area of rubbing surface shall be same in both cylinders.

Age of cylinder	28 days
Duration of Test	60 minutes
Total distance transversed during rubbing	About 2.4 km
Pressure on rubbing surface	0.04 kg/cm^2

A-3. Results of Tests

The following observations shall be made in both the cases:

Composition of the Test specimen
Mean thickness rubbed away
Percentage loss in weight

A-4. Remarks

Percentage loss in weight in the case of cylinders with concrete hardening compound, should not be more than 40 % of the percentage loss in the case of cylinder without concrete hardening compound.

APPENDIX - B

TEST REQUIREMENTS AND PROCEDURE FOR TESTING

"PRECAST CEMENT CONCRETE/TERRAZZO TILES" (Clause 22.14.1 & 22.15.1)

B-1. Sampling

The tiles required for carrying out test described below shall be taken by 'random sampling'. Each tile sample shall be marked to identify the consignment from which it was selected.

Minimum quantity of tiles for carrying out the test and frequency of test shall be as specified in the list of Mandatory Test. The number of tiles selected for each mandatory test shall be as follows:

1.	For conformity to requirements on shape and dimensions, wearing layer, and general quality	12 tiles
2.	For wet transverse strength test	6 tiles
3.	For resistance to wear test	6 tiles
4.	For water absorption	6 tiles

Note 1: The test on the tiles shall not be carried out earlier than 28 days from the date of manufacture.
Note 2: The tiles selected for 1 may as well after verification of requirements, be used for 2.

B-2. Wet transverse Strength Test

Six full size tiles shall be test for the determination of wet transverse strength. When tested according to the procedure laid down in Appendix 'E' if IS: 1237-1980, the average wet transverse strength shall not be less than 3 N/mm^2 (30 kgf/cm^2).

B-3. Resistance to Wear Test

B-3-1. Not less than twelve specimens shall be prepared as described in B.3.2 from the tiles selected in accordance with B.1. When tested in the manner specified in B.3.3.1. to B. 3.3.4 their average wear shall not exceed 3.5 mm and the wear on any individual specimen shall not exceed 4 mm.

B.3.2. Preparation of Test Specimens

The test specimens shall be square in shape and of size 7.06 cm x 7.06 cm (i.e., 50 sq. Cm in area)They shall be sawn off one only from each tile, preferably from the central part of the file. The deviation in the length of the specimen shall be within $\pm$ 2 per cent. The surface to be tested shall be ground smooth and filling removed.

B.3.3. Apparatus and Accessories.

B.3.3.1 Abrasion Testing Machine

The abrasion test of specimens shall be carried out in a machine conforming essentially to the requirements described in IS: 1237 -1980. The abrasive powder used for the test shall conform to the Specification given below:

The abrasive shall have an aluminium oxide content of not less than 95 per cent by weight. The grains shall be rounded shape and shall generally pass through IS Test Sieve 25 and be retained on IS test Sieve 20. The combined content of larger grains whose finest is not limited, shall not exceed 10 per cent. The specific gravity of the grains shall be between 3.9 and 4.1. The grains shall generally have hardness of 9 in Mohr's scale.

B.3.3.2. Measuring Instruments

A suitable instrument capable of measurements to an accuracy of 0.01 mm shall be used for determining the change in the thickness of the specimen after abrasion.

B.3.3.3. Procedure of Test

The specimen shall be dried at 110 degree centigrade for 24 hours and then weighed to the nearest 0.1 gm. The specimen after initial drying and weighing shall be placed in the thickness measuring apparatus with its wearing surface upper most and the reading of the measuring instrument taken.

The grinding path of the disc of the abrasion testing machine shall be evenly strewn with 20 gm of the abrasive powder. The specimen shall then be fixed in the holding device with the surface to be ground facing the disc and loaded at the centre with 30 kg. The grinding disc shall then be put in motion at a speed of 30 rpm. After every 22 revolutions, the disc shall be stopped, the abraded tile powder and the remainder of the abrasive powder shall be removed from the disc and fresh abrasive powder in quantities of 20 gm applied each time. After 110 revolutions, the specimen shall be turned about the vertical axis through an angle of 90 degree and then the test continued under the same conditions until 220 revolutions have been completed altogether. The disc, the abrasive powder and the specimen shall be kept dry throughout the duration of the test. After the abrasion is over, the specimen shall be rewieghed to the nearest 0.1 gm. It shall then be placed in the thickness measuring apparatus once again in the identical manner and the reading taken with the same position and setting of the dial guage as for the measurement before abrasion.

B.3.3.4. Determination of Wear

The wear shall be determined from the difference in readings obtained by the measuring instrument before and after the abrasion of the specimen. The value shall be checked up with the average loss in thickness of the specimen obtained by the following formula.

$$t = 10 \times (W_1 - W_2) \times V_1 / (W_1 \times A)$$

where:

t = Average loss in thickness, in mm;
W_1 = Initial weight, in gm of the specimen;
W_2 = Final weight, in gm of the abraded specimen
V_1 = Initial volume, in C.C., of the specimen, and
A = Surface area, in sqcm of the specimen.

B-4. Water Absorption

B-4.1. At the time of delivery to the site of the work, not less than six full tile specimens, selected in accordance with B_1, shall be prepared and then tested as described below, their average percentage of water absorption shall not exceed ten.

B.4.4.2. Preparation of Specimen.

Full size tiles shall be used for this test. They shall be immersed in water for 24 hours., then taken out, wiped dry and tested for water absorption.

B.4.3. Procedure of Test

Each tile shall be weighed immediately after saturation and wiping as in B.3.2. The tile shall be oven dried a temperature of 65 $\pm$ 1 degree centigrade for a period of 24 hours, cooled to room temperature and reweighed.

B.4.4. Determination of Water Absorption

The water absorption pre cent by weight for each tile shall be determined as follows:

On oven dry basis water absorption per cent by

Weight = $(W_1 - W_2) \times 100 / W_2$

Where

W_1 = Weight in gm of the saturated specimen: and
W_2 = Weight in gm of the oven dried specimen

The average value for percentage water absorption shall be calculated for the whole number of tiles tested.

25 ROOFING

25.1 Scope

25.1.1 These Specifications cover the general requirements of different kinds of roofing.

25.2 Applicable Codes

25.2.1 The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the Codes shall be referred to.

IS: 73-1992	Specification for Paving Bitumen (2nd Revision)
IS: 277-1992	Galvanised Steel Sheets (Plain and Corrugated) (5th Revision)
IS: 458-1988	Specification for Precast Concrete Pipes (with and Without Reinforcement) (3rd Revision)
IS: 459-1992	Corrugated and Semi Corrugated Asbestos Cement Sheets (3rd Revision)
IS: 651-1992	Salt Glazed Stone Ware Pipes and Fittings (5th Revision)
IS: 702-1988	Specification for Industrial Bitumen (2nd Revision)
IS: 1199-1959	Methods of Sampling and Analysis of Concrete (Reaffirmed 1991)
IS: 1200-1973 (Part:IX)	Method of Measurement of Building and Civil Engineering Works Part IX: Roof Covering (including Cladding) (Reaffirmed 1992) (2nd Revision)
IS: 1200-1973 (Part:X)	Method of Measurement of Building and Civil Engineering Works Part 10 Ceiling and Lining (Reaffirmed 1992) (2nd Revision)
IS: 1202-1978	Determination of Specific Gravity (Reaffirmed 1990)
IS: 1203-1978	Determination of Penetration (Reaffirmed 1990)
IS: 1205-1978	Determination of Softening Point (Reaffirmed 1988)
IS: 1208-1978	Determination of Ductility (Reaffirmed 1988)
IS: 1209-1978	Determination of Flash Point and Free Point (Reaffirmed 1988)
IS: 1211-1978	Determination of Water Content (Dean and Stark Method) (Reaffirmed 1988)
IS: 1212-1978	Determination of Loss On Heating (Reaffirmed 1988)
IS: 1230-1979	Cast Iron Rain Water Pipes and Fitting (Reaffirmed 1991) (2nd Revision)
IS: 1322-1982 (1322-1993)	Specifications for Bitumen Felts for Water Proofing and Damp Proofing (4th Revision)
IS: 1367-1983 (Part:XIII)	Technical Supply Conditions for Threaded Steel Fasteners Part: XIII: Hot Dip Galvanized Coatings On Threaded Fasteners (Reaffirmed 1991) (2nd Revision)
IS: 1609-1991	Code of Practice for Laying Damp Proofing Treatment Using Bitumen Felts (2nd Revision)
IS: 1626-1994 (Part:I)	Specification for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part: I: Pipe and Pipe Fittings (2nd Revision)
IS: 1626-1994 (Part:II)	Specification for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part: II: Gutter and Gutter Fittings (2nd Revision)
IS: 1626-1994 (Part:III)	Specification for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part: III: Roofing Accessories (2nd Revision)
IS: 2115-1980	Code of Practice for Flat Roof Finish: Mud Phuska (Reaffirmed 1992) (2nd Revision)
IS: 2633-1986	Methods of Testing Uniformity of Coating on Zinc Coating Articles (Reaffirmed 1992) (2nd Revision)
IS: 2645-1975	Specifications for Integral Cement Water Proofing Compounds (Reaffirmed 1992) (1st Revision)
IS: 3007-1964 (Part:I)	Code of Practice for Laying of Asbestos Cement Sheets: Part-I: Corrugated Sheets (Reaffirmed 1991)
IS: 3007-1965 (Part:II)	Code of Practice for Laying of Asbestos Cement Sheets: Part-II: Semi-corrugated Sheets (Reaffirmed 1991)

3384-1986	Specifications for Bitumen Primer for Water Proofing and Damp Proofing (Reaffirmed 1990) (1st Revision)
7193-1974 7193-1994	Specifications for Glass Fibre Base Coal Tar Pitch & Bitumen Felts (1^{st} Revision)

25.3 Corrugated Galvanised Steel (CGS) Sheet Roofing

25.3.1 C.G.S. Sheets

25.3.1.1 These shall be of the thickness specified in the description of the item and shall conform to IS: 277. The sheets shall be of 750 grade of coating (**See Appendix-A, of Chapter 23**) unless other wise specified in the description of item. The sheets shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The galvanizing shall be non-injured and in perfect condition. The sheets shall not show signs of rust or white powdery deposits on the surface. The corrugations shall be uniform in depth and pitch and parallel with side.

25.3.2 Purlins

25.3.2.1 Purlins of the specified material or M.S. rolled sections of requisite size shall be fixed over the principal rafters. These shall not be spaced at more than the following distances.

Thickness of C.G.S. Sheet	Maximum Spacing of Purlins
1.60 mm	2.80 m
1.25 mm	2.40 m
1.00 mm	2.00 m
0.80 mm	1.80 m
0.63 mm	1.60 m

25.3.2.2 The top surfaces of the purlins shall be uniform and plane. They shall be painted before fixing on top. Embedded portions of wooden purlins shall be coal tarred with two coats.

25.3.3 Slope

25.3.3.1 Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontal. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

25.3.4 Laying and Fixing

25.3.4.1 The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working Drawings or directed by the Engineer-in-Charge.

25.3.4.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

25.3.4.3 The sheets shall be laid with a minimum lap of 15 cm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 15 cm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 20 cm. The minimum lap of sheets with ridge, hip and valley shall be 20 cm measured at right angles to the line of the ridge, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

25.3.4.4 Lapping in C.G.S sheets shall be painted with a coat of approved steel primer and two coats of painting with approved paints suitable for GS sheet, before the sheets are fixed in place.

25.3.4.5 Sheets shall not generally be built into gables and parapets. They shall be bent up along their side edges close to the wall and the junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at-least 7.5 cm.

25.3.4.6 The laying operation shall include all scaffolding work involved.

25.3.4.7 Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc., with galvanised J or L hook bolts and nuts, 8 mm diameter, with bitumen and G.I. limpet washers or with a limpet washer filled with white lead as directed by the Engineer-in-Charge. While J hooks are used for fixing sheets on angle iron purlins, and L hooks re used for fixing to R.S. Joist, timber or precast concrete purlins. The length of the hook bolt shall be varied to suit the particular requirements. The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10 mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach screws shall not be used for fixing sheets to purlins.

25.3.4.8 The galvanised coating on J or L hooks, and bolts shall be continuous and free from defects such as blisters, flux stains, drops, excessive projections or other imperfections which would impair serviceability.

25.3.4.9 The galvanised coating should conform to IS: 1367 (Pt. XIII) (**See Appendix 'A' of chapter 23**).

25.3.4.10 Where slopes of roofs are less than 21.5 degrees (1 vertical to 2.5 horizontal) sheets shall be joined together at the side laps by galvanised iron bolts and nuts 25 x 6 mm size, each bolt provided with a bitumen and a G.I. limpet washer or a G.I. limpet washer filled with white lead. As the overlap at the sides extends to two corrugations, these bolts shall be placed zig zag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 60 cm. along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheets are on the ground.

25.3.5 Wind Tie

25.3.5.1 Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. The ties shall be paid for separately unless described in the item of roofing.

25.3.6 Finish

25.3.6.1 The roof when completed shall be true to lines, and slopes and shall be leak proof.

25.3.7 Measurements

25.3.7.1 The length and breadth shall be measured correct to a cm. Area shall be worked out in sqm correct to two places of decimal.

25.3.7.2 The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc., shall be included in the measurements of the roof.

25.3.7.3 Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

25.3.7.4 No deduction in measurement shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such openings. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed. No additions shall be made for laps cut through.

25.3.8 Rate

25.3.8.1 The rate shall include the cost of all the materials and labour involved in all the operations described above including a coat of approved steel primer and two coats of approved steel paint on over lapping of C.G.S. sheets. This includes the cost of roof sheets, galvanised iron J or L hooks, bolts and nuts, galvanised iron seam bolts and nuts, bituminous and galvanised iron limpet washers etc.

25.4 Ridges and Hips of Plain Galvanised Steel Sheets

25.4.1 Ridges and Hips

25.4.1.1 Ridges and hips of C.G.S. roof shall be covered with ridge and hip sections of plain G.S. sheet with a aluminium lap of 20 cm on either side over the C.G.S. sheets. The end laps of the ridges and hips; and between ridges and hips shall also be not less than 20 cm. The ridges and hips shall be 60 cm overall width plain G.S. sheet, 0.6 mm or 0.8 mm thick as given in the description of the item and shall be properly bent in shape.

25.4.2 Fixing

25.4.2.1 Ridges shall be fixed to the purlins below with the same 8 mm diameter G.I hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins.

25.4.2.2 Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm diameter G.I. hook bolts and nuts and bitumen and G.I limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible extra hook bolts shall be provided.

25.4.2.3 The end laps of ridges and hips shall be jointed together by galvanised iron seam bolts 25 x 6 mm size each with a bitumen and G.I. washer or white lead as directed by the Engineer-in-Charge. There shall be at least two such bolts in each end lap.

25.4.2.4 Surface of C.G.I. sheets of ridge and hip sections and the roofing sheets which overlap shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.S. sheets before they are fixed in place.

25.4.3 Finish

25.4.3.1 The edges of the ridges and hips shall be straight from end to end and their surfaces should be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

25.4.4 Measurement

25.4.4.1 The measurement shall be taken for the finished work in length along the centre line of ridge or hip, as the case may be, correct to a cm. The laps in ridges and hips between ridges and hips shall not be measured.

25.4.5 Rate

25.4.5.1 The rate shall include the cost of all labour and materials specified above, including painting, cost of seam bolts and any extra G.I. hook bolts, nuts and washers, required.

25.5 Valley and Flashing of Plain Galvanised Steel sheets

25.5.1 Valley and flashing

25.5.1.1 Valley shall be 90 cm wide overall plain G.S. sheet 1.6 mm thick or other size as specified in the item bent to shape and fixed. They shall lap with the C.G.S sheets not less than 25 cm width on other side. The end laps of valley shall also be not less than 25 cm.

25.5.1.2 Valley sheets shall be laid over 25 mm thick wooden boarding if so required.

25.5.1.3 Flashing shall be plain G.S. sheet of 40 cm overall width 1.25 mm thick or 1.00 mm thick as specified in the item bend to shape and fixed. They shall lap not less than 15 cm over the roofing sheets. The end laps between flashing pieces shall not be less than 25 cm.

25.5.2 Laying and Fixing

25.5.2.1 Flashing and valley sheets shall be fixed to the roof members below, such as purlins and valley rafters with the same 8 mm diameter G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members.

25.5.2.2 At least one of the fixing bolts shall pass through the end laps of the valley pieces on other side. If this is not possible extra hook bolts shall be provided. The free end of flashing shall be f fixed at least 5 cm inside masonry with the mortar of mix 1:3 (1 cement; 3 coarse sand).

25.5.3 Surface of G.S. sheets under overlaps shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.S. sheets.

25.5.4 Finish

25.5.4.1 The edges of valley and flashing should be straight from end to end. The surfaces should be true and without bulges and depressions.

25.5.5 Measurements

25.5.5.1 The length of the valleys and flashing shall be measured for the finished work correct to a cm. The laps along the length of the valley or flashing pieces, including the portion embedded in masonry, shall not be measured.

25.5.6 Rates

25.5.6.1 The rate for valleys, shall be for all the labour and materials specified above, including painting, cost of seam bolts and the cost of requisite G.I. hook bolts, nuts and washers required over and above those needed for connecting the roof sheets to the roof members. The rate for connecting the roof sheets to the roof members. The rate for valleys shall exclude the cost of boarding underneath which shall be paid for separately. The rate for flashing shall be for all the labour and materials specified above, and shall include the cost of painting and mortar for fixing in wall.

25.6 Gutter of Plain Galvanised Steel Sheets

25.6.1 Gutters

25.6.1.1 Gutter shall be fabricated from plain G.S. Sheets 1.25 mm thick or other size as specified in the items.

25.6.1.2 Eaves gutters shall be of the shape and section specified in the description of the item. The overall width of the sheet referred to therein shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall be turned back to the extent of 12 mm and beaten to form a rounded edge. The ends of the sheets at junctions of pieces shall be hooked into each other and beaten flush to avoid leakage.

25.6.2 Slope

25.6.2.1 Gutter shall be laid with a minimum slope of 1 in 120.

25.6.3 Laying and Fixing

25.6.3.1 Gutter shall be supported on and fixed to M.S. flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 metres.

25.6.3.2 Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bend to shape and fixed rigidly to the sides of rafters with 3 Nos. 10 mm diameter bolts, nuts and washers. The brackets shall overlap the rafter not less than 30 cm and the connecting bolts shall be at 12 cm centres.

25.6.3.3 Where the brackets are to be fixed to the purlins, the brackets shall consist of 50 x 3 mm M.S. flat iron bent to shape with one end turned at right angle and fixed to the purlin face with 2 Nos. of 10 mm diameter bolts nuts and washers. The bracket will be stiffened by provision of 50 x 3 mm. M.S. flat whose over hung portion bent to right angle shape with its longer leg connected to the bracket with 2 Nos. 6 mm diameter M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with 1 No. 10 mm diameter, bolt, nut and washer. The over hang of the vertical portion of the bracket from the face of the purlin shall not exceed 22.5 cm with this arrangement. The spacing of the brackets shall not exceed 1.20 metres.

25.6.3.4 The gutter shall be fixed to the brackets with 2 Nos. G.I. bolts and nuts 6 mm diameter, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

25.6.3.5 For connection to down take pipes, a proper drop end or funnel shaped connecting piece shall be made out of G.S. sheet of the same thickness as the gutter and riveted to the gutter, the other end tailing into the socket of the rain-water pipe. Wherever necessary stop ends, angles etc., should be provided.

25.6.4 Finish

25.6.4.1 The gutters when fixed shall be true to line and slope and shall be leakproof.

25.6.5 Measurement

25.6.5.1 Measurements shall be taken for the finished work along the centre line of the top width of the gutter connection to a cm. The hooked lap portion in the junctions and gutter lengths shall not be measured. The number of brackets which are fixed to purlins with stiffener flats should be measured.

25.6.6 Rate

25.6.6.1 The rate shall include the cost of all labour and materials specified above, including all special such as angles, junctions, drop ends or funnel shaped connecting pieces, stop ends etc., flat iron brackets and bolts and nuts required for fixing the latter to the roof members. Brackets of 50 x 3 mm flats fixed to purlins with stiffener flats will be paid extra.

25.7 Asbestos Cement Corrugated Sheet Roofing

25.7.1 Asbestos cement corrugated sheets

25.7.1.1 The sheets shall be of the approved quality and shall conform to IS: 459. The sheets shall be free from cracks, chipped edges or corners and other damages.

25.7.2 Slope

25.7.2.1 The roof shall not be pitched at flatter slope than 1 vertical to 5 horizontal. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

25.7.3 Laying

25.7.3.1 The sheets shall be laid on the purlins and other roof members as indicated in the working Drawings or as instructed by the Engineer-in-Charge.

25.7.3.2 The maximum spacing of purlins under the sheets shall be 1.40 metres in the case of 6 mm thick sheets and these shall in no case be exceeded. Ridge purlins shall be fixed at 75 mm to 115 mm from the apex of the roof.

25.7.3.3 The top bearing surfaces of all purlins and of other roof members shall be in one plane so that the sheets shall being fixed shall not require to be forced down to rest on the purlins. The finished roof shall present a uniform slope and the line of corrugations shall be straight and true. The sheets shall be laid with the smooth side upwards.

25.7.3.4 The sheets shall be laid with a side lap of half a corrugation and an end lap of 15 cm minimum in the case of roofs with a pitch flatter than 1 vertical to 2.5 horizontal (approx. 22 degree) or in the case of very exposed situations, the minimum permissible end lap shall be 20 cms. Side laps should be laid on the side facing away from the prevailing monsoon winds.

25.7.3.5 The free overhang of the sheets at the eaves shall not exceed 30 cms. Corrugated sheets shall be laid from left to right starting at the eaves. The first sheet shall be laid uncut but the remaining sheets in the bottom row shall have the top left hand corners cut or mitred. The sheets in the second and other intermediate rows except the first and the last sheets, shall have both the top left hand corner and bottom right hand corner cut. The last or top row sheets shall all have to bottom right hand corner cut with the exception of the last sheet which shall be laid uncut. If for any reason such as on considerations of the direction of prevailing winds, laying is to be started from the bottom right hand corner, then the whole procedure should be reversed.

25.7.3.6 The ‘Mitre’ described above is necessary to provide a snug fit where four sheets meet at a lap. It is cut from a point 15 cm (or whatever the length of the end lap may be) up the vertical side of the sheet to a point 5 cm along the horizontal edge. The cutting may be done with the ordinary wood saw at site.

25.7.4 Fixing

25.7.4.1 Sheets shall be secured to the purlins and other roof members by means of 8 mm diameter galvanised iron J or L hook bolts and nuts. While, J hooks are used for fixing to angle iron purlins, L hooks are used for fixing to R.S. joists, timber or precast concrete purlins.

25.7.4.2 The grip of the J or L hook bolt on the side of the purlin shall not be less than 25 mm. Each galvanised iron J or L hook bolt shall have a bitumen washer and a galvanised iron washer placed over the sheet before the nut is screwed down from above. On each purlin there shall be one hook bolt on the crown adjacent to the side lap on either side. Bitumen washer shall be of approved manufacture. Galvanising of G.I. J or L hooks and washers shall be as provided in **Clause** 23.3.4.8 and 23.3.4.9.

25.7.4.3 The G.I. flat washer shall be 25 mm in diameter, 1.6 mm thick and the bitumen washer shall be 35 mm in diameter and 1.5 mm thick. The length of J bolt or crank bolt shall be as specified in Table below.

Sr	Situation	No. of Bolts & Washers	Length of Bolts
1.	At horizontal (end) laps of Sheets. At eaves when filler pieces are used. At ridge when sheets and ridge pieces are secured by the same bolt.	Twice the No. of sheets in one horizontal course.	Depth of purlin plus 90 mm.
2.	At eaves when filter pieces are not used. At ridge when corrugated sheets and ridge pieces are not secured by the same bolt.	Twice the No. of sheets in the horizontal course.	Depth of purlin plus 75 mm.
3.	At intermediate purlins where horizontal laps do not occur.	Twice the No. of sheets in the horizontal course.	Depth of purlin plus 75 mm.

25.7.4.4 Each nut shall be screwed lightly at first. After dozen or more sheets are laid, the nuts shall be tightened to ensure a leak proof joint.

25.7.4.5 Holes for hook bolts etc., shall be drilled and not punched, always through the crown of the corrugation and not in valleys, in locations to suit the purlins while the sheets are on the roof in their correct position. The diameter of holes shall be 2 mm more than the diameter of the fixing bolts. No hole shall be nearer than 40 mm to any edge of a sheet or any accessory.

25.7.4.6 Roof ladders or planks shall always be used when laying and fixing the sheets, to avoid damage to the sheets, and to provide security to the workmen.

25.7.5 Wind Ties

25.7.5.1 Wind ties may be provided where the situation justify their provision. These shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eave ends of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. Wind ties shall be paid for separately unless described as included in the items of the roof work.

25.7.6 Finish

25.7.6.1 The completed roof shall present a neat and uniform appearance and be leakproof.

25.7.7 Measurements

25.7.7.1 Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

25.7.7.2 The superficial area of roof coverings shall be measured on the flat without allowance for laps and corrugations. Portions of roof covering overlapping the ridge or hips etc., shall be included in the measurements of the roof.

25.7.7.3 Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed. The breadth of the roof shall be measured along the rest of the curved sheets.

25.7.7.4 No deductions in measurements shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such opening. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed.

25.7.8 Rate

25.7.8.1 The rate shall include the cost of all the materials and labour involved in all the operations described above except otherwise stated. This includes the cost of roof sheets, galvanised iron J or L hook. Bolts and nuts, bituminous and galvanised iron washers.

25.8 Ridges and Hips of Asbestos Cement

25.8.1 Ridges and hips shall be of same manufacture as the corrugated or semicorrugated sheets used for roof, unless specially permitted in writing by the Engineer-in-Charge. The sections shall be free from cracks, chipped edges or corners or other damages.

25.8.1.1 Ridges shall be of the type specified in the item, such as:

1. One piece plain angular.
2. Serrated or plain wing adjustable.
3. Close fitting adjustable.
4. Northlight adjustable and appropriate for the corrugated or semi-corrugated roof which is to be covered 'Plain Wing Angular' type ridges can be used only if the slope of the roof is exactly 30 degree. Hips shall be of 'under-rated adjustable for hips' sections.
5. Unserrated adjustable.

25.8.2 Laying

25.8.2.1 The ridge sections shall be laid as per manufacturers instructions with the rolls of the two wings in the case of adjustable ridges fitting closely and with the serrations of serrated ridges registering correctly with the sheets underneath. The stagger lapping or two wings of an adjustable ridge section and the laps between adjacent pieces on the same wing of the ridges shall be as per manufacturers instructions. The end portions of the wings of the adjustable ridges which project beyond the verges of the roof shall be cut and trimmed off neatly. Asbestos cement expansion joint ridge pieces shall be provided every 45 metres (approx.) of ridge where the latter is of the semi-corrugated serrated adjustable type.

25.8.2.2 In laying hip pieces, serrations to suit the corrugations in the sheets below should be cut in them so that they will be snug fit over the sheets.

25.8.3 Fixing

25.8.3.1 The wings of ridges shall be fixed to the sheets below with the seam bolts and nuts 8 mm diameter G.I. J or L hook bolts and nuts and bitumen and G.I. washers which fix the sheets to the purlins. In additions, in northlight adjustable ridges the curves of the two wings shall be joined together at their crown with 8 mm diameter G.I. seam bolts and nuts, at the rate of 2 numbers per pair of wings. Each seam bolt shall be provided with one bitumen and a pair of G.I. washers.

25.8.3.2 Where 'Plain wing angular' or 'Plain wing adjustable' ridges are used, the gaps formed by the roofing corrugations and the wings shall be filled with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) upto the full length of the overlap. The exposed face shall be finished perpendicular to the sheeting.

25.8.3.3 Wing of hips shall be fixed to the roof members below with the same 8 mm diameter G.I. J or L hook bolts and nuts which fix the sheet to those members, in addition, they shall be secured to the sheets below with 8 mm diameter G.I. seam bolts, nuts and washers, so that taken together with hook bolts there shall be bolt on each wing atleast every fifth corrugation of the sheet below in the case of 'Corrugation' and at least every second corrugation of the sheet below in the case of 'semi-corrugated' sheets. The seam bolts shall each be provided with one bitumen and a pair of G.I. washers.

25.8.4 Measurements

25.8.4.1 The measurements for ridges and hips shall be taken for the finished work along the centre line of the ridge and hip lines in length, correct to a cm. The laps in adjacent ridges or hip pieces shall not be measured. The underlay of ridges under asbestos cement expansion joint pieces where the latter are provided shall however be measured.

25.8.5 Rate

25.8.5.1 The rate shall include the cost of all materials and labour specified above, but does not include (a) the cost of required G.I. hook bolts and nuts and their washers, (b) the cost of supplying and fixing asbestos cement expansion joint pieces, (c) the cost of closing the gaps between plain ridge and the sheet corrugations with concrete. Item (a) above will be covered by the rate for the asbestos cement sheet roofing while items (b) and (c) will be paid for separately unless specifically included in the description of the ridge or hip item.

25.9 Other Roofing Accessories of Asbestos Cement

25.9.1 Accessories

25.9.1.1 The other accessories that may be required to be used on a roof are (a) finishing pieces, eaves filler pieces, northlight and ventilator curves, barge boards and expansion joint sheets (b) ridge finials, cowl type ventilators, curved boards for northlight, curves, roof light expansion joints for ridge and expansion joint for northlight curves and (c) 'S' type louver. The accessories shall be of the type appropriate for use with corrugated or semi corrugated sheets which form the roofing.

25.9.1.2 The accessories shall be of the same manufacture as the corrugated or semi-corrugated sheets used for the roof. The pieces shall be free from cracks, chipped edges or corners and other damages.

25.9.2 Laying and Fixing

25.9.2.1 These shall be laid and secured with the same G.I. hook bolts which secure sheets to the roof members below where possible or with separate G.I. hook bolts to the roof members below and/or with 8 mm diameter G.I. seam bolts, nuts and washers to the sheeting, generally as per manufacturers printed instructions and as ordered by the Engineer-in-Charge. 'S' type louvers shall be fixed to ventilators to timber, M.S angle or flat iron vertcials spaced not more than 1.65 metre centres. The laps of adjacent pieces over the verticals shall not be less than 10 cm. The upper flat of the top most row of louvers shall be fixed to the vertical by 10 mm diameter G.I. bolts and nuts and bitumen and G.I. washers.

25.9.2.2 The lower flats of the top and intermediate rows of louvers and the flat of the louvers pieces below shall be secured together to the verticals behind by 10 mm diameter G.I. separating bolts threaded at both ends and of suitable length. Each of these bolts shall be quipped with 2 pair or nuts, G.I. and bitumen washers. The louver flats of the lowest line of louvers shall also be fixed to the verticals at the proper distance from the same by the use of similar separating bolts and nuts.

25.9.3 Measurements

25.9.3.1 The accessories listed under group (a) in **Clause 23.9.1.1** shall be measured for finished work in length correct to a cm. Laps between adjacent pieces shall not be measured.

25.9.3.2 The accessories listed under group (b) in **Clause 23.9.1.1** shall be measured and paid for in number. This applies in the case of final too where the unit shall consist of a pair of inter locking pieces.

25.9.3.3 The 'S' type louvers listed under group (c) in **Clause 23.9.1.1** shall be measured for the finished work in length of each row of louvers correct to a cm. The laps, between adjacent pieces of louvers will not be taken into account in the measurements.

25.9.4 Rate

25.9.4.1 The rates for supplying and fixing, asbestos cement accessories listed in groups (a) & (b) of **Clause 23.9.1.1** shall include the cost of all materials and labour involved in all the operations described in A.C. roofing accessories, bolts, nuts, washers and other fixing accessories but does not include the members.

25.9.4.2 The rate for supplying and fixing roof lights shall not unless otherwise described in the item, include the glazing which shall be paid for a separately.

25.9.4.3 The rate for supplying and fixing 'S' types louvers shall include all fixing accessories such as ordinary and separating G.I. bolts, nuts, and bitumen washers including drilling the holes for the same in the vertical supporting members behind but shall not unless otherwise described in the item the cost of supplying and fixing the supporting members which shall be paid for separately.

25.10 Eaves and Valley Gutters of Asbestos Cement

25.10.1 Gutters and Accessories

25.10.1.1 Eaves gutters shall be of the type specified in the item such as (1) plain ended eaves, (2) boundary wall, (3) socketed eaves ogee and (4) socketed half round. These shall be of standard size as stipulated in the item. Valley gutters shall be of the 'Plain' ended valley types and of size as stipulated in the item.

25.10.1.2 These shall be of approved manufacture, approved by the Engineer-in-Charge. The gutter sections and their accessories such as drop ends, stop ends, nozzles, angles and union clips shall be free from cracks, chipped edges or corners and other damages.

25.10.2 Laying and Fixing

25.10.2.1 Gutters shall be laid with a minimum slope of 1 in 120, which should be increased where possible. Gutters shall be true to line and slope and shall be laid with requisite accessories such as drop ends, stop ends, nozzles, angles and union clips as shown in the working Drawings or as ordered by the Engineer-in-Charge.

25.10.2.2 The size of outlet of drop ends and nozzles shall be of the same size as the size of the rain water pipes into which they shall be discharging the water.

25.10.2.3 Gutters and their accessories shall be supported by M.S. flat iron bracket. Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bent to shape and fixed rigidly to the sides of the rafter with 3 Nos. 10 mm diameter bolts, nuts and washers. The brackets shall overlap the rafter not less than 30 cm and the connecting bolts shall be 11.5 cm centres.

25.10.2.4 Where the brackets are to be fixed to the purlins they shall consist of 50 x 3 mm M.S.flat iron bent to shape with one end turned at a right angle, and fixed to the purlin face with a 10 mm diameter bolt, nut and washer. The perpendicular over hang portion of 50 x 3 mm bracket shall be stiffened by another 50 x 3 mm flat, bent to right angle shape with its lower leg connected to the bracket with 2 Nos. 6 mm diameter M.S bolts, nuts and washers and its shorter led fixed to face of purlin with one number 10 mm diameter bolt, nuts and washers. The overhang of the vertical portion of the flat iron bracket from the face of the purlin shall not exceed by 22.5 cm with this arrangement.

25.10.2.5 The requisite slope in the gutters shall be given in the line of the bracket. The brackets shall be placed at not more than 90 cm centres.

25.10.2.6 The gutters shall be fixed to the brackets with 2 Nos. 8 mm diameter G.I. seam bolts and nuts, each bolt and nut being equipped with a pair of bitumen and G.I. washers. These connecting bolts shall be above the water line of the gutters.

25.10.2.7 Spigot and socket ends of gutters of 'socketed eaves ornamental' or 'socketed half round' type and their accessories shall be connected together at their laps with one row of 8 mm diameter G.I. bolts and nuts, each bolt and nut being provided with a pair of bitumen and a pair of G.I. washers. The gap between the socket and spigot shall be packed with approved plastic roofing compound, flanked on both sides with 6 mm diameter asbestos rope. The connecting G.I. bolts are then tightened so that the lapped joints become leak proof. The outer faces of the packed asbestos rope shall not be farther than 6 mm from the edges of the spigot and socketed ends.

25.10.2.8 Where both ends of gutters and or their accessories to be connected together are of spigot ends they shall be laid as butt joints with 1.5 mm gap between over union clips (loose socket pieces). The union clip shall be connected to the two bolt ends of the gutter or other section with two rows (one row per ends) of 8 mm diameter G.I. bolts and nuts, each bolt and nut being provided with pair of bitumen and a pair of G.I. washers. The gap between the union clips and the butt ends of the gutter sections or accessories shall be packed with approved plastic roofing compound flanked at both edges by 6 mm diameter asbestos rope. The whole joint shall be made leak proof by tightening the bolts.

25.10.2.9 The ends of 'Plain' ended eaves or boundary wall type and 'Plain' ended valley type gutters and their accessories shall be laid with butt joints over union clips and connected together in the same manner as for connecting spigot and socket ends described in the preceding sub-para.

25.10.2.10 The number of connecting bolts, nuts and washers and the quantities of 6 mm diameter asbestos rope and plastic roofing compound required per spigot socket of 'ornamental' and 'half round' gutters of different sizes and butt joint of plain ended 'Boundary wall eave' and 'valley' type gutters of different sizes shall be as shown in the table below:

JOINTING MATERIALS PER JOINT OF GUTTER

Type of Gutter	Nominal Sizes	6 mm diameter Asbestos rope	Required per joint			
			Plastic roofing compound	8 mm dia nuts and bolts	G.I. Washer 25 mm dia.	Bitumen washer 25 mm dia.
Socketed ornamental	125 mm	0.57 m	170 g	1 No. 45 mm long	2 Nos.	2 Nos.
Socketed ornamental	200 mm	0.98 m	255 g	3 No. 45 mm long	6 Nos.	6 Nos.
Socketed half round	150 mm	0.57 m	170 g	1 No. 45 mm long	2 Nos.	2 Nos.
Socketed half round	250 mm	0.92 m	567 g	3 No. 45 mm long	6 Nos.	6 Nos.
Socketed half round	300 mm	1.07 m	709 g	3 No. 45 mm long	6 Nos.	6 Nos.
Plain ended boundary wall or eaves	275 x 125 x 175 mm	0.97 m	737 g	8 No. 40 mm long	16 Nos.	16 Nos.
Plan ended Boundary wall or eaves	300 x 150 x 225 mm	1.15 m	850 g	8 No. 50 mm long	16 Nos.	16 Nos.
Plan ended Boundary wall or eaves	450 x 150 x 300 mm	1.38 m	1020 g	8 No. 50 mm long	16 Nos.	16 Nos.

Type of Gutter	Nominal Sizes	6 mm diameter Asbestos rope	Required per joint			
			Plastic roofing compound	8 mm dia nuts and bolts	G.I. Washer 25 mm dia.	Bitumen washer 25 mm dia.
Plan ended Boundary wall or eaves	500 x 150 x 250 mm	1.43 m	1049 g	10 No. 50 mm long	20 Nos.	20 Nos.
Plain ended valley	400 x 125 x 250 mm	1.12 m	850 g	8 No. 50 mm long	16 Nos.	16 Nos.
Plain ended valley	50 x 125 mm	1.12 m	850 g	8 No. 50 mm long	16 Nos.	16 Nos.
Plain ended valley	600 x 150 x 225 mm	1.48 m	1105 g	8 No. 50 mm long	16 Nos.	16 Nos.
Plain ended valley	900 x 200 x 225 mm	2.08 m	1531 g	12 No. 50 mm long	24 Nos.	24 Nos.

25.10.3 Finish

25.10.3.1 The gutters and accessories when fixed shall be true to line and slope and shall be ridged. All the joints shall be leak proof.

25.10.4 Measurements

25.10.4.1 The measurement of gutters shall be taken for the finished work in length correct to a cm along the centre line of the gutters. The measured length of the finished gutters will include the length over accessories such as drop ends, stop ends, nozzles and angles, though the rate for the same shall not include the cost of the accessories unless specially described in the item. Laps between the adjacent pieces of gutter and gutter section or between gutter section and accessories shall not be measured.

25.10.4.2 Accessories such as drop ends, stop ends, nozzles and angles shall be measured and paid for separately.

25.10.4.3 Union clips (loose sockets) shall not be measured and paid for separately as they are included in the rate for gutters.

25.10.5 Rate

25.10.5.1 The rate for the gutters shall not, unless otherwise specified in the description of item, include the cost of providing and fixing accessories such as drop ends, stop ends, nozzles and angles. The rate shall include the cost of providing and fixing all union clips (loose sockets), all connecting G.I. bolts, nuts and bitumen and G.I. washers, M.S. flat iron brackets and their fixture to the gutter sections and to the roof members, asbestos rope and plastic roofing compound.

25.10.5.2 Extra over the rate for the gutter shall be paid for providing and fixing accessories, stop ends, drop ends, angles and nozzles. Where brackets of 50 x 3 mm size are provided in place of brackets of 40 x 3 mm size as indicted in **Clause 23.10.2.4** extra rate will be paid for separately.

25.11 Painting of Roof slab with Hot Bitumen

25.11.1 Preparing the Surface

25.11.1.1 The surface shall be painted only when it is thoroughly dry. The surface to be painted shall be cleaned with wire brushes and cotton or gunny cloth. All loose materials and scales shall be removed and the surface shall be further cleaned with a piece of cloth lightly soaked in kerosene oil.

25.11.2 Painting with bitumen

25.11.2.1 The Contractor shall bring the bitumen to site in its original packing and shall open and use it in the presence of the Engineer or his authorised representative. The containers shall not be removed from the site until the painting job is completed and the Engineer has satisfied himself regarding the quantity of bitumen actually used and has given his permission to remove the empty containers.

25.11.2.2 The surface prepared and treated shall be painted uniformly with bitumen of approved quality such as residual type petroleum bitumen of penetration 80/100, hot cut back bitumen or equivalent as per Specifications of the manufacturer. The coat of bitumen shall be continued 15 cm along the vertical surfaces joining the roof. In case of parapet walls it shall be continued upto the drip courses.

25.11.2.3 Residual type petroleum bitumen of penetration 80/100 shall be heated to a temperature of not less than 180 degree C and not more than 190 degree C and shall be applied on the roof surface at not less than 180 degree C. Similarly, hot cut back bitumen shall be heated to temperature of not less than 165 degree C and not more than 170 degree C and shall be applied on the surface at not less than 165 degree C.

25.11.2.4 Care shall be taken to see that no blank patches are left. The quantity of bitumen to be applied per 10 square metres of roof surface shall be 17 kg, unless otherwise stipulated in the description of the item and shall be carefully regulated so that the application is uniform at the stipulated rate of 17 kg per 10 square metre.

25.11.3 Spreading Sand

25.11.3.1 Immediately after painting, dry, clean sharp coarse sand at the rate of 60 cubic decimeter per 10 sqm. Shall be evenly spread and levelled over the surface when the bitumen is still hot.

25.11.4 Measurements

25.11.4.1 The superficial area of the surface painted shall be measured in square metres. No deduction in measurements shall be made for unpainted areas of roof slab occupied by chimney stacks, roof lights etc., of areas, each upto 40 sq. decimeter. The measurements of length and breadth shall be taken correct to a cm.

25.11.5 Rate

25.11.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

25.12 Mud Phuska Terracing with Tile Brick Paving

25.12.1 Mud Phuska

25.12.1.1 For mud phuska, selected soil which should be good quality earth suitable for brick making not containing excessive clay or sand, free from stones, kankar, vegetable maker and other foreign matter, shall be collected and stacked at site. The soil shall not be collected from a locality infested with white ants. Before laying on the roof, the soil shall be made damp by adding water about 12 hours earlier. It shall be turned over with phawaras so as to break clods and to pulverise the same. Quantity of water to be added to the soil shall be carefully regulated so that the soil shall have optimum moisture content at the time of laying and compaction on the roof. The soil shall be laid on the roof to requisite thickness and slope, well compacted with wooden rammers and thapies, to obtain an even surface to correct slope. Average thickness of soil after compaction shall be as specified for the item.

Note: A practical way of determining the moisture content of soil suitable for giving good compaction is that the soil should contain that much quantity of moisture, which when a handful of soil is moulded with hand to the shape of a ball, it shall just retain its form. If the soil

on moulding cannot retain its shape of a ball, moisture content is inadequate. On the other hand, if the ball can be plastically deformed on pressing with hand, the moisture content is on the high side.

25.12.2 Mud Plaster

25.12.2.1 After laying the mud phuska, the surface shall be given a coat of mud plaster 25 mm thick and the plaster shall be allowed to dry and crack.

25.12.2.2 The mud plaster shall be prepared from the same soil as for mud phuska. The dry soil shall be reduced to fine powder and mixed with water in a pit, adding fibrous reinforcing materials such as chopped straw (Bhusa) in proportion of 35 kg per cum of soil. The mixture shall be allowed to mature for a period of not less than 7 days. During this period it shall be worked over at intervals with feet and spades (Phawaras) so as to get pugged into a homogenous mass free from lumps and clods. The mud mortar shall be puddled again very thoroughly just before use.

25.12.2.3 The consistency of mud mortar shall be checked by taking it a trowel and observing how it slides off the face of trowel. The mortar shall readily slide off the trowel and should not be so wet as to part on to large drops before falling. Alternatively slump test may be performed in accordance with IS: 1199. The slump should be about 70 mm.

25.12.3 Gobri Leaping

25.12.3.1 After the mud plaster has dried, the surface should be given a coat of gobri leaping so as to completely fill any crack that may have formed in the mud plaster. Mortar for gobri leaping shall be prepared by mixing equal quantities of fresh gobar and finely sieved clay and adding sufficient water to form a thin paste. The quantity of gobar used in gobri leaping shall not be less than 0.03 cum per 100 sqm of plaster area. Five percent of cut back bitumen by mass of dry clay may be added to improve upon the water proofing quantities.

25.12.4 Laying of Tile Bricks

25.12.4.1 After the gobri leaping has dried, flat tile bricks shall be laid using the minimum amount of plain mud mortar (without bhusa) as bedding so as to obtain correct slope and even surface of tile floors. Care shall be exercised to see that mud mortar does not rise into the vertical joints of the tiles more than 12 mm. The tiles shall be laid close to each other, the thickness of joints shall not be less than 6 mm and more than 12 mm in width. After the tiles are well set and bedding mortar has dried, joints of the tiles are well set and bedding mortar has dried, joints of the tiles shall be grouted with cement mortar of mix 1:3 (1 cement: 3 fine sand) such that all the joints of tiles are completely filled with mortar and the joints should be finished neat. Cement used for the grouting mortar shall be mixed with 2% of integral water proofing compound which should conform to IS: 2645.

25.12.5 Curing

25.12.5.1 As soon as cement grouting obtains initial set, the surface of the tile brick floor shall be covered with wet gunny bags, hessian cloth or wet sand to prevent quick drying. After 8-12 hours, the tile brick floor shall be cured by frequent sprinkling of water on the surface for a period of 7 days. After curing has been done, the surface shall be swept clean.

25.12.5.2 The tile surface as completed shall be even and true to slopes of 1 in 48 or as specified and should be leak proof.

Note: When surplus earth of a suitable quality exists at the site of work, the Contractor shall be allowed to use the same free of cost for laying the mud terracing, mud plaster and gobri leaping on the top. The Engineer shall be the final authority to decide whether the earth obtained from excavation is surplus to the requirements at site and is suitable for mud phuska work.

25.12.6 Measurements

25.12.6.1 Length and breadth shall be measured correct to a cm. The measurements shall be taken for the finished work, (mud phuska a terracing stipulated thickness with mud plaster, gobri leaping and flat tile paving and grouting) over the tiles surface, in superficial area.

25.12.6.2 No deductions in measurements shall be made for either openings or recesses for chimney stacks, roof lights or khurras, of area upto 0.40 sqm. No extra shall be paid either for any extra materials or labour involved in forming such openings, recesses etc. For areas exceeding 0.40 sqm deductions will be made in the measurements for the full opening but no extra shall be paid for any extra labour, materials etc., in forming such openings.

25.12.6.3 For plus or minus deviation from the average thickness stipulated for the mud phuska in the item, payments will be adjusted in the rate admissible to the Contractor for the relevant schedule item provided that such deviations were authorised by the Engineer in writing.

25.12.7 Rate

25.12.7.1 The rate shall include the cost of all materials and labour involved in all the operations described above.

25.13 Cement Concrete Gola

25.13.1 Cement concrete

25.13.1.1 The Specifications for concrete shall be the same as described in **Chapter 9**.

25.13.2 Gola

25.13.2.1 A chase of 75 mm wide by 75 mm deep shall be cut in the parapet wall just above the junction of mud phuska or lime concrete with parapet wall and it shall be filled with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate 10 mm and down gauge) the external face finish with a slope of 1:0.75 and the exposed surface of the gola shall be plastered with cement under 1:3 (1 cement: 3 fine sand).

25.13.2.2 Expansion joint at every 3.5 to 4.5 metres shall be provided and filled with bitumen filler. The bitumen filler shall be prepared by mixing bitumen, cement and coarse sand in the ratio of 80:1:0.25 (80 kg of hot bitumen: 1 kg of cement and 0.25 cm of coarse sand).

25.13.3 Curing

25.13.3.1 The finished surface shall be cured for at least 7 days.

25.13.4 Measurements

25.13.4.1 The length of the finished gola shall be measured at its junction with the wall face correct to a cm. No deduction shall be made in measurements for gaps for water outlet.

25.13.5 Rate

25.13.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above including the cost of bitumen filler in expansion joint. The rate includes for all turnings and rounding at all the corners and riser.

25.14 Khurras

25.14.1 The khurras shall be constructed before the brick masonry work in parapet wall is taken up and it shall be 45 cm x 45 cm unless otherwise specified in the description of the item and shall be formed of cement concrete 1:2:4 mix (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) or other mix as stipulated in the description of the item.

25.14.2 Laying

25.14.2.1 A PVC sheet 1 m x 1 m x 400 micron shall be laid under the khurra and then cement concrete shall be laid over it to average thickness of 50 mm with its top surface lower than the level of adjoining roof surface by not less than

1. 20 mm in case of roof surface finished with lime concrete terracing.
2. 70 mm in case of roof surface finished with lime concrete terracing covered with brick tiles.
3. 50 mm in case of roof surface finished with mud phuska with brick tile covering.

25.14.2.2 The concrete shall be laid to a size greater than the stipulated size of the Khurra in such a way that the adjoining terracing whether of lime concrete or of the tile bricks shall overlap the concrete on its three edges by not less than 7.5 cm. The concrete will slope uniformly from the edges to the outlet, the slope being as much as possible and in no case less than 20 mm cement concrete at the outlet. The concrete shall be continued at the same slope through the width of the wall into the outlet opening to ensure a water tight joint.

25.14.2.3 The khurras and the sides of the outlet shall then be rendered with 12 mm coat of cement plaster 1:3 mix (1 cement: 3 coarse sand) or other mix as stipulated in the description of the item. This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of the khurras and sides of the outlet opening shall be well rounded. The size of the finished outlet opening shall be 10 cm wide by 20 cm high or as directed by the Engineer-in-Charge.

25.14.2.4 In cases where rain water is to be disposed off through rain water pipes, iron grating shall be provided at the outlet as a safeguard against choking, if so directed by the Engineer-in-Charge. Iron gratings, where provided, shall be of overall size 20 x 25 cm, with an outer frame of 15 x 3 mm M.S. flat to which 4 Nos. M.S. bars of 10 mm diameter shall be welded in a vertical direction keeping equal clear spacing of 2.5 cm or as directed by the Engineer-in-Charge.

25.14.3 Measurements

25.14.3.1 Khurras shall be counted in number.

25.14.4 Rate

25.14.4.1 The rate is for each completed khurra of the specified size and is inclusive of the cost of all materials and labour involved in forming the khurras and outlet opening as described above, except for iron gratings which shall be paid for separately.

25.15 Water Proofing with Bitumen Felts

Water proofing treatment with self finished felt shall be four courses or six courses as described in the item. Four courses water proofing treatment with self finished felt is a normal duty treatment suitable for buildings where the cost of roof treatment is required to be restricted. Six course water proofing treatment with self finished felt is a heavy duty treatment suitable for important structures.

25.15.1 Materials

25.15.1.1 Self finished felt (Appendix B and CONCRETE). The self finished felt shall be of brand and manufacture conforming to the type and grade given in the description of the item. This shall be one of the following types:

1. Type 2 grade 1 is a glass fibre base bitumen felt conforming to IS: 7193.
2. Type 2 grade 1 is a fibre (vegetable or animal) base felt conforming to in all respect to IS: 1322.
3. Type 2 grade 2 is fibre (vegetable or animal) base felt conforming in all respects to IS: 1322.
4. Type 3 grade 1 is a hessian base felt conforming in all respects of IS: 1322

	Ist course	**3rd course**	**5th course**
	in kg/sqm		
I. Four course treatment:	1.45	1.45	-
II. Six course treatment a) With type 3 grade 1 hessian base self finished bitumen felt b) With felts other than type 3 grade 1 hessian base.	1.45 1.45	1.20 1.20	1.45 1.70

25.15.1.2 Bonding Material

1. This shall consist of blown type petroleum bitumen conforming to IS: 702 or residual petroleum bitumen conforming to IS: 73 or mixture thereof. The bonding material shall be so selected as to withstand the local condition of temperature and gradient satisfactorily. The penetration of bitumen used shall not exceed 40 in any case. Suitable residual type petroleum bitumen is of penetration 30/40 (IS grade S-35)

2. Generally, blown type petroleum bitumen shall be used for the base and intermediate layers of bonding material and for flashing, while residual type petroleum bitumen with higher penetration and low softening point shall be used for the finishing layer. Suitable blown type petroleum bitumen is of IS grade 85/25 of approved quality.

3. Where proprietary brands of bonding materials are proposed to be used by the Contractor they shall conform in all respects to the Specifications in the preceding paras

25.15.1.3 Stone Grit and Pea-sized Gravel

1. Stone grit shall be 6 mm and down size. Where pea-sized gravel is used it shall be down size. Where pea-sized gravel is used it shall be hard, round and free from dust, dirt etc. The stone grit or pea-sized gravel shall not be spread over vertical and sloping faces of flashings and at drain mouths. At these places the surface shall be painted with two coats of bituminous solution.

2. The quantity of stone grit or pea-sized gravel required for the final course of four or six course treatment with hessian base self finished bitumen. Felt type 3 grade 1 shall be 6 cubic decimetre. For six course treatment with felt other than type 3 grade 1, the stone grit or pea sized gravel at 8 cubic decimetre per sqm shall be used.

25.15.2 Preparation of Surface

25.15.2.1 The surface to be treated shall have a minimum slope of 1 in 120. This grading shall be carried out with lime concrete, cement concrete or cement plaster with coarse sand, as ordered, to the average thickness required and finished smooth. Such grading shall be paid for separately

25.15.2.2 Junctions between the roof and vertical faces of parapet walls, chimneys etc. shall be cased by running triangular fillets 7.5x7.5 cm size, in lime concrete or cement concrete. At the drain mouths, the fillets shall be suitably cut back and rounded off for easy application of water proofing treatment and easy flow of water. The brick aggregate shall be 20 mm nominal size. Cement Concrete where used shall be 1:2:4 mix (1 cement: 2 coarse sand:4 graded stone aggregate 20mm nominal size). The provision of fillets shall be deemed to be covered by the item of water proofing and shall not be measured or paid for separately.

25.15.2.3 In existing roof where gola and drip course are provided at the junction of roof and vertical face of parapet wall, chimney stacks etc. These shall be dressed suitably and finished smooth so as to ensure an easy and gradual turning or the flashing. Any dismantlement or forming and finishing smooth the junction for forming the base of the flashing shall not be measured or paid for separately and shall be deemed to form, part of the preparation of the surface in the water proofing treatment.

25.15.2.4 While the grading of roof surface is being done, it shall be ensured that the outlet drain pipe have been fixed and mouth at the entrance have been eased and rounded off properly for easy flow of water.

25.15.2.5 When any pipe passes through the roof to be treated, angular fillet shall be built around it for the water proof treatment to be taken over it. These fillets shall not be measured or paid for separately.

25.15.2.6 For carrying over and tucking in the water proofing felts into the parapet walls, chimney stacks etc. a horizontal groove 6.5 cm deep, 7.5 cm wide section with its lower edge at not less than 15 cm above graded roof surface shall be left on the inner face of the same during construction if possible. When such groove has not been left, the same shall be cut out neatly and the base at rear of the groove shall be finished smooth with cement plaster 1:4 (1 cement: 4 course sand). Such cutting of the groove and its finishing smooth shall be deemed to be part of the water proofing item and shall not be measured or paid for separately. No deduction shall be made either for not making the groove or when the latter has already been left in the masonry by the construction agency.

25.15.2.7 Tucking in the water proofing felt will be required where the parapet wall exceeds 45 cm in the height from the graded surface. Where the height is 45 cm or less, no groove will be required as the water proofing treatment will be carried over the top of the parapet wall to its full thickness. In the case of low dividing walls of height 30 cm or less, outlets therein shall be cut open for full height and the bottom and sides shall be rendered smooth and corners rounded and such treatment shall not be measured and paid for separately.

25.15.2.8 Where expansion joints are left in the slab, the provision of dwarf walls and / or RCC slabs for covering them and finishing the surface smooth shall be the responsibility of the construction agency, which had laid the roof slab and will not be included the operation of water proofing.

25.15.2.9 The graded surface of the roof and concrete fillets and the faces of walls shall be thoroughly cleaned with wire brushes and all loose scales etc. removed. The surface shall then be dusted off. Any crack in the roof shall be cut to ‘V’ section, cleaned and filled up flush with cement mortar slurry 1:4 (1 cement:4 coarse sand) or blown type petroleum bitumen or IS grade 85/25, or approved quality conforming to IS: 702 such cleaning of the surface or treating the cracks shall not be paid for separately.

25.15.3 Priming Coat

25.15.3.1 Where so specified, or required by the Engineer-in Charge for example under slightly damp condition a priming coat consisting of a bitumen primer coat consisting of a bitumen primer conforming to IS: 3384 applied with brush on the roof and wall surface at 0.24 litres per sqm to assist adhesion of the bonding material (i.e. bitumen)

25.15.3.2 Such application of primer shall be paid for separately, unless specifically included in the water proofing item.

25.15.4 Underlay

25.15.4.1 Where a floating treatment of water proofing with self finished bitumen felt is required i.e. where water proofing treatment is required to be isolated from the roof structure, a layer of bitumen saturated felt (underlay) shall be spread over the roof surface and tucked into the flashing groove. No bonding material shall be used below, the underlay in order to keep the underlay free of the structure. The adjoining strips of the underlay shall overlap to a minimum of 7.5 cm at sides and 10 cm at ends. The overlaps shall be sealed with the same bonding material as used for the self finished felt treatment. Unless specifically included in the water proofing item, the underlay treatment shall be paid for separately

25.15.4.2 The underlay shall be of type 1 saturated felt conforming to IS: 1322 in all respects and having a total minimum weight of the finished bitumen felt in dry condition with mica dusting powder @ 6.8 kg per 10 sqm. The roll shall not be damaged or crack on being unrolled on a fairly smooth and flat surface.

25.15.5 Treatment

25.15.5.1 The water proofing shall consist of a four or six course treatment, as given in the description of the item, each layer of bonding material, self finished bitumen felt or stone grit or pea sized gravel being counted as course.

25.15.5.2 The choice of a four or six course treatment will depend on the climatic condition, the importance of the building, the durability required, cost and other relevant considerations.

25.15.5.3 A four course treatment shall consist of the following layers:

1. Initial layer of bonding material applied hot at specified weight per unit area.
2. 2nd layer of self finished bitumen felt of specified brand and manufacture conforming to the type and grade given in the description of the item.
3. Third layer of bonding material.
4. Final layer of stone grit of pea sized gravel spread at specified volume of material per unit area.

25.15.5.4 In a six course treatment, the first, second and third layer shall be of the same as in the four course treatment. The fourth and fifth layer shall consist of self finished felt and bonding material respectively. The sixth layer shall consist of stone grit or pea sized gravel.

25.15.5.5 The primer or under lay where required to be provided shall not count against the number of course specified.

25.15.6 Laying

25.15.6.1 Bitumen bonding material of required grade shall be heated to the working temperature specified for the particular grade by the bitumen manufacturers and conveyed to the roof in buckets or pouring canes in weighed quantities. Suitable working temperature for different grades of bitumen are as under:

1. Blown type petroleum bitumen of IS grade 85/25 - 180 degree C.

2. Residual type petroleum bitumen of penetration 30/40 180 degree to 190 degree C (IS grade S35).

25.15.6.2 Drain outlets shall be given a four or six course treatment as specified for the roof in the description of the item in the manner specified for the flat roof surface. Water proofing treatment shall be carried into the drain pipe or outlets by at least 10 cm.

25.15.6.3 The self finished felt shall be cut to the required length, brushed clean of dusting material and laid out flat on the roof to eliminate curls and subsequent stretching. The felt shall normally be

laid in length at right angles to the direction of the slope and laying shall be commenced at the lowest level and worked upto crest. The felt shall not be laid in single piece of very long lengths as they are likely to shrink. The roof surface shall be cleaned and dry before the felt treatment is begun. Each length of felt shall be laid in position and rolled up for a distance of half its length. The hot bonding material shall be poured on the roof across the full width of the rolled felt as the later is steadily rolled out and pressed down. The pouring shall be so regulated that the correct weight of bonding material per unit area is spread uniformly over the surface. Excess bonding material that gets squeezed out at the ends shall be levelled up as laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on the hot bonding material in the same way. Subsequent strips shall also be laid in the same manner. Each strips shall overlap the proceeding one by at least 7.5 cm at the longitudinal edges and 10 cm at the ends. All overlaps shall be firmly bonded with hot bitumen. Streaks and trailings of bitumen near edges of laps shall be levelled by heating the overlap with a blow lamps and levelling down unevenness..

25.15.6.4 The third layer of bonding material in the four course treatment shall be carried out in a similar manner after the flashing has been completed.

25.15.6.5 In a six course treatment the third and fourth layers of bonding material and self finished felt shall be laid in the manner already described, taking care that laps in the felt are staggered from those in the second layer. The fifth layer of bonding material shall be carried out after the flashing is done.

25.15.6.6 High Parapet Walls, Chimney Stacks etc.,

1. Felts shall be laid as flashings wherever junctions of vertical and horizontal surfaces occur. Longitudinal laps shall be 10 cm. The lower layer of flashing felt in a six course treatment shall overlap the roof water proofing by not less than 20 cm while the upper layer shall overlap the roofing felt by 10 cm. The minimum overlap of the flashing felt in four course Specification over the roofing felt shall be 10 cm.

2. The flashing shall consist of the same four or six course treatment as for the roof except that the final course of stone grit or pea-sized gravel shall be replaced by an application of bituminous solution of approved quality in two coats on the vertical and sloping faces only, of the flashing. The overlap along the length of flashing shall stagger with those in the second layer of flashing felt (in a six course treatment and with the joints in roof felt).

3. The upper edge of the flashing felt shall be well tucked into the flashing grooves in the parapet, chimney stacks etc., to a depth of not less than 6.5 cm. Corresponding applications of bonding material shall also be made. The flashing treatment shall be firmly held in place in the grooves with wood edges at intervals and the grooves shall filled up with cement mortar 1:4 (1 cement:4 course sand) or cement concrete 1:2:4 (1 cement: 4 coarse sand: 4 graded stone aggregate 6 mm nominal size) and surface finished smooth with the rest of the wall. The cement work shall be cured for 7 days, when dry, the exposed plaster joints of grooves shall be painted with bitumen and two coats of bituminous solution shall be applied on the vertical and sloping surface of flashing.

4. After the top flashing felt layer has been fixed, the penultimate layer of bonding material shall be applied over the roofing felt and the horizontal overlaps and vertical and sloping surfaces of the flashings at the specified rate. Stone grit or pea sized gravel shall then be spread uniformly over the hot bonding material on the horizontal roof surface at the specified quantity per unit area and pressed into it with a wooden roller.

25.15.6.7 Low Parapet Walls

Where parapet walls are of height 45 cm or less, bitumen felt flashings shall be provided in the same manner as for flashings in the case of high parapet wall except that the upper edge shall be carried upto the full height of the wall and taken right across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm.

25.15.6.8 Low Dividing Walls

Where low dividing walls or inverted beams are met with, the same shall be covered with a four or six layer treatment as for the main roof, the latter bearing carried down both sides of the wall and overlapping the roofing treatment as in the case of flashing of high parapet walls. Drain outlets where formed in the low dividing walls, shall be given water proofing treatment of the same number of courses as specified for the flat roof surface. The bottom and sides shall be so treated that all overlaps are in the direction of flow of drainage.

25.15.6.9 Expansion Joints

1. Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing. The cover slabs shall cover the vertical turned up dwarf walls by not less than 7.5 cm and are provided with throatings on their underside along their length. The water proofing treatment shall be taken up the sloping junction fillets and the vertical faces of the walls to the underside of the cover slabs. The cover slabs are given the water proofing treatment like the roof slabs, after the cross joints between adjacent cover slabs are first sealed with 15 cm width of roofing felt struck to them with bitumen. The water proofing treatment shall be carried down the sides of the cover slabs to their full thickness. Care shall be taken to see that overlaps if any in the roofing over the cover slabs stagger with the joints between cover slabs.

2. The formation of the expansion joints and provision of cover slabs shall be the responsibility of the construction agency. The formation of the junction fillets and the water proofing treatment of the joint and cover slabs shall be carried out by the water proofing agency. No extra shall be paid for the junction fillers or for the sealing of the cross joints in the cover slab with 15 cm width of bitumen strips.

25.15.6.10 Pipes

Where vertical pipe outlets are met with 7.5 x 7.5 cm fillets of lime or cement concrete shall be provided and flashing of four or six course treatment, same as for the roofing treatment shall be laid. The upper edge of the flashing shall be laid sloping down forward and butted against the pipe and annular depression so formed shall be filled with hot bitumen. A circular metal collar in the shape of an inverted truncated cone shall be fixed on the pipe to throw off the rain water clear of the flashing and this shall be paid for separately.

25.15.6.11 Terrace

Where roof surfaces are expected to be used precast cement concrete tiles or 40 mm thick cement concrete shall be laid on the water proofing treatment. In such cases, the final course or stone grit or pea sized gravel shall be laid in the water proofing treatment. Suitable adjustment in the rates will effected for not providing the stone grit to pea sized gravel layer. Cement concrete in situ flooring shall be laid in panel not exceeding 0.4 square metres each. Precast tiles or in situ concrete flooring where laid shall be paid for separately unless included in the description of the water proofing item.

25.15.7 Measurements

25.15.7.1 Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

25.15.7.2 Measurements shall be taken over the entire exposed area of roofing and flashing treatment including flashing over low parapet walls, low dividing walls and expansion joints and at pipe projections etc. Overlaps and tucking into flashing grooves shall not be measured.

25.15.7.3 Vertical and sloping surfaces of water proofing treatment shall also be measured under the four or six course treatment as the case may be, irrespective of the fact that final course of grit or pea sized gravel is replaced by bitumen primer.

25.15.7.4 Primer or saturated felt underlay, where provided, shall also be measured in the same manner as the water proofing treatment and paid for separately. No deduction in measurements shall be made for either openings or recesses for chimney stacks, roof lights and the like, for areas upto 40 square decimetre (0.4 sqm) nor anything shall be paid for forming such openings.

25.15.7.5 For similar areas exceeding 40 sq. decimeter deductions will be made in measurements for full opening and nothing extra shall be paid for forming such openings.

25.15.8 Rate

25.15.8.1 The rate shall include the cost of all labour and materials involved in all the operations described above and the particular Specification given under the different items, with the corrections noted in the relevant subparas.

25.16 Rain Water Spouts

25.16.1 The sectional area of rain water spouts provided shall be generally at the rate of 1 square cm per 70 to 80 square decimeter of roof area drained. However in locations subject to excessive and high intensities of rainfalls, the area of spouts provided may be suitably increased to suit local conditions. No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the position of openings in the wall.

25.16.2 Stone Ware Spouts

25.16.2.1 The spouts shall be 100 mm in diameters and 60 cm long.

25.16.2.2 The stone ware pipe shall be perfectly sound, free from fire cracks, imperfections of glazing etc. They must be straight cylindrical and of standard nominal diameter and length and depth of socket. Full length of pipes shall be used on the work. They must be thoroughly salt glazed inside the outside shall generally conform to IS: 651.

25.16.2.3 These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1.3 (1 cement: 3 coarse sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry alround the pipe and socket shall be thoroughly wetted and the holes shall be given a coat of cement mortar alround. The S.W. pipe shall then be inserted and fixed with a surround of mortar. In case the hole is made much larger than the size of the pipe, cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) shall be used to fill in annular space. The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance into the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate easy flow. Core shall be taken to ensure that the vertical plane through the centre line of the spouts is at right angles to the plane of the wall. Spouts in a row shall be true to line.

25.16.2.4 Measurements

Spouts shall be measured in numbers.

25.16.2.5 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including scaffolding.

25.16.3 Cement Concrete Spouts

25.16.3.1 These shall be 100 mm in diameter and 60 cm long.

25.16.3.2 All pipes shall be new and perfectly sound free from cracks, cylindrical, straight and of standard nominal diameter, length and depth of socket. They shall conform to IS: 458. They shall be of unreinforced cement concrete manufactured by pressure process and shall have texture. The length of the pipe shall be length of barrel exclusive of the internal depth of the socket.

25.16.3.3 Fixing, Measurements and Rate shall be as specified under **Clause 23.16.2.1.**

25.17 Cast Iron Rain Water Pipes

25.17.1 Cast Iron Pipes

25.17.1.1 Pipes shall conform to IS: 1230 and shall be true, smooth and cylindrical, their inner and outer surfaces being as nearly as practicable concentric. These shall be sound and uniform castings, free from laps, pin holes or other imperfections and shall be neatly finished and carefully fitted both inside and outside. The ends of pipes shall be reasonably square to their axes.

25.17.2 Dimensions

25.17.2.1 C.I rain water pipes shall be of the diameter specified in the description of the item and shall be in full length of 1.8 metre including socket ends of the pipes, unless shorter lengths are required at junctions with fittings. The pipe lengths shall be in each case be with socket. The pipes shall be supplied without ears unless otherwise specifically mentioned.

25.17.2.2 The pipes supplied shall be factory painted (with a tar base composition) both inside and outside which shall be smooth and tenacious.

25.17.2.3 Every pipe shall ring clearly when struck all over with a light hand hammer. Where shorter pipes are cut from full lengths they shall be cut with a hacksaw. The sizes, weights, sockets and tolerance of pipes shall be as shown in the Table below:

Nominal pipe size (internal dia in mm)		**50**	**75**	**100**	**125**	**150**
1.	Pipe					
	(a) External diameter in mm Tolerance in mm	53 ±3	79 ±3	104 ±3.50	130 ±3.50	156 ±4.00
	(b) Thickness in mm Tolerance in mm	3.00 ±1	3.00 ±1	3.00 ±1	3.00 ±1	4.00 ±1
	(c) Nominal weight of 1800 mm long pipe without ears in kg Tolerance in weight Tolerance in length in mm	7.50 (-)10% ±13.00	11.00 (-)10% ±13.00	14.00 (-)10% ±13.00	20.00 (-)10% ±13.00	26.00 (-)10% ±13.00
2.	Socket					
	(a) Internal diameter in mm Tolerance in mm	63 ±3.00	89 ±3.00	114 ±3.00	139 ±3.00	167 ±3.00
	(b) Thickness in mm Tolerance in mm	4.00 ±1.00	4.00 ±1.00	4.00 ±1.00	4.00 ±1.00	4.00 ±1.00
	(c) Internal depth in mm Tolerance in mm	60 ±10	65 ±10	65 ±10	75 ±10	75 ±10

Note:
1. *All dimensions are in mm.*
2. *Pipes weighting more than the nominal weight may be accepted provided they comply in every other respect with the requirements of this standard.*
3. *The above table applies only to rain water pipes fixed on wall face.*

25.17.3 Fixing and Jointing

25.17.3.1 Pipes shall be either fixed on face of wall or embedded in masonry, as required in the description of the item.

25.17.3.2 Plain pipes (without ears) shall be secured to the walls at all joints with M.S. holder bat clamps. The clamps shall be made from 1.6 mm thick galvanised M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semi-circular pieces, hinged with 6 mm diameter M.S. bolt on one side and provided with flanged ends on the other side with hole of fit in the screw bolt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long 10 mm diameter M.S bar, riveted to the ring at the centre of one semicircular piece. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm in 1:2:4 mix (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) for which necessary holes shall be made in the wall at proper places.

25.17.3.3 The clamps shall be kept about 25 mm clear off finished face of wall, so as to facilitate cleaning and painting of pipes.

Note: Where G.I. sheet clamps are not provided, M.S. sheet clamps of 3 mm thick and 20 mm wide shall be used for making the clamps.

25.17.3.4 The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipe shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The annular space between the socket and the spigot shall be filled with a few turns of spun yarn soaked in neat cement slurry. These shall be pressed home by means of caulking tool. More skins of yarn shall be wrapped if necessary and shall be rammed home. The joint shall then the filled with stiff cement mortar 1:2 (1 cement: 2 fine sand) well pressed with caulking tool and finished smooth at top at an angle of 45 degree sloping up. The joints shall be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly.

25.17.3.5 Where pipes are to be embedded in masonry these shall be fixed in masonry work as it proceeds. In such cases care shall be taken to keep the pipes absolutely vertical or to the line as directed by the Engineer-in-Charge. The pipe shall have a surrounding of 12 mm minimum thickness of mortar at every orientation of the external surface. The mortar shall be of the same mix as is used in the masonry. The joint shall be caulked with lead as soon as the next length of pipe is placed in position. The open end (socket end) of the pipe shall be kept closed till the next length is fitted and jointed, to prevent any brick bats or concrete or pieces of wood falling in and choking the pipe.

25.17.3.6 The depth of lead from the lip of socket shall be 25 mm minimum. In case of 100 mm diameter. 75 mm and 50 mm pipes, the quantity of lead required per joint shall be 1.00 kg, 0.66 kg and 0.50 kg respectively for purpose of reckoning theoretical consumption.

25.17.3.7 On order to ensure that required quantity of lead is poured into the joint and to control wastage of lead, at the beginning, three or four samples shall be made and the quantum of lead per joint approved by the Engineer-in-Charge.

25.17.3.8 The actual consumption of lead should be within ±5% of the approved sample job subject to the provision that a variation of ±20% shall be allowed over the theoretical quantity of lead due to dimensional tolerances allowed as per Indian Standards. This variations includes allowances of wastage also.

25.17.3.9 The spigot end shall butt the shoulder of the socket and leave no gap in between. The annular space between the socket and the spigot will be first well packed in with spun yarn leaving 25 mm from the lip of the socket for the lead. The joint shall then be lead caulked.

25.18 Cast Iron Fitting for Rain Water Pipes

25.18.1 C.I. Fittings

25.18.1.1 C.I. Fittings such as bends of various degrees, heads, offsets of different projections, branches and shoes shall conform to IS: 1230. The general Specifications for these as described in **Clause 23.17.1.1** shall apply.

25.18.1.2 Bends shall be of the nearest standard degree as actually required at site. Heads shall be of the flat or corner types as required. Offsets shall be of the projections as stipulated in the description of the item. Branches shall be single or double as described in the item and shall be of the nearest standard degree as actually required. Standard shoes shall be of overall vertical length, 180 mm for 75 mm diameter, 205 mm for 100 mm diameter and 275 mm for 150 mm diameter sized pipe from top of socket to lowest tip of shoe. Shoes of longer length if used shall be in lengths from top of socket to lowest tip of shoe of 300 mm, 375 mm, 450 mm, or 600 mm, as actually required at site.

25.18.2 Dimensions

25.18.2.1 The fittings shall be of the diameter specified in the description of the item.

25.18.2.2 The thickness of the fittings and details of spigots and sockets shall be same as those of the corresponding size of straight pipes. The fittings shall be supplied without ears unless otherwise specifically mentioned in the item. The fittings shall be factory painted with a tar basis composition both inside and outside which shall be smooth and tenacious. Every fittings shall ring clearly when struck all over with a light hard hammer. The fittings shall be of standard size and their individual weights shall conform to the weights given in the table below:

Weight of C.I. Rain Water Pipe Fittings

Sr.	Description	75 mm dia (weight in kg)	100 mm dia (weight in kg)	150 mm dia (weight in kg)	Unit
1.	Bends (Plain)	3.20	4.50	9.10	Each
2.	Offsets (Plain)				
	a) 55 mm projection	2.70	5.00	8.20	Each
	b) 75 mm projection	3.20	5.50	9.10	Each
	c) 115 mm projection	4.10	5.90	9.50	Each
	d) 150 mm projection	4.50	6.40	10.40	Each
	e) 225 mm projection	5.00	7.30	11.80	Each
	f) 300 mm projection	6.00	8.60	12.70	Each
3.	Branches (Plain)				
	Single	5.00	7.30	14.50	Each
	Double	6.80	10.00	19.10	Each
4	Standard shoes (Plain)	3.20	4.10	8.60	Each
5.	Longer shoes (Plain)				
	a) 300 mm	3.20	5.00	-	Each
	b) 375 mm	4.10	5.50	-	Each
	c) 450 mm	5.50	6.40	-	Each
	d) 600 mm	7.30	8.60	-	Each
6.	Heads	6.40	6.80	11.30	Each
7.	Extras:				
	a) For ears cast on any fittings and short pipes	0.90	0.90	11.35	Each
	b) For inspection doors fitted on any fitting	1.80	1.80	2.25	Each

Note:

1. *The above table applies only to rain water fittings which are part of pipe lines fixed on wall face. Permissible tolerance in weight of fittings shall be 5%.*
2. *For fittings to be used with pipe lines to be embedded in masonry, Specifications shall correspond with those of pipe fittings for soil, waste and vent pipes. For their weights, Specifications under S.C.I. soil, waste and vent pipes may be referred to.*

25.18.3 Fixing and jointing shall be as specified in **Clause 23.17.3**.

25.18.4 Finish shall be as specified in **Clause 23.17.3.9**.

25.18.5 Measurements

25.18.5.1 The fittings shall be measured by numbers. Where longer shoes are used in lieu of standard shoes specified in the description of the item, they shall be measured as standard shoes of 180 mm, 205 mm and 275 mm for 75 mm diameter, 100 mm diameter and 150 mm diameter respectively in number and the extra lengths of the shoes shall be measured and paid for under the corresponding size of pipes.

25.18.6 Rate

25.18.6.1 The rate shall include in the case of fittings fixed on the face of wall, the cost of all materials and labour involved in all the operations described above including jointing but excluding the supply and fixing the M.S. holder bat clamps in walls and the anchoring concrete. Unless otherwise specified in the description of the item, the rate shall apply for fittings without access doors. In the case of fittings forming part of a rain water pipe line embedded in masonry, the rate shall be for supplying and embedding the fittings in masonry but shall not include for the jointing and lead caulking which shall be paid for separately.

25.19 Asbestos Cement Rain Water Pipes

25.19.1 A.C. rain water pipes shall be fixed with standard holder bat clamps.

25.19.2 A.C. Pipes

25.19.2.1 The pipes shall conform to IS: 1626 (PT. 1). These shall be straight, true and smooth and regular in thickness. To determine the straightness of a pipe it shall be rolled along a plane surface in such a manner that the socket over hangs on one edge of the plain surface. The gap between the barrel of the pipe and the plane surface shall not exceed the limits indicated below:

Length of pipe in metre	Gap in mm
0.5	3
1.0	3
1.5	5
2.0	5
3.0	6

25.19.2.2 They should be sound, homogeneous and free from cracks and other flaws.

25.19.3 Dimensions

25.19.3.1 A.C. rain water pipes shall be of the diameter specified in the item. The pipes are available in lengths of 0.5m, 1 m, 1.5 m, 2 m and 3 m excluding the depth of socket. The pipe shall be fixed in lengths of 3 metres as far as possible. The thickness of pipes and tolerances on their thickness shall be as shown in table below:

Thickness of Pipes and Pipe Fittings and Tolerances On Thickness

Nominal diameter of pipe and pipe fittings in mm	Thickness of pipe or pipe fittings in mm	Tolerances on thickness in mm
50	6.5	± 1.0
60	6.5	± 1.0
80	8.0	± 1.0
100	8.0	± 1.0
150	9.5	± 1.5

25.19.4 Fixing and Jointing

25.19.4.1 Pipes shall be secured to face of the wall, below all joints by standard holder bat G.I. clamps. The bat clamps shall consist of a cast iron base with a projecting “I” shaped lug, to the web of which the two semi circular halves of the 1.8 mm thick G.I. sheet clamp or 3 mm thick M.S. clamps are bolted. The base of the holder bat clamp shall be screwed on a pair of wooden plugs fixed in the wall with screws of designation No. 18 of slotted counter sunk head wood screws driven through the holes in the base. The screws shall be not less than 75 mm long for 80 mm diameter pipes and 100 mm long for 100 mm diameter pipes. The plugs shall be fixed in the wall to a depth of 15 cm, in cement mortar 1:2 (1 cement: 2 fine sand) centrally to the holes. In the base of the bat clamps and with their front face projecting to such a length from the brick face that when the bat clamp is fixed, the outer face of its base shall be 11 x 5 cm wide at face increasing to 16 x 7 cm width at rear and shall be 7 cm deep throughout. The bat clamps shall be well galvanised.

25.19.4.2 The spigot of the upper pipe shall be properly fitted into the socket of the lower pipe, such that there is uniform, annular space for filling with the jointing material. One-third depth of this annular space between socket and spigot shall be filled in with spun approved quality and properly pressed with caulking tool. The remaining 2/3rd depth of the joint shall be filled in the stiff cement mortar 1:2 (1 cement: 2 coarse sand) and shall be pressed with caulking tool and finished smooth at top at an angle of 45 degree slopping up. This will be cured for a period of 7 days by tying a piece of gunny bag, four fold, to the pipes and keeping it wet.

25.19.5 Finish

25.19.5.1 The finished pipe line shall be truly vertical or to lines and slopes as directed and shall be at a uniform distance of 40 mm from the finished face of the wall.

25.19.6 Measurements

25.19.6.1 The pipes shall be measured net when fixed correct to a cm excluding all fittings along its length. When collars are used, these shall be measured along with and paid as pipes and no extra shall be paid for collars or for fixing them to wall with bat clamps. No allowance shall be made for the portions of pipe lengths centering the sockets of the adjacent pipe or fittings. The above will apply to both case i.e. whether the pipes are fixed on wall face or the pipes are embedded in masonry.

25.19.6.2 No deduction shall be made in the former case from the masonry measurements for the volume of concrete blocks embedded therein.

25.19.6.3 Similarly no deduction shall be made for volume occupied by the pipes from the masonry when the former are embedded in the latter.

25.19.7 Rate

25.19.7.1 The rate shall include the cost of all materials and labour involved in all operations described above including jointing but excluding the supply and fixing up walls plugs and bat clamp which shall be paid for separately.

25.20 Asbestos Cement Pipe Fittings

25.20.1 A.C. Fittings

25.20.1.1 By the term fittings are meant A.C. specials such as bends of various degrees, heads, offsets of different projections, branches and shoes. The general Specifications for these shall conform to those described in **Clause 23.19**. These shall confirm to IS: 1626 (Pt.1) and shall be of approved manufacture.

25.20.2 Dimensions

25.20.2.1 The fittings shall be of the type, diameter and size specified in the description of the item. The thickness of the fittings and details of spigots and sockets shall be the same as those of the corresponding size of straight pipes. The fittings shall be of standard size and their individual thickness and tolerance on thickness shall be as given in the earlier table. The fittings shall also conform to IS: 1626(Pt.1).

25.20.3 Fixing and Jointing

25.20.3.1 The Specifications for A.C. pipes in **Clause 23.19.4** shall also apply to fittings.

25.20.4 Measurements

25.20.4.1 The fittings shall be measured in numbers.

25.20.5 Rate

25.20.5.1 The rate shall include the cost of all materials and labour involved in all the operations described above including jointing but excluding the supply and fixing of wall plugs and bat clamps, which shall be paid for separately. Unless otherwise specified in the description of the item, the rate shall apply for plain fittings without access doors.

APPENDIX-A: GALVANISED STEEL SHEETS

A-1 Dimensions

A-1.0 Sizes of Plain Sheet

The pain sheets shall be supplied in any combination of the following lengths, widths and thickness.

1. Length : 2500 and 3000 mm
2. Width : 900 and 1000 mm
3. Thickness : 0.50, 0.63, 0.80, 1.00, 1.25 and 1.60 mm.

A-1.1 In case of sheets supplied in coil, the internal diameter of coil shall be 450, 510 and 610 mm and the mass of each coil shall not exceed 12 tonnes.

A-1.1.1 Coils weighing more than 12 tonnes may be supplied subject to mutual agreement between the contracting parties.

A-1.2 Corrugated Sheets

A-1.2.1 Length

The length of the corrugated sheets shall be as follows:
2500, 3000 mm

A-2 Zinc Coating

The weight of coating referred to in this Specification shall represent the total weight of Zinc both sides inclusive.

On any sample selected at random from the delivery, one set of three samples each 50 x 50 mm or 50 mm diameter shall be selected at random from one sheet for every 500 G.S. sheets, the coating for the different classes shall be with in the limits specified in table below:

Mass of Coating (Total Both Sides)

Grade of coating	Minimum average coating Triple spot test g/sqm	Minimum coating single spot test* g/sqm
750	625	550
600	500	425
450	350	300
375	275	250

** Minimum individual value obtained in triple spot test.*

A-3 Mass

The mass of sheets and coils shall be calculated as given in Table below on the basis of nominal dimensions and mass of zinc coating.

Calculation of Mass of Sheets or Coils

Type of materials	Order of Calculation	Method of Calculation	Number of Numerals in resultant value
Sheet	Mass of single sheet Total mass	Nominal mass of Single sheet plus mass of zinc coating Mass of single sheet (kg) x number of sheets	Rounded off to 4 effective figures Rounded off to integral value of kg
Coil	Unit mass of coil Mass of single coil Total mass (kg)	Unit mass of sheet (kg/m^3) x width (mm) x 10 Unit mass of coil (kg/m) x length (m) Total mass of each coil	Rounded off to 3 effective figures Integral number of (kg)

Note:

1. *Nominal mass of single sheet shall be calculated by calculating the volume of the sheet and multiplying the same with density of sheet (density 7.85 g/cubic cm) and rounding the same to 4 effective figures.*
2. *Mass of the coating shall be calculated by multiplying the surface area of single sheet with indicated nominal coating mass (g/square metre) as shown for triple spot test.*
3. *For calculation of corrugated sheet mass, the width before corrugation shall be considered while calculating the area.*

A-4 Corrugations

The depth of corrugation shall be 18 mm and shall have a pitch of 75 mm (nominal).

The number of corrugations shall be 8,10 or 11 per sheet. The overall width of the sheet before and after corrugation shall be as the dimensions given in table below:

Details of Corrugations

Number of corrugations	Nominal overall width of sheet measured between crowns of outside corrugations	
	Before corrugation (mm)	After corrugation (mm)
10	900	800
11	1000	885

26 GENERAL BUILDING SERVICES

26.1 Scope

26.1.1 These Specifications cover the general requirements for plumbing services including fixing of pipes, fittings and sanitary appliances in buildings and general requirements external (outside buildings) water supply and sewerage works.

26.1.2 For the purpose of water supply arrangements inside buildings, the work can be considered as to start from ferrules and service pipes.

26.1.3 All the items under this group shall conform to the detailed Specifications given for each of the items, in addition to the bye-laws of the local bodies within whose jurisdiction the items are executed. Where the bye-laws of the local bodies differ from the detailed specification for an item, the bye-laws shall override these Specifications.

26.2 Applicable codes

26.2.1 All materials used in the construction of any of the works or any of the appliances shall conform to the relevant Indian Standards where applicable. Where no such standards exit, the materials shall be of the quality and workmanship acceptable to Authority, and shall be open to inspection at the manufacturer's works before dispatch.

26.2.2 The following Indian Standard codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

IS: 458	Concrete pipes (with and without reinforcement)
IS: 651	Salt Glazed stoneware pipes and fittings
IS: 771 (Part I to IV)	Glazed fireclay Sanitary appliances
IS: 772	CI Sanitary Appliances
IS: 774	Flushing Cisterns for W/C and Urinals
IS: 775	CI Brackets and Supports for Wash Basins and Sinks
IS: 778	Gunmetal Gate, Globe and Check valves for general purposes
IS: 779	Water Meters (Domestic Type)
IS: 781	Sand-cast brass screw down bib and stop taps for water services
IS: 782	Caulking lead
IS: 783	Code of practice for laying of concrete pipes
IS: 784	Prestressed concrete pipes
IS: 804	Rectangular prestressed steel tanks
IS: 1200 (Part XVI)	Method of measurement for Building and Civil Engineering works - Laying of water, sewer lines including appurtenant items
IS: 1239	Mild steel tubes, tubulars and other wrought steel fittings
IS: 1536	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS: 1538 (Part I to XIII)	Cast Iron fittings for pressure pipes for water, gas and sewage
IS: 1545	Solid drawn copper alloy tubes
IS: 1700	Drinking fountains
IS: 1703	Ball valves (horizontal plunzer type) including floats for water supply purposes
IS: 1711	Method for simple torsion testing of steel wire
IS: 1729	Nahani Trap
IS: 1742	Code of practice for building drainage
IS: 1795	Pillar Taps
IS: 1916	Steel cylinder reinforced concrete pipes
IS: 2064	Code of practice for selection, installation and maintenance of sanitary appliances
IS: 2065	Code of Practice for Water Supply in buildings
IS: 2104	Water meter boxes (domestic type)

IS: 2326	Automatic Flushing Cisterns for Urinals
IS: 2379	Colour code for identification of pipe lines
IS: 2401	Code of practice for selection, installation and maintenance of domestic water meters
IS: 2470	Code of practice for design and construction of septic tanks
IS: 2548	Plastic water closet seats and covers
IS: 2556 (Part I to XV)	Vitreous sanitary appliances
IS: 2692	Ferrules for water services
IS: 3076	LDPE pipes for Potable Water Supplies
IS: 3114	Code of practice for laying of cast iron pipes
IS: 3438	Silvered glass mirror for general purpose
IS: 3589	Electrically welded steel pipes for water, gas and sewage (200 to 2000 mm nominal diameter)
IS: 3950	Surface boxes for sluice valves
IS: 4111	Code of practice for ancillary structures in sewerage system
IS: 4127	Code of practice for laying of Glazed stoneware pipes
IS: 4827	Tower Rail
IS: 5329	Code of practice for sanitary pipe work above ground for buildings
IS: 5455	Cast Iron steps for manholes
IS: 5822	Code of practice for laying of welded steel pipes for water supply
IS: 6295	Code of practice for water supply and drainage in high altitudes and or sub-zero temperature regions
IS: 7231	Plastic Flushing Cisterns for W/C and Urinals
IS: 10067	Material constants in building works

26.2.3 Other IS codes not specifically mentioned herein but pertaining to the work of internal water supply form part of these Specifications.

26.3 General Requirements

26.3.1 The following general requirements are applicable, though these are not explicitly specified / stated in the Drawings or designs given by the Engineer.

26.3.1.1 All work shall be done with skilled workmen experienced in the trade. All water supply installation work shall be carried through licensed plumbers.

26.3.1.2 All work shall be adequately protected, to the satisfaction of the Engineer, so that the whole work is free from damage throughout the period of construction upto the time of handing over.

26.3.1.3 No work shall be covered without the approval of the Engineer.

26.3.1.4 The Contractor shall be responsible for coordinating this work with works of other trades sufficiently ahead of time to avoid unnecessary hold-ups. Hangers, sleeves, recesses etc., shall be left in time as the work proceeds.

26.3.1.5 The Contractor shall submit as directedby the Engineer, samples, shop Drawings, manufacturer's Drawings, equipment characteristics and capacity data etc., of all equipment, accessories, devices etc., that he proposes to use in the installation, to the Engineer for approval.

26.3.1.6 Any damage caused to the building or to electric, sanitary, water supply or other installations etc., therein either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installations shall be restored to its original condition by the Contractor.

26.3.1.7 It is most important to ensure that the wholesome water supply provided for drinking and culinary purposes, is in no way liable to contamination from any less satisfactory water. There shall, therefore, be no cross connection whatsoever between a pipe or fitting for conveying or

containing wholesome water and a pipe or fitting for conveying or containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose. The provision of reflux or non-return valves or closed and sealed valves shall not be construed a permissible substitute for complete absence of cross-connection.

26.3.1.8 No piping shall be laid or fixed so as to pass into, through or adjoining any sewer, scour outlet or drain or any manhole connected therewith nor through any ashpit or manure-pit or any material of such nature that would be likely to cause undue deterioration of the pipe, except as permitted in the next Clause.

26.3.1.9 Where the laying of any pipe through fouled or corrosive soil or pervious material is unavoidable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means approved by the Engineer. Any piping or fitting laid or fixed, which does not comply with the above requirements, shall be removed and relaid in conformity with the above requirements and to the satisfaction of the Engineer.

26.3.1.10 Where lines are to be laid in close proximity to electric cables or in corrosive soils, adequate precautions should be taken to avoid electrical accidents and corrosion.

26.3.1.11 To reduce the frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection at the joints, whether of the jointing material or otherwise.

26.3.1.12 Change in diameter and in direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made which is likely to materially diminish or alter the cross-section.

26.3.1.13 All pipe work shall be so laid or fixed, and maintained as to be and to remain completely watertight, thereby avoiding waste of water, damage to property and the risk of contamination of the water conveyed.

26.3.1.14 Underground piping shall be laid at such a depth that it is unlikely to be damaged by frost or traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided, special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

26.3.1.15 The bottom of water service pipe, at all points, shall be at least 30 cm above the top of the sewer line at its highest point.

26.3.1.16 Water for drinking or for culinary purposes as far as possible shall be on branch pipes connected directly to the service.

26.3.1.17 In flats and tenements supplied by a common service pipe a stop tap shall be fixed to control the branch each separately occupied part. In large buildings a sufficient number of stop valves shall be fixed on branch pipes, and to control groups or ball valves and draw off taps, so as to minimize interruption of the supply during repairs, all such stop valves shall be fixed in accessible positions and properly protected from being tampered with, they may be of the gate type to minimise loss of head of friction.

26.3.1.18 Where the service pipe is of diameter less than 50 mm the stop valves shall be of the screw down type and shall have loose washer plates to act as non-return valves. Other stop valves in the service line may be of the gate type.

26.3.1.19 Service pipes shall be so constructed as to avoid air-locks, so that all piping and fittings above ground can be completely emptied of water to facilitate repairs. There shall be draining taps or draw-off taps (not underground) at the lowest points, from which the piping shall rise continuously to draw-off taps, ball valves, cisterns, or vents (where provided at the high points).

26.3.1.20 Piping shall be confined, as far as possible, to rooms where appliances are fixed, it shall have easy bends, and where quietness is particularly desired, holder bats or clamps shall be insulated from the piping by suitable pads.

26.3.1.21 The rising pipe to the storage cistern, if any, of any feed cistern shall be taken as directly as possible to the cistern and shall be fixed away from windows or ventilators.

26.3.1.22 Piping shall not be buried in walls or solid floors. Where unavoidable, piping may be buried for short distance provided that adequate protection is given against damage and that no joints are buried. If piping is laid in ducts or chases, these shall be roomy enough to facilitate repairs and shall be so constructed as to prevent the entry of vermin. To facilitate removal of pipe casing, floor boards covering piping shall be fixed with screws or bolts.

26.3.1.23 When it is necessary for a pipe to pass through a wall or floor, sleeves shall be fixed therein for reception of the pipe and to allow freedom for expansion and contraction and other movement. Piping laid in wooden floors shall, where possible, be parallel with the joist.

26.3.1.24 Where storage tanks are provided to meet over all requirements of water, connection of service pipe with any distributing pipe shall not be permitted except one direct connection for culinary or drinking requirements.

26.3.1.25 No service pipe shall be connected to any water closet or urinal. All such supplies shall be from flushing cisterns which shall be supplied form storage tank.

26.3.1.26 No service or supply pipe shall be connected directly to any hot water system or to any apparatus used for heating other than through a feed cistern thereof.

26.3.1.27 The service pipe shall pass into or beneath the building at a depth below the external ground level of not less than 0.75 m (provided the foundation is deeper than 0.75 m) and at its point of entry through the structure, it should be accommodated in a sleeve which should have previously been solidly built in. The space between the pipe and the sleeve shall be filled with bituminous or other suitable material for a minimum length of 15 cm at both ends.

26.4 Pipes and Fittings

26.4.1 Cast Iron (CI) pipes and fittings shall be used for external water supply services, unless otherwise specified. For piping arrangements inside buildings, Galvanized Iron (GI) pipes, medium class, conforming to IS: 1239, shall be used. For sewerage works Glazed Stoneware (GSW) pipes or Reinforced Cement Concrete (RCC) pipes shall be used as specified. Specifications for laying of these pipes are given in **Chapter 15**.

26.5 Material, Fittings, Appliances and Structures for Water Supply

26.5.1 General

26.5.1.1 All pipes, fittings and appliances shall be free from cracks and other flaws before fixing and shall be undamaged in all respects during and after fixing. Any damages shall have to be rectified satisfactorily.

26.5.1.2 All the pipes, fittings and appliances shall be thoroughly cleaned before fixing and particular care shall be taken to see that no extraneous material gets into them during fixing. All items required for ensuring leak proof jointing and efficient functioning of the pipes and appliances shall be carried out without extra claim. The pipes shall be carefully cleared of all foreign matter before being laid. They shall be thoroughly brushed out internally with a well-fitting hard brush, and after laying the open end shall be temporarily plugged to prevent ingress of water, soil etc., precaution shall be taken to prevent floatation of the plugged pipes.

26.5.1.3 All cutting and waste of pipes involved in fitting them shall be included in the rate.

26.5.1.4 All diameters of pipes shall be the diameters of the inside bore. All the pipes, appliances, fixtures and all other materials to be used shall be new and of good quality. Pipes and fittings

26.5.2 Fixtures and Appliances

26.5.2.1 Brass or Gunmetal water fittings

26.5.2.1.1 All brass or gunmetal fittings shall be of heavy quality and of approved manufacture and pattern. The fittings shall conform to IS: 778 and IS: 781. A sample of fittings shall be got approved by the Engineer and all fittings shall be provided according to the approved samples.

26.5.2.1.2 The standard size of bronze or gun metal fittings shall be designated by the nominal bore of the pipe outlet to which the fittings are attached. A sample of each kind of fittings shall be got approved from the Engineer and all supplies made according to the approved samples.

26.5.2.1.3 All cast fittings shall be sound and free from laps, blow holes and pittings. Both internal and external surfaces shall be clean, smooth and free from sand etc. Burning, plugging stopping or patching of the casting shall not be permissible. The bodies, bonnet, spindles and other parts shall be truly machined so that when assembled the parts shall be axial, parallel and cylindrical with surfaces smoothly finished. The area of the water way of the fittings shall not be less than the area of the nominal bore. Chromium plating wherever specified shall be of 0.3 micron thick, conforming to IS: 4827. The chromium shall never be deposited on brass unless a heavy coating of nickel is interposed. In the case of iron fittings, a thick coat of copper shall first be applied, then one coat of nickel and finally the coat of chromium shall be applied. In finish and appearance the plated article, when inspected, shall be free from plating defects such as blisters, pits, roughness and unplated areas and shall not be stained or discoloured. Before fitting is plated the washer plate shall be removed from the fittings, the gland packing shall be protected from the plating solution.

26.5.2.2 Bib cock (tap)s and stop cock (tap)

26.5.2.2.1 Bib cock and stop cock shall be of specified size and shall be of screw down type and shall conform to IS 781. The handle shall be either crutch or butterfly type, securely fixed to the spindle. Valve shall be of the loose leather seated pattern. The cocks (taps) shall open in anti-clockwise direction.

26.5.2.2.2 The bib cock and stop cock shall be polished bright. The minimum finished weights of bib tap and stop tap shall be as specified in the following table:

Size (mm)	Minimum finished weight	
	Bib tap (kg)	Stop tap (kg)
8	0.25	0.25
10	0.30	0.35
15	0.40	0.40
20	0.75	0.75

26.5.2.3 Screw Down Wheeled Stop Tap

26.5.2.3.1 The item shall conform to the Specifications covered in **Clause 24.5.2.2** in all respects except that it shall have an operating wheel. The material of the wheeled stop valve shall be gun metal or brass as specified in the item.

26.5.2.4 Self closing taps and other special fittings

26.5.2.4.1 Self closing taps and other special fittings of approved makes are to be used on direct pipes and distributing pipes from tanks. Self-closing taps shall be of non-concussion type and shall comply with IS: 1711.

26.5.2.5 Ferrules

26.5.2.5.1 The ferrules for connection with CI main shall generally conform to IS: 2692. It shall be of non-ferrous materials with a CI bell mouth cover and shall be fitted with a screw and plug or valve capable of completely shutting off the water supply to the communication pipe if and when required.

26.5.2.5.2 Service pipes of less than 50 mm bore may be connected to mains by means of right-angled screw-down ferrule. The main is drilled and tapped and the ferrule screwed in. In case of large-sized trunk mains, this may be done by a tapping under pressure machine, which will obviate any interference with the use of the main.

26.5.2.6 Water Meters

26.5.2.6.1 Water meters of approved type shall be permitted to be used subject to such conditions prescribed by the Implementing Agency or the local bye-laws. Metres of domestic type shall conform to the requirements of IS: 779. The meter shall be installed in accordance with IS: 2401. The meter shall be fitted beyond the stopcock with unions to facilitate the necessary periodic changing of the meter. If fitted in an exposed position outside the building, the meter shall be housed in water meter boxes conforming to IS: 2104.

26.5.2.7 Valves

26.5.2.7.1 Wheel Valves (Globe valves)

The wheel valves shall be of size as specified and conforming to IS: 778 (Globe Valves).

26.5.2.7.2 Gate Valves

The gate valve shall be of size as specified and conforming to IS: 778.

26.5.2.7.3 Sluice valves

Sluice valves shall be of the specified size and class and shall in all respects conform to the requirements of IS: 780, IS: 2906 and IS: 2685.

26.5.2.7.4 Non-Return valve (Brass)

The valves shall be of quality approved by the Engineer and shall generally conform to IS: 778. Weights of these valves shall be as prescribed in the following table with a tolerance of 5 percent.

Diameter (mm)	Weight (kg)	
	Horizontal type	Vertical type
15	0.30	0.25
20	0.55	0.25
25	0.90	0.75
32	1.25	0.90
40	1.70	1.20
50	2.90	1.45
65	5.25	2.15
80	7.70	4.10

26.5.2.7.5 Non-Return valve (Gunmetal)

The valves shall be of quality approved by the Engineer and shall generally conform to IS: 778.

26.5.2.7.6 Float / Ball valves

1. The float valves or ball valves shall be of specified size as per Specification conforming to IS: 1703. The valve shall be of Brass or Gunmetal of specified size conforming to IS: 1703. The valve shall be of following two classes:

   - High Pressure (HP) for use on mains having pressure of 1.75 kg/cm^2 and above. These shall remain closed at a test pressure of 10.5 kg/cm^2.
   - Low Pressure (LP) for use on mains having a pressure upto 1.75 kg/cm^2. These shall remain closed at a test pressure of 3.5 kg/cm^2.

2. The ball valves shall be of the nominal sizes 15 mm, 20 mm, 25 mm, 32 mm, 40 mm and 50 mm. The nominal size shall correspond with the nominal bore of the inlet shanks. Polyethylene floats shall conform to IS 9762. These valves shall be of the following dimensions and weights:

Sr. No.	**Item**	**Nominal Size of valve (mm)**					
		15	**20**	**25**	**32**	**40**	**50**
1.	Diameter of Spherical float (mm)						
	High pressure	127	152	203	229	254	305
	Low pressure	114	127	178	203	203	254
2.	Minimum weight of ball valve including back nut, body and piston (g)	283	446	823	1149	1589	1852

26.5.2.7.7 Landing Valves

Landing valves shall be of the specified size and class and shall in all respects conform to the requirements of IS: 5290, type B.

26.5.2.7.8 Full Way Valve (Brass)

The valve shall be of brass fitted with a cast iron wheel and shall be of gate valve type conforming to IS: 780, opening full way and of the size as specified. The valve shall be of best quality as approved by the Engineer.

26.5.3 Water Storage tanks on terraces

26.5.3.1 These tanks shall of RCC, cast in situ circular/rectangular in shape of required capacity and shall be as per approved Drawings.

26.5.3.2 The mix of RCC shall be 1:1.5:3 for walls and bottom slab and 1:2:4 for top slab. The Specifications for RCC shall be as per **Chapter 9**. For inlet, outlet and other connections fully threaded GI connections with hexagonal check nuts and washers on either side of the tank wall shall be provided. Holes for threaded connections shall be drilled and not punched. Pipes entering / leaving the tank shall be provided with unions and suitably supported on a firm basis to avoid damage to the tank walls.

26.5.4 Underground Water Storage Tanks

26.5.4.1 Underground Storage tanks shall be of RCC, as per the Specifications given for RCC storage tanks, in **Clause 24.5.3**. The following requirements shall also be complied with:

1. The tank shall project at least 30 cm above the highest flood level. Where this is not possible the manhole cover shall be raised 30 cm above the highest flood level of the locality or ground level whichever is higher.
2. The construction of the tank shall be such as to provide for the draining of the tank when necessary and water shall not be allowed to collect round about the tank.
3. The tank shall be perfectly watertight.
4. The inner surface of the tank shall be rendered smooth as far as possible.
5. The top of the tank shall be so leveled as to prevent accumulation of water thereon.

6. The tank shall have a complete cement concrete cover leaving a manhole opening provided with a properly fitting mosquito-proof hinged cast iron cover fitted with a leak proof cast iron frame. Where tank is of a large size, adequate number of manholes shall be provided.
7. No gap shall be allowed to remain round the suction pipe and arrangement shall be provided for proper discharge of spill water from the electric pump by connecting the pump cabin to the water drain, or by providing a small hole which will enable the water to flow out
8. The overflow pipes or vent shafts, if provided, shall have a wire gauge cover of 1.5 mm mesh properly screwed tightly to the opening.

26.5.5 Fittings and accessories for RCC Water Reservoirs

26.5.5.1 Where necessary, the pipes etc., shall be embedded during the casting of concrete. where not so necessary in the opinion of the Engineer, holes may be left while casting of the concrete and the accessories fixed later. All these holes shall be made good and waterproofed after fixing of the accessories. The frame of the manhole shall be embedded into the concrete while casting.

26.5.5.2 The following fittings and accessories are included under this item as given elsewhere:

1. Ball cock of the diameter of the supply pipe.
2. Galvanised iron overflow pipe with mosquito proof coupling.
3. Required number of 45 cm diameter manholes with cover and frame,
4. Connecting galvanised iron pipes,
5. 45 cm wide mild steel ladder of 40 mm x 6 mm mild steel flat stringers and stops of 20 mm diameter mild steel bars,

26.5.5.3 The intake and outtake pipes shall be as provided separately and shall not be included in this item.

26.6 Sanitary Fittings and Appliances

26.6.1 General

26.6.1.1 All porcelain sanitary ware shall be of approved make. All fittings shall be of first quality, free from warps, cracks and glazing defects. All sanitary ware, fittings and fixtures shall be as shown in Drawings and as described in detail in Bill of Quantities.

26.6.2 Protection

26.6.2.1 Fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of chromium plated fittings. Tool marks on chromium fixtures etc., shall not be accepted. All fixtures shall be fixed with chromium plated brass screws with washers wherever necessary. Protective paper on fixtures shall be removed with hot water only at the final completion of work.

26.6.3 Workmanship

26.6.3.1 All sanitary ware shall be fixed in a neat workmanlike manner, true to level and plumb. Manufacturer's instructions shall be followed closely regarding installation and commissioning.

26.6.4 Testing

26.6.4.1 When the installation has been completed to the satisfaction of the Engineer, it shall be tested in the following manner:

1. The entire system shall be slowly filled with water, allowing any trapped air to escape.
2. When all outlets are closed the system shall be checked for water tightness.
3. Each outlet shall then be checked for rate of flow and correct operations.

26.6.5 Bath, Lavatory and Mixing Taps

26.6.5.1 Bath, lavatory and mixing taps shall generally comply with the requirements specified for bib taps in **Clause 24.5.2.2**. Combination taps, mixing valves or blenders shall conform to IS: 1701. For mixing hot and cold water and discharging the mixture through a single outlet shall be fed with both hot water and cold water under pressure only from cisterns at the same level or from the same cistern.

26.6.6 Wash basins

26.6.6.1 The item pertains to the provision and fixing of wash basin of the specified size including all necessary fixtures and pipe connections upto the outside face of the wall.

26.6.6.2 The basin shall be fixed and supported on a pair of rolled steel or cast iron cantilever brackets embedded in wall or fixed to wall with wooden cleats and screws. The height of the top of the basin from the floor shall be 75 cm unless other heights are ordered by the Engineer. All the pipe connections shall be made as shown on the plan or as found necessary and ordered by the Engineer for the item. Chromium plated brass screw down stop tap shall be fixed on the supply pipe. The pipe connections shall conform to IS: 1742. The waste pipe shall be provided with a C.P. Brass bottle trap. All the exposed pipes and brackets shall be painted with one coat of red lead and two coats of good oil paint of approved shade.

26.6.6.3 Wash basins shall be of white vitreous china conforming to IS: 2556 (Part -I) and IS: 2556 (Part IV). Wash basins either of flat back or angle back as specified shall be of one piece construction, including a combined over-flow. All internal angles shall be designed so as to facilitate cleaning. Each basin shall have a rim on all sides, except sides in contact with the walls and shall have a skirting at the back. Basins shall be provided with single or double tap holes as specified. The tap holes shall be 28 mm square or 30 mm round or 25 mm round for pop up hole. A suitable tap hole button shall be supplied if one tap hole is not required in installation. Each basin shall have circular waste hole to which the interior of basin shall drain. The waste hole shall be either rebated or bevelled internally with 65 mm diameter at top. Each basin shall be provided with non-ferrous 32 mm waste fitting. Stud slots to receive the brackets on the underside of the wash basin shall be suitable for a bracket with stud not exceeding 13 mm diameter, 5 mm high and 305 mm from the back of basin to the centre of the stud. The stud slots shall be of depth sufficient to take 5 mm stud. Every basin shall have an integral soap holder recess or recesses, which shall fully drain into the bowl. A slot type of overflow having an area of not less than 5 cm^2 shall be provided and shall be so designed as to facilitate cleaning of the overflow.

26.6.6.4 Wash basins shall be enumerated. Rate shall include the cost of all the materials and labour involved in all the operations described above.

26.6.7 Mirror

26.6.7.1 The mirror shall be of superior sheet glass with edges rounded off or bevelled, as specified. It shall be uniformly silver plated at the back and shall be free from silvering defects and with marine plywood back. Mirror shall conform to the Specifications of IS: 3438.

26.6.7.2 Mirror shall be fixed in position by means of 4 Chromium Plated (C.P) brass screws and C.P brass washers, over rubber washers and wooden plugs firmly embedded in walls. C.P brass clamps with C.P brass screws may be an alternative method of fixing, where so directed. Unless specified otherwise the longer side shall be fixed horizontally.

26.6.7.3 The item, if measured separately, will be by number. It may be included in other items it so specified in BOQ.

26.6.8 Sink

26.6.8.1 Kitchen sink shall be provided at the location shown in the Drawing and as per the size mentioned.

26.6.8.2 Kitchen sink shall be of white glazed fire clay conforming to IS 771 (part II) and shall have combined overflow of weir type and their inverts shall be 30 mm below the top edge. Each sink shall be provided with a non-ferrous 50 mm diameter waste fitting. The waste fitting shall be of brass with chromium plated (CP).

26.6.8.3 The sink shall be provided with 40 mm CP brass union. CI brackets for supporting sink shall conform to IS: 775. Installation of sink shall consist of assembly of sink C.I brackets, union and GI waste pipe. The sink shall be supported on CI cantilever brackets, embedded in cement concrete (1:2:4) block of size 100 X 75 X 150 mm. Brackets shall be fixed in position before the dado work is done. The CP brass union shall be connected to 40 mm nominal bore GI waste pipe which shall discharge into a floor trap. The height of front edge of sink from the floor level shall be 80 cm. This item shall be measured by number including all items stated above and shall include cost of all fixing material.

26.6.8.4 Sinks shall be enumerated. Rate shall include the cost of all the materials and labour involved in all the operations described above.

26.6.9 Floor Trap

26.6.9.1 Floor Traps shall be of CI and self cleaning and deep water seal type with a 50 mm water seal. It shall have a 100 mm diameter grating. These shall be fixed in cement concrete blocks 1:2:4, to the required level and position. The gratings shall be got approved before use in work.

26.6.10 Water closet

26.6.10.1 Orissa Pattern Water Closet

26.6.10.1.1 Squatting pans shall be of white vitreous china conforming to IS: 2556 (Part-I) for general requirements and IS: 2556 (Part-III) for Orissa pattern water closet

26.6.10.1.2 This item pertains to provision and fixing of Orissa type white glazed earthenware Water Closet pan of specified dimensions with cast **iron** high level flushing cistern of 12.5 litres capacity, and other accessories and necessary pipe connections upto the soil and vent pipes fixed on the outside of walls.

26.6.10.1.3 Each pan shall have an integral flushing rim of suitable type. It shall also have art inlet or supply horn for connecting the flush pipes. The flushing rim and inlet shall be of the self draining type. It shall have weep hole at the flushing inlet to the pan. The flushing inlet shall be in the front unless otherwise specified or ordered by the Engineer The inside of the bottom of the pan shall have sufficient slope from the front towards the outlet and the surface shall be uniform and smooth to enable easy and quick disposal while flushing. The exterior surface of the outlet below the flange shall be an unglazed surface which shall have grooves at right angles to the axis of the outlet. In all cases a pan shall be provided with a (100 mm) S.C.I. trap with ‘P’ or ‘S’ type with approximately 50 mm water seal and 50 mm diameter vent horn, where required by the Engineer.

26.6.10.1.4 The pan shall be placed into position with the trap joined in cement mortar 1:1 and the connecting pipes duly connected including the lead pipe from the flushing cistern. The jointing of various pipes shall conform to IS: 1742.

26.6.10.1.5 The jointing of cast iron pipes shall be with 1:1 cement mortar with hemp yarn caulking.

26.6.10.1.6 The pan shall be sunk into the floor and embedded in a cushion of average 15 cm thick cement concrete 1:5:10 (1 cement: 5 fine and: 10 graded brick ballast 40 mm nominal size). The concrete shall be left 115 mm below the top level of the pan so and to allow flooring and its bed concrete. The joint between the pan and the trap shall be made leak proof with cement mortar 1:1 (1 cement: 1 fine sand). The pan shall be fixed slightly at a lower level than the level of the general flooring, which should slope on all sides towards the pan. If the pan is damaged in handling or fixing, it shall be replaced by the Contractor at his own expenses.

26.6.10.1.7 The flushing cistern shall be fixed on two iron or mild steel cantilever brackets fixed in the wall at the height indicated on the Drawing or as ordered by the Engineer.The inlet end shall be connected to the distribution pipe through a stop tap, pipe and bends. The lead flushing pipe shall be connected to the outlet nipple and tail pipe with a coupling brass nut. The 20 mm diameter overflow pipe shall be slightly bent downwards and shall be fixed with a mosquito proof coupling.

26.6.10.1.8 The C.P. flushing pipe shall be bent leaving a straight length of about 30 cm at the top and the lower portion after the bend shall be housed into the recess cut in the wall and shall be concealed with plaster.

26.6.10.1.9 The whole installation shall be tested for leak proof joints and satisfactory functioning.

26.6.10.1.10 The cistern, brackets and all the exposed pipes shall be painted with a base coat of red lead oil paint and the two coats of approved shade of good oil paint.

26.6.10.2 European type white glazed earthenware water-closet

26.6.10.2.1 The item pertains to the provision and fixing of European type white glazed earthenware water-closet pan, with 12.5 litres white steel enameled low level flushing cistern and other flushing accessories and necessary pipe connections up to the soil and vent pipes fixed on the outside of the wall. The pan shall be fixed into position in 1:1 cement mortar with the connecting pipes duly connected including the flushing cistern, piping etc., and the test shall be done as in previous Clause. The seat and lid shall be fixed to the pan with chromium plated brass hinges.

26.6.10.3 Measurement

26.6.10.3.1 Water closets shall be enumerated. Rate shall include the cost of all the materials and labour involved in all the operations described above.

26.6.11 Urinals

26.6.11.1 Half stall Urinals

26.6.11.1.1 The item pertains to the provision and fixing of a half stall type urinal with 10 litre auto flushing cistern (or any other type as defined in the BOQ) including all fittings and soil pipe connections upto the outside face of the wall. The installation of the urinal shall conform to paragraph 6.6 of IS 2064.

26.6.11.1.2 The urinal shall be securely fixed to the wall with the top of the bowl at 65 cm., from the floor or such distance as may be directed by the Engineer. All the pipe connections shall be made as shown on the Drawings or as necessary for the item.

26.6.11.1.3 The jointing shall confirm to paragraph 5 of IS: 1742. A 32 mm diameter GI pipe shall be provided with C.P. bottle trap.

26.6.11.1.4 The flushing cistern, its fixing and the pipe connections shall conform to the details given in **Clause 24.6.10.1** above. All the exposed lead and ferrous pipes and the bracket for the flushing cistern shall be painted with one coat of red lead and two coats of good anti-corrosive oil paint of approved shade.

26.6.11.1.5 Half stall urinals shall be of white vitreous china conforming to IS 2556 (Part VI Sec 2). They shall be of one piece construction with or without an integral flushing box rim provided with slots or alternative fixing arrangement at the flat back end. They shall be provided with ridges where integral flushing is not provided in the sides of the interior of the bowl, to divert the water towards the front line of the urinal where integral flushing box rim is specified, water spreaders provided shall conform to IS: 2556 Part VI: Sec 6. These shall be vitreous china of one piece construction with one integral flush inlet.

26.6.11.2 Squatting Plate Urinal

26.6.11.2.1 The Squatting Plate Urinal shall be of vitreous china conforming to IS 2556 (Part I) and IS 2556 (Part VI / Sec 3) with internal flushing rim with front or side inlet. Squatting plate shall be of one piece construction. Each urinal shall have integral longitudinal flushing pipe of suitable type which may be connected to flush pipe. There shall be 100 mm diameter white glazed vitreous china channel with stop and outlet piece in front.

26.6.11.3 Measurement

26.6.11.3.1 Urinals shall be enumerated. Rate shall include the cost of all the materials and labour involved in all the operations described above.

26.6.12 Toilet Requisites

26.6.12.1 Towel rail

26.6.12.1.1 It shall be of anodised aluminium with two aluminium anodised brackets. The size of the rail shall be 75 cm x 20 mm diameter or 60 cm x 20 mm diameter, 1.25 mm thick as specified. The bracket shall be fixed by means of CP 1 brass screws to wooden cleats firmly embedded in wall.

26.6.12.2 Toilet paper holder

26.6.12.2.1 The toilet paper holder shall be of CP brass or vitreous china as specified and of size and design as approved by the Engineer-in charge. It shall be fixed in position by means of CP brass screws and plugs embedded in the wall.

26.6.12.3 Shower

26.6.12.3.1 These shall be of CP finish swivel type as specified.

26.6.12.4 Towel pipe and towel cloth stand etc.

26.6.12.4.1 These shall be of CP / anodized aluminium as specified. These shall be fixed by means of CP brass screws to wooden cleats firmly embedded in the wall.

26.6.12.5 Measurement

26.6.12.5.1 All the items mentioned above under Clause ‘Toilet Requisites’ shall be measured per number and the quoted rates shall be on this basis which shall include the cost of respective materials, necessary fixtures, fixing in position.

26.6.13 Water Heaters

26.6.13.1 These shall be of best approved make, type and capacity as per BOQ. They shall be mounted on the wall / lift with necessary bolts of approved type. They shall have a 8 mm PVC inlet pipe, 12 mm lead pipe outlet and 15 mm non-return valve.

26.6.13.2 These shall be measured per number basis and the quoted rates shall include:

1. Cost of water heater with all the built-in electrical accessories like pilot lamp, thermostat, standard length of cable and three pin plug,
2. PVC inlet lead outlet pipe and non-return valve,
3. Fixing accessories like bolts, nuts etc.

26.6.14 Soil, Water and Vent Pipes

26.6.14.1 For soil, water and vent pipes shall be of Cast Iron conforming to IS: 1729 or IS: 3989. Pipes and fittings with irregular bore, blow holes and other manufacturing defects shall not be allowed to be used for work. All the fittings shall be of the degree specified or as required at site.

26.6.14.2 Cast Iron Rain Water Pipes

26.6.14.2.1 Cast Iron pipes shall be treated with Dr. Angus Smith's solution before use. Cast Iron grating shall be of a slightly bigger diameter than that of the pipe.

26.6.14.2.2 In the case of terraced roof, the cast iron grating shall be fixed at the inlet end of the pipes properly secured in the parapet wall to receive the rain water. The cast iron grating shall be recessed at a slightly lower level than the adjacent terrace floor.

26.6.14.2.3 The joints shall be sealed with a few turns of spun yarn soaked in bitumen or tar. It shall be pressed home with a caulking tool for 1/3rd the depth of the joint. More skein yarn shall be wrapped if necessary and well rammed home. The joint shall then be filled with cement mortar 1:3. At the ground level, they shall be supported on a 1:2:4 cement concrete block of 30 cm x 30 cm and of sufficient height.

26.6.14.2.4 All the necessary fittings shall be included in the pipeline at proper places. The inlet end shall be carefully fixed to admit water from the roof. The outlet shall be with a shoe.

26.6.14.2.5 The pipe shall be painted with one coat of red lead oil paint and two coats of good anticorrosive oil paint of approved shade.

26.6.14.2.6 Pipes, fittings and joints shall be tested for leakage, any defects noticed shall be rectified without any extra cost to the corporation.

26.6.14.3 Cast Iron Soil Vent Pipes

26.6.14.3.1 Cast iron pipes of specified diameter shall have sockets for underground and sockets with lugs for fixing on walls. They shall be treated with Dr. Angus Smith's solution. All the pipes, fittings, etc., should be free from cracks and flaws. The interior of the pipes and fittings shall be clean and smooth. All the fittings shall be of the same quality as that of the pipes. The fittings shall have cleaning eyes with plugs where necessary.

26.6.14.3.2 The socket end shall be the inlet end for the soil or waste pipes. In vent pipes the socket shall face up. The joints shall be filled with lead. The joining shall conform to IS: 1742. Where the cast iron pipes are fixed on the wall they shall be supported on a 1:2:4 cement block of 30x30 cm and of sufficient height in the ground. The pipes shall be fixed on the wall with nails driven through the lugs to the holder battens. Necessary fittings shall be included in the pipes. The exposed pipes shall be painted with a base coat of red lead and two coats of good anti corrosive oil paint of approved shade. For pipes fixed on the walls, smoke test shall be carried out.

26.6.15 Gully traps

26.6.15.1 Gully traps shall be of salt glazed stoneware conforming to IS 651. Each gully trap shall have one CI grating of square size corresponding to the dimensions of inlet of gully trap. It will also have a water tight CI cover with frame inside dimensions 300x300 mm the cover weighing not less than 4.50 kg and the frame not less than 2.70 kg. The grating cover and the frame shall be of sound and good casting and shall have truly square machined seating faces. These shall be housed in masonry chambers of 300 mm x 300 mm internal size.

26.6.15.2 The masonry chambers shall be constructed in first class bricks in cement mortar 1:5 with a 10 cm brick work round the gully trap from the top of the bed concrete upto ground level. The space between the chamber walls and the gully trap shall be filled with cement concrete 1:5:10. It shall be plastered with cement mortar 1:3 finished with a floating coat of neat cement.

26.6.15.3 CI cover with frame shall be fixed on the top of brick masonry with cement concrete 1:2:4 and rendered smooth. Cement concrete in bed shall be 10 cm thick and in 1:5:10 mix (40 mm nominal size stone aggregate), projecting 7.5 cm outside the chamber walls.

26.6.16 Cast iron nahani trap

26.6.16.1 Nahani trap shall be P or S type with minimum 50 mm seal. However if the plumbing is in two pipe system and with a gully trap at the ground level the minimum water seal shall be 35 mm. The traps shall be of self cleansing design and shall have exit of same size as that of waste pipe. These shall conform to IS 1729.

27 FENCING

27.1 Scope

27.1.1 The work comprises of fixing M.S. Posts and providing barbed wire fencing as per Drawings.

27.1.2 The M.S. Posts shall conform to IS: 226 and shall be of angle iron of size indicated in the Drawings. The angle iron shall be embedded in concrete to a sufficient depth below ground as indicated in the Drawings. The steel shall be fabricated and painted to conform to **Chapter 8 and Chapter 12** of this specification.

27.1.3 The barbed wire shall be of galvanised iron and shall conform to IS: 278-1978.

27.2 Measurements for Payment

The measurement shall be in running meter of the finished work.

27.3 Rate

The rate for the item of fencing shall cover the cost of all materials including transportation, fabrication, fixing, all labour, tools, equipment, supervision and all incidentals necessary for completing the work according to these Specifications and Drawings. The rate shall also include necessary stay and entry gates as shown in the Drawings and as directed by the Engineer.

28 RIVER TRAINING WORK AND PROTECTION WORK

28.1 Scope

River training and protection work shall include construction of guide bunds, guide walls, bank protection, flooring and approach embankment protection as required for ensuring safety of the structures and their approaches against damage by flood / flowing water. Construction of various components shall conform to IRC:89 and these Specifications or as directed by the Engineer.

28.2 Guide Bund

28.2.1 This work shall consist of construction of embankment of guide bund and provision of pitching / rivetment of slopes, apron, toe protection, curtain walls etc. As indicated on the Drawing in accordance with these Specifications or as approved by the Engineer.

28.2.2 The provisions given hereunder are applicable only to guide bunds for structures across alluvial rivers. Guide bunds for structures across submontane rivers shall call for supplemental Specifications.

28.2.3 The alignment and layout of guide bund shall be as indicated on the Drawing or as approved by the Engineer. The construction of embankment for guide bund shall conform to provisions of Chapter 5 of these Specifications. Pitching, filter underneath pitching and turfing, apron, toe protection, curtain walls, etc., shall be as per these Specifications.

28.2.4 Guide bunds shall generally be made of locally available materials from the river bed preferably cohesionless materials. Trial pits shall be taken in borrow holes to examine suitability of soil for construction and also to decide the types of earth moving machinery to be arranged. The borrow pits should be sufficiently away from the location of the launching apron. No borrow pits should be dug on the river side of the guide bunds.

28.2.5 Construction of guide bund shall be taken in hand along with the construction of the bridge Every effort shall be made to complete the work of the guide bund in one working season. Where there is any doubt about completion of the whole guide bund within one working season, suitable measures shall be planned and executed for protection of completed work. In such cases the construction of guide bund shall be started from abutment towards upstream.

28.2.6 Construction of apron and pitching of the guide bunds shall generally conform to **Clause 26.3 and 26.4** of these Specifications. Sufficient length of pit along the guide bund shall be ready within one to two months of commencement of work so that the placing of stones in the apron and in the slope pitching can be commenced. As a guideline, earthwork should be completed within 80 percent of working season and about 70 per cent working season shall be available for laying apron and pitching. No portion of the guide bund should be left below HFL before the onset of monsoon. Bottom of apron pit shall be as low as permitted by sub-soil water/lowest water level. Sufficient labour and appropriate earth moving machinery and trained staff shall be deployed in construction.

28.2.7 The Contractor shall furnish his planning for approval of the Engineer regarding transport of stones from the quarries to the site of work taking into account the quantities of stone required to be transported every day, train/truck, etc., deployed, available ferry or boats and labour available for loading and unloading and for laying within the time frame for construction of guide bund. Adequate reserve of stones should be maintained for major works as decided by the Engineer. Reserve stones shall be stacked far away from the main channel of the river.

28.2.8 Where the alignment of guide bund or the approach embankment crosses a branch channel of the river, the branch channel may be either diverted to the main channel of the river with the help of spurs, etc. or closed by a properly designed closing dyke or closure bund before taking up construction of guide bund.

28.3 Apron

28.3.1 General

28.3.1.1 This work shall consist of laying boulders directly or in wire crates on the bed of rivers for protection against scour.

28.3.1.2 Where the required size of boulders are not available economically, cement concrete blocks of equivalent weight shall be used. The grade of concrete shall be M 15 nominal mix. (This holds good for pitching on slopes and flooring also). Cement concrete blocks shall be preferred where practicable.

28.3.1.3 The stones used in apron shall be sound, hard, durable and fairly regular in shape. Stone subject to marked deterioration by water or weather shall not be used.

28.3.1.4 Quarry stones are preferable to round boulders as the latter roll off easily. Angular stones fit into each other better and have good interlocking characteristics.

28.3.1.5 Where the required size stones are not economically available, cement concrete blocks in M15 grade conforming to **Chapter 9** or stones in wire crates in combination may be used in place of isolated stones of equivalent weight. Cement concrete blocks will be preferred, wherever practicable.

28.3.2 Laying Boulder Apron

28.3.2.1 The size of stone should conform to **Clause 5.3.7.2 of IRC:89.**

28.3.2.2 The size of stone shall be as large as possible. In no case any fragment shall weigh less than 40 kg. The specific gravity of stones shall be as high as possible and it shall not be less than 2.65.

28.3.2.3 To ensure regular and orderly disposition of the full intended quantity of stone in a the apron, template cross walls in dry masonry shall be built about a metre thick and to the full height of the specified thickness of the apron at intervals of 30 m all along the length and width of the apron. Within these walls, the stone then shall be hand packed.

28.3.2.4 The surface on which the apron is to be laid shall be leveled and prepared for the length and width as shown on the Drawings. In case the surface on which apron is to be laid is below the low water level, the ground level may be raised upto low water level by dumping earth and the apron laid thereon. The quantity of stone required in the apron shall be re-worked out by taking the toe of pitching at higher level.

28.3.3 Laying Wire Creates and Mattresses in the Apron

28.3.3.1 Wire crates shall be made from hot dipped galvanised mild steel wire of diameter not less than 4 mm in annealed condition having tensile strength of 300-450 MPa conforming to IS: 280. The galvanizing coating shall be heavy coating for soft condition conforming to IS: 4826.

28.3.3.2 The mesh of the crate shall not be more than 150 mm.

28.3.3.3 Wire crates for shallow or accessible situations shall be 3 metre X 1.5 metre x 1.25 metre in size. Where these have to be deposited and there is a chance of overturning, the crate shall be divided into 1.5 meter compartments by cross netting.

28.3.3.4 For deep or inaccessible situations, wire crates can be made smaller subject to the approval of the Engineer.

28.3.3.5 Wire crates built in-situ, shall not be larger than 7.5 metres X 3 metres x 0.6 metre, nor smaller than 2 metres x 1 metre x 0.3 metre. Sides of large crates shall be securely stayed at intervals of not more than 1.50 metres to prevent bulging.

28.3.3.6 The netting shall be made by fixing a row of spikes on a beam at a spacing equal to the mesh. The beam must be a little longer than the width of netting required. The wire is to be cut to lengths about three times the length of the net required. Each piece shall be bent at the middle around one of the spikes and the weaving commenced from one corner.

28.3.3.7 A double twist shall be given at each intersection. This twisting shall be carefully done by means of a strong iron bar, five and half turns being given to the bar at each splice.

28.3.3.8 The bottom and two ends of the crate or mattress shall be made at one time. The other two sides shall be made separately and shall be secured to the bottom and the ends by twisting adjacent wires together. The top shall be made separately and shall be fixed in the same manner as the sides after the creates or mattress have been filled.

28.3.3.9 Wherever possible, crates shall be placed in position before filling with boulders. The creates shall be filled by carefully hand-packing the boulders as tightly as possible and not by merely throwing in stones or boulders.

28.3.3.10 For laying of wire crates in aprons of bridges, two situations arise:

1. Where the crates are to be laid in deep water and have to be dumped and then joined together.

2. Where depth of water is low or dry bed is available. In such cases, the crates can be laid at site.

28.4 Pitching / Revetment on Slopes

28.4.1 Description

28.4.1.1 This work shall consist of covering the slopes of guide bunds, training works and road embankments with stone, boulders, cement concrete blocks or stones in wire crates over a layer or granular material called filter. While river side slopes are given this protection against river action, the rear slopes, not subjected to direct attack of the river, may be protected against ordinary wave splashing by 0.3-0.6 metre thick cover of clayey or silty earth and turfed.

28.4.2 Pitching

28.4.2.1 Pitching: The pitching shall be provided as indicated in the Drawings. The thickness and the shape of stone pitching shall be shown on the Drawing.

28.4.2.2 The stone shall be sound, hard, durable and fairly regular in shape. Quarry stone should be used. Round boulders shall not be allowed. The stones subject to marked deterioration by water or weather shall not be accepted.

28.4.2.3 The size and weight of stone shall conform to **Clause 5.3.5.1 of IRC:89**. No stone, weighing less than 40 kg shall, however, be used. The sizes of spalls shall be a minimum of 25 mm and shall be suitable to fill the voids in the pitching.

28.4.2.4 Where the required size stones are not economically available cement concrete blocks in M15 grade conforming to **Chapter 9** or stones in wire crates may be used in place of isolated stones of equivalent weight. Cement concrete blocks will be preferred wherever practicable.

28.4.3 Filter media

28.4.3.1 The material for the filter shall consist of sand, gravel, stone or coarse sand. To prevent escape of the embankment material through the voids the stone pitching / cement concrete blocks as well as to allow free movement of water without creating any uplift head on the pitching, one or more layers of graded materials, commonly known as a filter medium, shall be provided underneath the pitching.

28.4.3.2 The gradation of the filter material shall satisfy the following requirements:

Provision of a suitably designed filter is necessary under the slope pitching to prevent the escape of underlying embankment material through the voids of stone pitching/cement concrete blocks when subjected to the attack of flowing water and wave action, etc. In order to achieve this requirement, the filter may be provided in one or more layers satisfying the following criteria:

- Ratio of D 15 (Filter) to D 85 (Base) shall be less than 5;
- Ratio of D 15 (Filter) to D 15 (Base) shall be within the limits of 4 and 20; and
- Ratio of D 50 (Filter) to D 50 (Base) shall be less than 25;

Notes:

1. *Filter design may not be required if embankment consists of CH or Ch soils with liquid limit greater than 30, resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded and its D 85 size shall be at least twice the maximum void size in pitching.*
2. *In the foregoing, D 15 means the size of that sieve which allows 15 per cent by weight of the filter material to pass through it and similar is the meaning of D 50 and D 85.*
3. *If more than one filter layer is required, the same requirement as above shall be followed for each layer. The finer filter shall be considered as abase material for selection of coarser filter.*
4. *The filter shall be compacted to a firm condition. The thickness of filter is generally of the order of 200 mm to 300 mm. Where filter is provided in two layers, thickness of each layer shall be 150 mm.*

28.4.4 Construction Operations

28.4.4.1 Before laying the pitching, the sides of banks shall be trimmed to the required slope and profiles put up by means of line and pegs at intervals of 3 metres to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

28.4.4.2 The filter granular material shall be laid over the prepared base and suitably compacted to the thickness specified on the Drawings.

28.4.4.3 The lowest course of pitching shall be started from the toe wall and built up in courses upwards. The toe wall shall be in dry rubble masonry (uncoursed) conforming to **Clause 11.5.3**, in case of dry rubble pitching and shall be in nominal mix cement concrete (M 15) conforming to **Chapter 9** in case of cement concrete block pitching.

28.4.4.4 The stone pitching shall commence in a trench below the tow of the slope. Stone shall be placed by derrick or by hand to the required length, thickness and depth conforming to the Drawings. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching.

28.4.4.5 The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

28.4.4.6 In hand placed pitching, the stone of flat stratified nature should be placed with the principal bedding plane normal to the slope. The pattern of laying shall be such that the joints are

broken and voids are minimum by packing with spalls, wherever necessary, and the top surface is as smooth as possible.

28.4.4.7 When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones shall be filled in with spalls of the proper size and wedged in with hammers to ensure tight packing.

28.4.4.8 When two or more layers of stones must be laid to obtain the design thickness of pitching, dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals and all along the length and width of the pitching. Within these walls the stones shall be hand packed as specified.

28.4.5 Toe Protection

28.4.5.1 In conformity with **Clause 5.3.7. of IRC:89**, a toe wall shall be provided at the junction of slope pitching and launching apron of a guide bund so as to protect the slope pitching from falling even when the apron is not laid at low water level. The toe wall shall be in dry rubble masonry (uncoursed) conforming to **Clause 11.5.3** in case of dry rubble pitching or pitching/revetment with stones in wire crates and in nominal mix cement concrete (M 15) conforming to **Chapter 9** in case cement concrete blocks have been used in pitching. For protection of toes of bank slopes terminating either in short aprons at bed levels or anchored in flooring / rocky bed, the provisions of **Clause 8.2.2. of IRC:89** may be complied with. The relevant Specifications of the protective works for individual components will be followed.

28.5 Rubble Stone/Cement Concrete Block Flooring Over Cement Concrete Bedding

28.5.1 This work shall consist of constructing rubble stone / C.C.block flooring laid over a cement concrete (M 15) bedding. The floor protection will comprise rigid flooring stated above with curtain walls and flexible apron.

28.5.2 Construction Operations

28.5.2.1 Excavations for laying the bedding and floor protection works shall be carried out as per Specifications under proper supervision. Before laying the foundation and protection walls, the excavated trenches shall be thoroughly inspected by the Engineer to ensure that:

1. There are no loose pockets and unfilled depressions left in the trench.
2. The soil at the founding level is properly compacted to true lines and level so as to have an even bedding.
3. All concrete and other elements are laid in dry bed.

28.5.2.2 Cement concrete nominal mix (grade M15) of 300 mm thickness shall then be laid in accordance with provisions given in **Chapter 9** except that the surface of the concrete shall not be given a smooth finish. The paving work shall be embedded in green concrete.

28.5.2.3 Flooring shall consist of 150 mm thick flat stone/cement concrete blocks (Nominal mix Grade M 15 conforming to **Chapter 9**). It shall be bedded on layer of cement mortar (1:3) prepared to **Clause 10.5**. Spalls shall be used to fill in the voids. The joints shall then be filled with cement mortar and finished neat. The stone shall break joints and the joints shall not exceed 20 mm in thickness. Spacing of joints may be 20 m or so. The top of flooring shall be kept to 300 mm below the lowest bed level.

28.6 Dry Rubble Flooring

28.6.1 This work shall consist of constructing dry rubble flooring at cross drainage works for relatively less important works.

28.6.2 The base for the flooring shall be prepared to the specified levels and slopes and compacted suitable with hand rammers or other means to have an even bedding.

28.6.3 The thickness of flooring shall be made with one stone only. The stones shall then be laid closely on the prepared base in one or more layers as specified and the bond used shall be as specified by the Engineer.

28.7 Curtain Wall and Flexible Apron

28.7.1 Curtain Wall

The rigid flooring shall be enclosed by curtain walls (tied to the wing walls) with a minimum depth below floor level or 2 m on upstream side and 2.5 m on downstream side. The curtain wall will be in cement concrete M 15/stone masonry in cement mortar 1:3 The rigid flooring shall be continued over the top width of curtain wall.

28.7.2 Flexible Apron

Flexible apron 1 m thick comprising loose stone boulders (weighting not less than 40 kg) shall be provided beyond curtain walls for a minimum distance of 3 m on upstream side and 6 m on down stream side. The work of floor protection shall be simultaneously completed along with the work on bridge foundations.

28.8 Tests and Standards of Acceptance

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

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

28.9 Measurements for Payment

28.9.1 The protection works shall be measured as set forth below. If directed by the Engineer for measurement, the materials may have to be stacked at site before laying and nothing extra will be paid to the Contractor for this stacking.

28.9.2 The earth work in construction of embankment of guide bund shall be measured in cubic metres unless otherwise specified.

28.9.3 The boulders/cement concrete blocks and wire crates in apron shall be measured in cubic metres.

28.9.4 The filter and stone pitching shall be measured separately in cubic metres unless otherwise specified.

28.9.5 Rubble stone/cement concrete blocks, flooring and cement concrete bedding shall be measured in cubic metres for each class of material.

28.9.6 Preparation of base for laying the flooring shall be deemed incidental to the work.

28.9.7 For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as given in **Clause 5.14.**

28.10 Rate

28.10.1 The contract unit rate for the construction of embankment for guide bund shall cover the cost of all materials including transportation, laying, compacting, all labour, tools, equipment,

sampling and testing, supervision and all incidentals necessary for completing the work according to these Specifications.

28.10.2 The contract unit rate for one cubic metre of finished work of apron shall include the cost of all material, labour, tools and plant for completing the work according to above Specifications. Excavation upto an average depth of 150 mm shall also be deemed to be included in the rate as dressing of the bed. Excavation beyond this depth shall be paid for separately unless otherwise specified.

28.10.3 The contract unit rate for one cubic metre of filter or stone/cement concrete block pitching on slopes shall include the cost of preparing the bases, putting to the profiles, laying and compacting the filter and stone pitching of dry rubble/cement concrete block rivetment for embankment slopes to the specified thickness, lines, curves, slopes and levels and all labour and materials as well as tools and plant required for the work.

28.10.4 The contract unit rate for rubble stone/cement concrete block flooring shall include the cost of all material, labour and tools and plant for completing the work as per these Specifications.

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