AN ISO 9001 & 14001 COMPANY

TENDER DOCUMENT

TENDER No: DLI/CON/COLD STORAGE/610

FOR

CONSTRUCTION OF MULTI COMMODITY 5000 MT CAPACITY COLD STORAGES INCLUDING REFRIGERATION, VENTILATION AND OTHER SERVICES AT TWO LOCATIONS IN ODISHA (2nd CALL).

VOLUME – II

ADDITIONAL CONDITIONS OF CONTRACT (ACC)

TECHNICAL SPECIFICATION

APPROVED MAKES

DRAWINGS
### ADDITIONAL CONDITIONS OF CONTRACT (ACC)

<table>
<thead>
<tr>
<th>1. <strong>GENERAL</strong></th>
</tr>
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<tbody>
<tr>
<td>The Additional Conditions shall be read in conjunction with General Conditions of Contract. Where the provision of these Additional Conditions is at variance with the provision of the General Conditions of Contract, the provisions of these Additional Conditions shall take precedence.</td>
</tr>
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<table>
<thead>
<tr>
<th>2. <strong>INTRODUCTION &amp; SCOPE OF WORK</strong></th>
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<tbody>
<tr>
<td>The Odisha State Agricultural Marketing Board, (OSAMB) Government of Odisha has decided for Construction of <strong>5000 MT Capacity MULTI COMMODITY COLD STORAGES</strong> including Refrigeration and Ventilation systems at Two locations in ODISHA and Engineering Project (India) Ltd., (A Government of India Enterprise) (EPI) has been appointed as executing agency for this work.</td>
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<tr>
<th>3. <strong>COMMENCEMENT AND COMPLETION OF PROJECT:</strong></th>
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<tr>
<td>The contractual completion period for the entire work shall be 8 months from 10th day of issue of LOI.</td>
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<tr>
<th>4. <strong>TAXES AND DUTIES</strong></th>
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<tr>
<td>The following shall be also read with clause no 13 of GCC:</td>
</tr>
<tr>
<td>1. The bidder/Contractor must be registered with GST and should have valid GSTIN number.</td>
</tr>
<tr>
<td>2. The bidder/contractor must submit as an compliances of GST Act, the invoices in GST compliant format failing which the GST amount shall be recovered/ adjusted by EPI without any prior notice from the next invoices or available dues with EPI.</td>
</tr>
<tr>
<td>3. The bidders/contractors are requested to update/upload the GST/Taxes data periodically so as to avail ITC credit by EPI failing which it shall be recovered/adjusted by EPI without any prior notice from the next invoices or available dues with EPI.</td>
</tr>
<tr>
<td>4. Rates to be quoted in this tender all inclusive with all taxes and duties etc. including GST.</td>
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<tr>
<td>5. Bidder while quoting the rates in the tender must also consider the ITC credit applicable for the works, if any.</td>
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<th>5. <strong>VARIATION IN TAXES &amp; DUTIES</strong></th>
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<tr>
<td>Any new taxes introduce by Central Govt / State Govt or variation in taxes is payable to contractor subject to reimbursement of same from client. If client has not reimbursed any new taxes and variation in taxes contractor does not have any claim on this and are not payable. Contractors are requested to submit the proof of deposit of taxes claimed failing which it shall not be claimed from client.</td>
</tr>
</tbody>
</table>
6. **FURNISHED OFFICE ACCOMMODATION & MOBILITY AND COMMUNICATION TO BE PROVIDED BY THE CONTRACTOR TO EPI**

   From clause 28.3 of GCC providing of vehicle for EPI staff is deleted and other requirements shall be as follows.

   The furnished office accommodation measuring min. 500 sq.ft for staff and Engineer In-Charge shall be provided at Site at each location. This office shall have all basic amenities like electricity, drinking water, pantry facility etc till completion of the project including Defect liability period. (The same is contractor property after DLP).

7. **PAYMENT**

   Each RA Bill accomplish by progress photos, all other terms of GCC Cl no 37.2 remains same. The progress report will be submitted along with bid in BQR chart/MSP format. GCC Cl no 37.4 revised as under

   All payment shall be released by NEFT/RTGS only from the available client funds with EPI.

8. **OPC CEMENT**

   **OPC Cement** only is to be used to this work, however in case any crisis for OPC Cement, the party shall submit the documentary proof in support, in such case the difference of cost of OPC and PPC cement shall be recovered from the party. (An amount of Rs. 20 per bag shall be recovered)

   Contractor shall make proper arrangements for the storage of cement at site as per standard practices.

9. **WORKS TO BE OPEN TO INSPECTION**

   GCC Clause No 53.2 is modified as under

   All works executed or under the course of execution in pursuance of this contract shall at all times be open to inspection and supervision of EPI. The work during its progress or after its completion may also be inspected, by Chief Technical Examiner of Government of India (CTE) and/or an inspecting authority of State Government of State in which work is executed and/or by third party checks by Owner/ Clients. The compliance of observations/improvements as suggested by the inspecting officers of EPI/CTE/ State authorities/ Owners shall be obligatory on the part of the Contractor at the cost of Contractor.

   Any recovery, penalty imposed by CTE due to non-performance, no compliance of agreed condition the same shall be recovered from RA Bill of contractor.

10. **MATERIALS PROCURED WITH THE ASSISTANCE OF EPI**

    GCC Clause No 68 is modified as under

    If any material for the execution of this contract is procured with the assistance of EPI...
either by issue from its stores or purchase made under orders or permits or licenses obtained by EPI, the Contractor shall hold and use the said materials economically and solely for the purpose of this contract and shall not dispose them without the written permission of Engineer-In-Charge. The Contractor, if required by EPI, shall return all such surplus or unserviceable materials that may be left with him after the completion of the contract or at its termination on whatsoever reason, on being paid or credited such price as EPI shall determine having due regard to the conditions of materials.

**Material procured with assist for all the material deemed to be in scope of contractor shall be arranged by him, however any such material procure with assist of EPI, an handling cost 10% will be levied on actual procure cost.**

### 11 DEFECT LIABILITY PERIOD AND OPERATION & MAINTENANCE (O & M)

Defect Liability Period is 24 (Twenty Four) Months. The commencement date of this “Defect Liability Period” shall be from the date when client certifies to EPIL in writing that the project has been 100% completed. A “Certificate of Initial Hand – Over” shall be issued by EPIL to the contractor after receiving the same from client. Until a “Certificate of Final Hand-Over” is issued by the client to EPIL at the end of Defect Liability Period, the contractor shall continue to be bounded by this contract. All other condition of GCC Clause No 74 is remains same.

Contractor shall undertake to carry out the annual operation and maintenance contract during DLP of 24 months from the date of commissioning of the cold storage units and render total operation and maintenance service of the plant and machinery excluding handing stock and store of the warehouses. The operation and maintenance is in scope of contractor. Sufficient manpower is to be kept for DLP and O&M.

### 12 ARBITRATION

General Conditions of Contract (GCC) Sub Clause no.76.1 and 76.3 of Arbitration Clause no.76.0 are amended as given below. Sub Clause no.76.2 will remain the same.

**76.0 ARBITRATION**

76.1 Before resorting to arbitration as per the clause given below, the parties if they so agree may explore the possibility of conciliation as per the provisions of Part III of the Arbitration and Conciliation Act, 1996 as amended by Arbitration and Conciliation (Amendment) Act, 2015.

When such conciliation has failed, the parties shall adopt the following procedure for arbitration:

i) Except where otherwise provided for in the contract, any disputes and differences relating to the meaning of the Specifications, Design, Drawing and Instructions herein before mentioned and as to the quality of workmanship or materials used in the work or as to any other questions, claim, right, matter or things whatsoever in any way arising out of or relating to the Contract, Designs, Drawings, Specifications, Estimates, Instructions, or these conditions or otherwise concerning the works of the execution or failure to execute the same whether arising during the progress of the work or after the completion or abandonment thereof shall be referred to the Sole Arbitrator.
appointed by the Chairman & Managing Director (CMD) of Engineering Projects (India) Limited (EPI) or any other person discharging the functions of CMD of EPI. The person approached for appointment as Arbitrator shall disclose in writing circumstances, in terms of Sub-Section (1) of Section (12) of the Arbitration and Conciliation Act, 1996 as amended by Arbitration and Conciliation (Amendment) Act, 2015 as follows:

a) such as the existence either direct or indirect, of any past or present relationship with or interest in any of the parties or in relation to the subject-matter in dispute, whether financial, business, professional or other kind, which is likely to give rise to justifiable doubts as to his independence or impartiality; and

b) which are likely to affect his ability to devote sufficient time to the arbitration and in particular his ability to complete the entire arbitration within a period of twelve months. The Arbitrator shall be appointed within 30 days of the receipt of letter of invocation of arbitration duly satisfying the requirements of this clause.

ii) if the arbitrator so appointed resigns or is unable or unwilling to act due to any reason whatsoever, or dies, the Chairman & Managing Director aforesaid or in his absence the person discharging the duties of the CMD of EPI may appoint a new arbitrator in accordance with these terms and conditions of the contract, to act in his place and the new arbitrator so appointed may proceed from the stage at which it was left by his predecessor.

iii) It is a term of the contract that the party invoking the arbitration shall specify the dispute/differences or questions to be referred to the Arbitrator under this clause together with the amounts claimed in respect of each dispute.

iv) The Arbitrator may proceed with the arbitration ex-parte, if either party, in spite of a notice from the arbitrator, fails to take part in the proceedings.

v) The work under the contract shall continue as directed by the Engineer-In-Charge, during the arbitration proceedings.

vi) Unless otherwise agreed, the venue of arbitration proceedings shall be at the venue given in the ‘Memorandum’ to the ‘Form of Tender’.

vii) The award of the Arbitrator shall be final, conclusive and binding on both the parties.

viii) Subject to the aforesaid, the provisions of the Arbitration and Conciliation Act, 1996 as amended by Arbitration and Conciliation (Amendment) Act, 2015 or any statutory modifications or re-enactment thereof and the Rules made there under and for the time being in force shall apply to the arbitration proceedings and Arbitrator shall publish his Award accordingly.

76.3 JURISDICTION:
The courts in Delhi alone will have jurisdiction to deal with matters arising from the contract.
### TECHNICAL STAFF FOR EACH LOCATION

In addition of Clause no 27.00 of GCC following numbers of technical manpower required at each Cold Storage locations.

<table>
<thead>
<tr>
<th>Contract period (Months)</th>
<th>Requirement of Technical Staff</th>
<th>Minimum Experience (Years)</th>
<th>Designation</th>
<th>Recovery in case of Non Compliance (per month in Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Qualification</td>
<td>Nos.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Months</td>
<td>(i) Project Manager with degree in Engineering</td>
<td>1</td>
<td>10</td>
<td>Project In-Charge</td>
</tr>
<tr>
<td></td>
<td>(ii) Degree Engineers in Civil, Electrical &amp; Mechanical Discipline</td>
<td>3</td>
<td>5</td>
<td>Project Engineers</td>
</tr>
<tr>
<td></td>
<td>iii) Supervisors</td>
<td>As Req'd.</td>
<td></td>
<td></td>
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### SIGNBOARDS

Contractor will arrange to fabricate and erect sign board at his own cost showing name of work, name of CLIENT, name of Architect/Consultants, name of EPI, date of commencement and completion etc of size and design as approved by EPI/CLIENT. Typical drawing is enclosed.

### SECURE ADVANCE AGAINST NON-PERISHABLE MATERIALS

The clause no 35.0 of GCC shall stands deleted: No Secured advance shall be paid to the contractor.

### Mobilization Advance

Clause no. 8.2 of GCC is amended as below: “Recovery of such sums advanced shall be made by the deduction from the contractors bills commencing after first ten percent of the gross value of the work is executed and paid, on pro-rata percentage basis to the gross value of the work billed beyond 10% in such a way that the entire advance is recovered by the time eighty percent of the gross value of the contractor is executed and paid, together with interest due on the entire outstanding amount up to the date of recovery of the installment.”
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description of work</th>
</tr>
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<td>CARRIAGE MATERIALS</td>
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<tr>
<td>2</td>
<td>EARTH WORK</td>
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<td>3</td>
<td>MORTARS</td>
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<td>4</td>
<td>CONCRETE WORK</td>
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<td>5</td>
<td>PILE WORK</td>
</tr>
<tr>
<td>6</td>
<td>REINFORCEMENT CEMENT CONCRETE WORK</td>
</tr>
<tr>
<td>7</td>
<td>BRICK WORK</td>
</tr>
<tr>
<td>8</td>
<td>TEST FOR DIMENSIONAL TOLERANCE</td>
</tr>
<tr>
<td>9</td>
<td>FINISHING</td>
</tr>
<tr>
<td></td>
<td>a) PLASTERING</td>
</tr>
<tr>
<td></td>
<td>b) PAINTINGS</td>
</tr>
<tr>
<td>10</td>
<td>STEEL WORK</td>
</tr>
<tr>
<td>11</td>
<td>REFRIGERATION SYSTEM</td>
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<tr>
<td>12</td>
<td>PLUMBING</td>
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<tr>
<td>13</td>
<td>FLOORING</td>
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<td>14</td>
<td>ROOFING</td>
</tr>
<tr>
<td>15</td>
<td>APPROVED MAKES</td>
</tr>
</tbody>
</table>

**Note**: All the item’s, specifications will be as per Odisha SOR & the item which are not included within this volume, the specification will be as per CPWD.
CHAPTER 1
CARRIAGE MATERIALS
LIST OF BUREAU OF INDIAN STANDARD CODES

<table>
<thead>
<tr>
<th>S. No.</th>
<th>I. S. No.</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IS 4082</td>
<td>Stacking &amp; storage of construction materials and components at site – Recommendations</td>
</tr>
<tr>
<td>2.</td>
<td>IS 1141</td>
<td>Seasoning of Timber – Code of Practice</td>
</tr>
</tbody>
</table>

1.1 LEAD
1.1.1 All distances shall be measured over the shortest practical route and not necessarily the route actually taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and as approved by Engineer-in-Charge along with reasons in writing.

1.1.2 Carriage by manual labor shall be reckoned in units of 50 meters or part thereof.

1.1.3 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 metres 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.

1.2 GENERAL CONSIDERATION FOR STACKING AND STORAGE
1.2.1 Planning of Storage Layout
For any site, there should be proper planning of the layout for stacking and storage of different materials, components and equipment’s with proper access and proper manoeuvrability of the vehicles carrying the material. While planning the layout, the requirements of various materials, components and equipment’s at different stages of construction shall be considered. The storage & stacking check list is given in Table 1.1. For further details refer IS- 4082.

1.2.2 Material shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

1.3 PROTECTION AGAINST ATMOSPHERIC AGENCIES
Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric actions, such as rain, sun, winds and moisture to avoid deterioration.

1.4 PROTECTION AGAINST FIRE AND OTHER HAZARDS
Materials like timber, coal, paints, etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials like kerosene and petrol, shall be stored in accordance with the relevant rules and regulations so as to ensure the desired safety during storage. Stacks shall conditions not be piled so high as to make them unstable under fire fighting and in general they shall not be more than 4.5 m in height. The provisions given in IS 13416 (part 5) shall be followed. Not be piled so high as to make them unstable under fire fighting conditions and in general they shall not be more than 4.5 m in height. The provisions given in IS 13416 (part 5) shall be followed.
1.5 STACKING AND STORAGE OF MATERIALS

1.5.1 Cement

1.5.1.1 In case cement is received in bags. Cement shall be stored at the work site in a building or a shed which is dry, leakproof and as moisture proof as possible. The building or shed for storage should have minimum number of windows and close fitting doors and these should be kept closed as far as possible.

1.5.1.2 Cement shall be stored and stacked in bags and shall be kept free from the possibility of any dampness or moisture coming in contact with them. Cement bags shall be stacked off the floor on wooden planks in such a way as to keep about 150 mm to 200 mm clear above the floor. The floor may comprise of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A space of 600 mm minimum shall be left around between the exterior walls and the stacks.

In the stacks the cement bags shall be kept close together to reduce circulation of air as much as possible. Owing to pressure on the bottom layer of bags sometimes ‘warehouse pack’ is developed in these bags. This can be removed easily by rolling the bags when the cement is taken out for use. Lumbed bags, if any should be removed and disposed off.

1.5.1.3 The height of stack shall not be more than 10 bags to prevent the possibility of lumping up under pressure. The width of the stack shall be not more than four bags length or 3 metres. In stacks more than 8 bags high, the cement bags shall be arranged alternately length-wise and cross-wise so as to tie the stacks together and minimize the danger of topping over. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received; a label showing date of receipt of cement shall be put on each stack to know the age of cement.

1.5.1.4 For extra safety during the monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a water proofing membrane such as polyethylene, which shall close on the top of the stack. Care shall be taken to see that the waterproofing membrane is not damaged any time during use.

1.5.1.5 Cement in gunny bags, paper bags and polyethylene bags shall be stored separately.

1.6 In case cement is received in drums
These shall be stored on plane level ground, as far as possible near the concrete mixing place. After taking out the required quantity of cement, the lid of the drum shall be securely tied to prevent ingress of moisture.

1.7 In case cement is received in silos
The silos shall be placed near the concrete batching plant. Proper access shall be provided for the replacement of silos.

1.7.1 Different types of cements shall be stacked and stored separately.
1.8 BRICKS

1.8.1 Bricks shall be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These shall not be dumped at site.

1.8.2 Bricks stacks shall be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows. Building bricks shall be loaded or unloaded a pair at a time unless palletized. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted.

1.8.3 Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting the stacks shall be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of each truck load shall be put in one stack.

1.8.4 Bricks of different types, such as clay bricks, clay fly ash bricks, fly ash lime bricks, sand lime (calcium silicate) bricks, auto-clave bricks etc. shall be stacked separately. Bricks of different classification and size consideration (such as, conventional and modular) shall be stacked separately. Also bricks of different types, such as, solid, hollow and perforated shall be stacked separately.
CHAPTER 2

EARTH WORK
2.1 EXCAVATION IN ALL KINDS OF SOILS

2.1.1 All excavation operations manually or by mechanical means shall include excavation and ‘getting out’ the excavated materials. In case of excavation for trenches, basements, water tanks etc. ‘getting out’ shall include throwing the excavated materials at a distance of at least one meter or half the depth of excavation, whichever is more, clear off the edge of excavation. In all other cases ‘getting out’ shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the items of excavation stating lead.

2.1.2 During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

2.1.3 In firm soils, the sides of the trenches shall be kept vertical up to a depth of 2 meters from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2 meters from the bottom. Alternatively, the excavation can be done so as to give slope of 1:4 (1 horizontal : 4 vertical). Where the soil is soft, loose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in-Charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-Charge regarding the stepping, sloping or shoring to be done for excavation deeper than 2 meters.

2.1.4 The excavation shall be done true to levels, slope, shape and pattern indicated by the Engineer-in-Charge. Only the excavation shown on the drawings with additional allowances for centering and shuttering or as required by the Engineer-in-Charge shall be measured and recorded for payment.

2.1.5 In case of excavation for foundation in trenches or over areas, the bed of excavation shall be to the correct level or slope and consolidated by watering and ramming. If the excavation for foundation is done to a depth greater than that shown in the drawings or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for leveling/bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

2.1.6 While carrying out the excavation for drain work care shall be taken to cut the side and bottom to the required shape, slope and gradient. The surface shall then be properly dressed. If the excavation is done to a depth greater than that shown on the drawing or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with stiff clay puddle at places where the drains are required to be pitched and with ordinary earth, properly watered and rammed, where the drains are not required to be pitched. In case the drain is required to be pitched, the back filling with clay puddle, if required, shall be done simultaneously as the pitching work proceeds. The brick pitched storm water drains should be avoided as far as possible in filled-up areas and loose soils.

2.1.7 In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed.

2.1.8 In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, additional filling wherever required on the account shall be done by the contractor at his own cost.
2.1.9 The excavation shall be done manually or by mechanical means as directed by Engineer-in-charge considering feasibility, urgency of work, availability of labor/mechanical equipment’s and other factors involved. Contractor shall ensure every safety measures for the workers. Neither any deduction will be made nor any extra payment be made on this account.

2.2 EARTH WORK BY MECHANICAL MEANS
Earth work by mechanical means involves careful planning keeping in view site conditions i.e. type of soil, nature of excavation, distances through which excavated soil is to be transported and working space available for employing these machines. The earth moving equipment should be accordingly selected.

The earth moving equipment consists of excavating and transporting equipment. Excavating equipment’s may be further classified as excavators and tractor based equipment’s.

2.2.1 Excavators
Excavators generally used at site are as follows:
(i) **Dipper–shovel**: It is used for excavating against a face or bank consisting of open-top bucket or dipper with a bottom opening door, fixed to an arm or dipper stick which slides and pivots on the jib of the crane. It is suitable for excavating all clay chalk and friable materials and for handling rock and stone. However, it is not suitable for surface excavation for which a skimmer is used.

(ii) **Backhoe**: It is similar to face shovel except that the dipper stick pivots on the end of the jib and the dipper or bucket works towards the chassis and normally has no bottom door but is emptied by swinging away from the chassis to invert the bucket. It may be designed to carry both a front–mounted bucket loading mechanism and a rear mounted backhoe. It is mainly used to excavate trenches and occasionally used for the excavation of open areas such as small basements.

In the backhoe mode the bucket lifts, swings and discharges materials while the undercarriage is stationary. When used in the ‘loader’ mode, the machine loads or excavated through forward motion of the machine, and lifts, transports and discharges materials.

(iii) **Skimmer**: This arrangement is similar to the face shovel except that in this case the bucket slides on rollers directly along the jib and thus has a more restricted movement. It is used for surface excavation and leveling in conjunction with transport to haul away the excavated material.

(iv) **Dragline**: It is usually fitted with a long slender boom or jib and the bucket, which in operation faces towards the machine and has no door, is supported by cable only as on a crane. It works from the side of the excavation at normal ground level and is used for excavating large open excavations such as basements when the depth is beyond the limit of the boom of a backhoe. It is commonly used for open cast mining operations.

(v) **Clamshell**: It consists of two hinged half-buckets or jaws pivoted to a frame which is suspended by cable from a long jib of an excavation. The grab is used for deep excavations of limited area on all types of soil except rock. Crane and Grab is a variant of this type of equipment.

2.2.2 Tractor–based Equipment
It is a self–propelled crawler or wheeled machine used to exert a push or pull force through mounted equipment. It is designed either as attachments to normal tracked or wheeled tractors or as machines in which the earth moving attachments and the tractor are designed as a single integrated unit. A tractor, which is hydraulically operated, can be rigged as : 
(i) **Loaders:** It is used for loading, light dozing, scraping and grabbing operations, lifting and transporting the materials (loose earth, rubble, sand, gravel aggregate etc) at various sites through forward motion of the machine.

(ii) **Tractor Shovel:** This consists of a tipping bucket at the front attached by strong pivoted arms or booms to the frame of the machine. It is used for stripping top soil, excavating against a face, bulldozing and for loading spoil or loose materials. It is similar to crawler dipper-shovel.

(iii) **Trench Digger:** It operates on the same principle as a backhoe excavator except that the bucket is controlled by hydraulic rams instead of cables and pulleys.

(iv) **Scraper:** Scrapers provide unique capability to excavate, load, haul and dump materials. Scrapers are available in various capacities by a number of manufacturers with options such as self – loading with elevators, twin engines or push-pull capability. They are cost effective where the haul distance is too long for bulldozers, yet too short for trucks. This distance typically ranges from 120 m to 1200 m; however, the economics should be evaluated for each project. Scraper has an open bowl with a cutting edge positioned between the axles, which cuts, loads, transports, discharges and spreads through forward motion of the machine. Loading through forward motion of the machine can be assisted by a powered mechanism (elevator) fixed to the scraper bowl.

(v) **Bulldozer and Angle-dozer:** The most common equipment used for clearing and leveling activities is a bulldozer. The terms bulldozer is used to define a tractor mounted with a dozing blade. The bulldozer consists of a rectangular steel blade with renewable cutting edge set at right angles (capable of only tilting but not angling) to the direction of travel and attached by steel arms to the side frames of a crawler tractor. It may be used for excavating natural soil or for moving loose soil or debris, which is pushed forward as the tractor forces it ahead.

(vi) **Angle dozer** is capable of both tilting and angling.

### 2.2.3 Transporting Equipment
This implies horizontal movement primarily but it can involve some vertical movement too.

(i) **Dumpers:** These are self-propelled wheeled machines, having an open body. It is designed for the transport of excavated materials and consists of a shallow tipping hopper or skip mounted on a wheeled chassis, such as, power barrow, dumper, multi-skip dumpers, high discharge dumpers, dump truck, etc. These can be rear dump, side dump or bottom dump.

(ii) **Vibratory Roller:** It is a single Drum Vibratory Roller for compaction of embankments, etc. The smooth drum version is for compaction of granular and mixed soil. The sheepsfoot Roller consists of a hallow cylindrical steel drum or drums on which projecting feet are mounted. These feet penetrate into the fill as a roller moves forward and cause compaction. The geometry of the foot may be sheep, club pyramid, cone or cylinder foot. Such rollers are employed for compaction (densification) of cohesive and semi-cohesive soils.

### 2.3 FILLING
2.3.1 The earth used for filling shall be free from all roots, grass, shrubs, rank vegetation, brushwood, tress, sapling and rubbish.

2.3.2 Filling with excavated earth shall be done in regular horizontal layers each not exceeding 20 cm in depth. All lumps and clods exceeding 8 cm in any direction shall be broken. Each layer shall be watered and consolidated with steel rammer or ½ tonne roller. Where specified, every third and
top must layer shall also be consolidated with power roller of minimum 8 tonnes. Wherever depth of filling exceeds 1.5 meter vibratory power roller shall be used to consolidate the filling unless otherwise directed by Engineer-in-charge. The top and sides of filling shall be neatly dressed. The contractor shall make good all subsidence and shrinkage in earth fillings, embankments, traverses etc. during execution and till the completion of work unless otherwise specified.

2.4 MEASUREMENTS
2.4.1 The length and breadth of excavation or filling shall be measured with a steel tape correct to the nearest cm. The depth of cutting or height of filling shall be measured, correct to 5 mm, by recording levels before the start of the work and after the completion of the work. The cubical contents shall be worked out to the nearest two places of decimal in cubic meters.

2.4.1.1 In case of open footings up to the depth of 1.5 meters, all-round excavation of 30 cm. beyond the outer dimension of footing shall be measured for payment to make allowances for centering and shuttering. Any additional excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment.

2.4.1.2 In case of open footings/Rafts at a depth of more than 1.5 metre, all-round excavation of 75 cm shall be measured for payment to make allowance for centering and shuttering. Additional excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment.

2.4.2 In case the ground is fairly uniform and where the site is not required to be levelled, the Engineer-in-Charge may permit the measurements of depth of cutting or height of filling with steel tape, correct to the nearest cm. In case of borrow pits, diagonal ridges, cross ridges or dead-men, the position of which shall be fixed by the Engineer-in-Charge, shall be left by the contractor to permit accurate measurements being taken with steel tape on the completion of the work. Deduction of such ridges and dead men shall be made from the measurements unless the same are required to be removed later on and the earth so removed is utilized in the work. In the latter case nothing extra will be paid for their removal as subsequent operation.

2.4.3 Where ordinary rock and hard rock is mixed. The measurement of the excavation shall be made as specified in 2.4.1 and 2.4.2. The two kinds of rock shall be stacked separately and measured in stacks. The net quantity of the two kinds of rocks shall be arrived at by applying deduction of 50% to allow for voids in stacks. If the sum of net quantity of two kinds of rocks exceeds the total quantity of the excavated material, then the quantity for each type of rock shall be worked out from the total quantity in the ratio of net quantities in stack measurements of the two types of rocks. If in the opinion of the Engineering-in-charge stacking is not feasible, the quantity of ordinary and hard rock shall be worked out by means of cross-sectional measurements.

2.4.4 Where soil, ordinary rock and hard rock are mixed, the measurements for the entire excavation shall be made as specified in 2.4.1 and 2.4.2. Excavated materials comprising hard rock and ordinary rock shall be stacked separately, measured, and each reduced by 50% to allow for voids to arrive at the 39 SUB HEAD 2.0 : EARTH WORK quantity payable under hard rock and ordinary rock. The difference between the entire excavation and the sum of the quantities payable under hard rock and ordinary rock shall be paid for as excavation in ordinary soil or hard soil as the case may be.

2.4.5 Where it is not possible or convenient to measure the depth of cutting by recording levels as specified in 2.4.1 quantity of excavation shall be worked out from filling. The actual measurements of the fill shall be calculated by taking levels of the original ground before start of the work after site clearance and after compaction of the fill as specified and the quantity of earth work so computed
shall be reduced by 10% in case of consolidated fills and by 5% in case the consolidation is done by heavy mechanical machinery to arrive at the net quantity of excavation for payment. No such deduction shall, however, be made in case of consolidation by heavy mechanical machinery at optimum moisture content, or when the consolidated filling is in confined situations such as under floors.

2.4.6. Recording Measurements for Earth Leveling Work

Specifications of these items are same as per CPWD Specifications.

2.5 SURFACE EXCAVATION

2.5.1 Excavations exceeding 1.5 m in width and 10 sqm. on plan but not exceeding 30 cm. in depth in all types of soils and rocks shall be described as surface excavation and shall be done as specified in 2.1 and 2.2.

2.5.2 Measurements

The length and breadth shall be measured with a steel tape correct to the nearest cm. and the area worked out to the nearest two places of decimal in square metres.

2.5.3 RATES

Rates for Earthwork shall include the following:
(a) Excavation and depositing excavated material as specified.
(b) Handing of antiquities and useful material as specified .
(c) Protection as specified .
(d) Site clearance as specified .
(e) Setting out and making profiles as specified .
(f) Forming (or leaving) dead – men or ‘Tell Tales’ in borrow pits and their removal after measurements.
(g) Bailing out or pumping of rain water from excavations.
(h) Initial lead of 50 m and lift of 1.5 m.
(i) Blasting operations for hard rock as specified.

No deduction shall be made from the rate if in the opinion of the Engineer- in-charge, operations specified in 2.5.3 (b) to (h) are not required to be carried out on any account whatsoever.

2.6 Refilling

Filling in trenches shall be commenced soon after the joints of pipes, cables, conduits etc. have been tested and passed. The space all-round the pipes, cables conduits etc. shall be cleared of all debris, brick bats etc. Where the trenches are excavated in hard/ soft soil, the filling shall be done with earth on the side and top of pipes in layers not exceeding 20 cm in depth. Each layer shall be watered, rammed and consolidated. All clods and lumps of earth exceeding 8 cm in any direction shall be broken or removed before the excavated earth is used for filling. In case of excavation trenches in ordinary/ hard rock, the filling up to a depth of 30cm above the crown of pipe, cable, conduits etc. shall be done with fine material like earth, moorum or pulverized/ decomposed rock according to the availability at site. The remaining filling shall be done with boulders of size not exceeding 15cm mixed with fine material like decomposed rock, moorum or earth as available to fill up the voids, watered, rammed and consolidated in layers not exceeding 30cm. Excavated material containing deleterious material, salt peter earth etc. shall not be used for filling. Ramming shall be done with iron rammers where feasible and with blunt ends of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, Cables, Conduits etc. laid in the trenches.
2.7 FILLING IN TRENCHES, PLINTH, UNDER FLOOR ETC.

2.7.1 Earth
Normally excavated earth from same area shall be used for filling. Earth used for filling shall be free from shrubs, rank, vegetation, grass, brushwood, stone shingle and boulders (larger than 75mm in any direction), organic or any other foreign matter. Earth containing deleterious materials, salt peter earth etc. shall not be used for filling. All clods and lumps of earth exceeding 8 cm in any direction shall be broken or removed before the earth is used for filling.

2.7.2 Filling
The space around the foundations and drains in trenches shall be cleared of all debris, brick bats etc. The filling shall be done in layers not exceeding 20 cm in depth. Each layer shall be watered, rammed and consolidated. Ramming shall be done with iron rammers where possible and with blunt end of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, drains, masonry or concrete in the trenches. In case of filling under floor, the finished level of filling shall be kept to the slope intended to be given to the floor.

2.8 SAND FILLING IN PLINTH

2.8.1 Sand
Sand shall be clean and free from dust organic and foreign matter and its grading shall be within the limits of grading zone IV or V specified in Section 3 ‘Mortars’.

2.8.2 Filling
Sand filling shall be done in a manner similar to earth filling in plinth specified in 2.7.2. except that consolidation shall be done by flooding with water. The surface of the consolidated sand filling shall be dressed to the required level or slope and shall not be covered till the Engineer-in-Charge has inspected and approved the sand filling.

2.8.3 Measurements
The length, breadth and depth of consolidated sand shall be measured with steel tape correct to the nearest cm and cubical contents worked out in cubic metres correct to two places of decimal.

2.8.4 Rates
The rates include the cost of material and labour involved in all the operations described above.

2.9 ANTI-TERMITE TREATMENT

2.9.0 Sub-terranean termites are responsible for most of the termite damage in buildings. Typically, they form nests or colonies underground. In the soil near ground level in a stump or other suitable piece of timber in a conical or dome shaped mound. The termites find access to the super-structure of the building either through the timber buried in the ground or by means of mud shelter tubes constructed over unprotected foundations. Termite control in existing as well as new building structures is very important as the damage likely to be caused by the termites to wooden members of building and other household article like furniture, clothing, stationery etc. is considerable. Anti-termite treatment can be either during the time of construction i.e. pre-constructional chemical treatment or after the building has been constructed i.e. treatment for existing building. Prevention of the termite from reaching the super-structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.
2.9.1 Materials
Specifications of these items are same as per CPWD Specifications.

2.9.1.1 Treatment
(i) Once the termites have an ingress into the building, they keep on multiplying and destroy the wooden and cellulosic materials, and as such it becomes essential to take measures for protection against termites. Anti termite measures described below are necessary for the eradication and control of termites in existing building. To facilitate proper penetrations of chemical in to the surface to be treated, hand operated pressure pump shall be used.

To have proper check for uniform penetration of chemical, graduated containers shall be used. Proper check should be kept so that the specified quantity of chemical is used for the required area during the operation. Chemical treatment for the eradication and control of subterranean termites in existing building shall be done as per IS 6313 (Part III). Treatment shall be got done only from the approved specialized agencies using the chemical procured directly by the Engineer-in-Charge from reputed and authorized dealers.

(ii) Treatment along outside of foundations: The soil in contact with the external wall of the building shall be treated with chemical emulsion at the rate of 7.5 litres per square metre of vertical surface of the sub-structure to a depth of 300 mm. To facilitate this treatment, a shallow channel shall be excavated along and close to the wall face. The chemical emulsion shall be directed towards the wall at 1.75 litres per running metre of the channel. Rodding with 12 mm diameter mild steel rods at 150 mm apart shall be done in the channel. If necessary, for uniform dispersal of the chemical to 300 mm depth from the ground level. The balance chemical of 0.5 litre per running metre shall then be used to treat the backfill earth as it is returned to the channel directing the spray towards the wall surface.

If there is a concrete or masonry apron around the building, approximately 12 mm diameter holes shall be drilled as close as possible to the plinth wall about 300 mm apart, deep enough to reach the soil below and the chemical emulsion pumped into these holes to soak the soil below at the rate of 2.25 litres per linear metre In soils which do not allow percolation of chemicals to desired depth, the uniform disposal of the chemical to a depth of 300 mm shall be obtained by suitably modifying the mode of treatment depending on site condition.

In case of RCC foundations the soil (backfill) in contact with the column sides and plinth beams along with external perimeter of the building shall be treated with chemical emulsion at the rate of 7.5 litres/sqm.of the vertical surface of the structure. To facilitate this treatment, trenches shall be excavated equal to the width of the shovel exposing the sides of the column and plinth beams upto a depth of 300 mm or upto the bottom of the plinth beams, if this level is less than 300 mm. The chemical emulsion shall be sprayed on the backfill earth as it is returned into the trench directing the spray against the concrete surface of the beam or column as the case may be.

(iii) Treatment of Soil under Floors: The points where the termites are likely to seek entry through the floor are the cracks at the following locations:

(a) At the junction of the floor and walls as result of shrinkage of the concrete;
(b) On the floor surface owing to construction defects;
(c) At construction joints in a concrete floor, cracks in sections; and
(d) Expansion joints in the floor.

Chemical treatment shall be provided in the plinth area of ground floor of the structure, wherever such cracks are noticed by drilling 12 mm holes at the junction of floor and walls along the cracks on the floor and along the construction and expansion joints at the interval of 300 mm to reach the soil below. Chemical emulsion shall be squirted into these holes using a hand operated
pressure pump to soak the soil below until refusal or up to a maximum of one litre per hole. The holes shall then be sealed properly with cement mortar 1:2 (1 cement: 2 coarse sand) finished to match the existing floors. The cement mortar applied shall be cured for at least 10 days as per instruction of Engineer-in-charge.

(iv) **Treatment of Voids in Masonry:** The movement of termites through the masonry wall may be arrested by drilling holes in masonry wall at plinth level and squirting chemical emulsions into the holes to soak the masonry. The holes shall be drilled at an angle of 45 degree from both sides of the plinth wall at 300 mm intervals and emulsion squirited through these holes to soak the masonry using a hand operated pump.

This treatment shall also be extended to internal walls having foundations in the soil. Holes shall also be drilled at wall corners and where door and window frames are embedded in the masonry or floor at ground. Emulsion shall be squirited through the holes till refusal or to a maximum of one litre per hole. Care shall be taken to seal the holes after the treatment.

(v) **Treatment at Points of Contact of Wood Work:** The wood work which has already been damaged beyond repairs by termites shall be replaced. The new timber shall be dipped or liberally brushed at least twice with chemical in oil or kerosene. All existing wood work in the building which is in contact with the floor or walls and which is infested by termites, shall be treated by spraying at the points of contacts with the adjoining masonry with the chemical emulsion by drilling 6 mm holes at a downward angle of about 45 degree at junction of wood work and masonry and squirting chemical emulsion into these holes till refusal or to a maximum of half a litre per hole. The treated holes shall then be sealed.

Infested wood work in chaukhats, shelves, joints, purlins etc., in contact with the floor or the walls shall be provided with protective treatment by drilling holes of about 3 mm diameter with a downward slant to the core of the wood work on the inconspicuous surface of the frame. These holes should be at least 150 mm centre to centre and should cover in entire frame work. Chemicals shall be liberally infused in these holes. If the wood is not protected by paint or varnish two coats of the chemicals shall be given on all the surfaces and crevices adjoining the masonry.
CHAPTER 4
CONCRETE WORK
## LIST OF MANDATORY TESTS

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<th>Clause</th>
<th>Test</th>
<th>Field/ Laboratory</th>
<th>Test Procedure</th>
<th>Min. qty of Material for Carrying out Test</th>
<th>Frequency of Testing</th>
</tr>
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<tr>
<td>Stone aggregate</td>
<td>4.1.2.2</td>
<td>(a) Percentage of soft or deleterious material</td>
<td>Field or Laboratory</td>
<td>IS 2386-Part II</td>
<td>As required By Engineering-in-charge</td>
<td>For all quantities</td>
</tr>
<tr>
<td></td>
<td>4.1.2.3</td>
<td>Particle size</td>
<td>Field/ Lab</td>
<td>Appendix ‘A’</td>
<td>45 cum</td>
<td>For every 45 cum or part thereof for RCC Work only. For rest of items as decided by Engineer-in-charge</td>
</tr>
<tr>
<td></td>
<td>4.1.2.5</td>
<td>a) Estimation of organic impurities</td>
<td>Field/ Lab</td>
<td>IS 2386-Part II</td>
<td>10 cum</td>
<td>For every 40 cum or part thereof</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Surface moisture</td>
<td>Field/ Lab</td>
<td>IS 2386</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Determination of 10% fine value</td>
<td>Field/ Lab</td>
<td>IS 2386</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Specific gravity</td>
<td>Field/ Lab</td>
<td>IS 2386</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) Bulk density</td>
<td>Field/ Lab</td>
<td>IS 2386</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f) Aggregate crushing strength</td>
<td>Field/ Lab</td>
<td>IS 2386</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>g) Aggregate impact value</td>
<td>Field/ Lab</td>
<td>IS 2386</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
<tr>
<td>Concrete</td>
<td>4.2.2</td>
<td>Slump test</td>
<td>Field</td>
<td>Appendix ‘D’</td>
<td>10 cum</td>
<td>-do-</td>
</tr>
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### LIST OF BUREAU OF INDIAN STANDARDS CODES

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<th>I. S. No.</th>
<th>Subject</th>
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<td>IS 383</td>
<td>Specification for coarse and fine aggregate from natural sources for concrete.</td>
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<td>2</td>
<td>IS 456</td>
<td>Plain and reinforced concrete - Code of practice</td>
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<td>3</td>
<td>IS 516</td>
<td>Method of test for strength of concrete</td>
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<td>4</td>
<td>IS 1199</td>
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<td>5</td>
<td>IS 1200 (Part II)</td>
<td>Method of measurement of building and civil engineering work (concrete work)</td>
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<td>IS 1322</td>
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<td>8</td>
<td>IS 2386</td>
<td>Method of test for aggregates for concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(a) Part I - Particle size and shape</td>
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<tr>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(d) Part IV - Mechanical properties.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(e) Part V – Soundness</td>
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<tr>
<td>9</td>
<td>IS 2505</td>
<td>General requirements for concrete vibrators - immersion type.</td>
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<td>10</td>
<td>IS 2506</td>
<td>General requirements for concrete vibrators - screed board concrete vibrators</td>
</tr>
<tr>
<td>11</td>
<td>IS 2645</td>
<td>Specification for integral water proofing compounds for cement mortar and concrete</td>
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<tr>
<td>12</td>
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<td>Specification for broken brick (burnt clay) coarse aggregate for use in concrete.</td>
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<td>13</td>
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<td>IS 4656</td>
<td>Specification for form vibrators for concrete.</td>
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<tr>
<td>16</td>
<td>IS 7861 (Part-II)</td>
<td>Code of practice for extreme weather concreting (Part-II) recommended.</td>
</tr>
<tr>
<td>17</td>
<td>IS 9103</td>
<td>Specification for concrete admixtures</td>
</tr>
</tbody>
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3.1.1 Chemical Admixtures
When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS 9103 and as specified in Chapter 5 - R.C.C.

3.1.1.1 Admixtures may be any one of the following classes for use in concrete:-
(a) Water Reducing Admixtures
(b) Retarding Admixtures
(c) Accelerating Admixtures.
(d) Water Reducing and Retarding Admixtures.
(e) Water Reducing and Accelerating Admixtures.
(f) Permeability reducing (water proofing) Admixtures.

3.1.1.2 Liquid Admixtures: Admixtures introduced into the concrete as liquids generally fall into the following categories.
(a) Air Entraining.
(b) Water Reducing.
(c) Water Reducing Retarders.
(d) Retarders.
(e) Water Reducing Accelerators.
(f) Accelerators.

Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal; Maximum Size

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Exposure</th>
<th>Plain Concrete</th>
<th>Reinforced Concrete</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum Cement Content kg/m3</td>
<td>Maximum Free Water Cement Ratio</td>
</tr>
<tr>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Mild</td>
<td>220</td>
<td>0.60</td>
</tr>
<tr>
<td>(ii)</td>
<td>Moderate</td>
<td>240</td>
<td>0.60</td>
</tr>
<tr>
<td>(iii)</td>
<td>Severe</td>
<td>250</td>
<td>0.50</td>
</tr>
<tr>
<td>(iv)</td>
<td>Very Severe</td>
<td>260</td>
<td>0.45</td>
</tr>
<tr>
<td>(v)</td>
<td>Extreme</td>
<td>280</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Notes:
1. Cement content prescribed in this Table is irrespective of the grades of cement. The additions such as fly or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio, if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.
2. Minimum grade for plain concrete under mild exposure condition is not specified.

3. The above minimum cement content and maximum water cement ratio apply only to 20 mm nominal maximum size aggregate. For other sizes of aggregate, these should be changed as per Table 6 of IS 456.

The minimum grade of concrete for plain and reinforced concrete shall be as per Table 4.6.

3.1.1.3 Concrete of grades lower than those given in Table 4.6 may be used for lean concrete, foundation for masonry walls or temporary reinforced concrete construction.

3.1.2 Work ability of Concrete

3.1.2.1 The concrete mix proportion chosen should be such that the concrete is of adequate work ability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested range of work ability of concrete measured in accordance with IS1199 are given below:

<table>
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<tr>
<th>Placing Conditions</th>
<th>Degree of Workability</th>
<th>Slump(mm)</th>
</tr>
</thead>
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<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Blinding concrete: shallow sections: Pavements using pavers</td>
<td>Very low</td>
<td>See4.2.2.2</td>
</tr>
<tr>
<td>Massconcrete: Liteyreinforced sections in slabs, beams, walls, columns, floors</td>
<td>Low</td>
<td>25-75</td>
</tr>
<tr>
<td>Hand placed pavements: canallining; Strip footing</td>
<td>Medium</td>
<td>50-100</td>
</tr>
<tr>
<td>Heavily reinforced sections in slabs, beams, walls,</td>
<td>Medium</td>
<td>75-100</td>
</tr>
<tr>
<td>Slipped form work: Pumped concrete</td>
<td>High</td>
<td>100-150</td>
</tr>
<tr>
<td>Trench fill</td>
<td>Very High</td>
<td>See4.2.2.3</td>
</tr>
</tbody>
</table>

Note:- For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete, vibrators are not required to be used (see also 4.2.7)

3.1.2.2 In the ‘very low’ category of work ability where strict control is necessary, for example, pavement quality concrete, measurement of work ability be determination of compacting factor will be more appropriate than slump (see IS1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

3.1.2.3 In the very high’ category of work ability, measurement of work ability by determination off low will be appropriate (see IS9103).
CHAPTER 4
PILE WORK
## LIST OF BUREAU OF INDIAN STANDARD CODES

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<td>Method of measurement of building and Civil Engineering Works – Piling.</td>
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<tr>
<td>10.</td>
<td>IS-6427</td>
<td>Glossary of terms relating to pile driving.</td>
</tr>
<tr>
<td>13.</td>
<td>IS-14362</td>
<td>Pile boring equipment’s. General requirements.</td>
</tr>
</tbody>
</table>
4.0 PILE WORK
4.0 TERMINOLOGY

Allowable Load: It is load which is applied to a pile after taking into account its ultimate load capacity, pile spacing, Overall bearing capacity of the ground, the allowable settlement, negative skin friction including reversal of loads.

Bearing Pile: A pile formed in the ground for transmitting load of a structure to the soil by the resistance developed at its tips and or along its surface. It is either vertical or batter pile. It may be ‘End bearing pile’ or friction pile if it supports the load primarily along the surface.

Board Compaction Pile: It is bored cast-in-situ with or without bulb. In this compaction of surrounding ground and freshly filled concrete in pile, bore is simultaneously achieved by suitable method. A pile with a bulb is called a “under-reamed bored compaction pile”. Under-reamed pile with more than one bulb is called Multi-under-reamed pile.

Constant Rate of Penetration (CRP) Test: The ultimate bearing capacity of preliminary piles and piles which are not used as working piles.

Constant Rate of Uplift (CRU) Test: The ultimate capacity in tension of preliminary piles and piles which are not used as working piles.

Cut of Level: It is the level where the installed pile is cut off to support the pile caps or beams

Datum Bar: A rigid bar placed on immovable supports.

Draft Bolt: A metal rod driven into hole bored in timber, the hole being smaller in diameter than the rod.

Drop of Stroke: The distance through which the driving weight is allowed to fall for driving the piles.

Factor of Safety: It is the ratio of the ultimate load capacity of a pile to the safe load of a pile.

Follower Tube: A tube which is used following the main casing tube and it requires to be extended further. The inner diameter of the follower tube should be the same as the inner diameter of casing. The follower tube shall preferably be an outside guide and should be water tight when driven in water bearing strata or soft clays.

Initial Test: This test is carried out with a view to determine ultimate load capacity and safe load capacity.

Raker or Batter Pile: The pile which is installed at an angle to the vertical. Raker piles are normally provided where vertical piles cannot resist the required applied horizontal forces. The maximum rake to be permitted in piles shall not exceed –

1 in 8 for cast-in-situ piles of large diameter viz. 750 mm dia,. and above.

1 in 5 for smaller dia. cast-on-situ piles.

1 in 4 pre-cast piles.

Routine Test: It is carried out with a view to check whether pile is capable of taking the working load assigned to it.
Safe Load: It is the load arrived at by applying a factor of safety to the ultimate load capacity of the pile.

Set: The net distance by which the pile penetrates in the ground due to stated number of blows of the hammer.

Spliced Pile: A pile composed of two or more lengths secured together, end to end to form one pile.

Test Pile: A pile which is selected for load testing and which is subsequently loaded for that purpose. This pile may form working pile itself if subjected to a routine load test with up to one and half time the safe load.

Total displacement (Gross): The total movement of the pile under a given load.

Total Elastic Displacement: This is the magnitude of the displacement of the pile due to rebound caused at the top after removal of given test load. This comprises two components as follows: 
(a) Elastic displacement of the soil participating in load transfer; and
(b) Elastic displacement of the pile shaft.

Trial Piles: These are installed initially to assess the load carrying capacity, it is either tested to ultimate bearing capacity or twice the estimated safe load.

Ultimate Load Capacity: The maximum load which a pile can carry before failure of ground (when the soil fails by shear) or failure of pile materials.

Working Load: It is a load assigned to a pile as per design.

Working Pile: It is a pile forming part of foundation of a structural system.

4.1 BORED CAST-IN-SITU REINFORCED CONCRETE PILES

4.1.1 General

The piles are formed within the ground by excavating or boring a pile within it with or without the use of temporary casing and subsequently filling it with plain or reinforced concrete. When the casing is left permanently it is termed as cased pile and when the casing is taken out it is termed as uncased pile.

4.1.2 Equipment

The equipment and accessories used for bored cast-in-situ piles shall depend on subsoil strata, ground water conditions, type of founding material and penetration etc.

General requirements of boring equipment are as per Appendix ‘D’. The equipment is applicable for bored piles without the use of betonies.

4.1.2.1 Boring operation shall be done by rotary percussion type drilling rigs using direct mud circulation or reverse mud circulation methods to bail out the cuttings or as specified. In soft clays and loose sand, bailer and chisel method should be used with caution to avoid the effect of suction. Rope operated grabbing tool Kelly mounted hydraulically operated grab are also used. This method of advancing the hole avoids suction. The size of cutting tool shall be as per [IS 2911 (Part I Section 2)] and not less than the diameter of pile by more than 75 mm.
4.1.2.2 Use of drilling mud is stabilizing sides of bore hole where specified shall have properties as defined in Appendix A.

Permanent casing where specified shall be used to avoid aggressive action of water.

4.1.3 Boring for installing Pile
4.1.3.1 Installation of Piles: As described under clause 20.1.3.1

Installation of piles shall be as accurate as possible and as per design and drawings. The vertically or the required batter should be correctly maintained. Particular care shall be taken in respect of installing either single pile or piles in two pile groups.

4.1.3.2 Deviation and Tolerance: As described under clause 20.1.3.2.
4.1.3.2.1 The deviation/tolerance should be as per IS 2911 (Part 1/Sec.1). The piles should not deviate more than 75 mm or D/4 whichever is less (75 mm or D/10 whichever is more in case of piles having diameter more than 600 mm) from their designed position at the working level.

4.1.3.2.2 In case of a single pile under a column, the positional deviation should not be more than 50 mm or D/4 whichever is less (100 mm in case of piles having diameter more than 600 mm. Greater tolerance may be prescribed for piles driven over water and for raking piles.

4.1.3.3 Procedure of Driving Pile Bore
4.1.3.3.1 Bored cast-in-situ concrete piles are installed by making a bore into the ground and removing out the material.

4.1.3.3.2 The ground shall be roughly leveled and position of pile marked. The boring shall be done with or without the use of temporary casing. The sides of bore hole; shall be stabilized with the aid of temporary casing or with the aid of drilling mud of suitable consistency.

4.1.3.3.3 The equipment and accessories shall depend upon the type of bored pile chosen for the job, consideration of sub-soil strata, ground water condition, type of founding material. Boring operation normally are done by rotary or percussion type drilling rigs using direct mud circulation on reverse mud tool shall be as detailed in IS 2911 (Part 1/Sec.2).

4.1.3.3.4 In case permanent/temporary casing is not used then bored pile is stabilised with drilling fluid. Bentonite supplied to site shall conform to IS 2720 (Part V). A certificate shall be obtained by the contractor from the manufacturer showing properties of each consignment and should be submitted to the Engineer-in-charge.

Bentonite shall be mixed thoroughly with fresh clean water to make a suspension which will maintain the stability of the pile excavation for the period necessary to place concrete and complete construction. The temperature of the water used in mixing the bentonite suspension and when supplied to bore hole shall not be lower than 5°C. Consistency of the drilling fluid suspension and when controlled throughout the boring as well as in concreting operations in order to keep the hole stabilized as well as to avoid concrete getting mixed up with thick suspension of mud. Frequency and methods of testing drilling fluid shall be as specified and the test results shall be as specified in IS 2720 (Part V).
4.1.3.3.5 Bored cast-in-situ piles in soils which are stable may often be installed with a small casing length at the top. A minimum of 2.0 m length of top of bore shall; invariably be provided with casing to ensure against loose soil falling in to drilling mud, or a suitable steel casing. The casing may be left in place permanently especially in cases where the aggressive action of the ground water is to be avoided, or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

4.1.3.3.6 For bored cast-in-situ piles, casing/liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as directed by the Engineer-in-charge. Materials inside the casing shall be removed progressively by air lift, grap or percussion equipment or other approved means.

4.1.3.3.7 Where bored cast-in-situ piles are used in soils liable to inflow, the bottom of the casing shall be kept low enough in advance of the boring tool; to prevent the entry of soil into the casing, thus presenting the formation of settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as tight as possible to minimize inflow of water or leakage of slurry during concreting.

4.1.3.3.8 Boring shall be carried out using rotary or percussion type equipment. Unless otherwise directed by the Engineer-in-charge the diameter of the bore holes shall be not more than the inside diameter of the liner.

4.1.3.3.9 After the boring has reached the required depth, the steel reinforcement shall be lowered in position maintaining the specified size of cover on all sides. The bore shall then be flushed with bentonite slurry and concreting shall be taken up exactly as described under clause 20.1.6.8.

4.1.4 Reinforcement

(i) The design of reinforcing age varies depending up on the driving and installation conditions, the nature of the sub soil land the nature of load to be transmitted by the shaft, axial or otherwise. The minimum area of longitudinal enforcement of any type or grade within the pile shaft shall be 0.4 percent of the sectional area calculated on the basis of the outside area of the casings of the shaft.

(ii) The curtailment of reinforcement along the depth of the pile, in general, depends on the type of loading and sub-soil strata. In case of piles subjected to compressive load only, the designed quantity of reinforcement may be curtailed at appropriate level according to design requirements. For piles subjected to uplift load, lateral load & moments, separately or with compressive loads, it may be necessary to provide reinforcement to the full depth of the pile. In soft clays or loose sands, or where there is likelihood of danger to green concrete due to driving of adjacent piles, the reinforcement should be provided up to full pile depth, regardless of whether or not it is required from uplift & lateral load considerations. However, in all cases, the minimum reinforcement specified in Para (i) above should be provided in full length of the pile.
(iii) Piles shall always be reinforced with a minimum amount of reinforcement as dowels keeping the minimum bond length into the pile shaft below its cut-off level, and with adequate projection into the pile cap, irrespective of design requirements.

**Note:** In some cases the cage may lift at bottom or at the laps during withdrawal of casing. This can be minimized by making the reinforcement “U” shaped at the bottom and up to well secured joints. Also the lifting 5 percent of length should be considered not to affect the quality of pile.

(iv) Clear cover to all main reinforcement in pile shaft shall be not less than 50 mm and shall be maintained by suitable spacers. The laterals of reinforcing cage may be in the form of links or spirals. The diameter and spacing of the same is chosen to impart adequate rigidity of the reinforcing cage during the handing and installation. The minimum diameter of links or spirals shall be 6 mm and the spacing of the links or spirals shall be not less than 150 mm. The minimum clear distance between two adjacent main reinforcement should normally be 100 mm for full depth of the cage.

(v) The reinforcing cage should be left with adequate protruding length above the cut off level for proper embedment in the pile cap. Prior to the lowering of reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials.

(vi) Reinforcement in the form of cage shall be assembled with additional support, such as spreader forks and lacings; necessary to form a rigid cage hoops, links, or helical reinforcement has to fit closely around the main longitudinal bars and shall be tied by binding wire of approved quality. The ends of the binding wire shall be turned into the interior of the pile. Reinforcement shall be placed and maintained in correct position. The reinforcements shall be joined wherever necessary by welding and the procedure of welding be followed as described in IS 2751.0 of CPWD Specifications.

4.1.5 Concrete
4.1.5.1 Cement: Cement shall be as specified in agreement item or as specified under sub-head 3.0 of CPWD Specifications. However, high alumina cement shall not be used.

4.1.5.2 Water: Water to be used for concreting shall be as specified under sub-head 3.0 of CPWD Specifications.

4.1.5.3 Fine Aggregate: Fine aggregate to be used for concreting shall be as specified under subhead 3.

4.1.5.4 Coarse Aggregate: For tremie concreting, coarse aggregate having nominal size more than 20 mm should not be used. Natural rounded shingle of appropriate size may also be used as coarse aggregate. It helps to give high slump with less water cement ratio.

4.1.5.5 Chemical Admixtures: Admixtures to be used in the concrete shall be as per IS 9103.

4.1.5.6 Concrete Grades to be adopted
(i) Concreting of piles shall be done only with design mix of appropriate grade with weigh batching of constituents. The grade of concrete to be kept as per nomenclature of the item.

(ii) Only concrete Grade M-25 and/or higher grades shall be used for concreting the piles. The exact grade of concrete to be used shall mainly depend upon the nature of work and the general design consideration. However, Concrete Grade M-15 and Grade M-20 shall not be used for concreting piles under any circumstances, even with weigh batching. The minimum cement content shall be 400 kg/m³ in all conditions.
(iii) When concreting under water or drilling mud 10 per cent additional cement over the minimum cement content for the particular grade shall be used subject to a minimum cement content of 370 kg/cum.

4.1.5.7 **Workability of Concrete:** The minimum slump shall be 100 mm when the concrete for the piles is being vibrated and when the concrete is not vibrated the maximum permitted slump is 150 mm. The degree of workability in both the cases is considered as very high.

4.1.5.9 **Placing Concrete under Water**

(i) Before concreting under water, the bottom of the hole shall be cleared of drilling mud and all soft loose materials very carefully. In case a hole is bored with use of drilling mud, concreting should not be taken up when the specific gravity of bottom slurry is more than 1.2. The drilling mud should be maintained at 1.5 m above the ground water level. Concreting under water for cast-insitu concrete piles may be done either with the use of tremie method or by the use of approved method specialty designed to permit under water placement of concrete. General requirements and precautions for concreting under water are as follows:

(a) The concreting of pile must be completed in one continuous operation. Also for bored holes, the finishing of the bore, cleaning of the bore, lowering of reinforcement cage and concreting of pile for full length must be accomplished in one continuous operation without any stoppage.

(b) The concrete should be coherent, rich in cement with high slump & restricted water cement ratio.

(c) The tremie pipe will have to be large enough with due regard to the size of the aggregate. For 30 mm aggregate the tremie pipe should be of diameter not less than 150 mm and for larger aggregate, larger diameter of tremie pipe may be necessary.

(d) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it to prevent mixing of water and concrete.

(e) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

(f) The pile should be concentrated wholly by tremie and the method of deposition should not be changed part way up the pile to prevent the laitance from being entrapped within the pile.

(g) All tremie tubes should be scrupulously cleaned after use.

When concreting is carried out under water a temporary casing should be installed to the full depth of the bore hole or 2 m into non collapsible stratum, so that fragments of ground cannot drop from the sides of the hole into the concrete as it is placed. The temporary casing may not be required except near the top when concreting under drilling mud.

4.1.6 **Testing of Concrete**

4.1.6.1 The concrete for the piles shall be sampled in accordance with the norms specified in IS 456. The frequency of sampling is given in Table 20.1.
TABLE 4.1

<table>
<thead>
<tr>
<th>Quantity of Concrete in the Work m³</th>
<th>Number of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>1</td>
</tr>
<tr>
<td>6-15</td>
<td>2</td>
</tr>
<tr>
<td>16-30</td>
<td>3</td>
</tr>
<tr>
<td>31-50</td>
<td>4</td>
</tr>
<tr>
<td>51 and above</td>
<td>4 plus one additional sample for each additional 50m³ or part thereof.</td>
</tr>
</tbody>
</table>

Notes: (i) At least one sample shall be taken from each shift.  
(ii) Where concrete is produced as continuous production unit, such as ready mix concrete plant. The frequency of sampling may be agreed upon mutually by suppliers and purchasers.

4.1.7.1 Test Specimen: Three test specimens shall be made for each sample for testing at 28 days. Additional samples may be required for various purposes such as to determine the strength of concrete at 7 days or to determine the duration of curing, or check the testing error, additional sample may also be required for testing samples cured by accelerated methods as described in IS 9103. The specimen shall be tested as described in IS 516.

4.1.7.2 Test Results of Samples: The test results of the samples shall be the average of the strength of three specimens. The individual variation should not be more than ±15% percent of the average strength. If the variation is more, the test result of the sample is invalid.

4.1.7 Measurement  
Dimension shall be measured nearest to a cm. Measurement of length on completion shall be along the axis of pile and shall be measured from top of shoe to the bottom of pile cap. No allowance shall be made for bulking, shrinkage, cut off tolerance, wastage and hiring of tools and equipment for excavating driving etc.

4.1.8 Ready Mix Concrete (RMC)  
Alternatively, the contractor can be allowed to use Ready Mix Concrete (RMC) with the permission of Engineer-in-Charge, provided that the manufacturer assures that for RMC supplied for the particular work contains the minimum cement content and it is in conformity of approved design mix.

The manufacturer of RMC has also to agree to the sampling and testing procedure as specified under clause 20.1.7 or alternatively he can propose his own sampling and testing procedure which should in turn be approved by the Engineer-in-Charge. Normally, RMC supplied to site are mixed with certain admixtures which enables the concrete to be used within 3 hours of supply at site. In case RMC supplied is not consumed within 3 hours of supply the quantity of RMC remaining unused beyond 3 hours shall be rejected and removed from site.

4.1.9 Measurement  
Dimensions shall be measured nearest to a cm. Measurement of length on completion shall be along the axis of pile and shall be measured up to the bottom of pile cap. No allowance shall be made for bulking, shrinkage, cut off tolerance, wastage and hiring of tools, equipment for excavating, driving etc.
4.2 UNDER-REAMED RCC PILES

4.2.1 General

(i) Under-reamed piles are bored cast-in-situ and bored compaction concrete types having one or more bulbs formed by suitably enlarging the bore hole for the pile stem. With the provision of bulb(s) substantial bearing or anchorage is available.

(ii) These piles find application in widely varying situations in different types of soils where foundation are required to be taken down to a certain depth in view of considerations like the following requirements:
   (a) To avoid the undesirable effect of seasonal moisture changes as in expansive soils.
   (b) To reach firm strata.
   (c) To obtain adequate capacity for downward, upward and lateral loads and moments
   (d) To take foundations below scour level.

(iv) When the ground consists of expansive soil e.g. black cotton soil, the bulb of the under ream pile provides anchorage against uplift due to swelling pressure apart from the increased bearing capacity.

(v) In case of filled up or otherwise weak strata overlying the firm strata, enlarged base in the form of under-reamed bulb in firm strata provides larger bearing area and piles of greater bearing capacity can be made.

(vi) In loose to medium pervious sandy silty strata, bored compaction piles can be used as the process of compaction increases the loads bearing capacity of the piles.

(vii) Under-reamed piles may also be used under situations where the vibration and noise caused during construction of piles are to be avoided. The provision of bulb(s) is of special advantage in under reamed piles to resist uplift and they can be used as anchors.

4.2.2 Pile Grouping

(i) For bored cast in situ under-reamed piles at usual spacing of 2 Du, the group capacity will be equal to the safe load of individual pile multiplied by the number of piles in the group. For piles at spacing of 1.5 Du the safe load assigned per pile in a group should be reduced by 10 per cent.

(ii) In under-reamed compaction piles, at the usual spacing of 1.5 Du, the group capacity will be equal to the safe load on individual pile multiplied by the number of piles in the group.

**Note:** In order-reamed compaction piles, the capacity of the group may be more than given in Para (i) above on account of compaction effect.

(iii) In non-expansive soils, when the cap of the pile group is cast directly on a reasonably firm stratum it may additionally contribute towards the bearing capacity of the group.

(iv) In load bearing walls piles should generally be provided under all wall junctions to avoid point loads on beams. Position of intermediate piles is then decided by keeping door openings fall in between two piles as far as possible.
4.2.3 Pile Boring

(i) Under-reamed piles may be constructed by selecting suitable installation techniques at
given site depending on sub-soil strata conditions and type of under-reamed piles and
number of bulbs.

(ii) In construction with equipment suggested under Appendix ‘B’ initially boring guide is
fixed with its lower frame leveled for making desired angular adjustment for piles at
batter/rake. Boring is done up to required depth and under-reaming is completed.

(iii) In order to achieve proper under-reamed bulb, the depth of bore hole should be
checked before starting under reaming. It should also be checked during under-
reaming and any extra soil at the bottom of bore hole; removed by auger before
reinserting the under-reaming tool.

(iv) The completion of desired under-reamed bulb is ascertained by
   (a) The vertical movement of the handle and
   (b) When no further soil is cut.

(v) In double or multi under-reamed piles, boring is fist completed to the depth to the
    first (top) under-ream only and after completing the under-reaming boring is
    extended further for the second under-ream and the process is repeated.

4.2.4 Reinforcement in Piles

(i) The provision of reinforcement will depend on nature and magnitude of loads, nature
of strata and method of installation. It should be adequate for vertical loads, lateral
load and moments acting individually or in combination. It may be curtailed at
appropriate depths only under the advice of the structural engineer. However,
provision of reinforcement shall be as specified in drawing.

(ii) The minimum area of longitudinal reinforcement (any type or grade) within the pile
    shaft should be 0.4 per cent of the sectional area calculated on the basis of outside
    area of shaft or casing if used.

(iii) Reinforcement is to be provided in the full length irrespective of any other
    considerations and is further subject to condition that a minimum number of three 10
    mm dia mild steel or three 8 mm dia high strength steel bars shall be provided. The
    transverse reinforcement as circular stirrups shall not be less than 6 mm dia. Mild steel
    bars at a spacing of not more than the stem diameter or 30 cm, whichever is less.

(iv) For under reamed compaction piles, a minimum number of four 12 mm diameter mild
    steel or four 10 mm diameter high strength steel bars shall be provided.

(v) For piles of lengths exceeding 5 m and or 37.5 cm diameter, a minimum number of
    six 12 mm diameter HSD bars shall be provided.

(vi) For piles exceeding 40 cm diameter a minimum number of six 12 mm diameter high
    strength steel bars shall be provided.

(vii) The circular stirrups for piles of length exceeding 5 m and diameter exceeding 37.5 cm
    shall be bars of 8 mm diameter.
(viii) For piles subject to uplift loads, adequate reinforcement shall be provided to take full up lift which shall not be curtailed at any stage.

(ix) For piles up to 30 cm diameter, if concreting is done by tremie, equivalent amount of steel placed centrally, may be provided at sides.

(x) The minimum clear cover over longitudinal reinforcement shall be 50 mm. In aggressive environment of sulphates etc. it may be increased to 75 mm.

4.2.4.1 Placing of Concrete

(i) Same as Para (i) to (x) under clause 20.1.6.8.

(ii) Concreting shall be done as soon as possible after completing the pile bore. The bore hole full of drilling mud should not be left un-concreted for more than 12 to 24 hours depending upon the stability of the bore hole.

(iii) For placing concrete in pile bores, a funnel should be used and method of concreting should be such the entire volume of the pile before is filled up without formation of voids and/or mixing of soil and drilling fluid in concrete.

(iv) In empty bore holes for under-reamed piles a small quantity of concrete is poured to give about 100 mm layer of concrete at bottom. Reinforcement is lowered next and positioned correctly. Then concrete is poured to fill the bore hole. Care should be taken that soil is not scrapped from side if rodding is done for compaction. Vibrators shall not be used.

(v) If water is confined up to the bucket length portion at the toe & seepage is low, the water should be bailed out and concreting should be done as prescribed in Para (iv) above.

(vi) In case the pile bore is stabilized with drilling mud or by maintaining water head within the bore hole, the bottom of bore hole shall be carefully cleaned by flushing it with fresh drilling mud and pile bore will be checked for its depth immediately before concreting.

(vii) Concreting shall be done by tremie method. The tremie should have a valve at bottom and lowered with valve closed at the start and filled up with concrete. The valve is then opened so permit the flow of concrete which permits upward displacement of drilling mud.

(viii) The pouring should be continuous and tremie is gradually lifted up such that the tremie pipe opening remains always in the concrete. At the final stage the quantity of concrete in tremie should be enough so that on final withdrawal some concrete spills over the ground.

Note: (1) The concrete should be coherent, rich in cement (not less than 350 kg/m³) and slump not less than 150 mm.

(2) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.
(ix) In inclined piles, concreting should be done through a chute or by tremie method.

(x) For under-reamed bored compaction piles, the pile bore is first filled up without placing any reinforcement. Concreting is done as prescribed in paras (iv) depending upon the situation. Soon after the specified core assembly shall be driven and extra concrete shall be poured in simultaneously to keep the concrete up to ground level. If hollow driving pipe is used in core assembly the pipe shall be withdrawn after filling it with fresh concrete which will be left behind.

4.2.4.2 Estimation of Concrete Quantity

(i) The extra quantity required for each bored cast-in-situ under-reamed bulb of 2.5 times the stem diameter may be taken equal to a stem length of 4 to 4.5 times its diameter, depending upon the nature of strata and other site conditions. The volume of concrete actually placed shall be observed in the case of quantities of the concrete and cement for the subsequent piles.

(ii) For under-reamed compaction piles the amount of concrete used is about 1.2 times of the under-reamed cast-in-situ piles.

Note: If the estimates of concrete consumption are on the volume of the bore holes and not on the basis of concrete quantity actually consumed, the concrete used may be found lesser than estimated and cement consumption may work out to be less.

4.2.4.3 Pile Cap

(i) Pipe cap are generally designed considering pile reaction as either concentrated loads or distributed loads. The depth of pile cap should be adequate for the shear, diagonal tension and it should also provide the necessary anchorage of reinforcement both for the column and the pile.

(ii) The pile caps may be designed by assuming that the load from column or pedestal is dispersed at 45° from the top of the cap up to the mid depth of the pile cap from the base of the column or pedestal. The reaction from piles may also to be taken to be distributed at 45° from the edge of the pile, up to the mid depth of the pile cap on this basis, the maximum bending moment and shear forces should be worked out at critical sections.

(iii) Full dimension of the cap shall be taken as width to analyze the section for bending and shear in respective direction. Method of analysis and allowable stresses may be according to IS 456.

(iv) The clear overhang of the pile cap beyond the outermost pile in the group shall normally be 100 to 150 mm depending upon the size of the pile.

(i) The cap is generally cast over a 75 mm thick leveling course of concrete. The clear cover for the main reinforcement of cap slab shall be not less than 75 mm.

(ii) The pile should project 50 mm into the cap concrete. The design of grade beams if used shall be as given in IS 2911 (Part III).
CHAPTER 5

REINFORCED CEMENT CONCRETE WORK
# LIST OF MANDATORY TESTS

<table>
<thead>
<tr>
<th>Material</th>
<th>Clause</th>
<th>Test</th>
<th>Field/ laboratory test</th>
<th>Test procedure</th>
<th>Min. quantity of material for carrying out the test</th>
<th>Frequency of testing</th>
</tr>
</thead>
</table>
| Reinforced cement concrete (Nominal Mix)      | 5.4.1    | (a) Slump test    | Field/Lab              | Appen-dix ‘D’ of Chapter 4 | (i) 5 cm in case of column
(ii) 20 cm for slabs, beams and connected columns
(iii) 20 cm for other R.C.C. work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out | (i) Every 5 cum of part thereof
(ii) Every 20 cum or part thereof
(iii) -Do- |
|                                               | 5.4.9.1  | (b) Cube Test     | Lab                    | Appen-dix ‘A’ | (i) 5 cm in case of column
(ii) 20 cm for slabs, beams and connected columns
(iii) 20 cm for other R.C.C. work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out | (i) Every 5 cum or part thereof
(ii) Every 20cum or part thereof
(iii) -Do- |
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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Cement Concrete (Design Mix)</td>
<td>Coarse Aggregates</td>
<td></td>
<td></td>
<td>50 cum or part thereof &amp; also on each change of source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Aggregates</td>
<td></td>
<td></td>
<td></td>
<td>50 cum or part thereof &amp; also on each change of source</td>
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<tr>
<td>Cement</td>
<td></td>
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<td>50 MT or on each change of source</td>
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</tr>
<tr>
<td>Fresh Concrete (a) Slump test Field Appendix ‘D’ of Chapter 4</td>
<td></td>
<td>10 cum</td>
<td></td>
<td>50 cum for R.C.C. work including in all other small location. R.C.C. done in a day is less than 50 cum test may be</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh Concrete (b) Cube Test Lab Appendix ‘A’</td>
<td></td>
<td>10 cum or part thereof</td>
<td></td>
<td>50 cum or 10 batches of 5-7 cum each for R.C.C. work in all location taken together. R.C.C. done in a day is less than 50 cum test may be carried out as required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced Cement Concrete (Ready Mix)</td>
<td>Coarse Aggregates</td>
<td></td>
<td></td>
<td>50 cum or part thereof &amp; also on each change of source</td>
<td></td>
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<tr>
<td>Fine Aggregates</td>
<td></td>
<td></td>
<td></td>
<td>50 cum or part thereof &amp; also on each change of source</td>
<td></td>
<td></td>
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<tr>
<td>Cement</td>
<td></td>
<td></td>
<td></td>
<td>50 MT or on each change of source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh Concrete (a) Slump test Field/Lab Appendix ‘D’ of Chapter 4</td>
<td></td>
<td>10 cum</td>
<td></td>
<td>50 cum for R.C.C. work including in all other small location. R.C.C. done in a day is less than 50 cum test may be carried out as</td>
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<tr>
<td></td>
<td></td>
<td>Fresh Concrete</td>
<td>(b) Cube</td>
<td>Lab</td>
<td>Appendix ‘A’</td>
<td>10 cum or part thereof</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.3</td>
<td>Steel for Reinforced cement concrete</td>
<td>(A) Physical Test and chemical tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</tbody>
</table>
# LIST OF BUREAU OF INDIAN STANDARDS CODES

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>I.S. No.</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IS 226</td>
<td>Structural Steel</td>
</tr>
<tr>
<td>2.</td>
<td>IS 432 (Part I)</td>
<td>Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement part-I mild steel and medium tensile steel bars.</td>
</tr>
<tr>
<td>3.</td>
<td>IS 432 (Part II)</td>
<td>Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement – Part-II hard drawn steel wire.</td>
</tr>
<tr>
<td>5.</td>
<td>IS 516</td>
<td>Method of test for strength of concrete.</td>
</tr>
<tr>
<td>6.</td>
<td>IS 716</td>
<td>Specification for pentachlorophenol</td>
</tr>
<tr>
<td>7.</td>
<td>IS 1199</td>
<td>Method of sampling and analysis of concrete.</td>
</tr>
<tr>
<td>8.</td>
<td>IS 1200 (Part II)</td>
<td>Method of measurement of building and civil engineering work – concrete work</td>
</tr>
<tr>
<td>9.</td>
<td>IS 1200 (Part V)</td>
<td>Method of measurement of building and civil engineering work – concrete work (Part 5- Form work)</td>
</tr>
<tr>
<td>10.</td>
<td>IS 1566</td>
<td>Specification for hard drawn steel wire fabric for concrete</td>
</tr>
<tr>
<td>11.</td>
<td>IS 1599</td>
<td>Method for bend test</td>
</tr>
<tr>
<td>12.</td>
<td>IS 1343</td>
<td>Code of Practice for Prestressed Concrete</td>
</tr>
<tr>
<td>13.</td>
<td>IS 1608</td>
<td>Method for tensile testing of steel products</td>
</tr>
<tr>
<td>14.</td>
<td>IS 1786</td>
<td>Specification for high strength deformed steel and wires for concrete reinforcement.</td>
</tr>
<tr>
<td>15.</td>
<td>IS 1791</td>
<td>Specification for batch type concrete mixes</td>
</tr>
<tr>
<td>17.</td>
<td>IS 2751</td>
<td>Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.</td>
</tr>
<tr>
<td>18.</td>
<td>IS 4925</td>
<td>Batch plants specification for concrete batching and mixing plant</td>
</tr>
<tr>
<td>19.</td>
<td>IS 4926</td>
<td>Ready – Mixed Concrete</td>
</tr>
<tr>
<td>20.</td>
<td>IS 6523</td>
<td>Specification for precast reinforced concrete door, window frames</td>
</tr>
<tr>
<td>21.</td>
<td>IS 10262</td>
<td>Recommended guidelines for concrete mix design</td>
</tr>
<tr>
<td>22.</td>
<td>IS 13311 (Part I)</td>
<td>Indian standard for non-destructive testing of concrete. Method of test for ultrasonic pulse velocity</td>
</tr>
<tr>
<td>23.</td>
<td>IS 13311 (Part II)</td>
<td>Indian standard for non-destructive testing of concrete. Method of testing by rebound hammer.</td>
</tr>
</tbody>
</table>
5.0 REINFORCED CEMENT CONCRETE WORK

5.0 GENERAL
Reinforced cement concrete work may be cast-in-situ or Precast as may be directed by Engineer-in-Charge according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work.

(a) Form work (Centering and Shuttering)

(b) Reinforcement

(c) Concreting: (1 – Cast-in-situ), (2 – Precast)

5.1 MATERIALS
5.1.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of chapter 03 mortars and chapter 04 concrete work as applicable.

5.1.2 Fly Ash admixed cement concrete (FACC) and fly ash Blended cements in Cement Concrete (PPCC) in RCC structures.

5.1.2.0 Fly ash Blended Cements conforming to IS 1489 (Part I) may be used in RCC structures as per guidelines given below:

5.1.2.1 General
(i) IS 456- 2000 Code of Practice for Plain and Reinforced Concrete (as amended up to date) shall be followed in regard to Concrete Mix Proportion and its production as under

(a) The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause-9 of IS 456 mentioned above.

(b) Concrete shall be manufactured in accordance with clause 10 of above mentioned IS 456 covering quality assurance measures both technical and organizational, which shall also necessarily require a qualified Concrete Technologist to be available during manufacture of concrete for certification of quality of concrete.

(ii) Minimum M -25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.

(iii) The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage of fly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to be significantly different and their values are to be taken same as those used for concrete made with OPC.

(iv) To control higher rate of carbonation in early ages of concrete both in fly ash admixed as well as PPC based concrete, water/binder ratio shall be kept as low as possible, which shall be closely monitored during concrete manufacture.

If necessitated due to low water/binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS 9103. The compatibility of chemical admixtures and super plasticizers with each set OPC, fly ash and/or PPC received from different sources shall be ensured by trials.
5.1.2.2 Use of Fly ash Admixed Cement Concrete (FACC) in RCC structures

There shall be no bar on use of FACC in RCC structures subject to following additional conditions.

(i) Fly ash shall have its chemical characteristics and physical requirements etc. conforming to IS 3812 (part I & II) and shall be duly certified.

(ii) To ensure uniform blending of fly ash with cement in conformity with IS 456, a specific facility needs to be created at site with complete computerized automated process control to achieve design quality or with similar facility from Ready Mix Concrete (RMC) plants.

(iii) As per IS 1489 (Part-I) maximum 35% of OPC by mass is permitted to be substituted with fly ash conforming to IS 3812 (Part –I) and same is reiterated.

(iv) Separate storage for dry fly ash shall be provided. Storage bins or silos shall be weather proof and permit a free flow and efficient discharge of fly ash. The filter or dust control system provided in the bins or silos shall be of sufficient size to allow delivery of fly ash maintained at specified pressure to prevent undue emission of fly ash dust, which may interfere weighing accuracy.

5.1.2.3 Use of Fly Ash Blended Cements in Cement Concrete (PPCC) in RCC Structures

(i) Subject to General Guidelines detailed out as above, PPC manufactured conforming to IS 1489 (Part-I) shall be treated at par with OPC for manufacture of Design Mix concrete for structural use in RCC.

(ii) Till the time, BIS makes it mandatory to print the %age of fly ash on each bag of cement, the certificate from the PPC manufacture indicating the same shall be insisted upon before allowing use of such cements in works.

(iii) While using PPC for structural concrete work, no further admixing of fly ash shall be permitted.
5.1.3 Steel for Reinforcement
5.1.3.1 The steel used for reinforcement shall be any of the following types:
   (a) Mild steel and medium tensile bars conforming to IS 432 (Part I)
   (b) High strength deformed steel bars conforming to IS 1786
   (c) Hard drawn steel wire fabric conforming to IS 1566
   (d) Structural steel conforming to Grade A of IS 2062
   (e) Thermo-mechanically treated (TMT) Bars.

5.1.3.2 Elongation percent on gauge length is \( \frac{565}{A} \) where A is the cross sectional areas of the test piece.

5.1.3.3 Mild steel is not recommended for the use in structures located in earthquake zone subjected to severe damage and for structures subjected to dynamic loading (other than wind loading) such as railway and highway bridges.

5.1.3.4 Welding of reinforcement bars covered in this specification shall be done in accordance with the requirements of IS 2751.

Nominal mass/weight: The tolerance on mass/ weight for round and square bars shall be the percentage given in Table 5.1 of the mass/ weight calculated on the basis that the masses of the bar/ wire of nominal diameter and of density 7.85 kg/ cm\(^3\) or 0.00785 kg/mm\(^3\).

**TABLE 5.1**

<table>
<thead>
<tr>
<th>Nominal size in mm</th>
<th>Tolerance on the Nominal Mass per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Batch</td>
</tr>
<tr>
<td>(a) Upto and including 10</td>
<td>( \pm 7 )</td>
</tr>
<tr>
<td>(b) Over 10, upto and including 16</td>
<td>( \pm 5 )</td>
</tr>
<tr>
<td>(c) Over 16</td>
<td>( \pm 3 )</td>
</tr>
</tbody>
</table>

+ for individual sample plus tolerance is not specified
(x) for coil batch tolerance is not applicable
Tolerance shall be determined in accordance with method given in IS 1786.
5.1.3.5 High strength deformed bars & wires shall conform to IS 1786. The physical properties for all sizes of steel bars are mentioned below in Table 5.2.

**TABLE 5.2**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Property</th>
<th>Fe 415</th>
<th>Fe 415 D</th>
<th>Fe 500 D</th>
<th>Fe 550 D</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>0.2 Per cent Proof stress/ yield stress, Min, N/mm²</td>
<td>415.0</td>
<td>415.0</td>
<td>500.0</td>
<td>550.0</td>
</tr>
<tr>
<td>(ii)</td>
<td>Elongation, per cent, Min. on gauge length 5.65 A, where A is the cross-sectional area of the test piece.</td>
<td>14.5</td>
<td>18.0</td>
<td>16.0</td>
<td>14.5</td>
</tr>
<tr>
<td>(iii)</td>
<td>Tensile strength, Min. 10 Per cent more than the actual 0.2 per cent proof stress/yield stress but not less than 485.0 N/mm²</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>(iv)</td>
<td>Total elongation at maximum force, percent, Min on gauge length 5.65 A, where A is the cross-sectional area of the test piece.</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Tests: Selection and preparation of Test sample. All the tests pieces shall be selected by the Engineer-in-Charge or his authorized representative either-

(a) From cutting of bars Or
(b) If he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from and any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer-in-Charge or his authorized representative.

The test pieces obtained in accordance with as above shall be full sections of the bars as rolled and subsequently cold worked and shall be subjected to physical tests without any further modifications. No deduction in size by machining or otherwise shall be permissible. No test piece shall be enated or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

Tensile Test: 0.2% proof stress and percentage elongation –
This shall be done as per IS 1608, read in conjunction with IS 226. RE- test: This shall be done as per IS 1786.

Rebend test: This shall be done as per IS 1786.

5.1.3.6 Chemical composition of reinforcement bars shall be as per Table 5.3 as follows:-

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Fe 415</th>
<th>Fe 415 D</th>
<th>Fe 500 D</th>
<th>Fe 550 D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.30</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.060</td>
<td>0.045</td>
<td>0.040</td>
<td>0.040</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.060</td>
<td>0.045</td>
<td>0.040</td>
<td>0.040</td>
</tr>
<tr>
<td>Sulphur and Phosphorus</td>
<td>0.110</td>
<td>0.085</td>
<td>0.075</td>
<td>0.075</td>
</tr>
</tbody>
</table>

5.1.3.7 Thermo Mechanically treated reinforcement bars:
(a) There is no BIS code for TMT bars. The available code BIS 1786 pertains to HSD Bars. Therefore there should be no stipulation that TMT bars should conform to relevant BIS code.

(b) The TMT bars are being produced under valid licence from either of the firms namely Tempcore, Thermex Evcon Turbo & Turbo Quench. These firms have acquired patents and are giving licences to various producers to produce TMT Bars.

(c) The TMT bars shall conform to IS 1786 pertaining to Fe 415 D or Fe 500 D or Fe grade of steel as specified.
(d) In design and construction of reinforced concrete building in seismic zone III and above, steel reinforcement of Grade Fe 415 D shall be used. However, high strength deformed steel bars, produced by thermo mechanical treatment process of grade Fe 415, Fe 500 and Fe 550 having elongation more than 14.5. % and conform to other requirements of Fe 415 D, Fe 500 D and Fe 550 D respectively of IS 1786 may also be used for reinforcement. In future, latest provision of IS 456 and IS 13920 or any other relevant code as modified from time to time shall be applicable.

5.1.4 Stacking and Storage
Steel for reinforcement shall be stored in such a way as to prevent distorting and corrosion. Care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable methods. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause minimum wastage in cutting from standard length.

5.1.5 Identification
Care shall also be taken to properly identify these bars at site. The staff shall be specially trained for looking for identification marks on these bars given by the manufacturers which are generally given colour code. It will be advisable to see that only one type/grade of bars are brought to site and used in the project after conducting tests for each lot.

5.2 FORM WORK (CENTRING & SHUTTERING)
5.2.1 Form Work
Form work shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

5.2.2 Design & Tolerance in Construction
Form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerance given below.

(a) Deviation from specified dimension of cross section of columns and beams +12 mm -6 mm
(b) Deviation from dimensions of footings
   (i) Dimension in Plan (+ 50 mm)
       (-12 mm)
   (ii) Eccentricity in plan 0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
   (iii) Thickness ± 0.05 times the specified thickness.

(Note: These tolerances apply to concrete dimensions only, and not to positioning of vertical steel or dowels).
5.2.3 General Requirement  
It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard board wedges where required shall be provided to make up any settlement in the formwork either before or during the placing of concrete.

Form shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections, care shall be taken to see that no piece is keyed into the concrete.

5.2.3.1 Material for Form Work  
(a) Propping and Centering: All propping and centering should be either of steel tubes with extension pieces or built up sections of rolled steel.

5.2.3.2 (a) Centering/Staging : Staging should be as designed with required extension pieces as approved by Engineer-in-Charge to ensure proper slopes, as per design for slabs/ beams etc. and as per levels as shown in drawing. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made form rolled structural steel sections.

(b) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast

(c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

5.2.3.3 Shuttering: Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of material as approved by the Engineer-in-Charge shall be provided in the joints. Steel shuttering used or concreting should be sufficiently stiffened. The steel shuttering should also be properly repaired before use and properly cleaned to avoid stains, honey combing, seepage of slurry through joints etc.

(a) Runner Joists: RSJ, MS Channel or any other suitable section of the required size shall be used as runners.

(b) Assembly of beam head over props. Beam head is an adopter that fits snugly on the head plates of props to provide wider support under beam bottoms.

(c) Only steel shuttering shall be used, except for unavoidable portions and very small works for which 12 mm thick water proofing ply of approved quality may be used.

5.2.3.4 Form work shall be properly designed for self weight, weight of reinforcement, weight of fresh concrete, and in addition, the various live loads likely to be imposed during the construction process (such as workmen, materials and equipment). In case the height of centering exceeds 3.50 metres, the prop may be provided in multi-stages.
5.2.3.5 **Camber:** Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per metre (1 to 250) or as directed by the Engineer-in-Charge, 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-in-Charge.

5.2.3.5.1 Typical arrangement of form work for ‘beams, columns and walls’ are shown in Figures 5.1 to 5.8 and form secured by wall ties is shown in Fig. 5.3.

5.2.3.6 **Walls:** The form faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts is considered best. A typical wall form with the components identified is given in Fig. 5.1, 5.2 & 5.3. The two shutters of the wall are to be kept in place by appropriate ties, braces and studs, some of the accessories used for wall form are shown in Fig. 5.3.

5.2.3.7 **Removal of Form work (Stripping Time):** In normal circumstance and where various types of cements are used, forms, may generally be removed after the expiry of the following periods:

<table>
<thead>
<tr>
<th>Type of Form work</th>
<th>Minimum period Before Striking Form work for OPC 33 grade</th>
<th>Minimum period Before Striking Form work for OPC 43 grade</th>
<th>Minimum period Before Striking Form work for PPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Vertical form work to columns, walls, beams</td>
<td>16-24 h</td>
<td>16-24 h</td>
<td>24-36 h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Form work</th>
<th>Minimum period Before Striking Form work for OPC 33 grade</th>
<th>Minimum period Before Striking Form work for OPC 43 grade</th>
<th>Minimum period Before Striking Form work for PPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) Soffit form work to slabs (Props to be refixed immediately after removal of formwork)</td>
<td>3days</td>
<td>3days</td>
<td>4days</td>
</tr>
<tr>
<td>(c) Soffit form work to beams (Props to be refixed immediately after removal of formwork)</td>
<td>7days</td>
<td>7days</td>
<td>10days</td>
</tr>
</tbody>
</table>
| (d) Props to slabs:  
  (1) Spanningupto4.5m | 7days | 7days | 10days |
|  (2) Spanningover4.5m | 14days | 14days | 20days |
(e) Props to beams and arches:

<table>
<thead>
<tr>
<th></th>
<th>Spanning upto 6m</th>
<th>14days</th>
<th>14days</th>
<th>20days</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td>Spanning over 6m</td>
<td>21days</td>
<td>21days</td>
<td>30days</td>
</tr>
</tbody>
</table>

**Note 1:** For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. Generally if Portland pozzolana or low heat cement or OPC with direct addition of fly ash has been used for concrete, the stripping time will be 10/7 of the period stated for OPC with 43 grade cement above.

**Note 2:** The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

**Note 3:** For rapid hardening cement, 3/7 of above periods for OPC 33 grade will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for at least 24 hours.

**Note 4:** In case of cantilever slabs and beams, the centering shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength.

**Note 5:** Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

**Note 6:** Work damaged through premature or careless removal of forms shall be reconstructed within 24 hr.
5.2.4 Surface Treatment
5.2.4.1 Oiling the Surface: Shuttering gives much longer service life if the surfaces are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

A typical mould oil is heavy mineral oil or purified cylinder oil containing not less than 5% pentachlorophenol conforming to IS 716 well mixed to a viscosity of 70-80 centipoises.

After 3-4 uses and also in cases when shuttering has been stored for a long time, it should be recoated with mould oil before the next use.

5.2.4.2 The design of form work shall conform to sound Engineering practices and relevant IS codes.

5.2.5 Inspection of Form Work
The completed form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discoloration of concrete etc. Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing and erection of form work which will be approved by Engineer-in-Charge.

Shuttering surface before concreting should be free from any defect/ deposits and full cleaned so as to give perfectly straight smooth concrete surface. Shuttering surface should be therefore checked for any damage to its surface and excessive roughness before use.

5.2.5.1 Erection of Form Work (Centering and shuttering): Following points shall be borne in mind while checking during erection.
(a) Any member which is to remain in position after the general dismantling is done, should be clearly marked.

(b) Material used should be checked to ensure that, wrong items/ rejects are not used.
(c) If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.

(d) (i) The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.
(ii) Sole plates shall be properly seated on their bearing pads or sleepers.
(iii) The bearing plates of steel props shall not be distorted.
(iv) The steel parts on the bearing members shall have adequate bearing areas.

(e) Safety measures to prevent impact of traffic, scour due to water etc. should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.
(f) Bracing, struts and ties shall be installed along with the progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be adequately restrained against tilting, over turning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.

(g) The stacked materials shall be placed as catered for, in the design.

(h) When adjustable steel props are used. They should:
   1. Be undamaged and not visibly bent.
   2. Have the steel pins provided by the manufacturers for use.
   3. Be restrained laterally near each end.
   4. Have means for centralizing beams placed in the for kheads.

(i) Screw adjustment of adjustable props shall not be over extended.

(j) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/ elastic shorting of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened/ clamped down after adjustment to prevent shifting.

(k) No member shall be eccentric upon vertical member.

(l) The number of nuts and bolts shall be adequate.

(m) All provisions of the design and/or drawings shall be complied with.

(n) Cantilever supports shall be adequate.

(o) Props shall be directly under one another in multistage constructions as far as possible.

(p) Guy ropes or stays shall be tensioned properly.

(q) There shall be adequate provision for the movements and operation of vibrators and other construction plant and equipment.

(r) Required camber shall be provided over long spans.

(s) Supports shall be adequate, and in plumb within the specified tolerances.
5.2.6 Measurements

5.2.6.1 General: The form work shall include the following:

(a) Splayed edges, notching, allowance for overlaps and passing at angles, sheathing battens, strutting, bolting, nailing, wedging, easing, striking and removal.

(b) All supports, struts, braces, wedges as well as mud sills, piles or other suitable arrangements to support the form work.

(c) Bolts, wire, ties, clamps, spreaders, nails or any other items to hold the sheathing together.

(d) Working scaffolds, ladders, gangways, and similar items.

(e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20mm wide to beams, columns and the like.

(f) Where required, the temporary openings provided in the forms for pouring concrete, inserting vibrators, and cleaning holes for removing rubbish from the interior of the sheathing before pouring concrete.

(g) Dressing with oil to prevent adhesion and

(h) Raking or circular cutting

5.2.6.2 Classification of Measurements: Where it is stipulated that the form work shall be paid for separately, measurements shall be taken of the area of shuttering in contact with the concrete surface. Dimensions of the form work shall be measured correct to a cm. The measurements shall be taken separately for the following.

(a) Foundations, footings, bases of columns etc. and for mass concrete.

(b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.

(c) Suspended floors, roofs, landings, shelves and their supports and balconies.

(d) Lintels, beams, plinth beams, girders, bressummers and cantilevers.

(e) Columns, pillars, piers, abutments posts and struts.

(f) Stairs (excluding landings) except spiral staircase.

(g) Spiral staircases (including landings).

(h) Arches, Domes, vaults, shells roofs, arch ribs, curvilinear shaped folded plates

(i) Extra for arches, domes, vaults exceeding 6 m span other than curvilinear shaped.
(j) Chimneys and shafts.
(k) Well steining.
(l) Vertical and horizontal fins individually or forming box, louvers and bands. facias and eaves board
(m) Waffle or ribbed slabs.
(n) Edges of slabs and breaks in floors and walls (to be measured in running meters where below 200 mm in width or thickness).
(o) Cornices and moldings.
(p) Small surfaces, such as cantilevers ends, brackets and ends of steps, caps and boxes to pilasters and columns and the like.
(q) Chullah hoods, weather shades, chajjas, corbels etc. including edges and
(r) Elevated water reservoirs.

5.2.6.3 Centering, and shuttering where exceeding 3.5 meter height in one floor shall be measured and paid for separately.

5.2.6.4 Where it is not specifically stated in the description of the item that form work shall be paid for separately, the rate of the RCC item shall be deemed to include the cost of form work.

5.2.6.5 No deductions from the shuttering due to the openings/ obstructions shall be made if the area of each openings/ obstructions does not exceed 0.4 square meter. Nothing extra shall be paid for forming such openings.

5.2.6.6 Form work of elements measured under categories of arches, arch ribs, domes, spiral staircases, well steining, shell roofs, curvilinear folded plates & curvilinear eaves board, circular shafts & chimneys shall not qualify for extra rate for circular work.

5.2.6.7 Extra for circular work shall be admissible for surfaces circular or curvilinear in plan or in elevation beyond the straight edge of supporting beam in respective mode of measurement. However, there may be many different types of such structures. In such cases, extra payment shall be made judiciously after deducting areas where shuttering for circular form work is not involved.

5.2.7 Rate
   The rate of the form work includes the cost of labour and materials required for all the operations described above.
5.3 REINFORCEMENTS
5.3.1 General Requirements
Steel conforming to para 5.1.3 for reinforcement shall be clear and free from loose mill scales, dust, loose rust, coats of paints, oil or other coating which may destroy or reduce bond. It shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Prior to assembly of reinforcement on no account any oily substance shall be used for removing the rust.

5.3.1.1 Assembly of Reinforcement: Bars shall be bent correctly and accurately to the size and shape as shown in the detailed drawing or as directed by Engineer-in-Charge. Preferably bars of full length shall be used. Necessary cutting and straightening is also included. Overlapping of bars, where necessary shall be done as directed by the Engineer-in-Charge. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25mm or 1 1/4 times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia. of such bars with two strands annealed steel wire of 0.90 mm to 1.6 mm twisted tight. The overlaps/splices shall be staggered as per directions of the Engineer-in-Charge. But in no case the overlapping shall be provided in more than 50% of cross sectional area at one section.

5.3.1.2 Bonds and Hooks Forming End Anchorages: Reinforcement shall be bent and fixed in accordance with procedure specified in IS 2502, code of practice of bending and fixing of bars for concrete reinforcement. The details of bends and hooks are shown below for guidance.

(a) U-Type Hook
In case of mild steel plain bars standard U type hook shall be provided by bending ends of rod into semicircular hooks having clear diameter equal to four times the diameter of the bar.

Note: In case of work in seismic zone, the size of hooks at the end of the rod shall be eight times the diameter of bar or as given in the structural drawings.

(b) Bends
Bend forming anchorage to a M.S. plain bar shall be bent with and internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times the diameter of the bar.

5.3.1.3 Anchoring Bars in Tension: Deformed bars may be used without end anchorages provided, development length equipment is satisfied. Hooks should normally be provided for plain bars in tension. Development length of bars will be determined as per IS: 456.

5.3.1.4 Anchoring Bars in Compression: The anchorage length of straight bar in compression shall be equal to the ‘Development length’ of bars in compression as specified in IS: 456. The projected length of hooks, bend and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

5.3.1.5 Binders, stirrups, links etc.: In case of binders, stirrups, links etc. the straight portion beyond the curve at the end shall be not less than eight times and nominal size of bar.
5.3.2 Welding of Bars
Wherever facility for electric arc welding or gas pressure welding is available, welding of bars shall be done in lieu of overlap. The location and type of welding shall be got approved by the Engineer-in-Charge. Welding shall be as per IS 2751 and 9417.

5.3.3 Placing in Position
5.3.3.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the Engineer-in-Charge. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during deposition of concrete.

Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by Engineer-in-Charge.

5.3.3.2 The bars shall be kept in correct position by the following methods:
(a) In case of beam and slab construction pre-cast cover blocks in cement mortar 1:2 (1 cement : 2 coarse sand) about 4x4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcements.
(b) In case of cantilevered and doubly reinforced beams of slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 mere or at shorter spacing to avoid sagging.
(c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them: or with clock of cement mortar 1:2 (1 cement: 2 coarse sand) of required size suitable tied to the reinforcement to ensure that they are in correct position during concreting.
(d) In case of other R.C.C. structure such as arches, domes, shells, storage tanks etc. a combination of cover blocks, spacers and templates shall be used as directed by Engineer-in-Charge.

5.3.3.3 Tolerance on Placing of Reinforcement: Unless otherwise specified by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

Tolerance in spacing

(a) For effective depth, 200 mm or less +10 mm
(b) For effective depth, more than 200 mm + 15 mm

5.3.3.4 Bending at Construction Joints: Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameter for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.
5.3.3.5 **Cover** : The minimum nominal cover to meet durability requirements shall be as under:

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Nominal Concrete cover in mm not less</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>20</td>
</tr>
<tr>
<td>Moderate</td>
<td>30</td>
</tr>
<tr>
<td>Severe</td>
<td>45</td>
</tr>
<tr>
<td>Very severe</td>
<td>50</td>
</tr>
<tr>
<td>Extreme</td>
<td>75</td>
</tr>
</tbody>
</table>

**Notes**:
1. For main reinforcement upto 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.
2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by + 10 mm.
3. For exposure condition ‘severe’ and ‘very severe’ reduction of 5 mm may be made, where concrete grade is M35 and above.
4. Nominal cover to meet specified period of fire resistance shall not be less than as given in Table 16A of IS 456.

5.3.4 **Measurement**

Reinforcement including authorized spacer bars and lappages shall be measured in length of different diametre, as actually (not more than as specified in the drgs.) used in the work nearest to a centimetre and their weight calculated on the basis of standard weight given in Table 5.4 below. In case actual unit weight of the bars is less than standard unit weight, but within variation, in such cases weight of reinforcement shall be calculated on the basis of actual unit weight. Wastage and unauthorized overlaps shall not be paid for. Annealed steel wire required for binding or tack welding shall not be measured, its cost being included in the rate of reinforcement.

Where tack welding is used in lieu of binding, such welds shall not be measured. Chairs separators etc. shall be provided as directed by the Engineer-in-Charge and measured separately and paid for.

**TABLE 5.4**

**Cross Sections Area and Mass of Steel Bar**

<table>
<thead>
<tr>
<th>Nominal Size mm</th>
<th>Cross sectional Area Sq.mm</th>
<th>Mass per metre Run Kg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>28.3</td>
<td>0.222</td>
</tr>
<tr>
<td>8</td>
<td>50.3</td>
<td>0.395</td>
</tr>
<tr>
<td>10</td>
<td>78.6</td>
<td>0.617</td>
</tr>
<tr>
<td>12</td>
<td>113.1</td>
<td>0.888</td>
</tr>
<tr>
<td>16</td>
<td>201.2</td>
<td>1.58</td>
</tr>
<tr>
<td>20</td>
<td>314.3</td>
<td>2.47</td>
</tr>
<tr>
<td>25</td>
<td>491.1</td>
<td>3.85</td>
</tr>
</tbody>
</table>
## 5.4.2.4 The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. In deep trenches and footings concrete shall be placed through chutes or as directed by the Engineer-in-Charge. In case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 metres at a time.
5.4.2.5 During cold weather, concreting shall not be done when the temperature falls below 4.5°C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone.

5.4.2.6 During hot weather precaution shall be taken to see that the temperature of wet concrete does not exceed 38°C. No concrete shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge.

5.4.2.7 It is necessary that the time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

5.4.3 Compaction
It shall be as specified in sub-head of Concrete Work of this specification.

5.4.3.1 Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations complying with IS 2505, IS 2506, IS 2514 and IS 4656. The Engineer-in-Charge may however relax this condition at his discretion for certain items depending on the thickness of the members and feasibility of vibrating the same and permit hand compaction instead. Hand compaction shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures, and into corners of the form. The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation; such that de-aeration and effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibration shall continue during the whole period occupied by placing of concrete, the vibrators being adjusted so that the center of vibrations approximates to the center of the mass being compacted at the time of placing.

5.4.3.2 Concrete shall be judged to be properly compacted, when the mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface. When this condition has been attained, the vibrator shall be stopped in case of vibrating tables and external vibrators. Needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets in case of internal vibration. In case both internal and external vibrators are being used, the internal vibrator shall be first withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers of the particular type of vibrator used shall be strictly complied with. Shaking of reinforcement for the purpose of compaction should be avoided. Compaction shall be completed before the initial setting starts, i.e. with 30 minutes of addition of water to the dry mixture.

5.4.4 Construction joints
Concreting shall be carried out continuously up to the construction joints, the position and details of which shall be as shown in structural drawing or as indicated in Fig. 5.26 or as directed by Engineer- in-Charge. Number of such joints shall be kept to minimum. The joints shall be kept at places where the shear force is the minimum. These shall be straight and
shall be at right angles to the direction of main reinforcement. Construction joints should comply with IS 11817.

5.4.4.1 In case of columns the joints shall be horizontal and 10 to 15 cm below the bottom of the beam running into the column head. The portion of the column between the stepping off level and the top of the slab shall be concreted with the beam.

5.4.4.2 When stopping the concrete on a vertical plane in slabs and beams, and approved stop board (see Fig. 26C) shall be placed with necessary slots for reinforcement bars or any other obstruction to pass the bars freely without bending. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stopboard. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stopboard shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set.

5.4.4.3 When the work has to be resumed, the joint shall be thoroughly cleaned with wire brush and loose particles removed. A coat of neat cement slurry at the rate of 2.75 kg of cement per square metre shall then be applied on the roughened surface before fresh concrete is laid.

5.4.5 Expansion Joints
Expansion joints shall be provided as shown in the structural drawings or as indicated in Fig. 5.10 to 5.25 or as directed by Engineer-in-Charge, for the purpose of general guidance. However it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints. The filling of these joints with bitumen filler, bitumen felt or any such material and provision of copper plate, etc. shall be paid for separately in running metre. The measurement shall be taken two places of decimal stating the depth and width of joint.

5.4.6 Curing
After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying by covering with moist gunny bags, sand, canvass Hessian or any other material approved by the Engineer-in-Charge. After 24 hours of laying of concrete, the surface shall be cured by ponding with water for a minimum period of 7 days from the date of placing of concrete in case of OPC and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather condition.

5.4.7 Finishing
5.4.7.1 In case of roof slabs the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set. Sprinkling of dry cement while finishing shall not be resorted to.

5.4.7.2 Immediately on removal of forms, the R.C.C. work shall be examined by the Engineer-in-Charge, before any defects are made good.
   (a) The work that has sagged or contains honey combing to an extent detrimental to structural safety or architectural concept shall be rejected as given in para 5.4.9.4 for visual inspection test.
(b) Surface defects of minor nature may be accepted. On acceptance of such a work by the Engineer-in-Charge, the same shall be rectified as follows:

1. Surface defects which require repair when forms are removed, usually consist of bulged due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms and bolt holes, bulges and ridges are removed by careful chipping or tooling and the surface is then rubbed with a grinding stone. Honey-combed and other defective areas must be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly under cut to provide a key at the edge of the patch.

2. Shallow patches are first treated with a coat of thin grout composed of one part of cement and one part of fine sand and then filled with mortar similar to that used in the concrete. The mortar is placed in layers not more than 10mm thick and each layer is given a scratch finish to secure bond with the succeeding layer. The last layer is finished to match the surrounding concrete by floating, rubbing or tooling on formed surfaces by pressing the form material against the patch while the mortar is still plastic.

3. Large and deep patches require filling up with concrete held in place by forms. Such patches are reinforced and carefully dowelled to the hardened concrete.

4. Holes left by bolts are filled with mortar carefully packed into places in small amounts. The mortar is mixed as dry as possible, with just enough water so that it will be tightly compacted when forced into place.

5. Tiered holes extending right through the concrete may be filled with mortar with a pressure gun similar to the gun used for greasing motor cars.

6. Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface colour is important, this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity being determined by trial.

7. The same amount of care to cure the materials in the patches should be taken as with the whole structure. Curing must be started as soon as possible, after the patch is finished to prevent early drying. Damp Hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound in these cases will be most convenient.

(c) The exposed surface of R.C.C. work shall be plastered with cement mortar 1:3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give smooth and even surface true to line and form. Any RCC surface which remains permanently exposed to view in the completed structure shall be considered exposed surfaced for the purpose of this specification.

Where such exposed surface exceeding 0.5 sqm in each location is not plastered with cement mortar 1:3 (1 cement : 3 fine sand) 6 mm thick, necessary deduction shall be made for plastering not done.
(d) The surface which is to receive plaster or where it is to be joined with brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give bond between concrete and plaster.

RCC work shall be done carefully so that the thickness of plaster required for finishing the surface is not more than 6 mm.

(e) The surface of RCC slab on which the cement concrete or mosaic floor is to be laid shall be roughened with brushes while the concrete is green. This shall be done without disturbing the concrete.

5.4.8 Strength of Concrete
The compressive strength on the work tests for different mixed shall be as given in Table 5.5 below:

**TABLE 5.5**

<table>
<thead>
<tr>
<th>Concrete Mix (Nominal Mix on Volume basis)</th>
<th>Compressive Strength in (Kg/ sq cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 days’</td>
</tr>
<tr>
<td>1:1:</td>
<td>210</td>
</tr>
<tr>
<td>1:1.5:3</td>
<td>175</td>
</tr>
<tr>
<td>1:2:</td>
<td>140</td>
</tr>
</tbody>
</table>

5.4.9 Testing of Concrete

5.4.9.0 Regular mandatory tests on the workability of the fresh concrete shall be done to achieve the specified compressive strength of concrete. These will be of two types
(a) Mandatory Lab. Test
(b) Mandatory Field Test
Results of Mandatory Field Test will prevail over mandatory Lab. Test.

5.4.9.1 Cube Test for Compressive Strength of Concrete - Mandatory Lab Test : Mandatory tests shall be carried out as prescribed in Appendix A of Chapter 5.

5.4.9.2 Additional Test: Additional test, if required, shall be carried out as prescribed in Appendix B of Chapter 5.

5.4.9.3 Slump Test: This test shall be carried out as prescribed in sub-head 4 of concrete.

5.4.9.1 Visual Inspection Test: The concrete will be inspected after removal of the form work as described in para 5.4.7.2 The question of carrying out mandatory test or other tests described in Appendix A and B (para 5.4.9.1 and 5.4.9.2) will arise only after satisfactory report of visual inspection.
The concrete is liable to be rejected if:

(i) It is porous or honeycombed as per para 5.4.7.2 (a).
(ii) Its placing has been interrupted without providing a proper construction joint.
(iii) The reinforcement has been displaced beyond tolerance specified or construction tolerances have not been met.

However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge at the risk and cost of the contractor.

5.4.10 Standard of Acceptance – for Nominal Mix
5.4.10.1 Mandatory Lab. Test: For concrete sampled and tested as prescribed in Appendix A of Chapter 5, the following requirement shall apply.

5.4.10.2 Out of six sample cubes, three cubes shall be tested at 7 days and remaining three cubes at 28 days.

5.4.10.3 7 days’ Tests
Sampling: The average of the strength of three specimen shall be accepted as the compressive strength of the concrete provided the variation in strength of individual specimen is not more than ±15% of the average. Difference between the maximum and minimum strength should not exceed 30% of average strength of three specimen. If the difference between maximum and minimum strength exceeds 30% of the average strength, then 28 days’ test shall have to be carried out.

Strength: If the actual average strength of sample accepted in para ‘sampling’ above is equal to or higher than specified strength upto ±15% then strength of the concrete shall be considered in order.

In case the actual average strength of sample accepted in the above para is lower than the specified or higher by more than 15% then 28 days’ test shall have to be carried out to determine the compressive strength of concrete cubes.

5.4.10.4 28 days’ Test
(a) The average of the strength of three specimen be accepted as the compressive strength of the concrete provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.

(b) If the actual average strength of accepted sample exceeds specified strength by more than 30% the Engineer-in-Charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of specified strength, it will be restricted to 130% only for computation of strength.

(c) If the actual average strength of accepted sample is equal to or higher than specified strength upto 30% then strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.

(d) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in-Charge (see para 5.4.13.2).
(e) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-Charge shall reject the defective portion of work represented by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken at the risk and cost of contractor. If, however the Engineer-in-Charge so desires, he may order additional tests (See Appendix B of Chapter 5) to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the contractor.

5.4.10.5 Acceptance Criteria of Field Test (Additional Test – Not Mandatory)

(A) Preparation of Standard Test Cubes for calibration of Rebound Hammer at site

(a) In the beginning the standard test cubes of the specified mix shall be prepared by field units before undertaking any concrete work in each project.

(b) At least 18 standard cubes necessary for formation of one specimen of specified mix, shall be cast by site staff well in advance. From these 18 cubes any 3 cubes may be selected at random to be tested for crushing strength of 7 days. The crushing strength obtained should satisfy the specified strength for the mix as per specification or agreement. If the strength is satisfactory then the remaining cube will form the standard samples for calibration of rebound hammer. In case of failure, the site staff should totally reject the samples and remove them also and then make another set of samples by fresh mixing or alternatively, out of the remaining 15 cubes, 3 cubes will be tested on 28 days. If the 28 days’ tests are found satisfactory then remaining 12 cubes will form the standard sample for calibration at 28 days’ strength otherwise all samples shall be rejected and whole procedure repeated to form a fresh specimen. All the results shall be recorded in a register.

(c) No concreting will be allowed unless the standard specimen cubes are obtained. The criteria for acceptance and calibration of hammer will be 28 days’ strength. The 7 days’ strength is only to facilitate the work to start.

(d) No work (for the concrete cast between 8th and 28th day) shall be allowed to be paid unless 28 days’ cube strength is obtained. For the concrete cast between 8th and 28th day, the decision to make the payment may be taken by the Engineer-in-charge on the basis of existing criteria. Concrete work will be rejected if 28 days’ strength falls short as per acceptance criteria. No further work will be allowed till the acceptable standard cubes are obtained.

(e) Frequency: it will be once in each quarter or as per the direction and discretion of Engineer- in-Charge. Whenever the acceptance criteria is changed or concrete mix or type of cement is changed or Engineer-in-Charge feels it necessary for recorded reasons with the approval of the authority according to technical sanction, fresh specimen shall be prepared.

(B) Calibration of Hammer

(a) Simultaneously, same three cubes to be tested on 28 days as referred in para A (b) above shall be used to correlate the compressive strength of their concrete with rebound number as per procedure described in para 5.2 of the IS 13311 (Part 2) “Indian standard for non- destructive testing of concrete Method of test by rebound hammer which is given below in para B (b). The average of values of the rebound number (minimum readings) obtained in respect of same three cubes passing on 28 days’ work test shall form the datum reference for remaining cubes for the strength of
cubes.

(b) The concrete cubes specimens are held in a compression testing machine under a fixed load, measurements of rebound hammer taken and then compressive strength determined as per IS 516. The fixed load required is of the order of 7 N/mm² when the impact energy of the hammer is about 2.2 NM.

If the specimen are wet cured, they should be removed from wet storage & kept in the laboratory atmosphere for about 24 hours before testing.

Only the vertical faces of the cubes as cast should be tested for rebound number. At least nine readings should be taken on each of the three vertical faces accessible in the compression testing machine when using rebound hammers. The points of impact in the specimen must not be nearer than 20 mm from the edge & should not be less than 20 mm from each other. The same points must not be impacted more than once.

(c) The rebound number of hammer will be determined on each of the remaining (18-3-3=12) cubes. Whenever the rebound number of hammer of any individual cube varies by more than +25% form the datum readings referred to in para B (a) above, that cube will be excluded and will not be considered for standard specimen cubes for calibration. It must be ensured that at least 8 cubes out of 12 that is 66.67% are within the permissible range of variation of rebound number i.e. +25% or otherwise whole procedure shall have to be repeated and fresh specimen prepared. These 8 cubes will form one standard sample in the beginning before commencement of work and shall be kept carefully for the visiting officers who will calibrate their hammers on these cubes.

(d) This calibration will be done by field staff with their hammer and then chart of calibration giving the details of the average readings, date & month of casting, mix of the concrete etc. shall be prepared and signed by Engineer-in-Charge and will be duly preserved for future reference as and when required.

(C) Preservation of Cubes at site
Standard sample cubes cast shall be carefully preserved at site under the safe custody of AE or his representative for making them available together with the charts, to the officers of QC/CTE or any other senior departmental officer, during their inspection of the work. They will calibrate their hammer on these cubes if required.

(D) Testing at Site
(D-1) Testing Equipment

(D-2) Testing will be done generally by non-destructive methods like rebound hammers etc. Each field Division/ Sub Division/ Unit will purchase rebound hammers and keep them in working order at work site. The testing will be done only by hammers which are duly calibrated.

(D-3) The relative strength of actual field work will be tested with reference to strength of these standard cubes and calibration charts of a hammer for determining the rebound number on the field work. The hammer will be used as per manufacturer's guidelines at various locations chosen at random. The number of location/reading on each wall, beam or column etc. shall not be less than 12. All the readings should be within the +25% range of values prescribed in calibration chart normally. However, reading indicating good
strength will be when it is at per with calibrated value or between 100% & 125% and very good if more than 125% any value between 100% & 75% of calibrated value shall be considered satisfactory. Values from 75% to 50% shall be considered for payment at rates reduced on prorate basis. The concrete indicating rebound number less than 50% of calibrated value shall be rejected and not paid for.

(E) Acceptance of Field Tests and Strength
If the relative strength of actual field work is found satisfactory considering the calibration charts with reference to the standard cube test kept at site, the representative work will be considered satisfactory. If the work is considered below satisfactory, the same will be dealt as stated in para D-3 above.

(F) 7 days’ Strength in Rare Cases only
Normally cube crushing strength on 28 days’ test shall form the basis of acceptance. However in rare cases of time bound projects/ urgent repairs 7 days’ cube test strength criteria may be adopted on similar lines using 7 days’ standard test cubes and calibration graphs/ curves/ charts for 7 days’ in lieu of 28 days’ and testing work done at 7 days’.

(G) Precautions
(G-1) The testing shall be done generally as per guidelines of manufacture of the apparatus and strictly in accordance with the procedure laid down in clause 6 of IS 13311 (Part 2): Indian Standard for Non-Destructive Testing of Concrete - Method of Test by Rebound Hammer.

(G-2) The rebound hammers are influenced by number of factor like type of cement aggregate, surface conditions, moisture content, age of concrete & extent of calibration of concrete etc. hence care shall be taken to compare the cement, aggregate etc. and tested under the similar surface conditions having more or less same moisture content and age. However effect of age can be ignored for concrete between 3 days & 3 months old.

5.4.11 Measurements
5.4.11.1 Dimensions shall be measured nearest to a cm except for the thickness of slab which shall be measured correct to 0.5 cm. The areas shall be worked out nearest to 0.01 Sq. mt. The cubical contents shall be worked out to nearest 0.01 cubic meter.

5.4.11.2 Reinforced cement concrete whether cast-in-situ or pre cast shall be classified and measured separately as follows.

(a) Raft, footing, bases of columns and mass concrete etc. all work up to plinth level, column up to plinth level, plinth beams.

(b) Wall (any thickness) including attached pilasters, buttresses plinth and string course, fillets, column, pillars, piers, abutments, post and struts etc.

(c) Suspended floors, roofs, landings and balconies.
(d) Shelves
(e) Chajjas

(f) Lintel, beams and bressumbers.

(g) Columns, pillars, piers, abutments, posts and struts.

(h) Stair-cases including waist or waist less slab but excluding landing except in (i) below.

(i) Spiral stair-case (including landing).

(j) Arches, arch ribs, domes and vaults.

(k) Chimneys and shafts.

(l) Well steining.

(m) Vertical and horizontal fins individually or forming box, louvers and facias.

(n) Kerbs, steps and the like.

(o) String courses, bands, coping, bed plates, anchor blocks, plain window sills and the like.

(p) Mouldings as in cornices, window sills etc.

(q) Shell, dome and folded plates.

(r) Extra for shuttering in circular work in plan.

5.4.11.3 Work under the following categories shall be measured separately.
   (a) Rafts, footings, bases of columns etc. and mass concrete.
   (b) All other items up to floor two level.
   (c) From floor two level to floor three level and so on.
   (d) R.C.C. above roof level shall be measured along with R.C.C. Work in floor just below.

5.4.11.4 No deduction shall be made for the following:
   (a) Ends of dis-similar materials (e.g. Joists, beams, post, griders, rafter, purlins, trusses, corbels steps etc.) upto 500 sq cm in cross-section.

   (b) Opening upto 0.1. sqm.
      **Note:** In calculating area of openings upto 0.1 sqm the size of opening shall include the thickness of any separate lintels or sills. No extra labour for forming such openings or voids shall be paid for.

   (c) The volume occupied by reinforcement.

   (d) The volume occupied by water pipes, conduits etc. not exceeding 25 sq cm each in cross sectional area. Nothing extra shall be paid for leaving and finishing such cavities and holes.
5.4.11.5 Measurement shall be taken before any rendering is done in concrete members. Measurement will not include rendering. The measurement of R.C.C. work between various units shall be regulated as below:

(a) Slabs shall be taken as running continuously through except when slab is monolithic with the beam. In that case it will be from the face to face of the beam.

(b) Beams shall be measured from face to face of columns and shall be including haunches, if any, between columns and beam. The depth of the beam shall be from the bottom of slab to the bottom of beam if beam and slab are not monolithic. In case of monolithic construction where slabs are integrally connected with beam, the depth of beam shall be from the top of the slab to the bottom of beam.

(c) The columns measurements shall be taken through.

(d) Chajjas along with its bearing on wall shall be measured in cubic metre nearest to two places of decimal. When chajjas is combined with lintel, slab or beam, the projecting portion shall be measured as chajjas, built in bearing shall be measured as per item of lintel, slab or beam in which chajja bears.

(e) Where the band and lintels are of the same height and the band serves as lintel the portion of the band to be measured as lintel shall be for clear length of opening plus twice the overall depth of band.

5.4.12 Tolerances
Subject to the condition that structural safety is not impaired and architectural concept does not hamper, the tolerances in dimensions of R.C.C. members shall be as specified in the drawings by the designer. Whenever these are not specified, the permissible tolerance shall be decided by the Engineer-in-Charge after consultations with the Designer, if necessary.

When tolerances in dimensions are permitted, following procedure for measurement shall apply.

(a) If the actual dimension of R.C.C. members do not exceed or decrease the design dimensions of the members plus or minus tolerance limit specified above, the design dimensions shall be taken for the purpose of measurement.

(b) If the actual dimensions exceed the design dimensions by more than the tolerance limit, the design dimensions only shall be measured for the purpose of payment.

(c) If the actual dimensions decrease more than the tolerance limit specified, the actual dimensions of the RCC members shall be taken for the purpose of measurement and payment.

(d) For acceptance of RCC members whose dimensions are not exactly as per design dimensions, the decision of Engineer-in-Charge shall be final. For the purpose of payment, however, the clarification as given in para a, b & c above shall apply.
5.4.13 Rate
5.4.13.1 The rate included the cost of materials and labour involved in all the operations described above except for the cost of centring and shuttering.

5.4.13.2 On the basis of mandatory lab tests, in case of actual average compressive strength being less than specified strength but up to 70% of specified strength, the rate payable shall be in the same proportion as actual average compressive strength bears to specified compressive strength.

5.4.13.3 Where throating or plaster drip or moulding is not required to be provided in RCC chajjas, deduction for not providing throating or plaster drip or moulding shall be made from the item of R.C.C. in chajjas. The measurement for deduction item shall be made in running metres correct to a cm of the edge of chajja.

5.4.13.4 No extra payment for richer mix which projects into any member from another member during concreting of junctions of beams and columns etc. will be made except to the extent structurally considered necessary and when so indicated in the structural drawings. The payment for work done under items of different mixed shall be limited strictly to what is indicated in the structural drawings.

5.5 ENCASING ROLLED STEEL SECTIONS
5.5.1 General Requirements
Before concrete work is started, the Engineer-in-Charge shall check that all rolled steel sections to be encased, have been erected truly in position. The sections shall be unpainted and shall be wire brushed to remove the loose rust/ scales etc. Where so specified, ungalvanised metal, having mesh or perforations large enough to permit the free passage of 12.5 mm nominal size aggregate through them shall be wrapped round the section to be encased and paid for separately.

5.5.2 Wrapping
5.5.2.1 In case of columns, the wrapping shall be arranged as illustrated in Fig. 5.27 to pass through the centre of the concrete covering. The wrapping of the entire length of the columns be carried out in stages and no stage shall cover more than 1.5 metre of height of columns. Successive wrappings shall be carried out only after the immediate adjacent wrapping has been encased in concrete. The surface and edges of the flanges of the steel columns shall have a concrete cover of not less than 50mm. The wrappings of the successive stages shall be tied together.

5.5.2.2 In the case of beams and grillages, the wire mesh or expanded metal shall be wrapped round the lower flange of the beam as illustrated in Fig. 5.28 and the wrapping shall be suspended by wire hangers 5 mm diameter placed at about 1.2 metres centres. The surfaces and edges of the steel sections shall have a concrete cover of not less than 50mm. The wrapping shall pass through the centre of the concrete covering at the edges and soffits of the flanges.

5.5.3 Form Work shall be as prescribed in 5.2.
5.5.4 Concreting
Concrete shall consist of a mix of 1:2:4 (1 cement : 2 coarse and : 4 graded stone aggregate of 12.5 mm nominal size) unless a richer mix is specified. The mix shall be poured solidly around the steel sections and around the wrapping by vibrating the concrete into position. Consistency of concrete, Placing of concrete and its compaction, curing, finishing and
strength of concrete shall be as described in 5.4.

5.5.5 Measurements
The length shall be measured correct to one cm and other dimensions correct of 0.5 cm. The cement concrete shall be measured as per gross dimensions of the encasing exclusive of the thickness of plaster. No deduction shall be made for the volume of steel sections, expanded metal, mesh or any other reinforcement used therein. However, in case of boxed stanchions or girders, the boxed portion only shall be deducted.

Fabric reinforcement such as expanded metal shall be measured separately in square metres stating the mesh and size of strands.

The description shall include the bending of the fabric as necessary, Racking or circular cutting and waste shall be included in the description.

5.5.6 Rate
The rate shall include the cost of materials and labour required for all the operations described above except the cost of fabric reinforcement. The cost of providing and erecting steel section and wire hangers shall be paid for separately.

5.6 DESIGN MIX
5.6.1 Definition
Design mix concrete is that concrete in which the design of mix i.e. the determination of proportions of cement, aggregate & water is arrived as to have target mean strength for specified grade of concrete. The minimum mix of M25 shall be used in all structural elements in both load bearing & RCC framed construction.

5.6.2 Mix Design and Proportioning
5.6.2.1 Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcement and completely fills the formwork. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.

5.6.2.2 Determination of the proportions by weight of cement, aggregates and water shall be based on design of the mix.

5.6.2.3 As a trial the manufacturer of concrete may prepare a preliminary mix according to provisions of SP: 23. Reference may also be made to ACI 211.1-77 for guidance.

5.6.2.4 Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer-in-Charge.

5.6.2.5 All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

5.6.2.6 Before using an admixture in concrete, its performance shall be evaluated by comparing the properties of concrete with the admixture and concrete without any admixture. Chloride content of admixture should be declared by the manufacturer of admixture and shall be within limits stipulated by IS:9103.
5.7 Standard Deviation
5.7.1 Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade designation shall be done in accordance with IS 456.

5.7.2 Acceptance Criteria
5.7.2.1 Compressive Strength: The concrete shall be deemed to comply with the strength requirements when both the following condition are met:
(a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col 2 of Table 5.6.

(b) Any individual test result complies with the appropriate limits in col. 3 of Table 5.6.

5.7.2.2 Flexural Strength: When both the following conditions are met, the concrete complies with the specified flexural strength.
(c) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².

(d) The strength determined from any test result is not less than the specified characteristic strength/0.3 N/mm².

5.7.2.3 Quantity of Concrete Represented by Strength Test Results: The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

For the individual test result requirements given in col 3 of Table 5.6 or in item (b) of 5.8.3.2. Only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m³.

5.7.2.4 If the concrete is deemed not to comply pursuant to 5.8.3 the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken.

5.7.2.5 Concrete of each grade shall be assessed separately.
5.7.2.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge.

5.7.3 Cement Content of Concrete
5.7.3.1 For all grades of concrete manufactured/produced, minimum cement content in the concrete shall be 330 kg per cubic metre of concrete. Also, irrespective of the grade of concrete the maximum cement content shall not be more than 500 kg per cubic metre of concrete. These limitations shall apply for all types of cements of all strengths.

5.7.3.2 Actual cement content in each grade of concrete for various conditions of variable shall be established by design mixes within the limits specified in para 5.8.4.1 above.

5.7.4 Water Cement Ratio and Slump
5.7.4.1 In proportioning a particular mix, the manufacturer/producer/contractor shall give
due consideration to the moisture content in the aggregates, and the mix shall be so designed as to restrict the maximum free water cement ratio to less than 0.5.

5.7.4.2 Due consideration shall be given to the workability of the concrete thus produced. Slump shall be controlled on the basis of placement in different situations. For normal methods of placing concrete, maximum slump shall be restricted to 100 mm when measured in accordance with IS 1199.

<table>
<thead>
<tr>
<th>Specified Grade</th>
<th>Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm³</th>
<th>Individual Test Results in N/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>M15</td>
<td>≥ fck + 0.825 x established standard deviation (rounded off to nearest 0.5 N/mm²) or fck +3 N/mm² Whichever is greater</td>
<td>≥ fck-3 N/mm²</td>
</tr>
<tr>
<td>M20 or above</td>
<td>≥ fck + 0.825 x established standard deviation (rounded off to nearest 0.5 N/mm²) or fck +4 N/mm², Whichever is greater</td>
<td>≥ fck-4 N/mm²</td>
</tr>
</tbody>
</table>

**NOTE** – In the absence of established value of standard deviation, the values given in Table may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

5.8 READY MIXED CONCRETE (as per IS 4926)
5.8.1 Materials

**5.8.1.1 Selection and Approval of Materials:** Materials used should satisfy the requirements for the safety, structural performance durability and appearance of the finished structure, taking full account of the environment to which it will be subjected. The selection and use of materials shall be in accordance with IS 456. Materials used shall conform to the relevant Indian Standards applicable. Where materials are used which are not covered by the provisions of the relevant Indian Standard, there should be satisfactory data on their suitability and assurance of quality control. Records and details of performance of such materials should be maintained. Account should be taken of possible interactions and compatibility between IS 4926 and materials used. Also, prior permission of the purchaser shall be obtained before use of such materials.
5.8.1.2 **Cement:** Cement used for concrete shall be in accordance with the requirements of IS 456.

5.8.1.3 **Mineral Admixtures:** Use of mineral admixtures shall be permitted in accordance with the provisions of IS 456.

5.8.1.4 **Aggregates:** Aggregates used for concrete shall be in accordance with the requirement of IS 456. Unless otherwise agreed testing frequencies for aggregates in plant shall be as given IS 4926.

5.8.1.5 **Chemical Admixtures**
(i) Use of chemical admixtures shall be permitted in accordance, with the provisions of IS 456 and IS 9103.

(ii) It shall be the responsibility of the producer to establish compatibility and suitability of any admixture with the other ingredients of the mix and the determine the dosage required to give the desired effect.

(iii) Admixtures should be stored in a manner that prevents degradation of the product and consumed within the time period indicated by the admixture supplier. Any vessel containing an admixture in the plant or taken to site by the producer shall be clearly marked as to its content.

(iv) When offering or delivering a mix to a purchaser it should be indicated if such a mix contains an admixture or combination of admixtures or not. The admixtures may be identified generically and should be declared on the delivery ticket.

(v) The amount of admixture added to mix shall be recorded in the production record. In special circumstances, if necessary, additional dose of admixture may be added at project site to regain the workability of concrete with the mutual agreement between the producer and the purchaser.

5.8.1.6 **Water:** Water used shall be in accordance with the requirement of IS 456. Unless otherwise agreed, the testing frequencies for water shall be as given in Annex A.

The use of re-cycled water is encouraged as long as concrete of satisfactory performance can be produced and steps are taken to monitor the build up of chlorides in any recirculate water and that any subsequent adjustments to the mix design are made to ensure that any overall limit on chloride contents is satisfied. The addition of any recycled water shall be monitored and controlled to meet these requirements.

The total amount of water added to the mix shall be recorded in the production record. The water content of concrete shall be regulated by controlling its workability or by measuring and adjusting the moisture contents of its constituent materials. The producer’s production staff and truck-mixer, drivers shall be made aware of the appropriate responses to variations in concrete consistency of a particular mix caused by normal variations in aggregate moisture content or grading.

5.9.2 **General Requirements**
5.9.2.1 **Basis of Supply:** Ready-mixed concrete shall be supplied having the quality and the quantity in accordance with the requirement agreed with the purchaser or his agent. Notwithstanding this, the concrete supplied shall generally comply with requirements of IS 456.
All concrete will be supplied and invoiced in terms of cubic metres (full or part) of compacted fresh concrete. All proportioning is to be carried out by mass except water and admixture, which may be measured by volume.

5.9.2.2 Transport of Concrete: Ready-mixed concrete shall be transported from the mixer to the point of placing as rapidly as practicable by methods that will maintain the required workability and will prevent segregation, loss of any constituents or ingress of foreign matter or water. The concrete shall be placed as soon as possible after delivery, as close as is practicable to its final position to avoid re-handling or moving the concrete horizontally by vibration. If required by the purchaser the producer can utilize admixtures to slow down the rate of workability loss, however this does not remove the need for the purchaser to place the concrete as rapidly as possible. The purchaser should plan his arrangements so as to enable a full load of concrete to be discharged within 30 minutes of arrival on site.

Concrete shall be transported in a truck-mixer unless the purchaser agrees to the use of non-agitating vehicles. When non-agitating vehicles are used, the mixed concrete shall be protected from gain or loss of water.

5.9.2.3 Time in Transport: The general requirement is that concrete shall be discharged from the truck-mixer within 2 h of the time of loading. However, a longer period may be permitted if retarding admixtures are used or in cool humid weather or when chilled concrete is produced.

The time of loading shall start from adding the mixing water to the dry mix of cement and aggregate or of adding the cement to the wet aggregate whichever is applicable.

Ready-mixed concrete plant shall have test facilities at its premises to carry out routine tests as per the requirement of the standard.

5.9.3 Sampling and Testing of Ready-Mixed Concrete

5.9.3.1 Point and Time of Sampling: For the assessment of compliance of ready-mixed concrete, the point and time of sampling shall be at discharge from the producer’s delivery vehicle or from the mixer to the site or when delivered into the purchaser’s vehicle. It is critical that the sampling procedure and equipment used enables as representative a sample as possible to be taken of the quantity of concrete delivered (see Annex A).

The sampling may be carried out jointly by the purchaser and the supplier with its frequency mutually agreed upon. However, it will not absolve the supplier of his responsibility from supplying in concrete as per the requirement given in this standard or otherwise agreed to where so permitted in the standard.

5.9.3.2 Workability: The test for acceptance is to be performed upon the producer’s delivery vehicle discharge on site or upon discharge into the purchaser’s vehicle. If discharge from the producers’ vehicle is delayed on site due to lack of preparedness on behalf of the purchaser then the responsibility passes to the purchaser after a delay of more than 30 min.
The workability shall be within the following limits on the specified value as appropriate:
Slump ± 25 mm or 1/3 of the specified value, whichever is less.
Compacting factor : ± 0.03, where the specified value is 0.90 or greater,
                   ± 0.04, where the specified value is less than 0.90 but more than
                   0.80,
                   ± 0.05, where the specified value is 0.80 or less.

Flow table test may be specified for concrete, for very high workability (see IS 9103)
Acceptance criteria for spread (flow) are to be established between the supplier and the
purchaser.

5.9.3.3 Specified Strength
   (i) Compliance shall be assessed against the requirements of IS 456 or other
       agreed Indian Standard. The purchaser may perform his sampling and testing or
       may enter into an arrangement with the producer to provide his testing requirements.

   (ii) Unless otherwise agreed between the parties involved, the minimum testing
        frequency to be applied by the producer in the absence of a recognized ready-mixed
        concrete industry method of production control should be one sample for every 50 m³
        of production or every 50 batches, whichever is the greater frequency. Three test
        specimens shall be made up for each sample for testing at 28 days (see also IS 456).
        In order to get a relatively quicker idea of the quality of concrete, optional test on
        beams for modulus of rupture at 72 ± 2 h or at 7 days or compressive strength test at 7
        days may be carried out in addition to 28 days compressive strength test. For this
        purpose the value should be arrived at based on actual testing. In all cases 28 days
        compressive strength shall alone be the criteria for acceptance or rejection of the
        concrete.

   (iii) The purchaser shall inform the producer if his requirements for sampling and testing
        are higher than one sample every 50 m³ or 50 batches, whichever is the greater
        frequency.

5.9.3.4 Additional Compliance Criteria: Any additional compliance criteria shall be
declared to the producer by the purchaser prior to supply and shall be mutually agreed
upon in terms of definition, tolerance frequency of assessment, method of test and
significance result.

5.9.3.5 Non-Compliance: The action to be taken in case of non-compliance shall be
declared and mutually agreed upon.

5.9.4 Information to be supplied by the Purchaser
5.9.4.1 The purchaser shall provide to the producer the details of the concrete mix or mixes
required by him and all pertinent information on the use of the concrete and the specified
requirements. Prior to supply taking place, it is recommended that a meeting is held between
the purchaser and the producer. Its objective to clarify operational matters such as notice to
be given prior to delivery, delivery rate, the name of the purchasers authorized representative
who will coordinate deliveries, any requirements for additional services such as pumping, on
site testing or training, etc.
5.9.4.2 Designed Mixes: Where the purchaser specifies a designed mix to be supplied it is essential that all relevant information is conveyed to the producer. In order to assist in this, the format given in Annex B may be completed and forwarded to the producer at the time of enquiry.

5.9.4.3 Prescribed Mixes: The concrete mix shall be specified by its constituent materials and the properties or quantities of those constituents to produce a concrete with the required performance. The assessment of the mix proportions shall form an essential part of the compliance requirements. The purchaser shall provide the producer with all pertinent information on the use of the concrete and the specified requirements. In order to assist in this, the format given in Annex B may be followed with suitable modifications as applicable to prescribed mixes.

5.9.5 Information to be Supplied by the Producer

When requested, the producer shall provide the purchaser with the following information before any concretes is supplied:

(a) Nature and source of each constituent material,

(b) Source of supply of cement,

(c) Proposed proportions or quantity of each constituent/ m³ of fresh concrete.

(d) Generic type(s) of the main active constituent(s) in the admixture;

(e) Whether or not the admixture contains chlorides and if so, the chloride content of the admixture expressed as a percentage of chloride ion by mass of admixture;

(f) Where more than one admixture is used, confirmation of their compatibility and

(g) Initial and final setting time of concrete when admixture is used at adopted dosage (tested as per IS 8142).

5.9.6.1 Measurement of Materials : Cement and mineral admixture materials shall be measured by mass in a hopper or compartment separate from those used for other materials and on a scale of appropriate sensitivity, measurement being taken from a zero reading. Aggregates shall be measured by mass, allowance being made for the free moisture content of the aggregates. The added water shall be measured by volume or by mass. Any liquid chemical admixture (or paste) shall be measured by volume or by mass and any solid admixture by mass. When weighing materials any build up in the hopper during the day must be tared out or allowed for in the batch weights. After measurement all materials shall be discharged into the mixer without loss.

The accuracy of the measuring equipment shall be within ± 2 percent of the quantity of cement and mineral admixtures being measured and within ± 3 percent of the quantity of aggregate, chemical admixture and water being measured. The plant operator shall be provided with a clear display of the quantities of materials to be batched for each mix and batch size with information identifying the display to be selected for each designed and prescribed mix to be produced. Analogue scale displays for the weighing of cement, mineral admixtures, aggregates and water shall be readily discernable from the operating position.
For digital readouts the numerals shall be readily discernable from the operating position.

Fully automatic production systems shall be fitted with control equipment to allow the correct operation of the plant to be monitored during weighing and batching. Automatic control systems on batching plants shall not commence batching until all hoppers have been emptied and/or tared and the scales zeroed unless such systems are designed to take account of build up in their programming.

All scales shall be tested and calibrated as per Annex C.

5.9.6.2 Mixing

(i) Washing Out Water: Before loading concrete materials or mixed concrete into either a stationary mixer or truck mixer any water retained in the mixing drum for washing out purposes shall be completely discharged.

(ii) Stationary or Central Mixers: Stationary mixers shall not be loaded in excess of the manufacturer’s rated capacity. The mixing time shall be measured from the time all the materials required for the batch, including water, are in the drum of the mixer. The mixing time shall not be less than that recommended by the manufacturer. Where a continuous mixing plant is used, the complete mixing time shall be sufficient to ensure that the concrete is of the required uniformity.

(iii) Truck Mixers: When a truck mixer is used for the partial or complete mixing of concrete, mixing shall be considered to commence from the moment when all the materials required for the batch, including water, are in the rotating drum of the mixer.

Truck or agitators shall not be loaded in excess of the manufacturer’s rated capacity. In order to produce a satisfactory mix, and where there is no data available to establish different period and speed of revolutions, mixing shall continue for not less than 60 revolutions of the truck mixer drum at a rate of not less than 7 revolutions/min. All completely truck mixed concrete shall be visually inspected for uniformity prior to leaving the plant.

When a truck mixer or agitator is used for transporting concrete which has been mixed before leaving the plant, the concrete shall be agitated during transit and remixed at the site for at least 2 min so that the concrete is of the required uniformity.

Where water is added to the concrete in the truck mixer through the truck mixer water meter and when such water is being accounted for in the total water within the mix, it shall be ensured that the truck mixer water meter is in operational condition and properly calibrated. Where a water meter is not available, water must be measured in a suitable container before being added to the truck mixer.

(iv) Condition of Mixers: Stationary and truck mixers shall be maintained in an efficient and clean condition with no appreciable buildup of hardened concrete or cement in the mixing drum, on the mixing blades, or on the loading hopper or discharge chutes.
5.10 PLACING CONCRETE BY PUMPING

5.10.1 General
Concrete conveyed by pressure through either rigid pipes or flexible hoses and discharged directly into the desired area is termed as pumped concrete.

Method of applying pressure to concrete is by pumps. Pumps to be used shall be either of the two types as mentioned below:-
(A) Piston type pumps
(B) Squeeze pressure type pumps.

Compressed air pressure pumps shall not be used in the works.

5.10.2 Pumping Equipment
5.10.2.1 Piston Pumps: Piston pump to be used in the works shall consist of a receiving hopper for mixed concrete, an inlet valve, an outlet valve, and the pump shall be a twin-piston pump.

The two pistons shall be so arranged that one piston retracts when the other is moving forward and pushing concrete into the pipe line to maintain a reasonably steady flow of concrete. Single piston pumps shall not be acceptable.

Inlet and outlet valve shall be any one of the following types:-
- Rotating plug type
- Sliding plate type
- Guided plunger type
- Swing type
- Flapper type
- Or any combination of the above.

The pistons shall be mechanically driven using a crank or chain or hydraulically driven using oil or water.

The receiving hopper shall have a minimum capacity of 1.0 cum and the hopper shall be fitted with remixing rotating blades capable of maintaining consistency and uniformity of concrete.

The primary power for pumps may be supplied by gasoline, diesel, or electric motors. The primary power unit and the pump unit may be truck, trailer or skid mounted.

5.10.2.2 Squeeze Pressure Pumps: Squeeze pressure pumps shall consist of a receiving hopper fitted with re-mixing blades. Re-mixing blades shall be such that these can push the concrete into the flexible hose connected at the bottom of the hopper.

The flexible hose shall pass through a metal drum around the inside periphery of the drum and come out through the top part of the drum.

The drum shall be maintained under a very high degree of a vacuum during operation. The drum shall be so fitted with hydraulically operation metal rollers., which when rotating, create a squeeze pressure on the flexible hose carrying concrete and forces the concrete out into the pipe line.
5.10.2.3 Effective Range and Discharge of Pumps: Effective range of pumps to be used in the work shall be decided after studying the site conditions. However, the minimum horizontal range shall not be less than 150 meters and minimum vertical range shall not be less than 50 meters.

Selection of pumps bases on discharge capacity shall be decided after studying the requirements for the project. Discharge capacity shall be worked out by the contractors and approval obtained from the Engineer-in-Charge. As a guide line figure the contractor may assume a discharge capacity of 15 cubic metre/hour/pump.

5.10.2.4 Pipe Lines: All concrete carrying pipe lines shall generally be rigid pipe lines. Flexible pipe lines may only be used at bend curves in lines or at discharge ends if required. Placements of flexible units shall be done judiciously and connected to the pipe lines only when it meets the approval of the Engineer-in-Charge.

(i) Rigid Line/ Hard Line/ Slick line: Such lines shall be made either of steel or plastic. Aluminum alloy pipes shall not be used.

Minimum pipeline diameter shall be 100 millimeters and shall have normal maximum length of 3 metre in each section connected through couplers.

(ii) Flexible Pipe Line: Flexible lines shall be made out of rubber or spiral wound flexible metal or plastic. The pipe shall again be such that they are in sections of 3 metre length each and connected through couplers. These pipes shall be such that they are interchangeable with rigid lines. While installing flexible units, care shall be taken that there are no links in the pipeline, which is a normal tendency with these pipes having diameter 100 mm and above.

5.10.2.5 Couplers: Couplers to be used for connecting pipe line sections (either hard or flexible) shall have adequate strength to withstand stresses due to handling, misalignments, poor support to pipe lines etc.

For horizontal runs of pipes and for vertical run upto 30 metre height the couplers shall be rated for a minimum pressure of 35 kg/ cm square. Couplers used for rising runs between 30 metre and 50 metre heights shall have a minimum pressure rating of 50 kg/cm square. Couplers shall be designed to allow for replacement of any pipe section without displacing other sections. These shall provide for the full internal cross section. These shall provide for the full internal cross section with no constructions or service. Which may disrupt the smooth flow of concrete. For pipelines of size 150mm and above, double tagged type coupler with a thick rubber gasket and secondary wedge-take-up is recommended. Types of couplers that may be used shall be any of the following:-

- Grooved end coupler
- One piece extended lever swing type couplers
- And full flow oil line type couplers.
5.10.2.6 Other Accessories: Other accessories which shall be catered for, are as under:

(a) Back up pump of rigid and flexible pipes of varying lengths of similar rating/specifications
(b) Curved sections of rigid pipes
(c) Swivel joints and rotary distributors
(d) Pin and gate valves to prevent back flow in pipe lines
(e) Switch valves to direct the flow into another pipe line
(f) Connection devices to fill forms from the bottom up
(g) Splints, rollers, and other devices for protection of conduit over rock concrete Reinforcing steel and form and to provide lifting and lashing points in the pipe line.
(h) Transitions for connecting different sizes of pipe sections
(i) Air vents for downward pumping.
(j) Clean out equipment.

For concreting of columns, walls and scattered small placement, recommendation is made for special cranes or power controlled booms carrying pipe lines with a pendant type concrete delivery hose.

5.10.2.7 Lubricating of Pipe Line
Before pumping concrete into the pipeline, the line shall be lubricated with a properly designed mortar/grout lubricant. This shall be ensured by starting the pumping operation with a properly designed mortar, or with a batch of regular concrete with the coarse aggregate omitted. The quantity of mortar required as lubricant is dependent on the smoothness and cleanliness of the pipelines. As a guide line, for a 100 mm diameter pipe line of 100 metre length, 0.08 cum to 0.10 cum of mortar should normally be adequate, but this shall not be taken as specified, and the contractor shall establish his requirements.

The quantity of mortar that comes out of the delivery end of the pipeline shall not be used in place of the concrete work. However, with the approval of Engineer-in-Charge, this mortar may be used as bedding mortar against construction joints. The rest of the mortar shall be wasted.

Lubrication shall be maintained as long as the pumping of concrete continues.

5.11 GUIDELINES FOR FIELD PRACTICE
5.11.1 General Precautions
(i) Proper planning of concrete supply, pump locations, line layout, placing sequence and the entire pumping operation will result in savings of time and expense.

(ii) The pump shall be placed as near the placement area as practicable. The surrounding
area of the pump shall be free of obstructions to allow for movement of concrete delivery trucks. The surface must be strong enough to withstand the loaded trucks operating on it. If the surface is a suspended slab, the truck route shall be adequately supported in consultation with the Engineer-in-Charge.

(iii) Pipe lines from the pump to the placing area shall be laid with minimum number of bend. For large placement areas, alternate lines shall be installed for rapid connection when required. A flexible pipe at the discharge end will permit placing over a large area directly without re-handling of pipelines. The pipeline shall be firmly supported.

(iv) If more than one size of pipe must be used, the smaller diameter pipe shall be placed at the pump end and the larger diameter at the discharge end.

(v) When pumping downwards, an air release valve shall be provided at the middle of the top bend to prevent vacuum or air buildup. Similarly, while pumping upwards, a no-return valve shall be provided near the pump to prevent the reverse flow of concrete.

(vi) It is essential that direct radio/telecommunication be maintained between the pump operator and the concrete placing crew. Good communication between the pump operator and the batching plant is also essential. The placing rate shall be estimated by the pump operator so that concrete can be ordered at an appropriate delivery rate.

(vii) The pump shall be started for a check run and operated without concrete to ensure that all moving parts are in operation properly. Before placing concrete, the pump shall be run with some grout/mortar for lubricating the line.

(viii) When concrete is received in the hopper, the pump shall be run slowly until the lines are completely full and the concrete is steadily moving. A continuous pumping must be ensured, because, if the pump is stopped, concrete in the line may be difficult to move again.

(ix) When a delay occurs because of concrete delivery or some form repair works or for any other reason, the pump shall be slowed down to maintain some movement of concrete in the pipe line. For longer delays, concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with intermittent strokes of the pump. It is sometimes essential to run a return line back to the pump so that concrete can be re-circulated during long delays.

(x) If after a long delay, concrete cannot be moved in the line, it may be necessary to clean out the entire line. However, quite often only a small section of pipe line may be plugged and requires cleaning. The pump operator who know such details as the length of line, age of concrete in the line etc., should be depended upon to aid in deciding the appropriate section to be cleaned.

(xi) When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a “go devil” inserted at the appropriate time so that concrete ahead of the go-devil shall be forced completion of the work. The go-devil shall be forced through the pipeline to clean it out. Use of water pressure is a safer method. The go-devil shall be stopped at the discharge end to ensure that water does not spill on the placement area, if air pressure is used, extreme care
shall be taken and the pressure must be carefully regulated. A trap shall be installed at the end of the line to prevent the go-devil being ejected as a dangerous projectile. An air release valve shall also be installed in the line to prevent air pressure build up.

(xii) It is essential to clean the line after concrete placing operation is complete. Cleaning shall be done in the reverse direction from the form work end to the pump-end where the concrete in the line can be dumped in bucket. After removal of all concrete, all pipe lines and other equipment’s shall be cleaned thoroughly and made ready for the next use.

5.11.2 Submittals
Along with their bid the contractors shall be required to submit the following information regarding the equipment’s proposed to be used by them:-

(i) Type, number, capacity, range, mounting, nature of primary power used and the operating weight of pump and mounting.

(ii) Manufacturer’s specifications for pipe lines giving pressure ratings, sizes and material for straight and curved sections.

(iii) Manufacturer’s certificates.

5.11.3 Sampling and Testing (Materials)
5.11.3.1 Aggregates

(i) Supplier of aggregates shall furnish the following information before the material is delivered to site:-
   - Precise location of source from where the material is to be supplied.
   - Trade group of principal rock type as per table 5.7 below:
   - Presence or reactive minerals

<table>
<thead>
<tr>
<th>Trade group name of Aggregates to be used for concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite, Gabbro, Dolerite, Rhyolite, Basalt, Quartzite, Gneiss.</td>
</tr>
</tbody>
</table>

(ii) The supplier shall also furnish reports on test results giving the following information for approval to Engineer-in-Charge before delivery of material at site:-
Specific gravity
Bulk density
Moisture content
Absorption Value
Aggregate crushing strength
Aggregate impact value
Abrasion value
Flakiness index
Elongation index
Limits of deleterious substances in the aggregate
Soundness of aggregate
Potential reactivity of aggregates.
All tests shall be conducted in accordance with IS 2386 (Part-I to VIII).
(iii) Change in quality of aggregate as per trade group name shall not be acceptable in the work. Change in source of aggregates shall also not be acceptable under normal circumstances, even if the aggregate belong to the same trade group. Engineer-in-Charge may with his discretion allow a change in the source. But, in that case, all test mentioned in para 5.8.9.1.2 above shall have to be repeated for the aggregates form the changed source and the test results submitted to Engineer-in-Charge for his approval before the delivery of material at site.

(iv) In addition to above, the following tests have to be performed on representative samples from every lot of aggregate after delivery at site. These test results are to be submitted to the Engineer-in-Charge for his approval. Acceptance criteria for aggregates shall be based on the results of this set of tests only. If in the opinion of the Engineer-in-Charge, the test results are not with in permissible limits, the lot of aggregates from which the samples have been obtained for testing shall stand rejected and the material shall be removed from the site.

Mandatory tests on Aggregates at site

<table>
<thead>
<tr>
<th>Tests</th>
<th>Nos. of test on each 50 cum of Material or part thereof</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Specific gravity</td>
<td>3</td>
</tr>
<tr>
<td>2. Bulk density</td>
<td>3</td>
</tr>
<tr>
<td>3. Aggregate crushing strength</td>
<td>3</td>
</tr>
<tr>
<td>4. Limits of deleterious substances</td>
<td>3</td>
</tr>
<tr>
<td>5. Aggregate impact value</td>
<td>3</td>
</tr>
</tbody>
</table>

Mean value of the results from above test shall be taken as the representative value and the acceptance criteria shall be based on these. All test procedures and computations for test results shall be as per IS 2386.

(v) All other tests in para iv being in compliance with requirements set in specifications, if only the limits of deleterious substances do not meet the requirements, and attempt may be made to wash the aggregate to bring the limits within permissible values. Under such circumstances, moisture content check shall be made and allowance made before batching.

(vi) Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. Sampling, procedure and computations for such test shall be done in accordance with IS 2430 and IS 2386 as applicable.

5.11.3.2 **Cement** : Supplier of cement shall furnish the following documents before the cement is delivered to site:-

(i) Certificate confirming that chemical composition and physical characteristics are within the stipulated values for types of cement supplied as per relevant codes.

(ii) Certificate confirming that the chloride content in the cement is not in excess of 0.05 percent of mass of cement.

(iii) If during subsequent testing of cement supplied in lots any of the properties are found to be outside the acceptable limits, the lot of cement shall be rejected.
(iv) Each 1000 bags or part thereof the cement or each wagon load of cement shall constitute one lot of cement for the purpose of conducting tests at site before cement is accepted.

(v) Samples for testing at site shall be taken at random from 2% of the total quantity supplied in one lot. For cement supplied in bags, samples shall be drawn from minimum of 5 bags and the 2% value shall be rounded off to the next higher integer.

For bulk cement, sampling shall be done with the help of slotted sampler to be as per IS 3535.

(vi) Results of test conducted on samples drawn shall be submitted to the Engineer-in-Charge for his approval. If in the opinion of the Engineer-in-Charge, the test results are not within permissible limits, the lot of cement from which samples have been obtained from testing shall stand rejected and the material shall be removed from site.

(vii) Following tests shall be conducted at site on each lot of cement delivered:-

<table>
<thead>
<tr>
<th>Mandatory tests</th>
<th>Number of test per lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Consistency of standard cement</td>
<td>5</td>
</tr>
<tr>
<td>2. Initial and final setting time</td>
<td>5 each</td>
</tr>
<tr>
<td>3. Compressive strength test</td>
<td>10</td>
</tr>
</tbody>
</table>

Mean values of the results from the above results shall be taken as the representative value and the acceptance criteria shall be based on these test. All test procedures and computation of test results shall be as per I.S. 4031.

(viii) Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. All such tests shall be done on representative samples taken from each lot and testing and computation of test results shall be done as per IS 4031.

5.11.3.3 Water

(i) Water to be used in manufacturing and curing of concrete shall be tested before use. All such test results shall be submitted to the Engineer-in-Charge for his approval before water is used.

(ii) Manufacturer/ Contractor responsible for curing concrete shall identify and inform the Engineer-in-Charge, precisely the location of source of water intended to be used. Each such source of water shall be separately tested. In the event of a change in the source of water all tests specified herein shall have to be repeated.

(iii) In the event water is drawn from tube wells or open-wells, water samples shall be tested for seasonal fluctuations in water table or at intervals to be directed by the Engineer-in-charge.
(iv) Water sample from each source shall be tested as under:

<table>
<thead>
<tr>
<th>Test</th>
<th>Number of test for each source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity</td>
<td>3</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>3</td>
</tr>
<tr>
<td>Presence of solids</td>
<td>3</td>
</tr>
</tbody>
</table>

Mean values of the above test shall be taken as the representative value and the acceptance criteria shall be based on these test results. All testing procedure and computation of test results shall conform to IS 3025.

5.11.3.4 Admixtures

(i) Suppliers of Admixtures for concrete shall supply the following before any admixtures is approved by the Engineer-in-Charge for their use:

Certificate that the use of a particular brand of admixture shall not be harmful to concrete in any way. Certificate confirming the exact dosage of admixture of a particular brand. Certificate stating the specific purpose for which the admixture is to be used.

Special precautionary measures to be taken in the manufacturer of concrete when using the particular brand of admixture.

Certificate confirming that the admixture conforms to specifications of IS 9103 or to ASTM-C260, ASTM – C10, ASTM – C 595 or to ASTM- C 618

(ii) Engineer-in-Charge at his discretion may require tests to be performed to reconfirm the characteristic properties of any admixture. All such tests shall be done in accordance with IS: 9103.

(iii) All tests described in paras 5.4.8 to 5.4.10 above shall be done at the site laboratory or at a laboratory to be identified by the Engineer-in-Charge depending on the test to be conducted.

(iv) All test shall be done in the presence of a representative nominated by the Engineer-in-Charge and a representative of the concrete Manufacturer/ Contractor when tests are performed at the site laboratory. All observation and reports of test shall be jointly signed by the two representatives before the test results are submitted to the Engineer-in-Charge.

(v) Expenses for all materials used for testing, sampling procedures and testing including preparing reports shall be borne by the concrete Manufacturer/ Contractor.

(vi) Rate of concrete is inclusive of cost of admixtures. The contractor shall not be paid anything extra for admixtures required for achieving direct workability without any change in specified water cement ration for RCC/CC work.

5.11.4 Sampling and Testing for Quality Control of Fresh Concrete

Fresh concrete shall be tested for
(a) Slump
(b) Compacting Factor/ Workability
(c) Consistency
(d) Weight per cubic meter, cement factor and air content

5.11.4.1 Slump

(i) For concrete totally mixed in a central plant, slump shall be checked at:-
   (a) Immediately during loading of trucks
   (b) Point of discharge from the delivery truck
   (c) Final placement location
   (d) At placement location the slump measured shall conform to the design slump. Manufacturer of concrete shall adjust for loss of slump in transit and establish the requirements of design mix. All slump measurements shall be done within a period of 20 minutes from the time cement is added to the mixer. Placement contractor shall transport concrete from truck discharge point to actual placement location within 10 minutes of delivery, before the final slump reading is taken at placement location.

(ii) For concrete entirely mixed in transit or for shrink mix concrete, slump reading shall be taken at:-
   (a) Point of discharge from delivery trucks
   (b) Final placement location
   In this case also, the slump measured at the final placement location shall conform to the design slump. The placement contractor shall be responsible for transporting concrete from delivery truck discharge point to final placement location within 10 minutes. However, in this case, the truck shall discharge the concrete within 1 hour and 30 minutes from the time cement is added in the mixer and slump measured at point of discharge immediately on delivery. Manufacturer of concrete shall ensure that the final slump measurement corresponds to the ordered slump.

(iii) For measuring concrete slump at point of discharge from delivery trucks, samples shall be taken from concrete omitting the first and the last 15% of the load. For concrete delivery of placed by pumping, sampling shall be similar to those specified for delivery trucks.

(iv) Slump measurements of ready mix concrete transported by buckets shall be at locations specified in para 5.11.4.1 with same limits on time. Sampling from buckets shall be such that the buckets containing discharge from mixer for the last 15% are omitted.

(v) At placement locations, samples for checking slump shall be collected from every 20 cum of concrete or part thereof placed at location for each type to concrete.

(vi) For all slump checks in the field at least two recordings shall be made and the average value taken as the recorded slump.

(vii) Slump checks for concrete in the laboratory shall be carried out as and when required by the manufacturer of concrete during the mix design stage and during the progress of work for control on field results.

(viii) Slump readings shall only be a guideline for concrete consistency and shall not be taken as the acceptability criteria for concrete placed at location. All slump test shall be carried out in accordance with IS 1199.
5.11.4.2 **Compacting Factor**

(i) For concrete whose ordered slump is 50 mm or less, compacting factor test shall be conducted at both field and central batch plant in addition to slump tests mentioned above.

(ii) Compacting factor check shall be done in field only at placement location, and shall also be conducted at central batch plant if concrete is totally mixed in plant.

(iii) For this test, sampling shall be done as for slump measurements in field and within the same frame as for slump test.

(iv) Only one compaction factor test shall be conducted for every 20 cum of concrete or part thereof placed at location for each type of concrete. Since the test is sensitive, every care shall be taken to conduct this test totally in compliance with procedure mentioned in IS 1199.

(v) Laboratory tests for determining compacting factor of concrete shall be done as per manufacturer's requirements for establishing and controlling the design mix of concrete.

(vi) Compacting factor test shall not be taken as an acceptance criteria and shall be treated only as a guideline to workability of concrete.

5.11.4.3 **Consistency of Concrete**: This test shall be performed only at the batching plant laboratory using a Vee-Bee Consist meter, for determining and predicting the slump of concrete. Number and frequency of these tests shall be based on requirements of the manufacturer of concrete. Care shall be taken in producing mix design of required characteristic strengths of concrete within limits of Vee-Bee Degrees between 1.6 and 4.5 for concrete transported and placed by normal method and between 0.8 and 3.5 for concrete transported and placed by pumping methods.

5.11.4.4 **Weight, Cement Factor and Air contents Test** : Freshly mixed concrete for every type shall be tested in the batch plant laboratory for each batch of concrete produced to determine weight per cubic metre of freshly mixed concrete, cement factor in concrete and the air content of the concrete. Frequency and number of test shall be finalized by the manufacturer of concrete in consultation with the Engineer-in-Charge for his requirement of the mode of measurement of concrete produced.

The Engineer-in-Charge may at his discretion require further tests over and above those specified above in para 5.11.4.1 to be conducted on fresh concrete. The manufacturer and the placement contractor shall have to comply with all such requirements.

5.11.5 **Sampling and Testing for Quality Control of Hardened Concrete**

(i) Test on cube crushing strength of concrete in accordance and compliance with IS 456 and IS 516 shall done as under:-

(a) Sample of fresh concrete shall be taken from concrete at central batch plant mixer while loading delivery trucks or other transport and also from concrete transported to placement location.
(b) Test on specimens made form samples collected at placement location shall be considered as field test specimens and results therefrom shall be the criterion of concrete strength. Test in specimens made from samples at the batch plant shall only be taken as guidelines test. Only in the case of doubtful result, the Engineer-in-Charge may refer to such guideline results for deciding on the quality of concrete.

(c) For truck mix concrete and shrink mix concrete guideline test specimens shall be made from samples collected at discharge location from mixing trucks. For this purpose first and last 15% of the load shall be omitted while collecting samples.

(d) Frequency of sampling shall be as given below in Table 5.8 for each grade of concrete of different workability’s and for each type of specimens (field test specimens and guideline test specimens) for conducting 28 days crushing strength tests.

<table>
<thead>
<tr>
<th>Quantity of concrete Delivered (cum)</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5</td>
<td>1</td>
</tr>
<tr>
<td>6 to 15</td>
<td>2</td>
</tr>
<tr>
<td>31 to 50</td>
<td>3</td>
</tr>
<tr>
<td>51 and above sample for each</td>
<td>4 plus one thereof additional 50 cum or part</td>
</tr>
</tbody>
</table>

Each sample shall be of adequate quantity so that a minimum of 3 specimen cubes can be made test of the sample in accordance with IS 516.

(e) All test specimens shall be made compacted cured and tested in compliance with IS 516 and test result interpreted in accordance with IS 456 for acceptance of concrete strength, field specimens test results shall not be less than values given in Table 5.6.

(f) In addition to 28 day crushing strength test on specimens made at frequencies specified in para 4 above, early strength tests at 7 days shall also be conducted on field specimens as well as guideline test specimens. Frequency of sampling for this set of test shall also be same as those specified in Table 5.8 above. 7 day strength shall conform to values given in Table 5.5. But these test results even if conforming to specified values shall only be taken a guideline values for projecting concrete strength and shall not be construed as conforming to specifications.

(g) For each grade of concrete and for all workability conditions with different water – cement ratios and compositions of admixtures, preliminary test shall be conducted for crushing strength on finalization to design mix for each type of concrete. Such test shall be conducted both at 7 days and 28 days under laboratory conditions. Six test specimens shall be made for 7 days test and six test specimens shall be made for 28 days test.

Average of the six test results of different periods shall not be less than those specified in Table 5.5.
(h) Crushing strengths on cubes shall also be conducted during the process of finalization of concrete design mix. Frequency and number of such tests shall be as per Mix of requirements of concrete manufacturer.

(i) All test specimens for conducting crushing strength shall be properly labeled for identification indicating:
   (i) Date of making specimen
   (ii) Grade of concrete
   (iii) Placement location exact
   (iv) Purchasers order number

(j) In addition to crushing strength test on concrete, the Engineer-in-Charge may call for other tests on hardend concrete. The placement contractor and the manufacturer of concrete shall comply with all such instructions.

(ii) **Non-destructive Tests**

(a) When the 28 days crushing values on field specimens and/or specimens and/or specimens made for guideline test fall short of specified values, or in case of doubtful placement of concrete, the Engineer-in-Charge shall call for non-destruction tests on the structure. Such tests may be any one or a combination of the following:
   - Rebound hammer test
   - Windsor Penetration Probe test
   - Pulse velocity (sonic or Ultrasonic) test
   - Core test
   - Load test

(b) Interpretation of rebound hammer, Windsor Probe and Pulse velocity test results shall rest with the Engineer-in-Charge.

(c) Core test, if ordered by the Engineer-in-Charge, shall be done in accordance with IS 516. Samples for such test shall be taken from locations to be identified by the Engineer-in-Charge and such samples shall be collected in compliance with IS:1199.

(d) If felt necessary, the Engineer-in-Charge may instruct load testing for any part of the structure based on doubtful concrete strengths. Such test shall be carried out as per details to be provided by the Engineer-in-Charge in consultation with the structural consultants.

(e) The concrete manufacturer/ concrete placement contractor shall arrange for all test to be conducted in accordance with these specifications, including all necessary tools, plants, equipment and material, and shall be responsible for conducting all test at his cost.

(f) All test conducted at the field laboratory shall be carried out by qualified technicians employed by the concrete manufacturer/ concrete placement contractor, in presence of authorized representative of the Engineer-in-Charge. All test reports and observation reports shall be jointly signed by the Engineer-in-Charge authorized representative and the technician conducting such test.

(g) Engineer-in-Charge shall alone decide where such tests are to be conducted. He may instruct tests to be conducted at laboratories other than the field laboratory
and such instructions shall be followed without claiming extra charges on this account.

(h) The Concrete Manufacturer/ Placement contractor shall set up a laboratory at his own expense which shall have facilities, for conducting all necessary field test on materials and field and laboratory test on concrete. The laboratory shall be staffed by the concrete Manufacturer/ Placement Contractor with qualified and experienced scientists and technicians.
CHAPTER 6
BRICK WORKS
### LIST OF MANDATORY TESTS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Material</th>
<th>Clause</th>
<th>Test</th>
<th>Field/ laboratory Test</th>
<th>Test Procedure</th>
<th>Minimum Qty. of material for carrying out test</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Bricks/ Brick Tiles</td>
<td>6.1.3, 6.1.4, 6.1.5</td>
<td>Testing of Bricks/Brick Tiles for dimensions, Compressive strength, Water absorption and efflorescence</td>
<td>Laboratory</td>
<td>Appendix A, B, C &amp; D of Chapter 6</td>
<td>As per Table 6.3 and 6.4</td>
</tr>
<tr>
<td>(ii)</td>
<td>Sewer Bricks</td>
<td>6.1.4</td>
<td>Dimensions, Compressive strength, Water absorption and Efflorescence</td>
<td>Laboratory</td>
<td>Appendix A, B, C &amp; D of Chapter 6</td>
<td>As per Table 6.3 and 6.4</td>
</tr>
<tr>
<td>(iii)</td>
<td>Burnt clay perforated building bricks</td>
<td>6.1.5</td>
<td>--do--</td>
<td>-- do--</td>
<td>-- do--</td>
<td>-- do--</td>
</tr>
</tbody>
</table>
6.0 BRICK WORK

6.0. TERMINOLOGY

Bond
The arrangement of the bricks in successive courses to tie the brick work together both longitudinally and transversely. The arrangement is usually designed to ensure that no vertical joint of one course is exactly over the one in the next course above or below it, and there is greatest possible amount of lap.

Bed Joint
Horizontal joint in brick work or masonry.

Closer
Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course (See Fig. 6.3).

Coping or Weathering
The cover applied over or the geometrical form given to a part of structure to enable it to shed rain water.

Corbel
A cantilever projecting from the face of a wall to form a bearing (see Fig. 6.1D)

Cornice
Horizontal or ornamental feature projecting from the face of a wall (see Fig. 6.1D)

Course
A layer of bricks including bed mortar.

Cross joint
A joint other than a bed joint normal to the wall face.

Efflorescence
A powdery incrustation of salts left by evaporation. This may be visible on the surface or may be below surface. In the latter case, this is termed as crypto Efflorescence.

Header
A brick laid with its length across the wall.

Indenting
The leaving recesses into which future work can be bonded.

Jamb
The part of the wall at the side of an opening.

Joint
A junction of bricks.

Jointing
The operation of finishing joints as the masonry work proceeds.
Pier
A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load. The thickness of a pier is the overall thickness including the thickness of the wall, or when bonded into one leaf of a cavity wall the thickness obtained by treating this leaf as an independent wall (see Fig. (6.1A, 6.1B)).

Sill
A brick work forming the lower boundary of door or window opening.

Spandrel
The space between the haunches and the road decking of an arch.

Strecher
A brick laid with its length in the direction of the wall.

String course
A horizontal course projecting from a wall usually introduced at every floor level or windows or below parapet for imparting architectural appearance to the structure and also keeping off the rain water. (see Fig. 6.1D).

Templet
A pattern of sheet metal used as a guide for setting out specific section and shape.

Toothing
Bricks left projecting in alternate courses to bond with future work.

Wall joint
A joint parallel to the wall face.
6.1 BRICKS/BRICK TILES/BRICK BATS/MECHANIZED AUTOCLAVE FLY ASH LIME BRICK

Bricks used in the masonry may be of the following type.

(a) **Fly Ash Lime Bricks (FALG Bricks)**: The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS 12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side.

*Fly Ash*: Fly ash shall conform to IS 3812.

*Note*: This item will be operated only for load bearing structure up to 2 storeys and for non-load bearing walls 23 cms thick for multi-strayed buildings.

Bottom ash used as replacement of sand shall not have more than 12% loss on ignition when tested.

*Sand*: Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

*Lime*: Lime shall conform to class ‘C’ hydrated lime of IS 712.

*Additives*: Any suitable additive considered not detrimental to the durability of bricks may be used.

(b) **Clay Fly Ash Bricks**: The clay fly ash bricks shall conform to IS 13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly Ash shall conform to grade I or grade II of IS 3812.

(c) **Mechanized Autoclave Fly Ash Lime Brick**: These bricks shall be machine moulded and prepared in plant by appropriate proportion of fly ash and lime. The autoclave fly ash bricks shall conform to IS 12894. Visually, the bricks shall be sound, compact and uniform shape, free from visible cracks, warpage and organic matters. The brick shall be solid with or without frog, and of 100/80 mm in length, 40 mm width and 10 to 20 mm deep one of its flat side as per IS 12894. The brick shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour. Fly ash shall conform to IS 3812 and lime shall conform to class ‘C’ hydrated lime of IS 712.

6.1.1 Dimensions

The brick may be modular or non-modular. Sizes for both types of bricks/tiles shall be as per Table 6.1. While use of modular bricks/tiles is recommended, non-modular (FPS) bricks/tiles can also be used where so specified. Non-modular bricks/tiles of sizes other than the sizes mentioned in Table 6.1 may also be used where specified.
TABLE 6.1

<table>
<thead>
<tr>
<th>Type of Bricks/Tiles</th>
<th>Nominal Size mm</th>
<th>Actual Size mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular Bricks</td>
<td>200 × 100 × 100 mm</td>
<td>190 × 90 × 90 mm</td>
</tr>
<tr>
<td>Modular tile bricks</td>
<td>200 × 100 × 40 mm</td>
<td>190 × 90 × 40 mm</td>
</tr>
<tr>
<td>Non-modular tile bricks</td>
<td>229 × 114 × 44 mm</td>
<td>225 × 111 × 44 mm</td>
</tr>
<tr>
<td>Non-modular bricks</td>
<td>229 × 114 × 70 mm</td>
<td>225 × 111 × 70 mm</td>
</tr>
</tbody>
</table>

6.1.2 Classification

Bricks/Brick tiles shall be classified on the basis of their minimum compressive strength as given below:

TABLE 6.2

<table>
<thead>
<tr>
<th>Class Designation</th>
<th>Average compressive strength</th>
<th>Not less than</th>
<th>Less than</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N/mm² (kgf/cm²)</td>
<td>N/mm² (kgf/cm²)</td>
</tr>
<tr>
<td>12.5 (125)</td>
<td>12.5</td>
<td>(125)</td>
<td>15.0</td>
</tr>
<tr>
<td>10 (100)</td>
<td>10</td>
<td>(100)</td>
<td>12.5</td>
</tr>
<tr>
<td>7.5 (75)</td>
<td>7.5</td>
<td>(75)</td>
<td>10</td>
</tr>
<tr>
<td>5 (50)</td>
<td>5</td>
<td>(50)</td>
<td>7.5</td>
</tr>
<tr>
<td>3.5 (35)</td>
<td>3.5</td>
<td>(35)</td>
<td>5.0</td>
</tr>
</tbody>
</table>

The bricks shall have smooth rectangular faces with sharp corner and shall be uniform in colour and emit clear ringing sound when struck.

(Note: Upper limits specified in Table 6.2 are for calculating the average compressive strength in accordance with Appendix B of Chapter 6).

6.1.3 Sampling and Tests

Samples of bricks shall be subjected to the following tests:
(a) Dimensional tolerance.
(b) Water absorption.
(c) Efflorescence.
(d) Compressive strength.

6.1.3.1 Sampling: For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random according to the size of lot as given in Table 6.3 below. The sample thus taken shall be stored in a dry place until tests are made. For the purpose of sampling, the following definition shall apply.

(a) Lot: A collection of bricks of same class and size, manufactured under relatively similar conditions of production. For the purpose of sampling a lot shall contain a maximum, of 50,000 bricks. In case a consignment has bricks more than 50,000 of the same classification and size and manufactured under relatively similar conditions of production, it shall be divided into lots of 50,000 bricks or part thereof.
(b) **Sample:** A collection of bricks selected for inspection and/or testing from a lot to reach the decision regarding the acceptance or rejection of the lot.

(c) **Defective:** A brick failing to meet one or more of the specified requirements.

6.1.3.2 The samples shall be taken as below:

(i) **Sampling from a Stack:** When it is necessary to take a sample from a stack, the stack shall be divided into a number of real or imaginary sections and the required number of bricks drawn from each section. For this purpose bricks in the upper layers of the stack shall be removed to enable units to be sampled from places within the stack.

*Note:* For other methods of sampling i.e. sampling in motion and sampling from lorries or trucks, IS :5454 may be referred.

Scale of sampling and criteria for conformity for visual and dimensional characteristics:—

**Visual characteristics:** The bricks shall be selected and inspected for ascertaining their conformity to the requirements of the relevant specification.

The number of bricks to be selected from a lot shall depend on the size of lot and shall be in accordance of Col. 1 and 2 of Table 6.3 for visual characteristics in all cases and dimensional characteristics if specified for individual bricks.

(ii) **Visual Characteristics:** All the bricks selected above in accordance with Col. 1 and 2 of Table 6.3 shall be examined for visual characteristics. If the number of defective bricks found in the sample is less than or equal to the corresponding number as specified in Col. 3 of Table 6.3 the lot shall be considered as satisfying the requirements of visual characteristics, otherwise the lot shall be deemed as not having met the visual requirements.

(iii) **Dimensional Characteristics:** The number of bricks to be selected for inspecting the dimensions and tolerance shall be in accordance with Col. 1 and 4 of Table 6.3. These bricks will be divided into groups of 20 bricks at random and each of the group of 20 bricks thus formed will be tested for all the dimensions and tolerances. A lot shall be considered having found meeting the requirements of dimensions and tolerance if none of the groups of bricks inspected fails to meet the specified requirements.

---

**TABLE 6.3**

**Scale of Sampling and Permissible Number of Defectives for Visual and Dimensional Characteristics**

<table>
<thead>
<tr>
<th>No. of bricks in the lot</th>
<th>For characteristics specified for</th>
<th>For dimensional characteristics for group of 20</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of bricks to be</td>
<td>Permissible no. of defective</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>2001—10000</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>10001—35000</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>35001—50000</td>
<td>50</td>
<td>3</td>
</tr>
</tbody>
</table>
Note: In case the lot contains 2000 or less bricks the sampling shall be as per decision of the Engineer-in-Charge.

(iv) **Scale of Sampling and Criteria for Physical Characteristics:** The lot which has been found satisfactory in respect of visual and dimensional requirements shall be next tested for physical characteristics like compressive strength, water absorption, efflorescence as specified in relevant material specification. The bricks for this purpose shall be taken at random from those already selected above. The number of bricks to be selected for each of these characteristics shall be in accordance with relevant columns of Table 6.4.

**TABLE 6.4**

<table>
<thead>
<tr>
<th>Lot size</th>
<th>Sample size for compressive strength, water absorption and efflorescence</th>
<th>Permissible No. of defectives</th>
<th>Warpage Sample Size</th>
<th>Permissible No of defects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) No. of samples</td>
<td>(2) (Sample size)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>2001—10000</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>10001—</td>
<td>10</td>
<td>0</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>35001—</td>
<td>15</td>
<td>1</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: In case the lot contains 2000 or less bricks, the sampling shall be as per decision of Engineer-in-Charge.

(v) A lot shall be considered having satisfied the requirements of physical characteristics if the condition stipulated here in are all satisfied.

(a) From the test results for compressive strength, the average shall be calculated and shall satisfy the requirements specified in relevant material specification.

**Note:** In case any of the test results for compressive strength exceeds the upper limit for the class of bricks, the same shall be limited to the upper limit of the class for the purpose of averaging.

(b) Wherever specified in the material specification, the compressive strength of any individual bricks tested in the sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 per cent.

(c) From the test results for water absorption, the average for the bricks in the sample shall be calculated and shall satisfy the relevant requirements specification in material specification.

(d) The number of bricks failing to satisfy the requirements of the efflorescence specified in the relevant specification should not be more than the permissible no. of defectives given in Col. 3 of Table 6.4.

6.1.3.3 **Dimensional Tolerances:** The dimensions of, modular bricks when tested as described above as per procedure described in Appendix A of Chapter 6 shall be within the following limits per 20 bricks or locally available size as approved by Engineer-in-charge.
(a) For modular size
   Length 7320 to 3880 mm (3800 ± 80 mm)
   Width 1760 to 1840 mm (1800 ± 40 mm)
   Height 1760 to 1840 mm (1800 ± 40 mm) for 90 mm high bricks
   760 to 840 mm (800 ± 40 mm) for 40 mm high bricks

(b) For non-modular bricks
   Length 4520 to 4680 mm (4600 ± 80 mm)
   Width 2240 to 2160 mm (2200 ± 40 cm)
   Height 1440 to 1360 mm (1400 ± 40 mm) for 70 mm high bricks
   640 to 560 mm (600 ± 40 mm) for 30 mm high bricks

**Brick Tiles**
760 to 840 mm (800 ± 40 mm) for 40 mm high brick tiles In case of non-modular bricks, % age tolerance will be ± 2% for group of 20 numbers of class 10 bricks, and ± 4% for other class of bricks.

### 6.1.3.4 Compressive Strength:
The bricks, when tested in accordance with the procedure laid down in Appendix B of Chapter 6 shall have a minimum average compressive strength for various classes as given in Table 6.2. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%. In case compressive strength of any individual brick tested exceeds the upper limit specified in Table 6.2 for the corresponding class of bricks, the same shall be limited to upper limit of the class as specified in Table 6.2 for the purpose of calculating the average compressive strength.

### 6.1.3.5 Water Absorption:
The average water absorption of bricks when tested in accordance with the procedure laid down in Appendix C of Chapter 6 shall be not more than 20% by weight.

### 6.1.3.6 Efflorescence:
The rating of efflorescence of bricks when tested in accordance with the procedure laid down in Appendix D of Chapter 6 shall be not more than moderate.

### 6.1.4 Sewer Bricks
6.1.4.1 Sewer bricks are intended for the lining of walls, roofs and floors of sewers used for ordinary sanitary (domestic) sewage. The general practice in the country is also to utilize common building bricks in the construction of sewers which is not satisfactory. However, these sewer bricks may not be suitable for sewers dealing with industrial effluent (sewage) for which the use of acid resistant bricks in accordance with IS 4860 may be considered. Sewer bricks shall conform to IS 4885.

### 6.1.4.2 Dimensions and Tolerances
**Dimensions:** The standard sizes of the sewer bricks shall be as follows:

<table>
<thead>
<tr>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>190</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>190</td>
<td>90</td>
<td>40</td>
</tr>
</tbody>
</table>
For sewers of special shapes, such as the oval sewers, the bricks may have to be suitable tapered to conform to the radii of curvature of the arches and barrels and sides of sewers.

**Tolerance:** The permissible tolerance on the dimensions specified in 6.1.4.2 shall be as follows:

<table>
<thead>
<tr>
<th>Dimensions (mm)</th>
<th>Total tolerance for 20 bricks mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>190</td>
<td>+ 80</td>
</tr>
<tr>
<td>90</td>
<td>+</td>
</tr>
<tr>
<td>40</td>
<td>+</td>
</tr>
</tbody>
</table>

6.1.4.3 **Compressive Strength:** The average compressive strength obtained on a sample of sewer bricks when tested in accordance with the procedure laid down in IS 3495 (Part I) shall be not less than 17.5 N/mm² (175 kgf/cm² approximately) and the individual strength of any brick shall be not less than 16 N/mm² (160 kgf/cm² approximately).

6.1.4.4 **Water Absorption:** The average value of water absorption for five bricks after 24 h cold water immersion test when tested in accordance with IS 3495 (Part 2) shall not exceed 10 per cent of the average dry weight of the brick and the absorption for any individual brick shall not exceed 12 per cent.

6.1.4.5 **Efflorescence:** When the bricks are tested in accordance with the method laid down in IS 3495 (Part 3), the rating of efflorescence shall not be more than ‘slight’.

6.1.5 **Burnt Clay Perforated Building Bricks**

6.1.5.1 **General Quality:** The bricks shall be made of suitable clay and shall be thoroughly burnt at the maturing temperature of clay. They shall be free from cracks, flaws and nodules of free lime. They shall have rectangular face with sharp straight edge at right angle. They shall be of uniform colour and texture. These bricks generally should conform to IS 2222.

6.1.5.2 **Dimensions and Tolerances:** The standard size of burnt clay perforated bricks shall be as follows:

<table>
<thead>
<tr>
<th></th>
<th>Length (L) mm</th>
<th>Width (W) mm</th>
<th>Height (H) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular</td>
<td>190</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Non Modular</td>
<td>230</td>
<td>110</td>
<td>70</td>
</tr>
</tbody>
</table>
The permissible tolerances on the dimensions shall be as follows:

<table>
<thead>
<tr>
<th>Dimensions (mm)</th>
<th>Tolerance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70, 90</td>
<td>4</td>
</tr>
<tr>
<td>110, 190</td>
<td>7</td>
</tr>
<tr>
<td>230</td>
<td>10</td>
</tr>
</tbody>
</table>

**Note:** The tolerances specified above shall apply to measurements on individual bricks.

6.1.5.3 **Perforations:** The area of perforation shall be between 30% and 45% of the total area of the corresponding face of the bricks.

The perforation shall be uniformly distributed over the surface. In the case of rectangular perforations, the larger dimension shall be parallel to the longer side of the brick. The shorter side of the perforation shall be less than 20 mm incase of rectangular perforations and less than 25 mm diameter in case of circular perforations.

The area of each perforation shall not exceed 500 mm².

The thickness of any shell shall not be less then 15 mm and that of any web not less than 10 mm.

6.1.5.4 **Compressive Strength:** The bricks when tested in accordance with the procedure laid down in IS 3495 (Parts 1 to 4) shall have a minimum average compressive strength of 7 N/mm² on net area.

The compressive strength of any individual brick tested shall not fall below the minimum compressive strength specified for the corresponding class of bricks. The lot shall then be checked for next lower class of brick.

6.1.5.5 **Water Absorption:** The bricks when tested in accordance with the procedure laid down in IS 3495 (parts 1 to 4): after immersion in cold water for 24 hours water absorption shall not be more than 20 percent by weight.

6.1.5.6 **Efflorescence:** The bricks when tested in accordance with the procedure laid down in IS 3495 (Parts 1 to 4) shall have a rating of efflorescence not more than 'slight'.

6.1.5.7 **War page:** The bricks when tested in accordance with the procedure laid down in IS 3495 (parts 1 to 4) the average war page shall not exceed 3%.

6.2 **BRICK WORK**

6.2.1 **Classification**

The brick work shall be classified according to the class designation of bricks used.

6.2.2 **Mortar**

The mortar for the brick work shall be as specified, and conform to accepted standards. Lime shall not be used where reinforcement is provided in brick work.
6.2.3 Soaking of Bricks
Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt earth etc.

**Note I:** The period of soaking may be easily found at site by a field test in which the bricks are soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in construction work.

**Note II:** If the bricks are soaked for the required time in water that is frequently changed the soluble salt in the bricks will be leached out, and subsequently efflorescence will be reduced.

6.2.4 Laying
6.2.4.1 Bricks shall be laid in English Bond (Fig. 6.2, 6.3, 6.4) unless otherwise specified. For brick work in half brick wall, bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment.

**Note:** Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top course of footing shall be headers.

6.2.4.2 All loose materials, dirt and set lumps of mortar which may be lying over the surface on which brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on a full bed of mortar, when laying, each brick shall, be properly bedded and set in position by gently pressing with the handle of a trowel. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow space are left inside the joints.

6.2.4.3 The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate course shall come directly one over the other. Quoin, Jambs and other angles shall be pro- perly plumbed as the work proceeds. Care shall be taken to keep the perpends properly aligned within following maximum permissible tolerances:

(a) Deviation from vertical within a storey shall not exceed 6 mm per 3 m height.
(b) Deviation in verticality in total height of any wall of building more than one storey in height shall not exceed 12.5 mm.
(c) Deviation from position shown on plan of any brick work shall not exceed 12.5 mm.
(d) Relative displacement between load bearing wall in adjacent storeys intended to be vertical alignments shall not exceed 6 mm.
(e) A set of tools comprising of wooden straight edge, masonic spirit levels, square, 1 metre rule line and plumb shall be kept on the site of work for every 3 masons for proper check during the progress of work.
6.2.4.4 All quoins shall be accurately constructed and the height of brick courses shall be kept uniform. This will be checked using graduated wooden straight edge or storey rod indicating height of each course including thickness of joints. The position of damp proof course, window sills, bottom of lintels, top of the wall etc. along the height of the wall shall be marked on the graduated straight edge or storey rod. Acute and obtuse quoins shall be bonded, where practicable in the same way as square quoins. Obtuse quoins shall be formed with squint showing three quarters brick on one face and quarter brick on the other.

6.2.4.5 The brick work shall be built in uniform layers. No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degrees or less with the horizontal. Tooothing shall not be permitted as an alternative to raking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

6.2.4.6 All pipe fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified, in their correct position as the work proceeds unless otherwise directed by the Engineer-in-Charge.

6.2.4.7 Top courses of all plinths, parapets, steps and top of walls below floor and roof slabs shall be laid with brick on edge, unless specified otherwise. Brick on edge laid in the top courses at corner of walls shall be properly radiated and keyed into position to form cut (maru) corners as shown in Fig 6.4. Where bricks cannot be cut to the required shape to form cut (maru) corners, cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) equal to thickness of course shall be provided in lieu of cut bricks.

6.2.4.8 Bricks shall be laid with frog (where provided) up. However, when top course is exposed, bricks shall be laid with frog down. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the brick in position.

6.2.4.9 In case of walls one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

6.2.4.10 To facilitate taking service lines later without excessive cutting of completed work, sleeves (to be paid separately) shall be provided, where specified, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

6.2.4.11 Top of the brickwork in coping and sills in external walls shall be slightly tilted. Where brick coping and sills are projecting beyond the face of the wall, drip course/throating (to be paid separately) shall be provided where indicated.

6.2.4.12 Care shall be taken during construction that edges of jambs, sills and projections are not damaged in case of rain. New built work shall be covered with gunny bags or tarpoulin so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Engineer-in-Charge.
6.2.4.13 Vertical reinforcement in the form of bars (MS or high strength deformed bars or thermo- mechanically treated bars as per direction of Engineer-in-Charge), considered necessary at the corners and junction of walls and jamb opening doors, windows etc. shall be encased with cement mortar not leaner than 1:4 (1 cement : 4 coarse sand), or cement concrete mix as specified. The reinforcement shall be suitably tied, properly embedded in the foundation and at roof level. The dia. of bars shall not be less than 8 mm and concrete grade shall be minimum 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size).

6.2.4.14 In retaining walls and the like, where water is likely to accumulate, weep holes, 50 to 75 mm square shall be provided at 2 m vertically and horizontally unless otherwise specified. The lowest weep hole shall be at about 30 cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

**Note:** Work of providing loose stone will be payable extra.

6.2.4.15 Work of cutting chases, wherever required to be made in the walls for housing G.I. pipe, CI pipe or any other fixtures shall be carried out in various locations as per guidelines given below:

(a) Cutting of chases in one brick thick and above load bearing walls.
   (i) As far as possible services should be planned with the help of vertical chases. Horizontal chases should be avoided.
   (ii) The depths of vertical chases and horizontal chases shall not exceed one-third and one-sixth of the thickness of the masonry respectively.
   (iii) When narrow stretches of masonry (or short length of walls) such as between doors and windows, cannot be avoided they should not be pierced with openings for soil pipes or waste pipes or timber joints, etc. Where there is a possibility of load concentration such narrow lengths of walls shall be checked for stresses and high strength bricks in mortar or concrete walls provided, if required.
   (iv) Horizontal chases when unavoidable should be located in the upper or lower one-third of height of storey and not more than three chases should be permitted in any stretch of a wall. No continuous horizontal chase shall exceed one metre in length. Where unavoidable, stresses in the affected area should be checked and kept within the permissible limits.
   (v) Vertical chases should not be closer than 2 m in any stretch of a wall. These shall be kept away from bearings of beams and lintels. If unavoidable, stresses in the affected area should be checked and kept within permissible limits.
   (vi) Masonry directly above a recess, if wider than 30 cm horizontal dimension) should be supported on lintel. Holes in masonry may be provided up to 30 cm width and 30 cm height without any lintel. In the case of circular holes in the masonry, no lintel need be provided for holes up to 40 cm in diameter.

(b) Cutting of chases in half brick load bearing walls.
No chase shall be permitted in half brick load bearing walls and no such no recessed conduits and concealed pipes shall be provided with half brick thick load bearing walls.

(c) Cutting of chases in half brick non-load bearing wall:
Services should be planned with the help of vertical chases. Horizontal chase should be provided only when unavoidable.
6.2.5 Joints
The thickness of all types of joints including brick wall joints and cross joints shall be such that four course and three joints taken consecutively shall measure as follows:
(i) In case of modular bricks conforming to IS 1077 specification for common burnt clay buildings bricks, equal to 39 cm.
(ii) In case of non-modular bricks, it shall be equal to 31 cm.

Note: Specified thickness of joints shall be of 1 cm. Deviation from the specified thickness of all joints shall not exceed one-fifth of specified thickness.

6.2.5.1 Finishing of Joints: The face of brick work may be finished flush or by pointing. In flush finishing either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequently plastering. The faces of brick work shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brick work. In pointing, the joints shall be squarely raked out to a depth of 1.5 cm while the mortar is still green and raked joints shall be brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give ruled finish. Some such finishes are ‘flush’, ‘weathered’, ruled, etc.

6.2.6 Curing
The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done 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.

6.2.7 Scaffolding
Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work.

6.2.7.1 Single Scaffolding: Where plastering, pointing or any other finishing has been indicated for brick work, single scaffolding may be provided, unless otherwise specified. In single scaffolding, one end of the put-logs/pole shall rest in the hole provided in the header course of brick masonry. Not more than one header for each put-log/pole shall be left out. Such holes shall not be allowed in the case of pillars, brick work less than one metre in length between the openings or near the skew backs of arches or immediately under or near the structural member supported by the walls. The holes for putlogs/poles shall be made good with brick work and wall finishing as specified.

6.2.7.2 Double Scaffolding: Where the brick work or tile work is to be exposed and not to be finished with plastering etc. double scaffolding having two independent supports, clear of the work, shall be provided.

Measurements
6.2.7.3 Brick work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e 1 cm. Areas shall be calculated to the nearest 0.01 sq mts and the cubic content shall be worked out to the nearest 0.01 cubic meters.
6.2.7.4 Brick work shall be measured separately in the following stages:
   (a) From foundation to floor one level (Plinth level)
   (b) Plinth (floor one) level to floor two level
   (c) Between two specified floor levels above floor two level

Note: (i) Brick work in parapet walls, mummy, lift machine room and water tanks constructed on the roof up to 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

6.2.7.5 No deductions or additions shall be done and no extra payment made for the following

Note: Where minimum area is defined for deduction of an opening, void or both, such areas shall refer only to opening or void within the space measured.
   (a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc.); up to 0.1 m² in section;
   (b) Opening up to 0.1 m² in area (see Note);
   (c) Wall plates, bed plates, and bearing of slabs, chajjas and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;
   (d) Cement concrete blocks as for hold fasts and holding down bolts;
   (e) Iron fixtures, such as wall ties, pipes upto 300 mm diameter and hold fasts for doors and windows; and
   (f) Chases of section not exceeding 50 cm in girth.
   (g) Bearing portion of drip course, bearing of moulding and cornice.

Note: In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any, shall also be excluded.

6.2.7.6 Walls half brick thick and less shall each be measured separately in square meters stating thickness.

6.2.7.7 Walls beyond half brick thickness shall be measured in multiples of half brick which shall be deemed to be inclusive of mortar joints. For the sizes of bricks specified in 6.1.1, half brick thickness shall mean 100 mm for modular and 115 mm for non-modular bricks.

Where fractions of half brick occur due to architectural or other reasons, measurement shall be as follows:
   (a) Up to 1/4th brick-actual measurements and
   (b) exceeding 1/4 brick-full half bricks.

6.2.7.8 String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection.

6.2.7.9 Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick.

6.2.7.10 Circular pillars shall be measured separately in cubic metres as per actual dimensions.
6.2.7.11 Brick work curved on plan shall be measured like the brick work in straight walls and shall include all cutting and wastage of bricks, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls. Nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.

6.2.7.12 Circular pillars shall be measured separately in cubic metres as per actual dimensions.

6.2.7.13 Brick work curved on plan shall be measured like the brick work in straight walls and shall include all cutting and wastage of bricks, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls. Nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.

6.2.7.14 Tapered walls shall be measured net as walls and extra payment shall be allowed for making tapered surface for brick work in walls.

6.2.7.15 Brick work with brick tiles shall be measured and paid for separately.

6.3 HALF BRICK WORK
Brick work in half brick walls shall be done in the same manner as described above in 6.2.4 except that the bricks shall be laid in stretcher bond. When the half brick work is to be reinforced, 2 Nos. M.S. bars of 6 mm dia., shall be embedded in every third course as given in the item (the dia of bars shall not exceed 8 mm). These shall be securely anchored at their end where the partitions end. The free ends of the reinforcement shall be keyed into the mortar of the main brick work to which the half brick work is joined. The mortar used for reinforced brick work shall be rich dense cement mortar of mix 1:4 (1 cement: 4 coarse sand). Lime mortar shall not be used. Over laps in reinforcement, if any shall not be less than 30 cm.

The mortar interposed between the reinforcement bars and the brick shall not be less than 5 mm. The mortar covering in the direction of joints shall not be less than 15 mm.

6.3.1 Measurements
The length and height of the wall shall be measured correct to a cm. The area shall be calculated in sq.m. where half brick wall is joined to the main walls of one brick or greater thickness and measurements for half brick wall shall be taken for its clear length from the face of the thicker wall.

6.3.2 Rate
The rate includes the cost of the materials and labor involved in all the operations described above except reinforcement which is to be paid for separately.

6.4 EXPOSED BRICK WORK
6.4.1 Facing Bricks
The facing bricks made from suitable soils shall be free from cracks, flaws, nodules of free lime war page and organic matter. These shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right angled edges. Facing bricks
shall have uniform colour and even texture. Unless otherwise specified, facing bricks shall be machine molded only. As far as possible, total requirement of facing bricks for a work shall be arranged from the same kiln. Bricks with chipped edges and broken corners shall not be used.

6.4.2 Dimensions and Tolerances
The standard sizes of machine moulded facing bricks shall be as specified in 6.1.1.

6.4.2.1 The permissible tolerances shall be as under:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Tolerance (For Machine moulded bricks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>Length</td>
<td>190 or 225</td>
</tr>
<tr>
<td>Width</td>
<td>90 or 111</td>
</tr>
<tr>
<td>Thickness</td>
<td>40 or 44</td>
</tr>
</tbody>
</table>

Note: Tolerance and Dimensions for selected hand molded bricks + .4 mm in length and + .3 mm in width and thickness).

6.4.3 Sampling
As per Para 6.1.3 and 6.1.3.2.

6.4.4 Physical Requirements
Facing bricks shall be of class designation 75 unless otherwise specified. Average compressive strength shall not be less than 7.5 N/mm², water absorption shall not exceed 20 per cent by weight and efflorescence rating shall be nil when tested in accordance with the procedure laid down and tolerance in dimensions shall be checked as per the procedure laid down in Appendix A-2.

Mortar, Soaking of Bricks and laying shall be as specified in Para 6.2.2, 6.2.3 and 6.2.4 respectively.

6.4.5 Joints in the exposed brick work shall be truly horizontal and vertical and kept uniform with the help of wooden or steel strips. The thickness of joints shall be as per 6.2.5.

6.4.6 Curing and scaffolding shall be as specified in 6.2.6 and 6.2.7 to 6.2.7.2 respectively.

6.4.7 Measurements
Exposed brick work in face using machine moulded bricks and selected hand moulded bricks shall be measured separately and the measurement shall be as specified in 6.2.8.

6.4.8 Rate
The rates shall be as specified in 6.2.9 and shall also include the following:
(a) Labour for selecting bricks and wastage of bricks where use of selected hand moulded brick is specified.
(b) Leaving uniform horizontal and vertical grooves of specified depth and providing joints of required thickness using wooden or steel strips as the work proceeds.
CHAPTER -7
TEST FOR DIMENSIONAL TOLERANCE
TEST FOR DIMENSIONAL TOLERANCE

A-2. Procedure
All the blisters, loose particles of clay and small projections shall be removed from the surface of bricks. Each specimen of 20 bricks shall then be arranged upon a level surface successively as indicated in Fig. A, B and C of para A-4 below in contact with each other and in straight line. The overall length of the assembled bricks (20 Nos) shall be measured with a steel tape sufficiently long to measure the whole row at one stretch.

A-3. Tolerance
The actual dimensions of bricks when tested as described in A-2 shall be within the following limits per 20 bricks.

Modular Bricks
Length 3720 to 3880 mm (3800 ± 80 mm)
Width 1760 to 1840 mm (1800 ± 40 mm)
Height 1760 to 1840 mm (1800 ± 40 mm) for 90 mm high brick
    760 to 840 mm (800 ± 40 mm) for 40 mm high brick

Non-Modular Bricks
For class 10
Length (4520 to 4680) mm (4600 ± 80 mm)
Width (2240 to 2160) mm (2200 ± 40 mm)
Height (1440 to 1360) mm (1400 ± 40 mm) for 70 mm high bricks
    (640 to 560) mm (600 ± 40 mm) for 30 mm high bricks

For other classes
Length (4320 to 4680) mm
Width (2130 to 2310) mm
Height (1340 to 1460) mm for 70 mm high bricks
    (840 to 920) mm for 44 mm high bricks

A-4. Criteria for Conformity
A lot shall be considered conforming to the requirements of dimensions and tolerances if all the groups of bricks are tested to meet the specified requirements.

‘A’ Measurement of Length

‘B’ Measurement of Width

‘C’ Measurement of Height
TEST FOR COMpressive STRENGTH

(Clause 6.1.3.4)

B-1. Specimen
Five whole bricks shall be taken from the samples as specimens for this test. Length and width of each specimen shall be measured correct to 1 mm.

B-2. Apparatus
The apparatus consists of compression testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the centre of which shall coincide with the center of the plate.

B-3. Procedure
(a) Pre-conditioning: The specimen shall be immersed in the water for 24 hours at 25° to 29° C. Any surplus moisture shall be allowed to drain at room temperature. The frog of the bricks should be filled flush with mortar 1:3 (1 cement : 3 clean coarse sand of grade 3 mm and down) and shall be kept under damp jute bags for 24 hours, after that these shall be immersed in clean water for three days.

After removal from water, the bricks shall be wiped out of any traces of moisture.

(b) Actual Testing: Specimen shall be placed with flat faces horizontal and mortar filled face upward between three 3 ply plywood sheets each of thickness 3 mm and carefully centered between plates of the testing machine. Plaster of Paris can also be used in place of plywood sheets to ensure a uniform surface.

Load shall be applied carefully axially at uniform rate of 14 N/mm² per minute till the failure of the specimen occurs.

B-4. Reporting the Test Results
The compressive strength of each specimen shall be calculated in N/mm² as under:

Compressive Strength = \frac{\text{Maximum load at failure (in N)}}{\text{Area of Specimen (in sq mm)}}

In case the compressive strength of any individual brick tested exceeds the upper limit of the average compressive strength specified for the corresponding class of brick, the same shall be limited to the upper limit of the class specified in 6.1.2 for the purpose of calculating the average compressive strength. Compressive strength of all the individual bricks comprising the sample shall be averaged and reported.

B-5. Criteria for Conformity
A lot shall be considered having satisfied the requirements of average compressive strength if the average compressive strength specified in 6.1.2 for the corresponding class of brick tested is not below the minimum average compressive strength specified for the corresponding class of bricks by more than 20 per cent.
TEST FOR WATER ABSORPTION

(Clause 6.1.3.5)

C-1. No. of Specimen
Five whole bricks shall be taken from samples as specimen for this test.

C-2. Apparatus
A balance required for this test shall be sensitive to weigh 0.1 percent of the weight of the specimen.

C-3. Procedure
(a) **Pre-conditioning:** The specimen shall be allowed to dry in a ventilated oven at a 110°C to 115°C till it attains a substantially constant weight. If the specimen is known to be relatively dry, this would be accomplished in 48 hours, if the specimen is wet, several additional hours may be required to attain a constant weight. It shall be allowed to cool at room temperature. In a ventilated room, properly separated bricks will require four hours for cooling, unless electric fan passes air over them continuously in which case two hours may suffice.

The cooled specimen shall be weight (W1) a warm specimen shall not be used for this purpose.

(b) **Actual Testing:** Specimen shall be completely dried before immersion in the water. It shall be kept in clean water at a temperature of 27°C ± 2°C for 24 hours. Specimen shall be wiped out of the traces of water with a damp cloth after removing from the water and then shall be weighed within three minutes after removing from water (W2).

C-4. Reporting the Test Results
The water absorption of each specimen shall be calculated as follows and the average of five tests shall be reported.
TEST FOR EFFLORESCENCE

(Clause 6.1.3.6)

D-1. **No. of Specimen**
Five whole bricks shall be taken as specimen for this test.

D-2. **Apparatus**
Apparatus required for this test shall be a shallow flat bottom dish containing distilled water.

D-3. **Procedure (actual testing)**
The brick shall be placed vertically in the dish with 2.5 cm immersed in the water. The room shall be warm (18°C to 30°C) and well ventilated. The bricks should not be removed until it absorbs whole water. When the whole water is absorbed and the brick appears to be dry, place a similar quantity of water in that dish and allow it to evaporate as before. The brick shall be examined after the second evaporation.

D-4. **Reporting the Test Results**
The rating to efflorescence in ascending order shall be reported as ‘NIL’, ‘SLIGHT’, ‘MODERATE’, ‘HEAVY’ or ‘SERIOUS’ in accordance with the following:

(a) **NIL**: When there is no perceptible deposit of efflorescence.

(b) **SLIGHT**: When not more than 10 per cent of the area of the brick is covered with a thin deposit of salts.

(c) **MODERATE**: When there is heavier deposit and covering upto 50% of the area of the brick surface but unaccompanied by powdering or flaking of the surface.

(d) **HEAVY**: When there is a heavy deposit of salts covering 50% or more of the brick surface but unaccompanied by powdering or flaking of the surface.

(e) **SERIOUS**: When there is heavy deposit of salts, accompanied powdering and/or flaking of the surface and tending to increase in the repeated wetting of the specimen.

D-5. **Criteria for Conformity**
A lot be considered having satisfied the requirements of efflorescence if for 4 out of the specimen of 5 bricks, the rating of efflorescence is not beyond “Moderate”.
CHAPTER - 8
FINISHING
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8.0 FINISHING
8.1 CEMENT PLASTER
The cement plaster shall be 12 mm, 15 mm or 20 mm thick as specified in the item.

8.1.1 Scaffolding
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.

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-charge in advance.

8.1.2 Preparation of Surface
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.

8.1.3 Mortar
The mortar of the specified mix using the type of sand described in the item shall be used. It shall be as specified in Subhead 3.0. For external work and undercoat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

8.1.4 Application of Plaster
8.1.4.1 Ceiling plaster shall be completed before commencement of wall plaster.

8.1.4.2 Plastering shall be started from the top and worked down towards the floor. All putlog 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 × 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 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 a sandy granular texture is required. Excessive troweling or over working the float shall be avoided.
8.1.4.3 All corners, arises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arises, provision of grooves at junctions etc. where required shall be done without any extra payment. Such rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

8.1.4.4 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 cement slurry before plaster is applied to the adjacent areas, to enable the two to properly join 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 coping tiles as these invariably lead to leakages. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

No portion of the surface shall be left out initially to be patched up later on. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

8.1.5 Thickness
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.

8.1.6 Curing
Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

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-in-Charge 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.

8.1.7 Finish
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.

8.1.8 Precaution
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-Charge.

(i) 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.

(ii) 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.

8.1.9 Measurements

8.1.9.1 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.

8.1.9.2 Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick work.

8.1.9.3 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.

8.1.9.4 The following shall be measured separately from wall plaster.

(a) Plaster bands 30 cm wide and under
(b) Cornice beadings and architraves or architraves molded wholly in plaster.
(c) Circular work not exceeding 6 m in radius.

8.1.9.5 Plaster over masonry pilasters will be measured and paid for as plaster only.

8.1.9.6 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.

8.1.9.7 Moulded cornices and coves.

(a) Length shall be measured at the centre of the girth.
(b) Moulded cornices and coves shall be given in square metres the area being arrived at by multiplying length by the girth.
(c) 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.
(d) Cornices which are curved in their length shall be measured separately.

8.1.9.8 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.’

8.1.9.9 Deductions in measurements, for opening etc. will be regulated as follows:

(a) 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.
(b) 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.

(i) When both faces of walls are plastered with same plaster, deductions shall be made for one face only.

(ii) 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 the frame for the doors, windows etc. on which width of reveals is less than that on the other side but no deduction shall be made on the other side.

Where width of reveals on both faces of wall are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.

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.

(iii) 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.

8.1.9.10 Rate
The rate shall include the cost of all labour and materials involved in all the operations described above.

8.2 6MM CEMENT PLASTER ON CEMENT CONCRETE AND REINFORCED CEMENT CONCRETE WORK

8.2.1 Scaffolding
Stage scaffolding shall be provided for the work. This shall be independent of the walls.

8.2.2 Preparation of Surface
Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition concrete surfaces to be plastered shall be pock marked with a pointed tool, at spacing’s of not more than 5 cm. Centres, the pock being made not less than 3 mm deep. This is to ensure a proper key for the plaster. The mortar shall be washed off and surface, cleaned off all oil, grease etc. and well wetted before the plaster is applied.

8.2.3 Mortars
Mortar of the specified mix using the types of sand described in the item shall be used. It shall be as specified in 3.2.

8.2.4 Application
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.

Plastering of ceiling shall not be commenced until the slab above has been finished and centring has been removed. In the case of ceiling of roof slabs, plaster shall not be commenced until the 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.

8.2.5 Finish
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 jamb and corners with a plumb bob as the work proceeds.

8.2.6 Thickness
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.

8.2.7 Curing
Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

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-in-Charge 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.

8.2.8 Precautions
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-Charge.

(i) 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.

(ii) 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.
8.2.9 Measurements
8.2.9.1 Length and breadth shall be measured correct a cm. and its area shall be calculated in sqm. correct to two places of decimal. Dimensions before plastering shall be taken.

8.2.9.2 Thickness of plaster shall be exclusive of the thickness of the key i.e. depth or rock marks and hacking.

8.2.9.3 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.

8.2.9.4 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 13.4.9.3.

8.2.9.5 Plastering on spherical and groined ceiling and circular work not exceeding 6 m in radius, shall be measured and paid for separately.

8.2.9.6 Flowing soffits (viz. portion under spiral stair case etc.) shall be measured and paid for separately.

8.2.9.7 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.

8.2.9.8 The mode of measurement of exterior plastering and patch plastering (in repairs) shall be as laid down in 13.1.9.8

8.2.9.9 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 openings shall be measured for payment.

8.2.10 Rate
The rate shall include the cost of all labour and materials involved in all the operations described above.

8.3 NEAT CEMENT PUNNING
8.3.1 The specifications given for floating coat described in 13.2.1 shall apply.

8.3.2 Specification for scaffolding and curing shall be as described in 13.1.1 and 13.1.6 respectively. Specifications for Finish and Precautions shall be as described in 13.1.7 and 13.1.8.

8.3.3 Measurement
8.3.3.1 The measurements for 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.
8.3.3.2 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 girted over the above features.

8.3.3.3 Punning over plaster on circular work also, of any radius shall be measured only as wall surfaces, and not separately.

8.3.3.4 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 lime punning.

8.3.3.5 Deductions in measurements for openings shall be regulated generally as described in 10.1.9.9.

8.3.4 Rate
The rate shall include the cost of all labour and materials involved in all the operations described above.

8.4 Rough Cast Plaster
8.4.0 Rough cast finish comprises of a mixture of sand and gravel in specified proportions dashed over a freshly plastered surface.

8.4.1 Scaffolding
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.

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.

8.4.2 Preparation of Surface
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.

8.4.3 Mortar
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.

8.4.4 Application
8.4.4.1 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.

8.4.4.2 12 mm Under Layer: This shall be applied in the same manner as specified in para 13.1.3 under 18 mm cement plaster except that the finishing, after the mortar has been brought to a level with the wooden straight edge, shall be done with wooden float only.
8.4.4.3 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 grouted hydrated lime by volume of cement, shall be added when preparing mortar for the top layer.

8.4.5 Finish
It shall be ensured that the base surface which is to receive rough 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 get 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-in-Charge.

8.4.6 Specification for other details like precautions, measurement and rate shall be as described under 13.1.

8.5 DRY DISTEMPERING

8.5.1 Materials
Dry distemper of required colour (IS 427) and of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer-in-Charge 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.

Distemper shall not be mixed in larger quantity than is actually required for one day's work.

8.5.2 Preparation of Surface

8.5.2.1 Before new work is distempered, the surface shall be thoroughly brushed free from mortar droppings and other foreign matter and sand papered smooth.

8.5.2.2 New plastered surfaces shall be allowed to dry completely, before applying, distemper.

8.5.2.3 In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt, etc.

8.5.2.4 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.
8.5.3 **Priming Coat**
A priming coat of whiting (see 13.16) 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.

The treated surface be allowed to dry before distemper coat is given.

8.5.4 **Application**
8.5.4.1 In the case of new work, the treatment shall consist of a priming coat of whiting (As per 13.16) followed by the application of two or more coats of distemper till the surface shows an even colour.

8.5.4.2 For old work, the surface prepared as described in para 13.14 shall be applied one or more coats of distemper till the surface attains an even colour.

8.5.4.3 The application of each coat shall be as follows:

The entire surface shall be coated with the 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.

8.5.4.4 The subsequent coats shall be applied only after the previous coat has dried.

8.5.4.5 The finished surface shall be even and uniform and shall show no brush marks.

8.5.4.6 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.

8.5.4.7 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.

8.5.5 The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under 13.14.

8.6 **OIL EMULSION (OIL BOUND) WASHABLE DISTEMPERING**

8.6.1 **Materials**
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 work shall be prepared.

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 Engineer-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-in-Charge.
8.6.2 Preparation of the Surface
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 allowed to dry for at least 48 hours. It 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 paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

2. In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

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.

8.7 Application

8.7.1 Priming Coat: 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 13.18.4.

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.

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.

For old work no primer coat is necessary.

8.7.1.2 Distemper Coat: 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 constitute one coat.

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 an even shade.

A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.

For old work the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade.

15 cm double bristled distemper brushes shall be used. After each days work, brushes shall be tho- roughly 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.
8.7.1.3 The specifications in respect of scaffolding, protective measures and measurements shall be as described under 13.14.

8.7.1.4 Rate
The rate shall include the cost of all labour and materials involved in all the above operations (including priming coat) described above.

8.8 CEMENT PAINT
8.8.1 Material
The cement Paint shall be (conforming to IS 5410) of approved brand and manufacture:

The cement Paint shall be brought to the site of work by the contractor in its original containers is 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-in-Charge. The empty containers shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the Engineer-in-Charge.

8.8.2 Preparation of Surface
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.

8.8.3 Preparation of Mix
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.

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.

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.

8.8.4 Application
8.8.4.1 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.
8.8.4.2 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.

8.8.4.3 For new work, the surface shall be treated with three or more coats of water proof cement Paint as found necessary to get a uniform shade.

8.8.4.4 For old work, the treatment shall be with one or more coats as found necessary to get a uniform shade.

8.8.5 Precaution
Water proof cement Paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, Paints etc. It shall not be applied on gypsums, wood and metal surfaces.

If water proofing cement is required to be applied on existing surface, previously treated with white wash, colour wash etc., the surface shall be thoroughly cleaned by scrapping off all the white wash, colour wash etc. completely. Thereafter, a coat of cement primer shall be applied followed by two or more coat of water proof cement.

8.8.6 The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under 13.14. The coefficient for cement Paint on RCC Jalli shall be the same as provided in Sl. No. 7 of Table 1 under para 13.23.6.4 for painting trellis for Jaffri work.

8.9 EXTERIOR PAINTING ON WALL
8.9.1 Material
The paint shall be (Textured exterior paint/Acrylic smooth exterior paint/premium acrylic smooth exterior paint) of approved brand and manufacture.

This 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-in-Charge. The empty containers shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge.

8.9.2 Preparation of Surface
For new work, the surface shall be thoroughly cleaned off all mortar dropping, dirt dust, algae, fungus or moth, grease and other foreign matter of brushing and washing, pitting in plaster shall make good, surface imperfections such as cracks, holes etc. should be repaired using white cement. The prepared surface shall have received the approval of the Engineer in charge after inspection before painting is commenced.

8.9.3 Application
Base coat of water proofing cement paint

8.9.3.1 All specifications in respect of base coat of water proofing cement paint shall be as described under 13.21.
8.9.3.2 Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its container, when applying also the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. Dilution ratio of paint with potable water can be altered taking into consideration the nature of surface climate and as per recommended dilution given by manufacturer. In all cases, the manufacturer’s instructions & directions of the Engineer-in-charge shall be followed meticulously.

The lids of paint drums shall be kept tightly closed when not in use as by exposure to atmosphere the paint may thicken and also be kept safe from dust.

8.9.3.3 Paint shall be applied with a brush on the cleaned 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.

8.9.4 The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under 13.14.

8.10 PAINTING
8.10.1 Materials
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.

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-in-Charge shall be used.

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 a fortnight’s work. The materials shall be kept in the joint custody of the contractor and the Engineer-in-Charge. 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-in-Charge.

8.10.2 Commencing Work
Painting shall not be started until the Engineer-in-Charge 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.

Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work.

The rooms should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the Paint work being started.

8.10.3 Preparation of Surface
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-in-Charge after inspection, before painting is commenced.
8.10.4 Application
8.10.4.1 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.

8.10.4.2 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 in 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.

8.10.4.3 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 employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

8.10.4.4 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 cleaned off dust before the next coat is laid.

8.10.4.5 No left over Paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

8.10.4.6 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.

8.10.4.7 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.

8.10.4.8 On painting steel work, special care shall be taken while painting over bolts, nuts, rivets overlaps etc.

8.10.4.9 The additional specifications for primer and other coats of Paints shall be as according to the detailed specifications under the respective headings.

8.10.5 Brushes and Containers
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.
8.10.5 Measurements
8.10.5.1 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.

8.10.5.2 Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

8.10.5.3 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.

Note: Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

8.11 WALL PAINTING WITH PLASTIC EMULSION PAINT
10.11.1 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.

8.11.2 Plastic Emulsion Paint as per IS 5411 of approved brand and manufacture and of the required shade shall be used.

8.11.3 Painting on New Surface
8.11.3.1 The wall surface shall be prepared as specified in 13.23.3.

8.11.3.2 Application: 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 surfaces to 2 to 3 hours on non-absorbent surfaces.

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 manufacturer’s instructions.

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.

8.11.3.3 Precautions
8.11.3.3.1 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. 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.

8.11.3.3.2 In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

8.11.3.3.3 Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.
8.11.3.3.4 Washing of surfaces treated with emulsion Paints shall not be done within 3
8.11.3.3.5 Other details shall be as specified in 13.23 as far as they are applicable.

8.11.3.4 Painting on Old Surface
8.11.3.4.1 Preparation of Surface: This shall be done, generally as specified in 13.24.2.1 except that the surface before application of Paint shall be flattened well to get the proper flat velvety finish after painting.

8.11.3.4.2 Application: The number of coats to be applied shall be as in description of item.

The application shall be as specified in 13.31.2.2 except that thinning with water shall not normally be required.

8.11.3.4.3 Other details shall be as specified in 13.23 as far as applicable.

8.12 Painting with Synthetic Enamel Paint
8.12.1 Synthetic Enamel Paint (conforming to IS 2933) 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 the top coat as recommended by the same manufacturer as far the top coat shall be used.

8.12.2 Painting on New Surface
8.12.3 Preparation of surface shall be as specified in 13.24.2 as the case may be.

8.12.3.1 Application: The number of coats including the undercoat shall be as stipulated in the item.

(a) 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 be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

(b) 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.

8.12.3.2 Other details shall be as specified in 13.22 as far as they are applicable.

8.12.4 Painting on Old Surface
8.12.4.1 Preparation of Surface: Where the existing Paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified Paint. The surface shall again be rubbed and made smooth and uniform.

If the old paint is blistered and flaked it will be necessary to completely remove the same as described in para 10.41. Such removal shall be paid for separately and the painting shall be treated as on new surface.
8.12.4.2 Painting: The number of coats as stipulated in the item shall be applied with synthetic enamel Paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If however, the surface is not satisfactory additional coats as required shall be applied to get correct finish.

8.12.4.3 Other details shall be specified in 13.22 as far as they are applicable.
CHAPTER-9
STEEL WORK
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9.0 STEEL WORK

9.1 DEFINITIONS/ TERMINOLOGY Bead
A single run of weld metal deposited on surface.

Butt Weld
A weld in which the weld metal lies substantially within the extension of the planes arc the surfaces on the parts joined.

Crater
A depression left in weld metal where the arc was broken or the flame was removed.

End Crater
A crater at the end of a weld or at the end of a joint.

Fillet Weld
A weld of approximately triangular cross-section joining two surfaces approximately at the right angles to each other in a lap joint, tee joint or corner joint. It is of two types:
(1) Continuous
(2) Intermittent.
(3) Fusion Welding
Any welding process in which the weld is made between metals in a state of fusion without hammering or pressure.

Non-fusion Welding
A term applied to the deposition, by the Oxy-Acetylene process of filler metal on parent metal without fusion of the latter.

Oxy-Acetylene Pressure Welding
Pressure welding in which any Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.

Run
The metal deposited during one passage of the electrode or blow pipe in the making of a joint.

Throat thickness
See Fig. 10.1.

Weld
A union between two pieces of metal at faces rendered plastic or liquid by heat or pressure, or both, Filler metal may be used to effect the union.
9.2 MATERIALS

Micro-Alloying Elements
Elements such as niobium, boron, vanadium and titanium added singly or in combination to obtain higher strength to weight ratio and better toughness, formability and weld ability as compared to Unalloyed steel of similar strength level.

Weld ability
A metallic substance is considered to be weldable by a given process and for the given purpose, when metallic continuity to a stated degree can be obtained by welding using a suitable procedure, so that the joints comply with the requirements specified in regard to both their local properties and their influence on the construction of which they form a part.

Controlled Rolling
A hot rolling process in which the temperature of the steel and its reduction ratio are controlled, particularly during the final rolling passes, in order to achieve fine grain micro structure and optimum mechanical properties.

Normalizing Rolling
A hot rolling process in which the final rolling passes are carried out at a suitable higher temperature, followed by cooling in natural air to a temperature below the transformation temperature, in order to produce a structure, analogous to that obtained by a separate normalizing treatment of hot rolled product.

9.2.1 Steel
9.2.1.1 Supply of Material: General requirements relating to supply of structural steel shall conform to IS 8910.

9.2.1.2 Grades: There shall be nine grades of steel as given in Tables 10.1 and 10.2. While placing the order the steel should be designated by ‘Designation’ (See Table 10.1 and 10.2).

9.2.1.3 Manufacture: The processes used in the steel making and further hot rolling into steel plates, strips, sections, flats, bars, etc., are left to the discretion of the manufacturer/supplier. If required, secondary refining may follow steel making, as also normalizing rolling/controlled rolling during manufacturing of sections or as per the agreement between the purchaser and the manufacturer/supplier.

9.2.1.4 Freedom from Defects
9.2.1.4.1 All finished materials shall be well and cleanly rolled to the dimensions, sections and masses specified. The finished material shall be reasonably free from surface flaws; laminations; rough/jagged and imperfect edges and all other harmful defects.

9.2.1.4.2 Minor surface defects may be removed by the manufacturer/supplier by grinding provided the thickness is not reduced locally by more than 4 percent below the minimum specified thickness. Reduction in thickness by grinding greater than 4 percent but not exceeding 7 percent may be made subject to mutual agreement between the purchaser and manufacturer/supplier.

9.2.1.4.3 Subject to agreement with the purchaser, surface defects which cannot be dealt with as in 9.2.1.4.2 may be repaired by chipping or grinding followed by welding and inspection by a mutually agreed procedure such that:
(a) After complete removal of the defects and before welding, the thickness of the item is not to be reduced by more than 20 percent at any place.
(b) Welding is carried out by procedure APPROVED by competent authority with approved electrodes and the welding is ground smooth to the correct nominal thickness; and
(d) Subsequent to the finish grinding, the item may be required to be normalized or otherwise heat-treated at the purchaser's discretion.

9.2.1.4.4 Welding as mentioned in 10.1.1.4.3 is not permissible for grade designation E 250 material.

9.2.1.5 Chemical Composition: Ladle Analysis the ladle analysis of the steel, when carried out by the method specified in the relevant part of IS 228 or any other established instrumental /chemical method, shall be as given in Table 10.1. In case of dispute, the procedure given in IS 228 and its relevant parts shall be the referee method and where test methods are not specified shall be as agreed to between the purchaser and the manufacturer/supplier.

9.2.2 Rivets
Rivets shall be made from rivet bars of mild steel as per IS 1148.

9.2.3 Bolts
These are of two types namely turned and fitted bolts and black bolts. Turned & fitted bolts are turned to exact diameter in automatic lathe. For these bolts, whether reamed or drilled bolts, the same unit stresses are allowed as for rivets. In case of black bolts which are not finished to exact sizes, a lower working stress other than for turned bolts is adopted. They shall conform to IS 1367 – Technical supply conditions for threaded steel fasteners.

9.2.4 Electrodes
The electrodes required for metal arc welding shall be covered electrodes and shall conform to IS 814.

9.3 STEEL WORK IN SINGLE SECTION FIXED INDEPENDENTLY WITH CONNECTING PLATE
9.3.0 The steel work in single section of R.S. joists, flats, Tees Angles fixed independently with or without connecting plate, is described in these clauses.

9.3.1 Fabrication
The steel sections as specified shall be straightened and cut square to correct lengths and measured with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of member.

All straightening and shaping to form, shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of the metal.

9.3.2 Painting
All surfaces which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust. Surfaces not in contact but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections. Part to be encased in concrete shall not be painted or oiled. A priming coat of approved steel primer such as Red Oxide/Zinc Chromate primer conforming to IS 2074 shall be applied before any member of steel structure are placed in position or taken out of workshop.

9.3.3 Erection
Steel work shall be hoisted and placed in position carefully without any damage to itself and other building work and injury to workmen. Where necessary mechanical appliances such as lifting tackle winch etc. shall be used. The suitability and capacity of all plant and equipment used for erection shall be up to the satisfaction of the Engineer-in-charge.
9.3.4 Measurements
The work as fixed in place shall be measured in running metres correct to a millimetre and weights calculated on the basis of standard tables correct to the nearest kilogram. The standard weight of steel sections shall conform to IS 808 with tolerance in sizes as per IS 1852. Tolerance in weight is given in Table 10.3. Steel sections shall be acceptable within tolerance limits. Payment for steel sections shall be made as per actual weight within tolerances. Sections having weight on higher side than permissible tolerance, may be acceptable but payment shall be made on the basis of standard weight only. Steel sections having weight variations lower side than permissible variation shall not be acceptable.

Unless otherwise specified, weight of cleats, brackets, packing pieces, bolts, nuts, washers, distance pieces, separators, diaphragm gussets (taking overall square dimension) fish plates, etc. shall be added to the weight of respective items. In riveted work allowance is to be made for weight of rivet heads. Unless otherwise specified an addition of 2.5% of the weight of structure shall be made for shop and site rivet heads in riveted steel structures.

No deduction shall be made for rivet/ or bolt holes (excluding holes for anchor or holding down bolts).

Deduction in case of rivet or bolt hole shall however be made if its area exceeds 0.02 sqm.

The weight of steel sheets, plates and strips shall be taken from relevant Indian standards based on 7.85 Kg/m2 for every millimeter sheet thickness. For rolled sections, steel rods and steel strips, weight given in relevant Indian Standards shall be used.

9.3.5 Rate
Rate includes the cost of labour and materials required for all the operations described above.

9.4 STEEL WORK IN BUILT UP SECTIONS (RIVETED AND BOLTED)
The steel work in built up section (Riveted and bolted) such as trusses, framed work etc. is specified in this clause.

9.4.1 Laying Out
A figure of the steel structure to be fabricated shall be drawn on a level platform to full scale. This may be done in full or in parts, as shown on drawings or as directed by the Engineer-in-Charge. Steel tape shall be used for measurements.

9.4.2 Fabrication
Fabrication shall generally be done as specified in IS 800. In major works or where so specified, shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details or rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer-in-charge. The drawings shall indicate the shop and field rivets, bolts and welds. The steel members shall be distinctly marked or stenciled with paint with the identification marks as given in the shop drawings.

Great accuracy shall be observed in the fabrication of various members, so that these can be assembled without being unduly packed, strained or forced into position and when built up, shall be true and free from twist, kinks, buckles or open joints.
Wooden or metal sheet templates shall be made to correspond to each member, and position of rivet holes shall be marked accurately on them and holes drilled. The templates shall then be laid on the steel members, and holes for riveting and bolting marked on them. The ends of the steel members shall also be marked for cutting as per required dimensions. The base of steel columns and the positions of anchor bolts shall be carefully set out at the required location.

9.4.2.1 The steel section shall be straight or to be straightened or flattened by pressure unless required to be of curvilinear form and shall free from twists. These shall be cut square either by shearing or sawing to correct length and measured by steel tape. No two pieces shall be welded or joined to make up for the required length of member.

9.4.2.2 Making Holes: Holes through more than one thickness of materials for members, such as compound stanchion and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 3mm less in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall be not greater than 16 mm.

**Rivet Holes**

The diameter for rivets and black bolts holes shall be taken as the nominal diameter of a rivet/ black bolts plus 1.5 mm for rivets/ bolts of nominal diameter less than or equal to 25 mm” and 2.0 mm for rivets of nominal diameter exceeding 25 mm, unless specified otherwise. Holes for turned and fitted bolts shall be drilled or reamed large by 0.2 to 8 mm depending upon the dia. of bolts.

Holes shall have their axis perpendicular to the surface bored through. The drilling or reaming shall be free from burrs, and the holes shall be clean and accurate. Holes for rivets and bolts shall not be formed by gas cutting process.

Holes for counter sunk bolts shall be made in such a manner that their heads sit flush with the surface after fixing.

9.4.2.3 Assembly: Before making holes in individual members, for fabrication and steel work intended to be riveted or bolted together shall be assembled and clamped properly and tightly so as to ensure close abutting, or lapping of the surfaces of the different members. All stiffeners shall be fixed (or placed) tightly both at top and bottom without being drawn or caulked. The abutting joints shall be cut or dressed true and straight, and fitted close together.

Web plates of girders, which have no cover flange plates, shall have their ends flush with the tops of angles unless otherwise required. The web plate when spliced, shall have clearance of not more than 5mm. The erection clearance of cleated ends of members connecting steel to steel shall preferably be not greater than 1.5 mm. The erection clearance at the ends of beams without web cleats shall not be more than 3 mm at each end but where for practical reasons, greater clearance is necessary, seating designed suitably shall be provided.

Column splices and butt joints of struts and compression members requiring contact for stress transmission shall be accurately, machined and close butted over the whole section. In column caps and bases, the ends of shafts together with the
attached gussets, angles, channels etc. after riveting together shall be accurately machined so that the parts connected, butt against each other over the entire surfaces of contact. Connecting angles or channels shall be fabricated and placed in position with great accuracy so that they are not unduly reduced in thickness by machining.

The ends of all bearing stiffeners shall be machined or grounded to fit tightly both at top and bottom.

9.4.2.3 Riveting: Rivets shall be used, where slip under load has to be avoided.

Preliminaries before Riveting’s:- Members to be riveted shall have all parts firmly placed and held together before and during riveting, and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

Process of Riveting

The riveting shall be carried out by using machines of the steady pressure type. However, where such facilities are not available hand riveting may be permitted by the Engineer-in-charge. The rivets shall be heated red hot, care being taken to control the temperature of heating so as not to burn the steel. Rivets of diameter less than 10mm may be driven cold. Rivets shall be finished neat with heads full and of equal size. The heads shall be central on shanks and shall grip the assembled members firmly.

All loose, burnt, or badly formed rivets with eccentric or deficient heads shall be cut out and replaced. In cutting out rivets, care shall be taken so as not to injure the assembled members. Caulking and recapping shall not be permitted.

For testing rivets, a hammer weighing approx. 0.25 kg shall be used and both heads of the rivet (Specially the machine head) shall be tapped. When so tested, the rivets shall not give a hollow sound and a jar where so specified, other tests shall be carried out to ensure the soundness of rivets.

All rivets heads shall be painted with approved steel primer paint within a week of their fixing.

9.4.2.4 Bolting: The nominal length of the bolt shall be the distance from the underside of the head to the further end of the shank. The nominal diameter of the bolt shall be the diameter at the shank above the screwed threads. Bolts, nuts and washers shall be thoroughly cleaned and dipped in double boiled linseed oil, before use. All bolts heads and nuts shall be hexagonal 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 at least two clear threads beyond the nuts when fixed in position, and these shall fit in the holes without any shake. The nuts shall fit in the threaded ends of bolts properly.

Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut at least two thread. In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nuts to avoid any threaded portion of the bolt being within the thickness of the parts bolted together.
Where there is a risk of the nuts being removed or becoming loose due to vibrations or
reversal of stresses, these shall be secured from slackening by the use of lock nut, spring
washers as directed by the Engineer-in-charge.

9.4.3 Erection
Steel members shall be hoisted and erected in position carefully, without any damage
to itself, other structures and equipment and injury to workmen. The method of hoisting and
erction proposed to be adopted by the contractor shall be get approved from the
Engineer-in-charge in advance. The contractor however shall be fully responsible for the work
being carried out in a safe and proper manner without unduly stressing the various members
and proper equipment such as derricks, lifting tackles, winches, ropes etc. shall be used.

9.4.3.1.1 The work of erection may be done in suitable units as may be directed by the
Engineer-in-charge. Fabricated members shall be lifted at such points so as to avoid
deformation or excessive stress in members. The structure or part of it placed in position
shall be secured against over-turning or collapse by suitable means.

During execution, the steel members shall be securely bolted or otherwise fastened when
necessary temporarily braced to provide for all loads including those due to erection
equipment’s and its operation to be carried safely by structure during erection. The steel
members shall be placed in proper position as per approved drawing, final riveting or
permanent bolting shall be done only after proper alignment has been checked and confirmed.

9.4.3.2 Trusses shall be lifted only at nodes. The trusses above 10 m in span shall not be
lifted by slinging at two mid points of rafters, which shall be temporary braced by a wooden
member of a suitable section. After the trusses are placed in position, purlins and wind
bracings shall be fixed as soon as possible.

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the
other end kept free to move. In case of trusses of spans upto 10m the free end of the truss shall be
laid on lead sheet or steel plate as per design, and the holes for holding down bolts shall be made in
the form of oblong slots so as to permit the free movements of the truss end. For larger spans the
truss shall be provided with proper bearing as per design.

9.4.3.3 Columns and stanchions shall be erected truly vertical with the necessary cross bracing etc.
and the base shall be properly fixed with the foundation concrete by means of anchor bolts etc. as
per drawing.

9.4.3.4 Anchor bolts to be placed in the concrete foundation should be held in position with a
wooden template. At the time of concreting anchor bolt locations shall be provided with suitable
timber mould or pipe sleeve to allow for adjustment which shall be removed after initial setting of
concrete. The spaces left around anchor bolts shall be linked to a stopping channel in the concrete
leading to the side of the pedestal and on the underside of the base plate to allow the spaces being
grouted up after the base plate is fixed in the position along with the column footing. Grouting shall
be of cement mortar 1:3 (1 cement: 3 coarse sand) or as specified
9.4.3.5 Bedding of Column, Stanchions etc.:- Bedding shall not be carried out until the steel work has been finally leveled, plumbed and connected together. The stanchion shall be supported on steel wedges and adjusted to make the column plumb. For multistoreyed buildings, the bedding shall not be done until sufficient number of bottom lengths of stanchions have been properly lined, leveled and plumbed and sufficient floor beams are fixed in position. The base plates shall be wedged clear of the bases by M.S. wedges and adjusted where necessary to plumb the columns. The gaps under the base plate may be made up to 25 mm which shall be pressure grouted with cement grouts.

With small columns, if permitted by the Engineer-in-charge, the column base shall be floated on a thick cement grout on the concrete pedestal. The anchor bolt holes in the base plate may be made about 10 to 15 mm larger than the bolts. In such cases suitable washers shall be provided.

9.4.4 Painting
Before the members of the steel structure are placed in position or taken out of the workshop these shall be painted as specified in 10.2.2.

9.4.5 Measurements
The work as fixed in position shall be measured in running metres correct to a millimeter and their weight calculated on the basis of standard tables correct to the nearest kilogram.

The standard weight of steel sections shall conform to IS 808 with tolerance in sizes as per IS 1852. Tolerance in weight is given in Table 10.3. Steel sections shall be acceptable within tolerance limits. Payment for steel sections shall be made as per actual weight within tolerances. Sections having weight on higher side than permissible tolerance may be acceptable but payment shall be made on the basis of standard weight only. Steel sections having weight variations lower than permissible variation shall not be acceptable.

Unless otherwise specified. Weight of cleats, brackets, packing pieces, bolts nuts, washers, distance pieces, separators diaphragm gussets (taking overall square dimensions) fish plates etc. shall be added to the weight of respective items. No deductions shall be made for skew cuts. In riveted work, allowance is to be made for weight of rivet heads. Unless otherwise specified and addition of 2.5% of the weight of structure shall be made for shop and site rivet heads in riveted steel structures. No deduction shall be made for rivet/ or bolt holes (excluding holes for anchor or holding down bolts). Deduction in case of rivet or bolt hole shall, however, be made if its area exceeds 0.02 m2.

The weight of steel sheet and strips shall be taken from relevant Indian Standards based on 7.85 kg/m² for every millimeter sheet thickness. For rolled sections, steel rods and steel strips, weight given in relevant Indian Standards shall be used.

9.4.6 Rate
The rate shall include the cost of all materials and labor involved in all the operation described above.

9.5 STEEL WORK IN BUILT UP SECTION (WELDED)

9.5.1 The steel work in built up sections (welded) such as in trusses, form work etc. is specified in this clause.

9.5.2 Laying out
9.5.3 Fabrication

9.5.3.1 Straightening, shaping to form, cutting and assembling, shall be as per 10.3.2 as far as applicable, except that the words “riveted or bolted” shall be read as “welded” and holes shall only be used for the bolts used for temporary fastening as shown in drawings.

9.5.3.2 Welding: Welding shall generally be done by electric arc process as per IS 816 and IS 823. The electric arc method is usually adopted and is economical. Where electricity for public is not available generators shall be arranged by the contractor at his own cost unless otherwise specified. Gas welding shall only be resorted to using oxyacetylene flame with specific approval of the Engineer-in-charge. Gas welding shall not be permitted for structural steel work. Gas welding required heating of the members to be welded along with the welding rod and is likely to create temperature stresses in the welded members. Precautions shall therefore be taken to avoid distortion of the members due to these temperature stresses.

The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used. Symbol for welding on plans and shops drawings shall be according to IS 813.

As far as possible every efforts shall be made to limit the welding that must be after the structure is erected so as to avoid the improper welding that is likely to be done due to heights and difficult positions on scaffolding etc. apart from the aspect of economy. The maximum dia of electrodes for welding work shall be as per IS 814. Joint surfaces which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter, which adversely affect the quality of weld and workmanship.

9.5.3.3 Precautions: All operation connected with welding and cutting equipment shall conform to the safety requirements given in IS 818 for safety requirements and Health provision in Electric and gas welding and cutting operations.

9.5.3.4 Operation, Workmanship and process of Welding is described in Appendix B,

9.5.3.5 Inspection and testing of welds shall be as per IS 822.

9.5.3.6 Assembly: Before welding is commenced, the members to be welded shall first be brought together and firmly clamped or tack welded to be held in position. This temporary connection has to be strong enough to hold the parts accurately in place without any disturbance. Tack welds located in places where final welds will be made later shall conform to the final weld in quality and shall be cleaned off slag before final weld is made.

9.5.3.7 Erection: The specification shall be as described in 10.3.3 except that while erecting a welded structure adequate means shall be employed for temporary fastening the members together and bracing the frame work until the joints are welded. Such means shall consists of applying of erection bolts, tack welding or other positive devices imparting sufficient strength and stiffness to resist all temporary loads and lateral forces
including wind. Owing to the small number of bolts ordinarily employed for joints which are to be welded, the temporary support of heavy girders carrying columns shall be specially attended. Different members which shall be fillet welded, shall be brought into as close contact as possible. The gap due to faulty workmanship or incorrect fit if any shall not exceed 1.5 mm if gap exceeds 1.5 mm or more occurs locally the size of fillet weld shall be increased at such position by an amount equal to the width of the gap.

9.5.3.8 **Painting** : Before the member of the steel structures are placed in position or taken out of the workshop these shall be painted as specified in para 10.2.2.

9.5.4 **Measurements**
The mode of measurements shall be the same as specified in 10.2.4 except that weight of welding material shall not be added in the weight of members for payment and nothing extra shall be paid for making and filling holes for temporary fastening of members during erection before welding.

9.5.5 **Rate**
The rate shall include the cost of all labour and materials involved in all the operations described above.

9.6 **TUBULAR / HOLLOW SECTION TRUSSES**

9.6.1 **Structural Steel Tube**
These shall be of:
1. Hot finished welded (HFW) type, or
2. Hot finished seamless (HFS) type, or
3. Electric resistance or induction butt welded (ERW), having carbon content less than 0.03 percent, yield stress of 21.5 kg/mm² (YST 210) type.

Conforming to the requirement of IS 1161. The steel tubes when analyzed in accordance with the method specified in IS 228 shall show not more than 0.06 percent sulphur, and not more than 0.06 per cent phosphorous.

Tubes shall be designated by their nominal bore. These shall be light, medium or heavy as specified depending upon the wall thickness. The standard size and weights of tubes are listed in Appendix C. Hollow sections shall be as per IS 4923.

Tubes shall be clean finished and reasonably free from scale. They shall be free from cracks, surface flaws, laminations and other defects. The ends shall be cut clean and square with axis of tube, unless otherwise specified.

9.6.2 **Minimum Thickness of Metals**
Wall thickness of tubes used for construction exposed to weather shall be not less than 4 mm and for construction not exposed to weather it shall be not less than 3.2 mm where structures are not readily accessible for maintenance; the minimum thickness shall be 5 mm.

9.6.3 **Fabrication**
9.6.3.1 The component parts of the structure shall be assembled in such a manner that they are neither twisted nor otherwise damaged and be so prepared that the specified cambers, if any, are, maintained. The tubular steel work shall be painted with one coat of approved steel primer after fabrication. All fabrication and welding is to be done in an
approved workshop. The joint details shall be generally as per S.P-38 of B.I.S publication.

9.6.3.2 Straightening: All material before being assembled shall be straightened, if necessary, unless required to be of curvilinear form and shall be free from twist.

9.6.3.3 Bolting: Washers shall be specially shaped where necessary, or other means, used to give the nuts and the heads of bolts a satisfactory bearing.

In all cases, where the full area of the bolts is to be developed, the threaded portion of the bolt shall not be within the thickness of the parts bolted together and washers of appropriate thickness shall be provided to allow the nuts to be completely tightened.

9.6.3.4 Welding: Where welding is adopted, it shall be as per IS 816.

9.6.3.5 Caps and Bases for Columns: The ends of all the tubes, for columns transmitting loads through the ends, should be true and square to the axis of the tubes and should be provided with a cap or base accurately fitted to the end of the tube and screwed, welded or shrunk on. The cap or base plate should be true and square to the axis of the column.

9.6.3.6 Sealing of Tubes: When the end of a tube is not automatically sealed by virtue of its connection be welding to another member the end shall be properly and completely sealed. Before sealing, the inside of the tubes should be dry and free from loose scale.

9.6.3.7 Flattened Ends: In tubular construction the ends of tubes may be flattened or otherwise formed to provide for welded. Riveted or bolted connections provide that the methods adopted for such flattening do not injure the material. The change of sections shall be gradual.

9.6.4 Hoisting and Erection
Tubular trusses shall be hoisted and erected in position carefully, without damage to themselves, other structure, equipment and injury to workman.

The method of hoisting and erection proposed to be adopted shall be got approved from the Engineer-in-charge. The contractor shall however be fully responsible, for the work being carried out in a safe and proper manner without unduly stressing the various members. Proper equipment such as derricks, lifting tackles, winches, ropes etc. shall be used.

9.6.5 Measurements
The work as fixed in place shall be measured in running metres correct to a centimeter on their weights calculated on the basis of standard tables correct to the nearest kilogram unless otherwise specified.

Weight of cleats, brackets, packing pieces bolts nuts, washers distance pieces separators diapharam gussests (taking overall square dimensions) fish plates, etc. shall be added to the weight of respective items unless otherwise specified. No deduction shall be made for skew cuts.
9.6.6 Rate
The rate shall include the cost of labour and materials involved in all the operations described above including application of one coat of approved steel primer, i.e. red oxide zinc chrome primer conforming to IS 2074.

9.7 M.S. HOLLOW RECTANGULAR DOOR FRAMES (I-TYPE SECTION)

9.7.1 Materials
Steel door frames shall be manufactured from commercial mild steel sheet of 1.60 mm thickness, conforming to IS 2062 and 4351.

Steel door frames shall be made in the profiles as per drawings and/or as directed by the Engineer- in-charge.

9.7.2 Construction
Each door frame shall consist of hinge jamb, lock jamb, head and if required angle threshold. These shall be welded or rigidly fixed together by mechanical means. Where no angle threshold is required, temporary base tie shall be screwed to the feet of frames in order to form a rigid unit. Where so specified base ties shall be pressed mild steel 1.60 mm thick adjustable to suit floor thickness of 35 or 40 mm and removable, or alternatively, threshold of mild steel angle of section 50 x 25 mm, minimum shall be provided for external doors frames.

9.7.3 Fabrication
The M.S hollow rectangular steel door frames shall be got fabricated in an approved workshop as approved by the Chief Engineer.

9.7.3.1 Fixing Lugs : There shall be three adjustable lugs with split end tail to each jamb.

The head of the fixing lug shall be 120 mm long and made up flat steel strip 25 mm wide and 1.60 mm thick.

9.7.3.2 Hinges 100 mm mild steel butt hinges shall be used. Floor door frames 80 cm wide and under, three hinges shall be rigidly fixed to one jamb and for frames of door above 80 cm wide, four hinges shall be rigidly fixed to one jamb, if it is single shutter. Where the height of door shutter exceeds 2.15 metres, one additional hinge shall be provided for every 0.5 m or part thereof of the additional height.

In all cases the hinges shall be so fixed that the distance from the inside of the head rebate to the top of the upper hinge is 20 cm and the distance from the bottom of the door frame to the bottom of the bottom hinge is also kept about 200 mm. The middle hinges shall be at equal distance from lower and upper hinges or as agreed to between the purchaser and the supplier. Hinges shall be made of steel 2.5 mm thick with zinc coated removable pin of 6 mm diameter. The space between the two leaves of the hinge when closed shall be 3 mm and the leaf that is not welded to the frame shall have four counter sunk holes to take Number-10 cross recessed head wood screws.

9.7.3.3 Aldrops, Sliding Bolts and Tower Bolts : Provisions shall be made for aldrops,
sliding bolts and tower bolts in the frames as per the positions given by the purchaser. Necessary mortar guards/metallic or nylon bushes shall be provided inside the frames for aldrops, sliding bolts and tower bolts.

9.7.3.4 **Lock Strike Plate:** Provision shall be made to fix lock stricke plates of mortise locks or latches, complying with the relevant Indian Standards. A slot suitable for lock stricke plate shall be pierced into the rebate of the frame and necessary fixing arrangement and mortar guard from the inside of the frame shall be provided.

9.7.3.5 **Shock Absorbers:** For side-hung door there shall be not less than three buffers of rubber or other suitable material inserted in holes in the rebate and one shall be located at the centre of the lock jamb of frame and other two shall be 300 mm from top and bottom of the frame. For double leaf doors two buffers shall be provided.

9.7.4 **Finishing**
The surface of door frame shall be thoroughly cleaned, free of rust, mill —scale dirt, oil etc. either by mechanical means, for example sand or shot blasting or by chemical means such as picking. After pretreatment of the surface one coat of approved primer i.e. red oxide zinc chrome primer conforming to IS 2074. Two coats of paints as directed by the Engineer-in-Charge shall be applied to the exposed surface.

9.7.5 **Fixing**
Frames shall be fixed up right in plumb and plane. To avoid sag or bow in width during fixing or during construction phase, temporary struts across the width preventing sides bulging inwards may be provided. Wall shall be built solid on each side and grouted at each course to ensure solid contact with frame leaving no voids behind the frame.

Three lugs shall be provided on each jamb with spacing not more than 75 cm the temporary struts should not be removed till the masonry behind the frame is set. In case screwed base tie is provided, this should be left in position till the flooring is laid when it can be removed.

After pretreatment of the surface one coat of steel primer and two coats of paint, as directed by Engineer-in-charge shall be applied to the exposed surface.

9.7.6 **Measurements**
The length shall be measured in running metre correct to a cm. along the centre line of the frames.

9.7.7 **Rate**
The rate shall include the cost of labour and material involved in all the operation described above including one coat of approved steel primer but excluding two coats of paint.

**9.8 STEEL WORK WELDED IN BUILT-UP SECTIONS USING STRUCTURAL STEEL**

(A) In Stringers, Treads, Landing etc. of Stair cases including use of Chequred Plate wherever Required

(B) In Grating, Frames, Guard Bar, Ladder, Railings, Brackete, Gates and similar work.

9.8.1 General specifications for these items to be same as for steel work welded in built-up sections as mentioned in para 10.4 except that steel used for fabrication of these items to be of type used for structural use/purposes.
9.8.2 Steel members used for fabricating these items to be designed structurally to withstand the all loads to be carried out by the members during erection, fixing and functional use in designed life. Work to be executed as per structural drawings.

9.9 STEEL WORK WELDED IN BUILT-UP SECTIONS FOR HAND RAIL USING M.S. TUBULAR/ERW TUBULAR PIPES AND G.I. PIPES

9.9.1 General specifications to be same as for steel work welded in built-up section as mentioned in para 10.4.

9.9.2.1 Hot finished welded (HFW) Hot finished seamless (HFS) and electric resistance welded tube shall conform to IS 1161

9.9.2.2 G.I. pipes used for Hand rail to be conforming to IS 1239-Part I for medium grade. GI pipes to be screwed and socketed type and of required nominal bore.

9.9.2.3 Galvanising of GI pipes shall conform to IS 4736.

9.9.2.4 All screwed tubes and socket of GI pipes shall have pipe threads conforming to the requirements of IS 554

9.9.2.5 The fittings for GI pipes to be conforming to IS 1239 (Part-II)

9.9.3 Measurement of Hand Rail of M.S. Tubular/E.R.W Tubular Pipes

The work as fixed in place shall be measured in running metres correct to a centimeter and their weights calculated on the basis of standard tables correct to the nearest kilogram or actual weight whichever is less, the current shall be adjusted or the electrode size changed. unless otherwise specified.

WELDING PROCESS

(Clause 10.4.2.4)

(a) The work shall be positioned for downward welding wherever possible.

(b) Arc length voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work. The welding current and electrode sizes for different types of joints shall be as per IS 9595.

(c) The sequence of welding shall be such as will avoid undue distortion and minimize residual shrinkage stresses. Recommendation of IS 9595 shall be followed.

Process of Welding

The electrode manipulation during welding shall be such as to ensure that:
(1) The parent metal is in a fused stage when the filler metal makes contact with it.
(2) The weld metal does not overflow upon any unfused parent metal forming overlapping.
(3) The parent metal is not under-cut along the weld toes.
(4) The flowing metal floats, the slag, the oxides, and the gas bubbles to the surface behind the advancing pool. In case any of these requirements is unattainable by manipulation

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 move 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 deposit 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 deposit and the adjoining base metal shall be wire brushed and cleaned at all points. The requirements shall apply not only to successive layers, but also to successive beads, and to the overlapping area wherever a junction is made on starting a new electrode.

(5) The welds shall be free from cracks, discontinuity in welding and other defects such as (i) under-size (ii) over-size, (iii) under-cutting and (iv) over-cutting in the case of fillet welds and defects (ii), (iii) & (iv) in the case of butt welds.

All defective welds which shall be considered harmful to the structural strength shall be cut out and rewelded. In case of welded butt joints in steel of thickness up to 50mm the weld joint shall be subjected to radiographic examination as described in IS 1182.

All welds shall be cleaned of slag and other deposits after completion. Till the work is inspected and approved painting shall not be done. The surface to be painted shall be cleaned of spatter, rust, loose scale, oil and dirt.
CHAPTER 10

REFRIGERATION SYSTEM
10. Refrigeration System & Equipment Selection
Vapour Compression systems are commonly used.

- **Refrigerant issues – eco-friendly, safety, energy efficiency.**
  Ammonia seems to be the best refrigerant in terms of environment (being natural) and energy efficiency for this application.

- **Compressor – reciprocating/ screw with capacity control**
  Multiple multi cylinder reciprocating compressors or screw compressors with appropriate capacity control is used. Typically the holding capacity may just be 50% of the peak capacity during loading. So, it is proposed to go for two same sized compressors each suitable for holding capacity at peak loads. A third compressor as standby compressor is recommended. Compressors should be able to deliver the desired capacity at worst conditions not at rated conditions. VFD’s can also be used for closer control in some cases. Capacity of compressor shall be confirmed by datasheet of manufacturer.

- **Condenser – atmospheric**
  Condensers are considered air cooled type with atmospheric type of it.

- **Cooling coils – ceiling / wall mounted**
  Delta T (difference between evaporating and air inlet temperatures) should be kept low for higher humidity in the chamber. Typical values shall be 4.4 or less during holding period and can go up to 6 during peak loading period. This shall be confirmed by data sheet of manufacturer. This increases the coil surface substantially. The coils selected are kept on the higher side to keep higher humidity levels even during loading/ pull down periods. Ammonia coils are typically MS hot dip galvanized or SS/ aluminium tubes with Aluminium fins.

- **Capacity control of fans**
  Fans’ operation can be cycled to save power during part load operation.

- **Testing and Charging the system**
  Installation, Testing & Commissioning should be carried out as per BIS (for standards available). ASHRAE standards may be referred to as guidelines but not mandatory.

- **Air purger (manual or automatic)**
  It is desirable to remove air and other non-condensable gases from the refrigeration circuit to keep the compressor head pressures lower and also improve heat transfer coefficients.

- **Defrosting method – water/ hot gas/electric/air etc.**
  Water defrosting is a simple method and can be done manually or through a timer.

- **Equipment de-rating at higher ambient**
  A designer should match the loads with the de-rated equipment capacity at higher ambient conditions.
10.1 GENERAL SPECIFICATIONS FOR REFRIGERATION SYSTEM
(Typical Designs Enclosed Separately)

Brief Specifications for Equipment / Materials / Services

i. Refrigeration Compressors & Motors

<table>
<thead>
<tr>
<th>Quantity</th>
<th>For Cold storage, 3 No. each of 50% capacity (one preferred as standby) can be provided in case of ammonia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>For ammonia as refrigerant, reciprocating, 3 cylinders complete with water-cooled head / jackets, with accessories like oil separators, capacity control &amp; unloaded start.</td>
</tr>
<tr>
<td>Capacity at critical operating conditions</td>
<td><strong>Compressor Model</strong></td>
</tr>
<tr>
<td></td>
<td>Cylinder Arrangement</td>
</tr>
<tr>
<td></td>
<td>Number of Cylinder</td>
</tr>
<tr>
<td></td>
<td>Cylinder Bore</td>
</tr>
<tr>
<td></td>
<td>Piston Stroke</td>
</tr>
<tr>
<td>Permissible Speed</td>
<td>Belt Drive</td>
</tr>
<tr>
<td>Swept Volume at 1000 rpm</td>
<td>m3/hr</td>
</tr>
<tr>
<td>Direction of Rotation</td>
<td>Anti-Clockwise looking from flywheel end</td>
</tr>
<tr>
<td>Maximum Pressure</td>
<td>Discharge bar</td>
</tr>
<tr>
<td>Oil Charge Capacity</td>
<td>L</td>
</tr>
<tr>
<td>Cooling Water Flow for each Cylinder Jacket (for KC series only)</td>
<td>8 LMP/Cyl at water inlet temp. 30°C, 15 LPM/Cyl at water inlet emp. 40°C.</td>
</tr>
<tr>
<td>Weight of Compressor (Without Flywheel)</td>
<td>kg</td>
</tr>
<tr>
<td>Moment of Inertia GD2 of crank mechanism</td>
<td>Kg.m²</td>
</tr>
<tr>
<td>I e (block) Mixing Capacity with Ammonia Tones/day)</td>
<td>TPD</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>KW</td>
</tr>
</tbody>
</table>

Estimated Motor rating

*Electric motor of 50 HP and 1440 RPM, induction for operation on 440/400 volts, 50 cycles, 3 phase AC supply for driving the Compressor.*
### ii. Evaporative Condenser for Ammonia:-

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil section</td>
<td>Atmospheric Condenser of 10 Pipes of MS 50 mm thk Round pipe with fabrication and erection with angle grame 65x65x6 with water ling in GI 50mm B Class Pipe with header of 150mm dia GI pipe, all Complete item suitable for heat load of 550KW including sand blasting and ZINC spray galvanizing 120GSM.</td>
</tr>
<tr>
<td>Fan section</td>
<td>With 2 / 3 Axial Flow Fans with Cast Aluminium OR S.S impellers, complete with TEFC Sq. cage motors, Class F insulation &amp; IP-55 protection</td>
</tr>
<tr>
<td>Water sump tank</td>
<td>S.S.304 or M.S. Epoxy coated with necessary connections</td>
</tr>
<tr>
<td>Unit casing</td>
<td>Removable G.S sheet panels &amp; inspection windows etc.</td>
</tr>
<tr>
<td>Estimated Heat rejection capacity at 38 deg ‘C’ condensing &amp; and applicable WB temp</td>
<td>550 KW</td>
</tr>
<tr>
<td>Suggested Standard</td>
<td>ARI Std 490</td>
</tr>
</tbody>
</table>

**Air cooled / water cooled condenser for HFC / HCFC.**

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### iii) H.P. Receiver for Ammonia:-

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Ammonia receiver complete</td>
<td>With necessary connections, reflex type level gauge etc.</td>
</tr>
<tr>
<td>Size</td>
<td>600x6mtr long</td>
</tr>
<tr>
<td>Material of Construction</td>
<td>14mm thk plates</td>
</tr>
<tr>
<td>Quantity</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>Suggested Standard</td>
<td>ANSI / ARI 495/ BIS Code IS 2825</td>
</tr>
</tbody>
</table>

### iv) Air Cooling Units:

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Finned cooling coil</td>
<td>Coil design to be suitable for gravity feed / pump circulation for ammonia &amp; DX operation for HCFC / HFC as per design</td>
</tr>
<tr>
<td>M.O.C</td>
<td>Hot dip galvanized coil with M.S. pipes and with MS fins. Aluminium fins OR Aluminium tubes &amp; Aluminium fins with Proper bonding system with bullet drawn expansion / equivalent expansion for Ammonia.</td>
</tr>
<tr>
<td>Fin spacing</td>
<td>4 FPI</td>
</tr>
<tr>
<td>b) Axial Flow fans</td>
<td>3x710mm axial fans with cast aluminium / S.S. / FRP impellers, with variable pitch, TEFC</td>
</tr>
</tbody>
</table>
### ENGINEERING PROJECTS (INDIA) LIMITED

<table>
<thead>
<tr>
<th>Squirrel cage motors with class F insulation, IP-55 protection.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>c) Accumulator</strong> Vertical / horizontal with necessary connections (in case of gravity feed units) for Ammonia</td>
</tr>
<tr>
<td><strong>d) Unit casing</strong> G.I sheet duly powder coated, painted, drain pan of G.S with epoxy paint</td>
</tr>
<tr>
<td><strong>e) Defrosting arrangement</strong> Water</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Unit capacities</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number per chamber</strong> 3 Nos.</td>
</tr>
<tr>
<td>Estimated capacity each at critical operating conditions Refrigeration capacity 36 KW suitable for 0 deg ‘c’</td>
</tr>
<tr>
<td>Estimated air flow capacity each Air volume 48000 CMH</td>
</tr>
</tbody>
</table>

#### v. Refrigerant Piping, Fittings & Valves

| Piping Interconnecting piping between compressor, condenser, receive and cooling units M.S. black piping conforming to IS-1239 / ASTM A Gr.106B for 40 NB & smaller sizes / ASTM A Gr.53B for 50 NB & larger sizes. Pressure vessels as per BIS Code IS 2825). Reference to ASHRAE B-31.5 recommended |

#### vi. Water Piping, Fittings & Valves

<table>
<thead>
<tr>
<th>Piping shall be used for a. Condenser water circulation Piping to be G.I class B or sizes up to 65 NB &amp; M.S. black pipe conforming to IS-1239. Valves up to 40 NB to be Gate / Globe type. Valves 50 NB / larger to be butterfly type. b. Compressor cooling.</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. Defrosting</td>
</tr>
<tr>
<td>d. Drain lines</td>
</tr>
</tbody>
</table>

#### vii. Water Pump sets

<table>
<thead>
<tr>
<th>Water flow capacity to take care of condenser water flow &amp; compressor head / jacket cooling 2 nos. (one standby)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity 12m head, 12 LPS</td>
</tr>
</tbody>
</table>

#### viii. Thermal insulation for refrigerant piping etc.

<table>
<thead>
<tr>
<th>Material for insulation for refrigerant suction line, accumulators etc. a. EPS pipe section</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. PUF pipe section With 0.6 mm Aluminium or 0.5 mm G.S. pre-coated sheet cladding</td>
</tr>
<tr>
<td>c. Nitrile Rubber / EPDM / chemically cross linked polyethylene pipe section / other acceptable materials with woven glass cloth with UV treated pigmented epoxy Coating.</td>
</tr>
</tbody>
</table>
xii. **Controls**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA Monitoring Equipment</td>
<td>Oxygen and Carbon Di-oxide must be monitored daily or more frequently to ensure they are within the prescribed limit. Automatic gas analyzer and monitoring equipment is more accurate and widely used. This is further connected to a controller to automatically maintain proper gas concentration.</td>
</tr>
<tr>
<td>Pressure Equalization</td>
<td>Changes in pressure difference between the cold rooms and outside can damage the gas seal. Therefore suitable equalization system is necessary. This can be achieved by using breather bags which have the advantage of capturing the gas mixture and allowing it to re-enter the room at a later stage when the pressure drops.</td>
</tr>
<tr>
<td>Temperature control</td>
<td>Temp Indicators cum controllers for individual chambers. Temperature scanners and a centralized temperature indication in machine room. The thermostat sensors are usually placed 1.5 Mtr above the floor and should not be placed near source of heat like door openings, walls or exterior surface. Neither they should be placed near the cooling coil discharge. The thermometer / thermostat should be collaborated and periodically check for accuracy.</td>
</tr>
<tr>
<td>RH control</td>
<td>RH indicator &amp; controller</td>
</tr>
<tr>
<td>CO₂ control</td>
<td>CO₂ sensors for regulation of ventilation system. Automatic regulation is recommended</td>
</tr>
<tr>
<td>Refrigerant flow controls</td>
<td>Liquid level controls, solenoid valves etc.</td>
</tr>
<tr>
<td>PLC control systems</td>
<td>For overall control of various parameters</td>
</tr>
</tbody>
</table>
Puf panel for insulation

Make : Lloyd or Equivalent make

Specification as follows

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
<th>150</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>'U' Values W/m²K</td>
<td>0.36</td>
<td>0.26</td>
<td>0.21</td>
<td>0.19</td>
<td>0.14</td>
<td>0.11</td>
</tr>
<tr>
<td>Panel Weight Kg/m²</td>
<td>11.25</td>
<td>12.02</td>
<td>12.85</td>
<td>13.65</td>
<td>14.85</td>
<td>16.85</td>
</tr>
</tbody>
</table>

Properties of Polyurethane Foam (CFC Free)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>40±2 Kg/m³</td>
</tr>
<tr>
<td>Compressive Strength At 10% deformation</td>
<td>2.1 Kg/cm²</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>3.7 Kg/cm²</td>
</tr>
<tr>
<td>Bending Strength</td>
<td>4.0 Kg/cm²</td>
</tr>
<tr>
<td>Adhesion Strength (Foam to Steel)</td>
<td>2.9 Kg/cm²</td>
</tr>
<tr>
<td>Dimensional Stability (-25°C &amp; +38°C)</td>
<td>0.1%</td>
</tr>
<tr>
<td>&amp; 90% RH</td>
<td>0.1%</td>
</tr>
<tr>
<td>&amp; 90% RH (48hours)</td>
<td>0.4%</td>
</tr>
<tr>
<td>Close Cell Content</td>
<td>90-95%</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-180°C to +110°C</td>
</tr>
<tr>
<td>Thermal Conductivity at 10°C (design value)</td>
<td>0.020 k-cal/m-hr°C</td>
</tr>
<tr>
<td>(or 0.023 W/m·K)</td>
<td>0.018 k-cal/m-hr°C</td>
</tr>
<tr>
<td>Fire Horizontal Extent of Burn BS 4735</td>
<td>&lt;125mm</td>
</tr>
<tr>
<td>Self-Extinguishing ASTM D 1692 (Fire retarded foam chemical)</td>
<td>Passes</td>
</tr>
<tr>
<td>Hot easily ignitable as per BS: 476 Pt.5 &amp; Class -1 as per BS :476 Pt. 7 (for Panel)</td>
<td></td>
</tr>
<tr>
<td>Water Absorption</td>
<td>0.2% volume at 100% RH</td>
</tr>
<tr>
<td>Water Vapour Permeability (at 90% RH &amp; 38°C)</td>
<td>0.08-0.12 gms/hr m²</td>
</tr>
</tbody>
</table>

Poly Urethene composite sandwich Ceiling panels 100mm thk. For Ceiling with 0.50mm BMT pre painted Galvalume PPGL sheet on both sides, with tounge and groove joints.
INDUCTION MOTORS:-

Introduction:
AC three phase induction motors has to be designed and engineered in compliance with latest technical knowledge and production processes.

Applications:

Specification of equivalent makes:

<table>
<thead>
<tr>
<th>Performance</th>
<th>As per IS 325 and IS 12615</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>80-280; Dimension as per IS1231</td>
</tr>
<tr>
<td>Output</td>
<td>0.55kw to 90 kw</td>
</tr>
<tr>
<td>Voltage</td>
<td>41510% V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50Hz 5%</td>
</tr>
<tr>
<td>Combined Variation</td>
<td>10% (Absolute)</td>
</tr>
<tr>
<td>Insulation</td>
<td>Class Fº</td>
</tr>
<tr>
<td>Rating/Duty</td>
<td>Continuous/S1</td>
</tr>
<tr>
<td>Mounting</td>
<td>Foot Mounting: B3,B6,B7,B8,V5,V6 Flange Mounting: B5,V1,V3 Face Mounting: B14,V18,V19</td>
</tr>
<tr>
<td>Ambient/Temperature rise</td>
<td>50°C/70°C (Limited to Class ‘B’ Temperature Rise)</td>
</tr>
<tr>
<td>Enclosure</td>
<td>TFFC</td>
</tr>
<tr>
<td>Degree of Protection</td>
<td>IP55 as per IS: 4691</td>
</tr>
<tr>
<td>Altitude</td>
<td>Up to 1000m above mean sea level</td>
</tr>
<tr>
<td>Direction of Rotation</td>
<td>Bi-directional</td>
</tr>
</tbody>
</table>

Conformance to Standards:
Induction motors has to be specially designed in accordance with latest BIS standard specifications and relevant IEC publications.

<table>
<thead>
<tr>
<th>Standard Specification</th>
<th>BIS</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Phase Induction motor specifications</td>
<td>IS 325</td>
<td>60034 – 1</td>
</tr>
<tr>
<td>Method of determination of efficiency of rotating electrical machines</td>
<td>IS 4889</td>
<td>60034 – 2</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IS 4691</td>
<td>60034 – 5</td>
</tr>
<tr>
<td>Designation of method of cooling of rotating electrical</td>
<td>IS 6362</td>
<td>60034 – 6</td>
</tr>
<tr>
<td>Description</td>
<td>IS</td>
<td>Number</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>-------</td>
<td>--------------</td>
</tr>
<tr>
<td>Type of construction and mounting arrangement for rotating electrical machines</td>
<td>2253</td>
<td>60034 – 7</td>
</tr>
<tr>
<td>Terminal marking and direction of rotation for electrical rotating machines</td>
<td>4728</td>
<td>60034 – 8</td>
</tr>
<tr>
<td>Permissible limit of noise level for rotating Electrical machines</td>
<td>12065</td>
<td>60034 – 9</td>
</tr>
<tr>
<td>Mechanical vibration of rotating electric machines with shaft height 56 mm and above - Measurement, Evaluation and limit of vibration severity</td>
<td>12075</td>
<td>60034 – 14</td>
</tr>
<tr>
<td>Three phase foot mounted induction motors dimensions</td>
<td>1231</td>
<td>-</td>
</tr>
<tr>
<td>Three phase flange mounted AC induction motors dimensions</td>
<td>2223</td>
<td>60072 –1</td>
</tr>
<tr>
<td>Specification for energy efficient Three Phase Induction motor</td>
<td>12615</td>
<td>-</td>
</tr>
<tr>
<td>Class of insulation</td>
<td>1271</td>
<td>60085</td>
</tr>
</tbody>
</table>
CHAPTER - 11
PLUMBING
11.1 APPLIANCES AND FITTINGS

11.1.0 All vitreous sanitary appliances (Vitreous China) shall conform to IS 2556 (Part-I) general requirements.

11.1.1 Flushing Cisterns (Fig. 17.3)
The flushing cisterns shall be automatic or manually operated high level or low level as specified, for water closets and urinals. A high level cistern is intended to operate with minimum height of 125 cm and a low level cistern with a maximum height of 30 cm between the top of the pan and the underside of the cistern.

Cisterns shall be of following type (i) Vitreous China (IS 774) for Flushing type (ii) Automatic Flushing Cistern (IS 2326) and (iii) Plastic cisterns (IS 7231).

11.1.1.1 Vitreous Chine Cisterns: The thickness of the body including cover shall be not less than 6 mm for vitreous China cisterns. The outlet of each syphon or stand pipe shall be securely connected to the cistern by means of lock nut. The cistern shall be free from manufacturing faults and other defects affecting their utility. All working parts shall be designed to operate smoothly and efficiently. Cistern shall be mosquito proof. A cistern shall be considered mosquito proof only if there is no clearance anywhere which would permit a 1.6 mm wire to pass through in the permanent position of the cistern i.e. in the flushing position or filling position.

The breadth of a low level cistern, from front to back shall be such that the cover or seat, or both, of water closet pan shall come to rest in a stable position when raised.

The cistern shall be supported on two cast iron brackets of size as approved by the Engineer-in-Charge and embedded in cement concrete 1:2:4 block 100 x 75 x 150 mm. These shall be properly protected by suitable impervious paint. Alternatively the cisterns shall have two holes in the back side above the overflow level for screwing into the wall, supplemented by two cast iron wall supports. A 5 liters cistern, however, may be supported by larger brackets cast on the body of the cistern.

The cistern shall have a removable cover which shall fit closely on it and be secured against displacement. In designs where the operating mechanism is attached to the cover this may be made in two sections, but the section supporting the mechanism shall be securely bolted or screwed to the body. The outlet fitting of each cistern shall be securely connected to the cistern. The nominal internal diameter of cistern outlet shall be not less than 38 ± 1mm for low level cisterns respectively. The length of the outlet of the cistern shall be 37 ± 2 mm.

Ball valve shall be of screwed type 15 mm in diameter and shall conform to IS 1703. The float shall be made of polyethylene as specified in IS 9762. (The design shall permit the cistern to fill in rapidly and close effectively when the level of water reaches the working water level.)

In the case of manually operated cisterns the siphonic action of the flushing cistern shall be capable of being rapidly brought into action by the operating lever, but shall not self siphon or leak. When tested according to IS 774 the discharge rate shall be 10 ± 0.5 litre in 6 seconds and 5 ± 0.5 litre in 3 seconds for cisterns of capacities 10 litre and 5 litre respectively. The cisterns shall be so designed that there is not appreciable variation in the force of flush during the discharge of the required quantity of water. The cistern shall have a discharge capacity of 5 & 10 litres as specified. When required to give a full flush, they shall respectively discharge 5 litres and 10 litres with variation of ± 0.5 litres.
The flush pipe shall be of (a) medium quality galvanized iron having internal diameter of 38 ± 1 mm for low level cistern. The flush pipe shall be of suitable length with bends etc. as required for fixing it with front or back inlet W.C. Pan. (b) Polyethylene pipes low density conforming to IS 3076 or high density (c) Unplasticised PVC pipes. For high density polyethylene and unplasticised PVC pipes, the outside diameter of the pipes shall be 40 mm. When PVC plumbing pipes are used the outside diameter of the pipe shall be 40 mm for high level cisterns and 50 mm for low level cisterns.

In case of low level cistern the flush pipe shall be a vertical pipe 30 cm long and having a nominal internal dia 38 ± 1 mm (except plastic flush pipes).

**Over Flow Pipe**

11.1.2 GI overflow pipe shall be of not less than 20 mm nominal bore and shall incorporate a noncorrodible mosquito proof brass cover having 1.25 mm dia perforation, screwed in a manner which will permit it to be readily cleaned or renewed when necessary. No provision shall be made whereby the overflow from the cistern shall discharge directly into the water closet or soil pipe without being detected.

The invert of the overflow pipe in the case of high level and low level cisterns shall be 19 mm minimum above the working water level. In case of overflow due to any reason water should drain out through the over flow pipe and not through the siphon pipe.

11.1.3 The plastic overflow pipes shall be manufactured from high density polyethylene conforming to IS 4984 or unplasticised P.V.C. conforming to IS 4985.

**Inlet and Overflow Holes:** The cistern shall be provided with inlet and overflow holes, situated one at each end which shall be capable of accommodating an overflow pipe of not less than 20 mm nominal bore and a 15 mm size ball valve. The holes shall be cleanly cast or drilled and the adjacent surfaces shall be smooth.

11.2 Sand Cast Iron or Centrifugally Cast (Spun) Iron Pipes and Fittings

Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories shall conform to IS 1729. Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories shall conform to IS 3989.

The fittings shall conform to the same I.S. specifications to which the pipe itself conforms in which they are connected.

The pipes shall have spigot and socket ends, with head on spigot end in case of sand cast iron pipes and without head on spigot end in case of cast iron (Spun) pipes. The pipes and fittings shall be true to shape, smooth and cylindrical, their inner and outer surface being as nearly as practicable concentric. They shall be sound and shall be free from cracks, taps, pinholes and other imperfection sand shall be neatly dressed and carefully fettled. All pipes and fittings shall ring clearly when struck with a light hand hammer.

The ends of pipes and fittings shall be reasonably square to their axis. The sand cast iron pipes shall be 1.5/1.8/2.0 metre in length including socket ends, cast iron (Spun) pipes shall be 1.5/1.75/2.0/2.5/3.0 metre in length excluding socket ends, unless shorter lengths are either specified or required at junctions etc. The pipe and fittings shall be supplied without ears, unless specified or directed otherwise.
All pipes and fittings shall be coated internally and externally with the same material at the factory, the fitting being preheated prior to total immersion in a bath containing a uniformly heated composition having a tar or other suitable base. The coating material shall have good adherence and shall not scale off. In all instances where the coating material has tar or similar base it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 77 degree centigrade but not so brittle at a temperature of 0 degree centigrade as to chip off when scribed lightly with a pen knife.

The standard weights and thicknesses of pipes and their tolerances shall be as prescribed in Appendix A.

The thickness of fittings and their socket and spigot dimensions shall conform to the thickness and dimensions specified for the corresponding sizes of straight pipes. The tolerance in weights & thicknesses shall be the same as for straight pipes.

The access door fittings shall be designed so as to avoid dead spaces in which filth may accumulate. Doors shall be provided with 3 mm rubber insertion packing and when closed and bolted, these shall be water tight.

**Sand Cast Iron Floor Trap or Nahani Trap**
Sand cast Iron Floor trap or 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.

**11.2.1 Sinks**
Laboratory sinks and Kitchen sinks shall be of white glazed fire clay confirming to IS 771 (Part-2) with up to date amendments. The kitchen sink shall be of one piece construction with or without rim but without overflow.

**11.2.1.1 Stainless steel kitchen sink** shall be of sizes as specified and shall be conforming to IS 13983

**11.3 Urinals**
**11.3.1 Bowl Type Urinals**: Urinal basins shall be of flat back or corner wall type lipped in front. These shall be of white vitreous china conforming to IS 2556-(Part 6). The urinals shall of one piece construction. Each urinal shall be provided with not less than two fixing holes of minimum dia 6.5 mm on each side. Each urinal shall have an integral flushing rim of suitable type and inlet or supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. It shall have a weep hole at the flushing inlet of the urinals.

At the bottom of the urinal an outlet horn for connecting to an outlet pipe shall be provided. The exterior of the outlet horn shall not be glazed and the surface shall be provided with grooves at right angles to the axis of the outlet to facilitate fixing to the outlet pipe. The inside surface of the urinal shall be uniform and smooth throughout to ensure efficient flushing. The bottom of pan shall have sufficient slope from the front towards the outlet such that there is efficient draining.

**11.3.2 Half Stall Urinals**: They shall be of white vitreous China conforming to IS 2556 (Part 6). They shall be of one piece construction with or without an integral flushing box rim and provided with slots or alternative fixing arrangement at the flat back end. They shall be provided with ridges where integral flushing rim 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-6 (Fig. 17.13). These shall be vitreous China of one piece construction with integral flush inlet. The tolerance of ± 4 per cent may be allowed on the dimensions specified.

11.3.3 Urinal Partition Slabs: Urinal Partition slabs shall be provided, as specified in the item of work.

11.3.4 Squatting Plate Urinal : The plates shall be of white vitreous china conforming to IS 2556 (Part-1) and IS 2556 (Part-6) 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. These shall be 100 mm dia white glazed vitreous china channel with stop and outlet piece in front.

11.3.5 Wash Basins
Wash basins shall be of white vitreous china conforming to IS 2556 (Part-I) and IS 2556 (Part-4). Wash basins either of flat back or angle back as specified shall be of one piece construction, including a combined overflow. 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 diameter of 65 mm at top. Each basin shall be provided with a 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 sq. cm, shall be provided and shall be so designed as to facilitate cleaning of the overflow.

Where oval shape or round shape wash basins are required to be fixed these shall be fixed preferably in RCC platform with local available stone topping either fully sunk in stone top or top flush with the stone topping as directed by Engineer-in-Charge.

The wash basins shall be one of the following patterns and sizes as specified (Fig. 17.14).
(a) Flat back: 660 x 460 mm (Surgeon’s Basin)
630 x 450 mm
550 x 400 mm
450 x 300 mm

(b) Angle back: 600 x 480 mm
400 x 400 mm

White glazed pedestals for wash basins, where specified shall be provided. The quality of the glazing of the pedestal shall be exactly the same as that of the basin along with which it is to be installed. It shall be completely recessed at the back to accommodate supply and waste pipes and fittings. It shall be capable of supporting the basin rigidly and adequately and shall be so designed as to make the height from the floor to top of the rim of basin 75 to 80 cm as shown in Fig. 17.14, 17.15, 17.16, 17.17 & 17.18. All the waste fittings shall be brass chromium plated, or as specified.
11.3.6 Waste Fittings for Wash Basins and Sinks (Fig. 17.8)

The waste fittings shall be of nickel chromium plated brass, with thickness of plating not less than service grade 2 of IS 4827 which is capable of receiving polish and will not easily scale off. The fitting shall conform in all respect to IS 2963 and shall be sound, free from laps, blow holes and fittings and other manufacturing defects. External and internal surfaces shall be clean and smooth. They shall be neatly dressed and be truly machined so that the nut smoothly moves on the body.

Waste fitting for wash basins shall be of nominal size of 32 mm. Waste fittings for sinks shall be of nominal size 50 mm.

11.3.7 Water Closet (Fig. 17.19, 17.20, 17.21, 17.22 & 17.23)

11.3.7.1 Squatting Pans (Indian Type W.C.) (Fig. 17.19, 17.20 & 17.21) : Squatting pans shall be of white vitreous china conforming to IS 2556 Part-I for General Requirements and relevant IS codes for each pattern as described below:

(i) Long pattern-conforming to IS 2556 (Part-3).
(ii) Orissa pattern-conforming to IS 2556 (Part-3).
(iii) Integrated type conforming to IS 2556 (Part-14).

Preferably Orissa type pan should be used.

Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush pipes, as shown in Fig. 17.19, 17.20 & 17.21. 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-in-Charge. 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 ‘P’ or ‘S’ type with approximately 50 mm water seal and 50 mm dia vent horn, where required by the Engineer-in-Charge.

11.3.7.2 Wash Down Type (European Type W.C.) (Fig. 17.22 & 17.23) : Water closets shall be of white vitreous china conforming to IS 2556 (Part-1) and 2556 (Part-2), as specified and shall be of “Wash down type”. The closets shall be either of the two patterns (Pattern I & Pattern II) and sizes as shown in Fig. 17.22 & 17.23 as specified. The closets shall be of one piece construction. Each water closet shall have not less than two holes having a minimum diameter of 6.5 mm for fixing to floor and shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flushing pipe of dimensions as shown in table in Fig. 17.20 & 17.21 the flushing rim may be boxed or open type. In the case of box rims adequate number of holes, on each side together with a slot opposite the inlet shall be provided. The flushing rim and inlet shall be of the self draining type. The water closet shall have a weep hole at the flushing inlet. Each water closet shall have an integral trap with either ‘S’ or ‘P’ outlet with at least 50 mm water seal. For P trap, the slope of the outlet shall be 14 deg. below the horizontal. Where required the water closet shall have an antisiphonage 50 mm dia vent horn on the outlet side of the trap with dimension conforming to those given in Fig. 17.22 and on either right or left hand or centre as specified set at an angle of 45 deg. and invert of vent hole not below the central line of the outlet. The inside surface of water closets and traps shall be uniform and smooth in order to enable an efficient flush. The serrated part of the outlet shall not be glazed externally. The water closet, when sealed at the bottom of the trap in line with the back plate, shall be capable of holding not less than 15 litres of water between the normal water level and the highest possible water level of the water closet as installed.
CHAPTER 12

FLOORING
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12.1 BRICK ON EDGE FLOORING

12.1.1 Bricks
Bricks of Specified class designations shall be used. These shall conform to the specifications described in Subhead 6.0. Broken bricks shall not be used in flooring except for closing the line. The bricks shall be laid on edge.

12.1.2 Mortar
The mortar used shall be as specified (in case of dry bricks flooring fine sand shall be filled in the joints).

12.1.3 Base Concrete
12.1.3.1 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-in-Charge. Floors in water closet portion shall have slope of 1 : 30 or as decided by the Engineer-in-Charge to drain off washing water. Plinth masonry off-set shall be depressed so as to allow the base concrete to rest on it.

12.1.3.2 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.

12.1.3.3 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.

12.1.4 Soaking of Bricks
Bricks required for flooring shall be perfectly soaked in stacks before use, by profusely spraying clean water at regular intervals for a period of not less than six hours so as to keep them wet to the satisfaction of the Engineer-in-Charge. (In case the joints are to be filled with sand, the bricks need not be soaked).

12.1.5 Laying
12.1.5.1 The bricks shall be laid on the edge, diagonal herring bone bond, or other pattern as specified or directed by the Engineer-in-Charge.
12.1.5.2 Bricks shall be laid on edge on 12 mm thick mortar of specified ratio 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.
12.1.5.3 On completion of a portion of flooring, the vertical joints shall be fully filled from the top with mortar. During laying, the surface of the flooring shall be frequently checked with a straight edge of length at least 2 m, so as to obtain a true plain surface with the required slope.
12.1.6 Joints
Bricks shall be so laid that all joints are full of 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 done and all mortar droppings removed promptly.

12.1.7 Curing
Brick work shall be protected from rain by suitable covering when the mortar is green. Brick work in cement mortar, shall be kept constantly moist on all faces for a minimum period of seven days. Brick work carried out shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period.

12.1.8 Measurements
Length and breadth of the flooring shall be measured correct to a cm and area 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. Brick flooring when laid in diagonal herring bone bond or other pattern as specified or directed by the Engineer-in-Charge shall be measured separately.

12.1.9 Rate
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.

12.1.10 Dry Brick Flooring
All provisions of para’s 12.1.1 to 12.1.8 will be applicable except that 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 thin as possible and not exceeding 5 mm which will be filled with fine sand. No curing is to be done.

1.1.10.1 Rate: The rate shall include the cost of all materials and labour involved in all the operations described above.

12.2 CEMENT CONCRETE FLOORING
12.2.1 Cement Concrete
Cement concrete of specified mix grade shall be used and it shall generally conform to the specifications described under sub head 4.0.

12.2.2 Base Concrete
12.2.2.1 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-in-Charge. Floors in water closet portion shall have slope of 1:30 or as decided by the Engineer-in-Charge to drain off washing water. Further, necessary drop in flooring in bath, WC, kitchen near floor traps ranging from 6 mm to 10 mm will also be provided to avoid spread of water. Necessary margin to accommodate this drop shall be made in base concrete. Plinth masonry off set shall be depressed so as to allow the base concrete to rest on it.

12.2.2.2 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 @ 2 kg of cement spread over an area of one sqm so as to get a good bond between the base and concrete floor.

12.2.2.3 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 @ 2 kg of cement spread over an area of one sqm so as to get a good bond between the base and concrete floor.

12.2.3 Thickness
The thickness of floor shall be as specified in the description of the item.

12.2.4 Laying
12.2.4.1 Panels: Flooring of specified thickness shall be laid in the pattern including the border as given in the drawings or as directed by the Engineer-in-Charge. The border panels shall not exceed 450 mm in width and the joints in the border shall be 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. The joints of borders at corners shall be mitred for provision of strips.

12.2.4.2 Laying of Flooring with Strips: Normally cement concrete flooring shall be laid in one operation using glass/aluminium/PVC/brass strips/stainless steel strips or any other strips as required as per drawing or instructions of the Engineer-in-Charge, 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 2 mm PVC strips or 2 mm aluminium or brass strips shall be fixed with their tops at proper level, giving required slopes. Use of glass and metallic strips shall be avoided in areas exposed to sun. Cost of providing and fixing strips shall be paid for separately.

Concreting: Cement concrete shall be placed in the panels and be levelled with the help of straight edge and trowel and beaten with thapy or mason’s 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. Surface of flooring be true to required slopes. While laying concrete, care shall be taken to see that the strips are not damaged/disturbed by the labourers. The tops of strips shall be visible clearly after finishing with cement slurry.

12.2.4.3 Laying of Flooring without Strips: Laying of cement concrete flooring in alternate panels may be allowed by the Engineer-in-Charge in case strips are not to be provided.

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.

Concreting: The concreting shall be done in the manner described under 12.2.4.2. 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.

12.2.5 Finishing
12.2.5.1 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 stiffening the concrete to absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided.
12.2.5.2 Fresh cement shall be mixed with water to form a thick slurry and spreaded @ 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.

12.2.5.3 The edges of sunk floors shall be finished and rounded with cement mortar 1:2 (1 cement : 2 coarse sand) and finished with a floating coat of neat cement.

12.2.5.4 The junctions of floor with wall plaster, dado or skirting shall be rounded off where so specified.

12.2.5.5 The men engaged on finishing operations shall be provided with raised wooden platform to sit on so as to prevent damage to new work.

12.2.6 Curing
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 bag shall be avoided as the colour of the flooring is likely to be bleached due to the remanents of cement dust from the bags.

12.2.7 Precautions
Flooring in lavatories and bath room shall be laid only 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 W.C.’s squatting pans and floor traps during the execution of work shall be made good.
During cold weather, concreting shall not be done when the temperature falls below 4°C. 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°C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge. 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.

12.2.8 Measurement
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.
The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

12.2.9 Rate
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.

12.3 CEMENT CONCRETE FLOORING WITH METALLIC HARDENER TOPPING
12.3.0 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 hardner is justified on the basis of cost. Where metallic hardener topping is used, it shall be 12 mm thick.

12.3.1 Metallic Hardening Compound
The compound shall be of 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-in-Charge it shall be tested as described in Appendix A.

**12.3.2 Base Concrete**
It shall be as specified in 12.2.2.

**12.3.3 Under Layer**
Cement concrete flooring of specified thickness and mix (mentioned in item for under layer) shall be laid as under layer (12.2.1 and 12.2.4). The top surface shall be roughened with brushes while the concrete is still green and the forms/strips shall be kept projecting up 12 mm over the concrete surface, to receive the metallic hardening compound topping.

**12.3.4 Topping**
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 pacca platform. This 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) and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete. 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.

The junction of floor with wall plaster, dado or skirting and finishing operations shall be dealt with as described in 12.2.5.

The men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as to prevent damage to new work.

**12.3.5** The specifications for curing, precautions to be taken, ‘Measurements’ and ‘Rates’ shall be as specified in 12.2.

**12.4 CEMENT PLASTER IN RISERS OF STEPS, SKIRTING, DADO**

**12.4.0** 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 or projecting out uniformly by 6 mm from the 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.

**12.4.1 Thickness**
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 shall not be less than the specified thickness. The average thickness should be regulated at the time of plastering by keeping suitable thickness of the gauges. Extra thickness required in rounding of corners at junctions of wall shall be ignored.

**12.4.2 Preparation of Wall Surface**
The joints shall be raked out to a depth of at least 15 mm in masonry walls. In case of concrete walls, the surfaces shall be roughened by hacking. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

**12.4.3 Application**
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 with top truly horizontal and joints truly vertical except where otherwise indicated.
12.4.4 Finishing
The finishing of surface shall be done simultaneously with the borders or 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. Where skirting is flush with plaster, a groove 10 mm wide and upto 5 mm deep shall be provided in plaster at the junction of skirting with plaster.

12.4.5 Curing
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.

12.4.6 Measurement
Length and height shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimals for a specified 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.

12.4.7 Rate
Rate shall include the cost of all materials and labour involved in all the operations described above.

12.5 CEMENT CONCRETE PAVEMENT IN COURTYARD AND TERRACE ETC.
12.5.1 Specifications described in 12.2.1, 12.2.2.1, 12.2.3, 12.2.4, 12.2.6 and 12.2.7 shall hold good as far as applicable except that:
(i) 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.
(ii) Concreting shall be done in alternate panels only and no glass/asbestos strips shall be provided.

12.5.2 Finishing
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 mix on the surface to stiffen the concrete or to absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided. When the 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.

12.5.3 Measurements
Same as 12.2.8 except that the volume will be calculated in cum nearest to two decimal places.

12.5.4 Rate
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.

12.6 TERRAZO (MARBLE CHIPS) FLOORING LAID IN SITU
12.6.1 Under Layer
Cement concrete of specified mix shall be used and the specifications given under sub head 4.0 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 @ 2.00 kg per sqm shall be applied before laying of under layer over the base cement concrete/RCC base.
12.6.2 Fixing of Strips
4 mm thick glass strips or 2 mm thick PVC strips/aluminium strips/brass strips / stainless steel strips/copper 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. Use of glass and metallic strips shall be avoided in areas exposed to sun. The fixing and laying shall be as specified in para 12.2.4.2.

12.6.3 Top Layer
12.6.3.1 Mortar : The mix for terrazo 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 1. 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 crystaline 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 12.1 below:

<table>
<thead>
<tr>
<th>Grade No.</th>
<th>Size of Aggregates in (mm)</th>
<th>Proportion of Aggregates to Binder Mix</th>
<th>Minimum Thickness of Top Layer (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>1 — 2</td>
<td>1.75 : 1</td>
<td>6</td>
</tr>
<tr>
<td>0</td>
<td>2 — 4</td>
<td>1.75 : 1</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>4 — 7</td>
<td>1.5 : 1</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>7 — 10</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Aggregate of size larger than 10 mm are used, the minimum thickness of topping shall not be less than one and one third 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.

Before starting the work, the contractor shall get the sample of marble chips approved from the Engineer-in-Charge. This shall be done in advance by mixing different colour marble chips and panel samples of minimum 1 m x 1 m size shall be prepared and got approved from the Engineer-in-charge before laying of flooring. The cement to be used shall be ordinary grey cement, white cement, 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-in-Charge. 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 contain just sufficient water to make it workable.

The terrazo 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 the 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 up and are spread uniformly over the surface.

**12.6.3.2 Curing, Polishing and Finishing** : The surface shall be left dry for air-curing for a duration of 12 to 18 hours depending on atmospheric temperature conditions. It shall then be cured by allowing water to stand in pools over it for a period of not less than 4 days.

The grinding and polishing may be commenced not before 2 days from the time of completion of laying for manual grinding and not before 7 days for machine grinding. For polishing by machines, 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 and proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to dry for 24 hours and wet cured for 4 days and then rubbed with machine fitted with fine grit blocks (No. 120). Curing shall be done by ponding of water between panels formed with fine sand. 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 mere fine grit blocks (No. 320) to get even and smooth surface without pin holes. The finished surface should show the marble chips evenly exposed.

Where use of machine for polishing is not feasible or possible, rubbing and polishing shall be 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 polishing.

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, the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

Curing shall be done by suitable means such as laying moist sawdust or ponding water.

**12.6.4 Precautions**

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.

During cold weather, concreting shall not be done when the temperature falls below 4°C. The concrete placed 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 exceed 38°C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge.

**12.6.5 Measurements**

**12.6.5.1** Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. The area as laid shall be calculated in sqm correct to two decimal places.

The thickness of the under layer shall be measured correct to a cm. The thickness of top layer shall not be less than that specified.

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 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room or Courtyard.

**12.6.5.2** Terrazo (Marble Chips) flooring laid as floor borders, margins and similar bands upto 30 cm width and on staircase treads shall be measured under the item of terrazo 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 for staircase treads etc. 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 metres for this purpose.

12.6.5.3 Dividing strips inserted in terrazo to form bays, patterns shall be described stating the materials, its width and thickness and measured in running metres.

12.6.5.4 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.

12.6.6 Rate
The rate shall include the cost of all materials 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 be paid for separately.

12.7 TERRAZO (MARBLE CHIPS) SKIRTING IN SITU
12.7.1 Under Coat
The under coat of skirting shall be of cement plaster of the thickness and mix described in the item. Specifications given under 12.4.0, 12.4.1 and 12.4.2 shall apply. As regards application, the work shall be carried out in the manner described in para 12.4.3 except that the under coat shall be finished rough with a scratching tool to form a key for the top coat.

12.7.2 Top Coat
The specifications as in para 12.6.3 shall hold good as far as applicable and shall include cutting to line and fair finish to top edges of terrazo and polishing.

12.7.3 Thickness
The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of the total 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.

12.7.4 Measurements
Length and height 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 of skirting does not exceed 30 cm and when the height exceeds 30 cm it shall be measured correct to a cm.

12.7.5 Rates
The rate shall include the cost of all materials and labour involved in all the operations described above.

12.8 WAX POLISHING
12.8.1 Application, Polishing and Precautions
Wax polish shall be of approved brand and manufacture and in sealed containers. It shall be applied in uniform layer to the dry surface of the floor/skirting.
12.8.2 When the layer of the wax is stiffened and surface of floor is saturated with the polish, polishing shall be resorted with machine fitted with bobs (pad of rags) and shall be done until shades of all chips have appeared and glossy surface is obtained.
12.8.3 The fresh polished floor surface shall be spreaded with dry saw dust to a thickness of about 12 mm uniformly. After the surplus wax has been soaked from the floor surface the saw dust shall be removed.

12.8.4 Measurements
Length and breadth shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimal.

12.8.5 Rates
The rate shall include the cost of all materials and labour involved in all the operations described above.

12.9 CRAZY MARBLE FLOORING (Fig. 12.1)

12.9.1 Base Concrete
Crazy marble stone flooring shall be laid on cement 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.

Before laying the flooring on RCC slabs, the laitance shall be removed, the surface of slab hacked and a coat of cement slurry at rate of 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.

12.9.2 Under Layer
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 para 4.2 of sub-head ‘Cement Concrete’.

12.9.3 Top Layer
The mix of crazy marble stone flooring shall consist of white cement 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 contractor shall get the sample of marble stone approved by the Engineer-in-Charge. The marble stone pieces shall be of sizes as approved by the Engineer-in-Charge 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.

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 stains, cracks decay and weathering.

12.9.4 Laying
A coat 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 and brought to the level of the laid marble stone pieces.
12.9.5 Polishing
Curing and Finishing shall be as described in 12.6.3.2.

12.9.6 Precautions
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.

12.9.7 Measurements
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.

12.9.8 Rate
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.

12.10 TERRAZO TILE FLOORING
12.10.1 Terrazo Tiles
Terrazo tiles shall generally conform to IS 1237-Edition 2.3. Requirements and methods of testing of tiles are described in Appendix B. Unless otherwise specified, the tiles shall be supplied with initial grinding and grouting of wearing layer.

The size of tiles shall be as given in Table 12.2 or as shown in the drawings or as required by the Engineer-in-Charge. Half tiles for use with the full tiles shall be such as to make two half tiles when joined together, match with the dimensions of one full tile.

<table>
<thead>
<tr>
<th>Length</th>
<th>Breadth Nominal</th>
<th>Thickness not less than</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 mm</td>
<td>200 mm</td>
<td>20 mm</td>
</tr>
<tr>
<td>250 mm</td>
<td>250 mm</td>
<td>22 mm</td>
</tr>
<tr>
<td>300 mm</td>
<td>300 mm</td>
<td>25 mm</td>
</tr>
</tbody>
</table>

12.10.2 Laying
12.10.2.1 Base concrete or RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with cement mortar of specified proportion and in conformity with provisions in relevant para of chapter on ‘Mortar’. Cement mortar 1:4 (1 Cement : 4 coarse sand) bedding shall be used. Average thickness of the bedding mortar shall be 20 mm and the thickness at any place shall not be less than 10 mm.

12.10.2.2 Cement 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 terrazo tiles, these shall be set immediately after laying the mortar. Over this bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 4.4 kg of cement per square 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 mm and in straight lines or to suit the required pattern. The joints shall be properly cleaned before filling with cement grout of matching colour.

12.10.2.3 The surface of the flooring during laying shall be frequently checked with a straight edge of length at least 2 metre, so as to obtain a true surface with the required slope.

12.10.2.4 Where full tiles or half tiles can not 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.

12.10.2.5 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.

12.10.2.6 After the tiles have been laid, surplus cement grout that may have come out of the joints shall be cleared off.

12.10.3 Curing, Polishing and Finishing
12.10.3.1 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 then 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.

12.10.3.2 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 pin hole 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).

12.10.3.3 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-in-Charge.

12.10.3.4 For small areas or where circumstances so require, hand grinding/polishing with hand grinder may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1st grinding — coarse grade stone (No. 60)
Second grinding — medium grade (No. 80)
Final grinding — fine grade (No. 120)
In all other respects, the process shall be similar as for machine polishing.

12.10.3.5 After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square metre 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.

12.10.3.6 If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.
12.10.4 Measurements
12.10.4.1 Terrazo tiles flooring with tiles manufactured from ordinary grey cement without pigment and coloured terrazo tile flooring shall be measured separately according to para 12.6.5. Terrazo tile flooring shall be measured as laid in square metre 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 nor for laying the floor at different levels in the same room or courtyard.

12.10.4.2 Terrazo tile flooring laid in floor borders and similar band shall be measured under the item of terrazo tile flooring. Nothing extra shall be paid in respect of these and similar bands formed of half size or multiples of half size standard tiles or other uncut tiles.

12.10.4.3 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.

12.10.5 Rate
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.

12.11 TERRAZO TILES IN RISERS OF STEPS, SKIRTING AND DADO
12.11.1 The terrazo tiles shall be as specified in 11.10.1, 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 up to 12 mm and not less than 6 mm for size of chips varying from the smallest up to 20 mm. Where the bigger sized chips are used the tiles shall be not less than 20 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.

12.11.2 Preparation of Surface
The specification for this shall be same as specified in 11.4.2.

12.11.3 Laying
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 then 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 with projection from finish wall surface not more than tile thickness and joints truly vertical except where otherwise indicated. 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 (sawn) to the required size and their edges rubbed smooth.

12.11.4 Curing, Polishing and Finishing
The specifications as in 12.10.3 shall hold good as far as applicable. Polishing shall be done only with hand.

12.11.5 Measurements
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 cm, 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. 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.

12.11.6 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be payable for use of cut (sawn) tiles to suit the size of risers, skirting, portions of dado etc.

12.12 CHEQUERED TILE FLOORING
12.12.1 Chequered Tiles
The tiles shall be of nominal sizes such as 20 × 20 cm, 25 × 25 cm and 30 × 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-in-Charge. The centre to centre distance of chequers shall not be less than 2.5 cm and not more than 5 cm.

The overall thickness of the tiles shall not be less than 30 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 terrazo 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.

The terrazo tiles shall be given the first grinding with machine before delivery to site. The tiles shall conform to the specifications for plain cement concrete or terrazo tiles in respect of method of manufacture and the mix of the backing and wearing layers.

12.12.2 Laying, curing, Polishing and Finishing shall be as specified in 12.10.2 and 12.10.3 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 tiles normally do not require polishing but where polishing is required the same shall be done as described above.

12.12.3 Measurement and Rate: Shall be as specified in 12.10.4 and 12.10.5.

12.13 CHEQUERED TILES IN STAIR TREADS (FIG. 12.2)
12.13.1 Chequered Tiles
The specifications for tiles shall be as specified in 12.12.1 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 mm.
(4) The front portion of the tile for a minimum length of 75 mm from and including the nosing shall have grooves running parallel 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.

12.13.2 Preparation of Surface and Laying
12.13.2.1 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 cement mortar 1:4 (1 cement : 4 coarse sand) or of specified mix. The minimum thickness of bedding mortar at any place shall be 10 mm. 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 butting 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 as thin as possible and in straight lines. The surface shall be
checked with a straight edge during laying to obtain a true surface.

12.13.2.2 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 mm.

12.13.2.3 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.

12.13.2.4 After the tiles have been laid surplus cement grout shall be cleaned off.

12.13.3 Curing, Polishing and Finishing
The specifications shall be as described in 12.10.3 except that polishing of the treads nosing and chequered grooves, after laying, may be done by hand in the same manner as specified under terrazo tile 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.

12.13.4 Measurements
Chequred 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 not exceeding 0.10 square metre.

12.13.5 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.
Nothing extra shall be payable for cutting the tiles to suit the size of treads and also for nosing.

12.14 ACID OR ALKALI RESISTANT TILES
12.14.0 Manufacture and Finish
The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 1200°C and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogenous. The tiles shall be sound, true to shape, flat and free from flows and manufacturing defects affecting their utility.

The tiles shall be conforming to IS 4457. The tiles to be tested for water absorption, compressive strength, acid resistance as per IS 4457. Sampling procedure for acceptance tests and criteria for conformity to be as per IS 4457. The tiles shall be of required colour.

12.14.1 Dimensions and Tolerances
Ceramic unglazed vitreous acid-resistant tiles shall be made in three sizes namely 98.5 X 98.5 mm, 148.5 X 148.5 mm and 198.5 X 198.5 mm. They shall be available in the following thickness: 35, 30, 25, 20 and 15 mm. The depth of the grooves on the under side of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be + 2 percent.

12.14.2 Shape
The tiles shall be square shaped. Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be as agreed to between the purchaser and the manufacturer. Tiles shall be checked for squareness and warp as per IS
12.14.3 Performance Requirements
The tiles when tested in accordance with method given in IS 4457, shall conform to be requirement specified in the code (IS 4457).

12.14.4 Loss in Abrasion
The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS 1237, shall be as mentioned in IS 4457.

12.14.5 Marking
Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark. Manufacturer’s batch number and year of manufacture.
Each tile may also be marked with the ISI certification mark.

12.13.4 Measurements
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 not exceeding 0.10 square metre.

12.13.5 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.
Nothing extra shall be payable for cutting the tiles to suit the size of treads and also for nosing.

12.14 ACID OR ALKALI RESISTANT TILES
12.14.0 Manufacture and Finish
The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 1100°C and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogenous. The tiles shall be sound, true to shape, flat and free from flows and manufacturing defects affecting their utility.
The tiles shall be conforming to IS 4457. The tiles to be tested for water absorption, compressive strength, acid resistance as per IS 4457. Sampling procedure for acceptance tests and criteria for conformity to be as per IS 4457. The tiles shall be of required colour.

12.14.1 Dimensions and Tolerances
Ceramic unglazed vitreous acid-resistant tiles shall be made in three sizes namely 98.5 X 98.5 mm, 148.5 X 148.5 mm and 198.5 X 198.5 mm. They shall be available in the following thickness: 35, 30, 25, 20 and 15 mm. The depth of the grooves on the under side of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be + 2 percent.

12.14.2 Shape
The tiles shall be square shaped. Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be as agreed to between the purchaser and the manufacturer. Tiles shall be checked for squareness and warp as per IS 4457.

12.14.3 Performance Requirements
The tiles when tested in accordance with method given in IS 4457, shall conform to the requirement specified in the code (IS 4457).

12.14.4 Loss in Abrasion
The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS 1237, shall be as mentioned in IS 4457.

12.14.5 Marking
Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark. Manufacturer’s batch number and year of manufacture.

Each tile may also be marked with the ISI certification mark.

12.14.6 Preparation of Surface and Laying
Preparation of surface and laying to be according to para 12.15.4, except the cement used to be acid and or alkali resistant cement and cement mortar to be used to be acid and or Alkali resistant mortar. Thickness of bedding of mortar for flooring to be 10 mm or specified on the item and for dado/skirting to be 12 mm or specified on item.

12.14.7 Pointing and Finishing
As per para 12.15.5, except that cement used for pointing to be acid and or alkali resistant cement.

12.14.8 Measurements
As per para 12.15.6.

12.14.9 Rate
The rate for flooring shall include the cost of all materials and labor involved in all the operations described above. For tiles of sizes upto 0.16 Sqm, unless otherwise specified in the description of the item. Nothing extra shall be paid for the use of cost (Sawn) tiles in the work.

12.15 PRESSED CERAMIC TILE FLOORING
12.15.1 Pressed Ceramic Tiles
The tiles shall be of approved make and shall generally conform to IS 15622. They shall be flat, and true to shape and free from blisters crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tiles shall be tested as per IS 13630. Classification and Characteristics of pressed ceramic tiles shall be as per IS 13712. The tiles shall be square or rectangular of nominal size. Table 1,3,5, and 7 of IS 15622 give the modular preferred sizes and table 2,4,6 and 8 give the most common non modular sizes. Thickness shall be specified by the manufacturer. It includes the profiles on the visible face and on the rear side. Manufacturer/supplier and party shall choose the work size of tiles in order to allow a nominal joint width upto 2mm for unrectified floor tiles and upto 1mm for rectified floor tiles. The joint in case of spacer lug tile shall be as per spacer. The tiles shall conform to table10 of IS 15622 with water absorption 3 to 6% (Group BII).

The top surface of the tiles shall be glazed. Glaze shall be either glossy or matt as specified. The underside of the tiles 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 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.

12.15.2 Coloured Tiles
Only the glaze shall be coloured as specified. The sizes and specifications shall be the same as for the white glazed tiles.

12.15.3 Decorative Tiles
The type and size of the decorative tiles shall be as follows:

(i) Decorated white back ground tiles
The size of these tiles shall be as per IS 15622.
(ii) **Decorated and having coloured back-ground**

The sizes of the tiles shall be as per IS 15622.

**12.15.4 Preparation of Surface and Laying**

12.15.4.1 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 1:4 (1 cement : 4 coarse sand) or as specified. The average thickness of the bedding shall be 20 mm or as specified while the thickness under any portion of the tiles shall not be less than 10 mm.

12.15.4.2 Mortar shall be spread, tamped 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.

12.15.4.3 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 an area upto one square metre. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being 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 and in straight lines or to suit the required pattern.

12.15.4.4 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. In bath, toilet W.C, kitchen and balcony/verandah flooring, suitable tile drop or as shown in drawing will be given in addition to required slope to avoid spread of water. Further tile drop will also be provided near floor trap.

12.15.4.5 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. Tiles which are fixed in the floor adjoining the wall shall enter not less than 10 mm under the plaster, skirting or dado.

12.15.4.6 After tiles have been laid surplus cement slurry shall be cleaned off.

**12.15.5 Pointing and Finishing**

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. Where spacer lug tiles are provided, the half the depth of joint shall be filled with polysulphide or as specified on top with under filling with cement grout without the lugs remaining exposed. 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.

**12.15.6 Measurements**

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 coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves. 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. Areas, where glazed tiles or different types of decorative tiles are used will be measured separately.

**12.15.7 Rate**

The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. For tiles of sizes upto 0.16 sqm. unless otherwise specified in the description of the item. Nothing extra shall be paid for the use of cut (sawn) tiles in the work. 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.
12.16 PRESSED CERAMIC TILE FLOORING (VITRIFIED TILE FLOORING)
12.16.1 Operations as described in 12.15.1 to 12.15.6 shall be followed except the tiles shall conform to Table 12 of IS 15622 (Tiles with water absorption $E \leq 0.08$ per cent Group Bla) and the joint thickness in flooring shall not be more than 1mm.

12.16.2 Rate
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.

12.17 FIXING OF TILE FLOORING WITH CEMENT BASED HIGH POLYMER MODIFIED QUICK SET ADHESIVE (WATER BASED)
12.17.1 When tile flooring is to be laid over the existing flooring without dismantling old flooring it can be laid with adhesive. The old flooring shall be thoroughly cleaned and checked for undulations, if any shall be rectified with cement mortar 1:3 (1 cement: 3 coarse sand). Old cement concrete surface shall be hacked and cleaned off to have proper bond with the old surface.

12.17.2 High polymer modified quick set tile adhesive (conforming to IS 15477) shall be thoroughly mixed with water and a paste of zero slump shall be prepared so that it can be used with in 1.5 to 2 hours. It shall be spread over an area not more than one sqm at one time. Average thickness of adhesive shall be 3 mm The adhesive so spreaded shall be combed using suitable trowel. Tiles shall be pressed firmly in to the position with slight twisting action checking it simultaneously to ensure good contact gently being tapped with wooden mallet till it is properly backed with adjoining tiles. The tiles shall be fixed within 20 minutes of application of adhesive. The surplus adhesive from the joints, surface of the tiles shall be immediately cleaned.

12.17.3 The surface of the flooring shall be frequently checked during laying with straight edge of above 2m long so as to attain a true surface with required slope.

12.17.4 Where spacer lugs tiles are provided these shall be filled with grout with lugs remaining exposed.

12.17.5 Where full size tile can not be fixed these shall be cut (sawn) to the required size and edges rubbed smooth to ensure straight and true joints. Tiles which are fixed in floor adjoining to wall shall enter not less than 10 mm under plaster, skirting or dado.

12.17.6 Finishing: para 12.15.5 shall apply.

12.17.7 Measurements: para 12.15.6 shall apply.

12.17.8 Rate
Provisions of para 12.15.7 and 12.16.2 shall apply.

12.18 PRESSED CERAMIC TILES IN SKIRTING AND DADO
12.18.1 The tiles shall be of approved make and shall generally conform to IS 15622. The tiles shall be pressed ceramic covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility. The top surface of the tiles shall be glazed. The underside of the tiles 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 up to 50 per cent 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-in-Charge. There may be more than one colour on a tile.

**12.18.1 (a) Dimensions and Tolerances**
Glazed pressed ceramic tiles shall be made square or rectangular in sizes Table 1, 3, 5 & 7 of IS 15622 give the modular sizes and table 2, 4, 6 & 8 of IS 15622 gives the sizes of non modular tiles. The tiles shall conform to IS 15622 for dimensional tolerance, physical and chemical properties.
Half tiles for use as full tiles shall have dimensions which shall be such as to make the half tiles when jointed together (with 1 mm joint) match with dimensions of full tiles. Tiles may be manufactured in sizes other than those specified. above.
The thickness of the tiles shall be 5 mm or 6 mm or as specified.
The dimensions of fittings associated with the glazed tiles namely cover 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.

**12.18.2 Preparation of Surfaces**
The joints shall be raked out to a depth of at least 15 mm in masonry walls.
In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

**12.18.3 Laying**
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.
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 be truly horizontal and joints truly vertical except where otherwise indicated. Odd size/cut size of tile shall be adjusted at bottom to take care of slope of the flooring.
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. Skirting /dado shall not project from the finished “surface of wall” by more than the tile thickness, undulations if any shall be adjusted in wall.

**12.18.4 Curing and Finishing**
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. After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

**12.18.5 Measurements**
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 as 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.
Areas where coloured tiles or different types of decorative tiles are used will be measured separately to be paid extra over and above the normal rate for white tiles.

**12.18.6 Rates**
The rate shall include the cost of all material and labour involved in all the operations described above, for tiles of sizes upto 0.14 sqm. unless otherwise specified in the description of the item. 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
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meters separately.

12.19 MARBLE STONE FLOORING
12.19.1 Marble Stone
It shall be as specified in sub head 8.0.

12.19.2 Dressing of Slabs
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 laid 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 slabs are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surfaces is in contact with every point on it. The sides and top surface of slabs 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. The thickness of the slabs shall be 18, 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.

12.19.3 Laying
12.19.3.1 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 as given in the description of the item.

12.19.3.2 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.

12.19.3.3 The slabs shall be laid in the following manner:
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. 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 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-in-Charge. Joint thickness shall not be more than 1 mm. 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-in-Charge.

12.18.6 Rates
The rate shall include the cost of all material and labour involved in all the operations described above, for tiles of sizes upto 0.14 sqm. unless otherwise specified in the description of the item. 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.

12.19 MARBLE STONE FLOORING
12.19.1 Marble Stone
It shall be as specified in sub head 8.0.
12.19.2 Dressing of Slabs
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 laid 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 slabs are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surfaces is in contact with every point on it. The sides and top surface of slabs 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. The thickness of the slabs shall be 18, 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.

12.19.3 Laying
12.19.3.1 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 as given in the description of the item.

12.19.3.2 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.

12.19.3.3 The slabs shall be laid in the following manner:
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.
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 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-in-Charge. Joint thickness shall not be more than 1 mm. 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-in-Charge. The joints shall be as fine as possible but not more than 1 mm. The top line of skirting and risers shall be truly horizontal and joints truly vertical, except where otherwise indicated. The risers and skirting slab shall be matched as shown in drawings or as instructed by the Engineer-in-Charge.

12.20.4 Curing, Polishing and Finishing
It shall be as specified in 12.11.4 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.

12.20.5 Measurements
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 0.5 cm. The areas shall be calculated in square metre correct to two places of decimal. Dado and lining of pillars etc. shall be measured as ‘Marble work in wall lining. If the thickness is
12.20.6 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

12.21 KOTA STONE FLOORING
12.21.1 Kota Stone Slabs
The slabs shall be of selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering and flaws. They 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-in-Charge. 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 contractor shall get the samples of slabs approved by the Engineer-in-Charge.

12.21.2 Dressing
Every slab 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. 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 ±2 mm shall be allowed for the thickness. In respect of length and breadth of slabs Tolerance of ± 5 mm for hand cut slabs and ± 2 mm for machine cut slabs shall be allowed.

12.21.3 Preparation of Surface and Laying
The specification shall be as described in 12.19.3 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. The thickness of the joints should be minimum as possible. In any location, it shall not exceed 1 mm.

12.21.4 Polishing and Finishing
The specifications shall be as described in 12.19.3 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.

12.21.5 Measurements and Rates
These shall be as described in paras 12.19.5 and 12.19.6.

12.22 KOTA STONE IN RISERS OF STEPS, SKIRTING AND DADO
12.22.1 Kota Stone Slabs and Dressing shall be as specified in 12.21.1 and 12.21.2 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.

12.22.2 Preparation of surface shall be as specified in 12.20.2.

12.22.3 Laying shall be as specified in 12.20.3 except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

12.22.4 Curing, Polishing and Finishing shall be as specified in 12.20.4 except that first polishing with coarse grade carborundum stone shall not be done.

12.22.5 Measurements
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 to 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. Lining of pillars etc. shall also be measured under this item.

12.22.6 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

12.23 RED OR WHITE FINE DRESSED SAND STONE FLOORING
12.23.1 Stone Slabs
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 contractor shall get samples of slabs approved by the Engineer-in-Charge.
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.

12.23.2 Dressing of Slabs
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 it. 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.
The thickness of the slabs after dressing shall be 40 mm or as specified in the description of item with a permissible tolerance of ± 2 mm.

12.23.3 Laying
12.23.3.1 Base concrete on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:5 (1 cement : 5 coarse sand) or as given in the description of the item.

12.23.3.2 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.

12.23.3.3 The slab shall be laid in the following manner:
Mortar of specified mix shall be spreaded 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 joints finished flush.

12.23.3.4 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-in-Charge.

12.23.3.5 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.

12.23.3.6 The finished floor shall not sound hollow when tapped with wooden mallet.
12.23.4 Finishing
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.

12.23.5 Measurements
These shall be as specified in para 12.19.5.

12.23.6 Rate
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.

12.24 RED OR WHITE FINE DRESSED AND RUBBED SAND STONE FLOORING
12.24.1 Stone Slabs shall be as specified in 12.23.1.

12.24.2 Dressing
The specifications for dressing the top surface and the sides shall be as described in 12.23.2. 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.
The thickness of the slabs after dressing shall be as specified with a permissible tolerance of ± 2
mm.

12.24.3 Laying
The slabs shall be laid with 3 mm thick or 5 mm thick joints as specified in the description of the item.
Where the joints are to be limited to 3 mm thickness, the slabs shall be laid as specified in 12.19.3
except that the bedding mortar shall be as specified in 12.23.3 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.
Where the slabs are to be laid with 5 mm thick joints, the specifications for laying shall be as described in
12.23.3.

12.24.4 Finishing shall be as specified in 12.23.4 except that chisel marks and unevenness shall be
removed by rubbing with coarse grade carborundum stone.

12.24.5 Measurement and Rate shall be as specified in 12.23.5 and 12.23.6.

12.25 WOODEN FLOORING

12.25.0 Seasoning and Preservation
All timber used for timber floors shall be thoroughly seasoned in accordance with IS 1241. After
seasoning the timber shall be treated with preservative in accordance with IS 401. Seasoning and
preservative treatment shall be paid for separately unless otherwise specifically included in the
description of the item of flooring.

12.25.1 Supporting Joists
Main beams and joists of the class of wood sections specified in the description of the item for
beams and joists, or as instructed by the Engineer-in-Charge shall be fixed in position to dead levels.
The width of the joints shall not be less than 50 mm. The arrangement and spacing of beams joists etc.
shall be as per design furnished.

12.25.2 Boards
It shall be of the class of timber and thickness specified in the description of the item. The timber
shall be as specified in para 9.1. Only selected boards of uniform width shall be used. Unless otherwise
specified or shown in the drawings, the width of boards selected shall not be less than 100 mm nor more than 150 mm. The same width of boards shall not be maintained throughout except where the width of the room is not an exact multiple of the boards. In the latter case, the difference shall be equally adjusted between the two end boards (adjacent to walls). The length of the boards shall not exceed 3 metre anywhere. Ordinarily, the minimum length of boards shall be such that the boards shall rest at least on three supports, except where otherwise required by the pattern specified in the drawings or as directed by the Engineer-in-Charge.

The boards shall be planed true on the top face only unless otherwise specified in the description of the item. Where the bottom face is exposed and it is also required to be planed, then such planing shall be paid for extra.

Unless otherwise described in the item, the longitudinal joints of planks shall be tongued and grooved to a minimum depth of 12 mm while the heading joints shall be of the square butt type and shall occur over the centre line of the supporting joists. Heading joists in adjacent boards shall be placed over the same joists.

12.25.3 Iron Screws
Iron screws shall be of the slotted counter sunk head type, of length not less than the thickness of planks plus 25 mm, subject to a minimum of 40 mm, and of designation No. 9 conforming to IS 451.

12.25.4 Fixing
The joists on which the planks shall be fixed shall be checked and corrected to levels. The end boards shall be accurately fixed with the sides parallel and close to the walls. Each adjoining board shall be carefully jointed and shall be tightened in position and screwed. For fixing the boards to the joists, two screws shall be used at each end of the boards and one screw at each of the intermediate joists in a zig zag manner. The screws shall be countersunk and screw holes filled with approved stopping.

The junction between timber flooring and adjacent flooring shall be formed by inserting a metal strip (brass or aluminium) at the junction. The metal strip shall be fixed to the end of the planks by screws.

The strips shall be paid for extra.

The flooring shall be truly level and plane. The joints shall be truly parallel and or perpendicular to the walls, unless otherwise specified.

The floor shall be planed in both directions and made perfectly even, true and smooth.

Note: No wood of any kind shall be placed within 60 cm of any fire place or flue. Provision shall be made for ventilation in the space below the floor in case of ground floor and between floor and top of ceiling in the case of upper floors. Such arrangements shall be paid for separately.

12.25.5 Finishing
The surface of the floor shall be bees waxed or finished otherwise as directed by the Engineer-in-Charge. The lower face shall be painted or treated with wood preservative as directed. The finishing shall be paid for separately unless specifically included in description of the flooring item.

12.25.6 Measurements
Length and breadth of superficial area of the finished work shall be measured correct to a cm. The area shall be calculated in square metre correct to two places of decimal. 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.

12.25.7 Rate
The rate shall include the cost of the labour and materials involved in all the operations described above, with the exceptions noted in the relevant sub-paras.

12.26 WOOD BLOCK FLOORING
12.26.1 Wood Blocks
The wood blocks shall be of the class of timber specified in the description of the item and shall be in
accordance with the general specifications for 'Wood Work' given under para 9.1. The size of blocks shall be as shown in the drawings. The longitudinal edges of the blocks shall be dovetailed grooved near the bottom. The blocks shall be truly rectangular in shape with clean sharp edges and true faces. The top and sides shall be planed true. The thickness of the blocks shall be 38 mm unless otherwise specified. The timber used for making the blocks shall be thoroughly seasoned in accordance with IS 1241. After seasoning, the timber shall be treated with preservatives in accordance with IS 401.

12.26.2 Base Concrete
The specifications shall be same as in 12.2.2.

12.26.3 Levelling Concrete
The levelling layer of concrete shall be of cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 stone aggregate 10 mm nominal size) by volume unless otherwise described in the item. Its thickness shall be 25 mm. Cement concrete shall be placed in position and levelled up with the help of a straight edge and trowel. It shall then be beaten with wooden 'Thappy' or a mason's trowel till the cream comes up. The surface shall be finished with a wooden float to give a sand paper finish, plane and true to level. The finished level of the concrete shall be lower than the proposed finished level of the flooring by the specified thickness of the wooden blocks plus a minimum of 1.5 mm. The levelling layer shall be cured for a week and then allowed to dry thoroughly, before paving with wood blocks.

12.26.4 Laying
The wood blocks shall be first laid ‘dry’ to the margin and pattern shown in the drawings or as directed by the Engineer-in-Charge. The blocks shall fit closely and sides and end shall be corrected by further planing if necessary to get closed and even joints. After the blocks have been fitted and matched they shall be removed and stacked in such a way as to facilitate their repaving in the same order.

12.26.5 Finishing
The floor shall be Bees waxed or polished with ready made wax polish or given any other finish as required.

12.26.6 Measurements
Length and breadth of superficial areas of the finished work shall be measured correct to a cm. The area shall be calculated in square metre correct to two places of decimal. 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.

12.26.7 Rate
The rate shall include the cost of all labour and materials involved in all the operations described above but shall not include the cost of base concrete bees waxing or other finishing unless otherwise specifically described in the item.
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13.0 TERMINOLOGY

13.0.1 Accessories
Purpose made fittings, such as apron flashing pieces, barge boards, bottom glazing flashing, corner piece (corner flashing), eaves filler pieces, expansion joints, hip capping, hip tile or cap, ridge capping, ridge finials, roof lights, ventilators, with which the roof is furnished.

13.0.2 Eaves
The lower edge of the inclined roof.

13.0.3 Finial
A decorative fitting used at the junction of ridges and hips to form a waterproof covering and at the top of conical, pyramidal, or dome roofs.

13.0.4 Flashing
A strip of impervious material, usually metal used to exclude water from the junction between a roof covering and another part of the structure.

13.0.5 Gable
Part of wall above the general eaves level at tie end of ridged or partially hipped roof.

13.0.6 Gutter
Any form of roof water channel.

13.0.7 Hip
The outer angle (more than 180 degree) formed by the inclined ridge between two intersecting roof slopes.

13.0.8 Pitch
13.0.8.1 The angle of inclination with the horizontal of the rafters or substructure surface on which the roof coverings are laid.

13.0.8.2 In patent glazing, the angle at which the plane of a stretch of glazing is inclined to the horizontal.

13.0.9 Pitched Roof
A roof the pitch of which is greater than 10 degree to the horizontal.

13.0.10 Ridge
The horizontal inter-section at the apex of the two rising roof surfaces inclined in opposite directions.

13.0.11 Valley
The re-entrant angle formed by the inter-section of two inclined roof surfaces.

13.0.12 Verge
Free edge of a roof surface ending at a gable.

13.1 CORRUGATED GALVANISED STEEL SHEET ROOFING

13.1.1 C.G.S. Sheets
These shall be of the thickness specified in the description of the item and shall conform to IS 277. The sheets shall be of 275 grade of coating (See Appendix-A) unless otherwise 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 galvanising 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 the side.

13.1.2 Purlins
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. (Table 13.1)

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<td>1.00 mm</td>
<td>2.00 metre</td>
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<td>0.80 mm</td>
<td>1.80 metre</td>
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<tr>
<td>0.63 mm</td>
<td>1.60 metre</td>
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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.

13.1.3 Slope
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.

13.1.4 Laying and Fixing
13.1.4.1 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.

13.1.4.2 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.

13.1.4.3 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.

13.1.4.4 Lapping in C.G.S. sheets shall be painted with a coat of approved steel primer and two coats of painting with approved paint suitable for G.S. sheet, before the sheets are fixed in place.

13.1.4.5 Sheets shall not generally be fixed 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.

13.1.4.6 The laying operation shall include all scaffolding work involved.

13.1.4.7 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 are used for fixing the sheet to R.S. joists, 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.

13.1.4.8 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.

The galvanised coating should conform to IS 1367 (Pt. XIII) The mass of coating per square meter of the surface shall be as under:

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<thead>
<tr>
<th>Mass and Equivalent Thickness of Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Mass (g/m²)</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>375</td>
</tr>
</tbody>
</table>

13.1.4.9 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.

13.1.5 Wind Tie
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.

13.1.6 Finish
The roof when completed shall be true to lines, and slopes and shall be leak proof.

13.1.7 Measurements
13.1.7.1 The length and breadth shall be measured correct to a cm. Area shall be worked out in sqm correct to two places of decimal.

13.1.7.2 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.

13.1.7.3 Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

13.1.7.4 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.
13.1.8 Rate
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 overlapping 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.

13.2 RIDGES AND HIPS OF PLAIN GALVANISED STEEL SHEETS
13.2.1 Ridges and Hips
Ridges and hips of C.G.S. roof shall be covered with ridge and hip sections of plain G.S. sheet with a minimum 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 of 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.

13.2.2 Fixing
13.2.2.1 Ridges shall be fixed to the purlins below with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins.

13.2.2.2 Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm dia 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.

13.2.2.3 The end laps of ridges and hips shall be joined together with C.G.S sheet 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.

13.2.2.4 Surface of C.G.I. sheets of ridge and hip sections and the roofing sheets which overlap each other 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.

13.2.3 Finish
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.

13.2.4 Measurement
The measurements 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 and between ridges and hips shall not be measured.

13.2.5 Rate
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.

13.3 VALLEY AND FLASHING OF PLAIN GALVANISED STEEL SHEETS
13.3.1 Valley and Flashing
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. Valley sheets shall be laid over 25 mm thick wooden boarding if so required. Flashing shall be of 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.
13.3.2 Laying and Fixing
Flashing and valley sheets shall be fixed to the roof members below, such as purlins and valley rafters with the same 8 mm dia 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 the valley pieces on other side. If this is not possible extra hook bolts shall be provided. The free end of flashing shall be fixed at least 5 cm inside masonry with the mortar of mix 1: 3 (1 cement: 3 coarse sand). Refer Fig. 13.3.

13.3.3 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.

13.3.4 Finish
The edges of valley and flashing should be straight from end to end. The surfaces should be true and without bulges and depressions.

13.3.5 Measurements
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.

13.3.6 Rates
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 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.

13.4 GUTTERS MADE OF PLAIN GALVANISED STEEL SHEETS
13.4.1 Gutters
Gutter shall be fabricated from plain G.S. Sheets of thickness as specified in the item. 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.

13.4.2 Slope
Gutter shall be laid with a minimum slope of 1 in 120.

13.4.3 Laying and Fixing
13.4.3.1 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.

13.4.3.2 Where these brackets are to be fixed to the sides of rafters, they shall be of 40 × 3 mm section bend to shape and fixed rigidly to the sides of rafters with 3 Nos. 10 mm dia 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.

13.4.3.3 Where the brackets are to be fixed to the purlins, the brackets shall consist of 50 × 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 dia bolts nuts and washers. The bracket will be stiffened by provision of 50 × 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 dia M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with 1 No. 10 mm dia, 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.

13.4.3.4 The gutter shall be fixed to the brackets with 2 Nos. G.I. bolts and nuts 6 mm dia, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

13.4.3.5 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.

13.4.4 Finish
The gutters when fixed shall be true to line and slope and shall be leakproof.

13.4.5 Measurements
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.

13.4.6 Rate
The rate shall include the cost of all labour and materials specified above, including all specials 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 × 3 mm flats fixed to purlins with stiffener flats will be paid extra.

13.5 NON-ASBESTOS HIGH IMPACT POLY PROPYLENE REINFORCED CEMENT CORRUGATED SHEET ROOFING
13.5.1 Non-Asbestos High Impact Poly Propylene Reinforcement Cement Corrugated Sheets
The sheets shall be of the approved quality and shall conform to IS 14871. The sheets shall be free from cracks, chipped edges or corners and other damages.

13.5.1 (a) General Composition of Sheets
The product shall be composed essentially of an inorganic hydraulic binder (see Note) or a calcium silicate binder formed by the chemical reaction of a silicate binder formed by the chemical reaction of a siliceous (includes ground silica, pulverized fuel ash and amorphous silica) and calcareous material reinforced by organic fibres and/or inorganic synthetic fibres. Pozzolanic materials process aids, fillers and pigments which are compatible with the fibre reinforced cement may be added. The inorganic hydraulic binder shall be either 33 grade ordinary Portland cement conforming to IS 269 or 43 grade ordinary Portland cement conforming to IS 8112 or 53 grade ordinary Portland cement conforming to IS 12269 or Portland pozzolana (fly ash based) cement conforming to IS 1489. (Part 1) or Portland pozzolana cement (calcined clay based) conforming to IS 1489 (Part 2) or rapid hardening cement conforming to IS 8041 or Portland slag cement conforming to IS 455. Fly ash used shall be conforming to IS 3812.

Note : In case of Portland pozzolana cement and Portland slag cement, addition of pozzolanic materials and slag shall not be permitted.

13.5.1 (b) Classification – Sheets may be classified according to thickness as under :
Type A - The thickness of the sheets shall be approximately constant throughout the width of profile.
Type B - The thickness of the sheets shall vary regularly between the valley and the crown for corrugated sheets or between the lower part and the upper part of ribs for asymmetrical section sheets, in the same cross-section.
The sheets shall be categorized based on height of corrugations, ‘h’ and minimum thickness ‘e’ as under:
<table>
<thead>
<tr>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Thickness (mm)</td>
</tr>
<tr>
<td>Class</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>A (15 mm ≤ h ≤ 55 mm)</td>
</tr>
<tr>
<td>B (25 mm ≤ h &lt; 55 mm)</td>
</tr>
<tr>
<td>C (40 mm ≤ h &lt; 80 mm)</td>
</tr>
<tr>
<td>D (60 mm ≤ h &lt; 150 mm)</td>
</tr>
</tbody>
</table>

13.5.2 Slope
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.

13.5.3 Laying
13.5.3.1 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.

13.5.3.2 The maximum spacing of purlins under the sheets shall be 1.40 metres in the case of 5.5 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.

13.5.3.3 The top bearing surfaces of all purlins and of other roof members shall be in one plane so that the sheets when 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.

13.5.3.4 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.

13.5.3.5 The free overhang of the sheets at the eaves shall not exceed 30 cm. 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 the 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.

13.5.3.6 The ‘Mitred’ 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. This cutting may be done with an ordinary wood saw at site.
13.5.4 Fixing
13.5.4.1 Sheets shall be secured to the purlins and other roof members by means of 8 mm diameter polymer coated 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. The grip of the J or L hook bolt on the side of the purlin shall not be less than 25 mm. Each 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 washers shall be as provided in para 13.1.4.8. Polymer coating of hooks, bolts and nuts shall be as per IS code 14871.

13.5.4.2 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 13.2 below.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Situation</th>
<th>No. of Bolts &amp; Washers</th>
<th>Length of Bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>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.</td>
<td>Twice the No. of sheets in one horizontal course.</td>
<td>Depth of purlin plus 90 mm.</td>
</tr>
<tr>
<td>2.</td>
<td>At eaves when filler pieces are not used. At ridge when corrugated sheets and ridge pieces are not secured by the same bolt.</td>
<td>Twice the No. of sheets in the horizontal course.</td>
<td>Depth of purlin plus 75 mm.</td>
</tr>
<tr>
<td>3.</td>
<td>At intermediate purlins where horizontal laps do not occur.</td>
<td>Twice the No. of sheets in the horizontal course.</td>
<td>Depth of purlin plus 75 mm.</td>
</tr>
</tbody>
</table>

13.5.4.3 Each nut shall be screwed lightly at first. After a dozen or more sheets are laid, the nuts shall be tightened to ensure a leak proof joint.

13.5.4.4. 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.

13.5.4.5 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.

13.5.5 Wind Ties
Wind ties may be provided where the situation justify their provision. These shall be of 40 × 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.

13.5.6 Finish
The completed roof shall present a neat and uniform appearance and be leakproof.

13.5.7 Measurements
13.5.7.1 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.
13.5.7.2 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.

13.5.7.3 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.

13.5.7.4 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 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.

13.5.8 Rate
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, polymer coated or L hook, bolts and nuts, bituminous and galvanised iron washers.

13.6 NON-ASBESTOS HIGH IMPACT POLY PROPYLENE REINFORCED CEMENT SEMI-CORRUGATED

SHEET ROOFING
13.6.1 Non Asbestos High Impact Poly Propylene Reinforced Cement Semi Corrugated Sheets
These shall be of the specified thickness and of approved quality and shall conform to IS 14871 they shall be free from cracks, chipped edge corners or other damages.

13.6.2 Laying
The specifications for laying shall be the same as described in 13.5.3 except that (a) the sheets shall be laid with the end stamped ‘Top’ on the smooth side pointing towards the ridge, (b) the sheets shall invariably be laid from right to left starting at the eaves with the procedure for mitring etc. described under 13.5.3.5 and 13.5.3.6 reversed, (c) the side laps provided will be of one corrugation, the left hand small corrugation of each sheet being covered by the right hand large corrugation of the next sheet and (d) asbestos cement expansion joints shall be inserted every 45 metres or so in the length of the roof. Specially manufactured expansion joint pieces shall be used for the purpose. The end lap of expansion joints shall not be less than 150 mm. If the expansion joints may be between the purlins, these should be stitched with seam bolts.

13.6.3 Fixing
The specifications shall be same as described in 13.5.4 except that along each line of purlin there shall be a hook bolt in every vertical side lap corrugation and at the two verges and there shall be an additional hook-bolt through one of the two intermediate corrugations on each sheet. When sheets are supported over intermediate purlins as in the case of length over 1.40 metres for 5.5 mm thick sheets, fixing accessories are required on the intermediate purlins, through each side lap and the verges only. The number and length of bolts and number of bitumenous felt and galvanised iron washers are given in Table 13.3.

TABLE 2.3
In laying hip pieces, serrations to suit the centimetres (approx.) of ridge where the latter is of the semi-cut and trimmed off neatly. Asbestos cement expansion joint ridge pieces shall be provided every 45 end portions of the wings of the adjustable ridges which project beyond the verges of the between adjacent pieces on the same wing of the ridges shall be as per manufacturers instructions. The with the sheets underneath. The stagger l

13.6.4 Wind Ties & Finish
The specifications shall be as described in 13.5.5 and 13.5.6.

13.6.5 Measurements
It shall be as described in 13.5.7 in addition, the end lap of the sheets under asbestos cement expansion joints where provided shall also be included in measurements. Gap between the sheets under expansion joint shall not be measured. The expansion joint sheets shall be measured for the finished work correct to one cm.

13.6.6 Rate
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, polymer coated J or L hook bolts and nuts, bituminous and galvanised iron washers.

13.7 RIDGES AND HIPS OF NON-ASBESTOS HIGH IMPACT POLYPROPYLENE REINFORCED CEMENT
13.7.0 Ridges and hips shall be of the same manufacture as the corrugated or semi-corrugated sheets used for roof, unless specifically permitted in writing by the Engineer-in-Charge. The sections shall be free from cracks, chipped edges or corners or other damages. 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. Un-serrated adjustable.

13.7.1 Laying
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.
In laying hip pieces, serrations to suit the corrugations in the sheets below should be cut in them so

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Situation</th>
<th>No. of Bolts &amp; Washers</th>
<th>Length of Bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>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.</td>
<td>Short bolts: The number of sheets in one horizontal course plus two Long bolts: The number of sheets in one course less one.</td>
<td>Depth of purlin plus 75 mm</td>
</tr>
<tr>
<td>2.</td>
<td>At eaves when filler pieces are not used. At ridge when sheets and ridge pieces are not secured by the same bolt.</td>
<td>Twice the No. of sheets in one horizontal course plus one.</td>
<td>Depth of purlin plus 75 mm</td>
</tr>
<tr>
<td>3.</td>
<td>At intermediate purlin when horizontal laps do not occur.</td>
<td>The No. of sheets in one horizontal course plus one.</td>
<td>Depth of purlin plus 75 mm</td>
</tr>
</tbody>
</table>
that they will be a snug fit over the sheets.

13.7.2 Fixing
13.7.2.1 The wings of ridges shall be fixed to the sheets below with the seam bolts and nuts 8 mm diameter polymer coated 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 dia polymer coated 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.

13.7.2.2 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.

13.7.2.3 Wing of hips shall be fixed to the roof members below with the same 8 mm dia polymer coated 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 dia polymer coated 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 ‘semicorrugated’ sheets. The seam bolts shall each be provided with one bitumen and a pair of G.I. washers.

13.7.3 Measurements
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 expansion joint pieces where the latter are provided shall however be measured.

13.7.4 Rate
The rate shall include the cost of all materials and labour specified above, but does not include (a) the cost of required polymer coated hook bolts and nuts and their washers, (b) the cost of supplying and fixing 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 non-asbestos cement sheet roofing while items (b) and (c) will be paid for separately unless specifically included in the description of item of the ridge or hip item.

13.8 OTHER ROOFING ACCESSORIES OF NON-ASBESTOS HIGH IMPACT POLYPROPYLENE REINFORCED CEMENT
13.8.1 Accessories
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 joints 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. 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.

13.8.2 Laying & Fixing
These shall be laid and secured with the same polymer coated hook bolts which secure sheets to the roof members below where possible or with separate polymer coated hook bolts to the roof members below and/or with 8 mm dia polymer coated 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 verticals 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 dia polymer coated bolts and nuts and bitumen and polymer coated washers.
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 dia G.I. separating bolts threaded at both ends and of suitable length. Each of these bolts shall be equipped with 2 pair of 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.

13.8.3 Measurements
The accessories listed under group (a) in 13.8.1 shall be measured for finished work in length correct to a cm. Laps between adjacent pieces shall not be measured.
The accessories listed under group (b) in 13.8.1 shall be measured and paid for in number. This applies in the case of finial too where the unit shall consist of a pair of inter locking pieces.
The ‘S’ type louvers listed under group (c) in 13.8.1 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.

13.8.4 Rate
13.8.4.1 The rates for supplying and fixing, non-asbestos cement accessories listed in groups (a) & (b) of 13.8.1 shall include the cost of all materials and labour involved in all the operations described above bolts, nuts, washers and other fixing accessories but does not include the members.

13.8.4.2 The rate for supplying and fixing roof lights shall not unless otherwise described in the item, include the glazing which shall be paid for separately.

13.8.4.3 The rate for supplying and fixing ‘S’ type louvers shall include all fixing accessories such as ordinary and separating polymer coated bolts, nuts, and bitumen washers including drilling the holes for the same in the vertical supporting member 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.

13.9 EAVES AND VALLEY GUTTERS OF NON-ASBESTOS HIGH IMPACT POLYPROPYLENE REINFORCED CEMENT

13.9.1 Gutters and Accessories
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. CPWD SPECIFICATIONS 2009 498
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.

13.9.2 Laying and Fixing
13.9.2.1 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 the requisite accessories such as drop ends, stop ends, nozzles, angles and union clips as shown in the working drawing or as ordered by the Engineer-in-Charge.

13.9.2.2 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.

13.9.2.3 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.

13.9.2.4 Where the brackets are to be fixed to the purlins they shall consist of 50 × 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 dia bolt, nut and washer. The perpendicular over hang portion of 50 × 3 mm bracket shall be stiffened by another 50 × 3 mm flat, bent to right angle shape with its lower leg connected to the bracket with 2 Nos. 6 mm dia M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with one number 10 mm dia 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.

13.9.2.5 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.

13.9.2.6 The gutters shall be fixed to the brackets with 2 Nos. 8 mm dia polymer coated seam bolts and nuts, each bolt and nut being equipped with a pair of bitumen and polymer coated washers. These connecting bolts shall be above the water line of the gutters.

13.9.2.7 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 dia polymer coated bolts and nuts, each bolt and nut being provided with a pair of bitumen and a pair of polymer coated washers. The gap between the socket and spigot shall be packed with approved plastic roofing compound, flanked on both sides with 6 mm dia non-asbestos rope. The connecting polymer coated bolts are then tightened so that the lapped joints become leak proof. The outer faces of the packed nonasbestos rope shall not be farther than 6 mm from the edges of the spigot and socketed ends.

13.9.2.8 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 in between over union clips (loose socket pieces). The union clip shall be connected to the two butt ends of the gutter or other section on both ends with two rows (one row per ends) of 8 mm dia polymer coated 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 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 dia non-asbestos rope as before. The whole joint shall be made leak proof by tightening the bolts.

13.9.2.9 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.

13.9.2.10 The number of connecting bolts, nuts and washers and the quantities of 6 mm diameter nonasbestos 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 or eave’ and ‘valley’ type gutters of different sizes shall be shown in Table 13.4.
TABLE 13.4
Jointing Materials per Joint of Gutter

<table>
<thead>
<tr>
<th>Type of Gutter</th>
<th>Nomin al Sizes</th>
<th>6 mm dia Asbesto s Rope</th>
<th>Required per joint</th>
<th>Plastic Roofing Compound</th>
<th>8 mm dia nuts and</th>
<th>G.I. Washer 25mm</th>
<th>Bitumen Washer 25mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socketed ornamental</td>
<td>125 mm</td>
<td>0.57 m</td>
<td>170 g</td>
<td>1 No. 45 mm long</td>
<td>2 Nos</td>
<td>2 Nos</td>
<td></td>
</tr>
<tr>
<td>Socketed ornamental</td>
<td>200 mm</td>
<td>0.98 m</td>
<td>255 g</td>
<td>3 Nos. 45 mm long</td>
<td>6 Nos</td>
<td>6 Nos</td>
<td></td>
</tr>
<tr>
<td>Socketed half round</td>
<td>150 mm</td>
<td>0.57 m</td>
<td>170 g</td>
<td>1 No. 45 mm long</td>
<td>2 Nos</td>
<td>2 Nos</td>
<td></td>
</tr>
<tr>
<td>Socketed half round</td>
<td>250 mm</td>
<td>0.92 m</td>
<td>567 g</td>
<td>3 Nos. 45 mm long</td>
<td>6 Nos</td>
<td>6 Nos</td>
<td></td>
</tr>
<tr>
<td>Socketed half round</td>
<td>300 mm</td>
<td>1.07 m</td>
<td>709 g</td>
<td>3 Nos. 45 mm long</td>
<td>6 Nos</td>
<td>6 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>275 × 125</td>
<td>0.97 m</td>
<td>737 g</td>
<td>8 Nos. 40 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>275 × 175</td>
<td>0.97 m</td>
<td>737 g</td>
<td>8 Nos. 40 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>300 × 150</td>
<td>1.15 m</td>
<td>850 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>300 × 225</td>
<td>1.15 m</td>
<td>850 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>450 × 150</td>
<td>1.38 m</td>
<td>1020 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>450 × 300</td>
<td>1.38 m</td>
<td>1020 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>500 × 150</td>
<td>1.43 m</td>
<td>1049 g</td>
<td>10 Nos. 50 mm long</td>
<td>20 Nos</td>
<td>20 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>500 × 250</td>
<td>1.43 m</td>
<td>1049 g</td>
<td>10 Nos. 50 mm long</td>
<td>20 Nos</td>
<td>20 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>400 × 125</td>
<td>1.12 m</td>
<td>850 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>400 × 225</td>
<td>1.12 m</td>
<td>850 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>50 × 125</td>
<td>1.12 m</td>
<td>850 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>600 × 150</td>
<td>1.48 m</td>
<td>1105 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>600 × 225</td>
<td>1.48 m</td>
<td>1105 g</td>
<td>8 Nos. 50 mm long</td>
<td>16 Nos</td>
<td>16 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>900 × 200</td>
<td>2.08 m</td>
<td>1531 g</td>
<td>12 Nos. 50 mm long</td>
<td>24 Nos</td>
<td>24 Nos</td>
<td></td>
</tr>
<tr>
<td>Plain ended boundary wall or</td>
<td>900 × 225</td>
<td>2.08 m</td>
<td>1531 g</td>
<td>12 Nos. 50 mm long</td>
<td>24 Nos</td>
<td>24 Nos</td>
<td></td>
</tr>
</tbody>
</table>

13.9.3 Finish
The gutters and accessories when fixed shall be true to line and slope and shall be ridged. All the joints shall be leak proof.

13.9.4 Measurements
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. Accessories such as drop ends, stop ends, nozzles and angles shall be measured and paid for separately.
Union clips (loose sockets) shall not be measured separately as they are included in the rate for gutters.

13.9.5 Rate
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.
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and bitumen and G.I. washers, M.S. flat iron brackets and their fixture to the gutter sections and to the roof members, non-asbestos rope and plastic roofing compound. 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 $50 \times 3$ mm size are provided in place of brackets of $40 \times 3$ mm size as indicated in para 13.9.2.4 extra rate will be paid for separately.

13.10 PAINTING OF ROOF SLAB WITH HOT BITUMEN
13.10.1 Preparing the Surface
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.

13.10.2 Painting with Bitumen
13.10.2.1 The contractor shall bring the bitumen to site in its original packing and shall open and use it in the presence of the Engineer-in-Charge or his authorised representative. The containers shall not be removed from the site until the painting job is completed and the Engineer-in-Charge has satisfied himself regarding the quantity of bitumen actually used and has given his permission to remove the empty containers.

13.10.2.2 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.

13.10.2.3 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 a 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.

13.10.2.4 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. It shall be carefully regulated so that the application is uniform at the stipulated rate of 17 Kg. per 10 square metres.

13.10.3 Spreading Sand
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.

13.10.4 Measurements
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. decimetre. The measurements of length and breadth shall be taken correct to a cm.

13.10.5 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

13.11 MUD PHUSKA TERRACING WITH BRICK TILE PAVING
13.11.1 Mud Phuska
For mud phuska, selected soil which should be a good quality earth suitable for making bricks not containing excessive clay or sand, free from stones, kankar, vegetable matter and other foreign matter, shall be collected and stacked at site. The soil shall not be collected from a locality infested with white
Before laying on the roof, the soil shall be made damp by adding water about 13 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 thappies, 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.

### 13.11.2 Mud Plaster
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. 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 with feet and spades (Phawaras) at intervals so as to get pugged into a homogeneous mass free from lumps and clods. The mud mortar shall be puddled again very thoroughly just before use. The consistency of mud mortar shall be checked by taking it on 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.

### 13.11.3 Gobri Leaping
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 qualities.

### 13.11.4 Laying of Bricks Tile
After the gobri leaping has dried, brick tiles 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 brick tiles shall be either flat tile bricks of class designation 100 or machine moulded tile bricks of class designation 125 conforming to IS 2690 (Prt I) as per the nomenclature of the item. The tiles shall be laid such that 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 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 mortar shall be mixed with 2% of integral water proofing compound which should conform to IS 2645.

### 13.11.5 Curing
As soon as cement grouting obtains initial set, the surface of the brick tile floor shall be covered with wet gunny bags, hessian cloth or wet sand to prevent quick drying. After 8-12 hours, the brick tile 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. 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-in-Charge 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.

13.11.6 Measurements
Length and breadth shall be measured correct to a cm. The measurements shall be taken for the finished work, (mud phuska terracing of stipulated thickness with mud plaster, gobri leaping and tile paving and grouting) over the tiled surface, in superficial area.
No deductions in measurements shall be made for either openings or recesses for chimney stacks, roof lights or khurras, of area up to 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 extra shall be paid for any extra labour, materials etc. in forming such openings.
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-Charge in writing.

13.11.7 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

13.12 PAVING OVER MUMTY ROOFS WITH BRICKS TILE
13.12.0 The roofs shall be paved with bricks tile laid flat and grouted with cement mortar.

13.12.1 Bricks Tile
These shall conform to the specifications detailed in subhead 6.0 of brick work

13.12.2 Cement Mortar
The cement mortar shall be of 1:3 mix (1 cement : 3 fine sand) unless otherwise specified in the description of the item and shall conform to the specifications described in subhead 3.0 of Mortars.

13.12.3 Preparing the Surfaces
The surface shall be hacked, roughened and cleaned of all dust and other foreign matter. It shall then be wetted before applying the mortar.

13.12.4 Paving and Grouting
Cement mortar shall be spread in 12 mm layer over the surface evenly to required slope. Brick tiles which had been soaked as in brick work in water for at least an hour before hand shall then be laid open jointed and flat on the mortar and lightly pressed, and set to plane surface true to slopes etc. using a trowel and wooden straight edge. The brick tiles shall be laid with their joints not more than 10 mm wide. They shall be laid with their longitudinal lines of joints truly parallel and horizontal and at right angles to the sloping edges of the roof.
Transverse joints in alternate rows should come directly in line with one another. Transverse joints in adjacent courses shall not have distance by less than 5 cm. As soon as the paving is done, the open joints shall be grouted with cement mortar 1:3 (1cement : 3 fine sand). Cement used for grouting mortar shall be mixed with 2% (by unit of cement) water proofing compound conforming to IS 2645. Care shall be taken to see that no joints are left unfilled or inadequately filled. The joints shall be finished flush with the brick surface.

13.12.5 Curing
The tile paving shall be cured for at least 7 days during which period it shall be suitably protected from damage.
13.12.6 Measurements
Length and breadth shall be measured correct to a cm. Measurements shall be taken for the finished work in superficial area covered.
No deduction in measurement shall be made for either openings or recesses for chimney stacks, roof lights, or for khurras, for areas upto 0.40 sqm nor extra shall be paid for forming such openings. For similar areas exceeding 0.40 sqm deduction shall be made in measurements for all openings but nothing extra shall be paid for forming such openings.

13.12.7 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

13.13 CEMENT CONCRETE GOLA

13.13.1 Cement Concrete
The specifications for concrete shall be the same as described in subhead 4.0 of concrete work.

13.13.2 Gola
A chase of 75 mm wide and 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 mortar 1 : 3 (1 cement : 3 fine sand).
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 cum of coarse sand).

13.13.3 Curing
The finished surface shall be cured for at least 7 days.

13.13.4 Measurements
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 outlets.

13.13.5 Rate
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 roundings at all the corners and risers.

13.14 KHURRAS

13.14.0 The khurras shall be constructed before the brick masonry work in parapet wall is taken up and it shall be of size 45 cm x 45 cm unless otherwise specified in the description of the item and shall be made 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.

13.14.1 Laying
13.14.1.1 A PVC sheet of size 1 m x 1 m x 400 micron (alternatively, aluminium foil of 32 SWG) 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 50 mm.

13.14.1.2 The concrete shall be laid to a size greater than the stipulated size of the khurra in such a way that the adjoining terracing 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.

13.14.1.3 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. 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 and by 20 cm high or as directed by the Engineer-in-Charge.

13.14.1.4 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, shall be of overall size 20 × 25 cm. with an outer frame of 15 × 3 mm M.S. flat to which 4 Nos M.S. bars of 10 mm dia shall be welded in a vertical direction keeping equal clear spacing of 2.5 cm. or as directed by the Engineer in Charge.

13.14.2 Measurements
Khurras shall be counted in numbers.

13.14.3 Rate
The rate is for each completed khurra of the specified size and is inclusive of the cost of all materials and labour in forming the khurras and outlet opening as described above, except for iron gratings which shall be paid for separately.

13.15 RED OR WHITE SAND STONE ROOFING
13.15.1 Sand Stone Slabs
The stone slabs shall be hard, even, sound and durable and shall conform to standards as detailed in subhead 7.0 of stone work. Slabs shall have been sawn or chiselled in a plane parallel to the natural bed of the stone. The slabs shall be rough chisel dressed on the top so that the dressed surface shall not be more than 6 mm from a straight edge placed on it. The edges of the depressions or projections shall be chisel dressed in a slant, so that surface does not have sharp unevenness. The sides shall also be chisel dressed to a minimum depth of 20 mm so that the dressed edges shall at no place be more than 3 mm from a straight edge butted against it. The thickness of the slab shall be uniform and as specified in the item with a permissible tolerance of 2 mm. The slabs shall be uniform in length, the length being 5 to 8 mm less than the centre to centre spacing of the supporting wooden Joists (Karries) or RCC battens. Unless the design require some other shape the slabs shall be rectangular. The width of the slabs may vary unless otherwise stipulated. It shall not be less than 40 cm.

13.15.2 Rafter Spacing
The maximum spacing of rafters (karries) or RCC battens supporting the slabs shall not exceed figures given in Table 12.5.

<table>
<thead>
<tr>
<th>Thickness of Slab</th>
<th>Maximum Spacing of Rafter</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 mm</td>
<td>52.5 cm.</td>
</tr>
<tr>
<td>45 mm</td>
<td>60 cm.</td>
</tr>
<tr>
<td>50 mm</td>
<td>68 cm.</td>
</tr>
</tbody>
</table>

The bearing of slabs over the supporting rafts karries shall not be less than 30 mm. Where a raft karry supports a slab from one side only, the bearing of such slab shall be for full width of the rafts. For bearing over the wall, the stone slabs shall be bedded over a layer of cement mortar 1 : 4 (1 cement : 4 fine sand) of thickness not less than 12 mm.

13.15.3 Laying
The slabs shall be washed clean and wetted before being laid. The stone slabs shall be jointed in cement mortar 1:4 (1 cement : 4 coarse sand). The width of joints shall not be more than 8 mm not less
than 5 mm. The top joints shall be finished flush and ceiling joints pointed with the cement mortar 1:3 (1 cement : 3 fine sand).

13.15.4 Finish
The finished surface shall be truly levelled or slopped as shown in the plan or as directed by the Engineer-in-Charge. It shall be cleaned off all mortar droppings and cement markings both on top and on the under side.

13.15.5 Curing
The slabs and their joints shall be kept wet during progress of work and for 7 days after completion.

13.15.6 Measurements
Length and width of finished stone slab work including bearing shall be measured correct to a cm. The area shall be calculated in sqm correct up to two places of decimal. No deduction in area shall be made for openings in roof slab for chimney, stacks, roof lights etc. of area upto 40 square decimetre nor any extra shall be paid for extra labour, materials etc. involved in cutting and wastage, in forming such openings. For openings exceeding 40 sq. decimeter in area, deduction shall be made in measurements for the full opening but extra shall be paid for extra labour, material etc. required in forming such openings.

13.15.7 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

13.16 WOODEN CEILING
13.16.1 Boards
13.16.1.1 Boards shall be of the class of timber and of finished thickness as specified in the description of the item and shall be in accordance with the general specifications for wood work. Only selected boards of uniform width shall be used. Unless otherwise specified in the description of the item or shown in the drawings, the width of boards selected for use shall not be less than 100 mm nor more than 150 mm.

13.16.1.2 The specific width of boards once selected within these two limits shall be maintained throughout and shall not be varied except in the first and last lines of boards adjustment to the two walls, where remaining odd width shall be adjacent equally on both sides. The maximum length of the board in the finished work shall be 180 cm. The minimum length of board in the finished work shall be such that it will span at least two spacings of the supporting frame work except where shorter lengths are unavoidable, depending on the arrangements of the lines of heading joints which shall be carried out to the pattern ordered by the Engineer-in-Charge. The boards shall be planed true on the exposed side.

13.16.1.3 Unless stipulated otherwise in the description of the item, the longitudinal joints of the boards shall be tongued and grooved, while the heading joints shall be of the square butt type and shall occur under the centre line of the supporting joint. Heading joints in adjacent boards shall not be placed over the same joists, those in alternate boards being arranged in the same line, except where the joints are to be concealed by headings.

13.16.2 Frame
Timber frame of the class of timber and section specified in the description of the item or as ordered by the Engineer-in-Charge shall be provided. The width of the frame scantling shall not be less than 50 mm. The arrangements and spacing of the frame scantling shall be as per design furnished. The frame shall be given two coats of approved preservative paint before the boarding is screwed. The frame and paints thereof shall be paid for separately unless specifically included in the description of the item. M.S. angles or other sections shall be used for suspending the frame and paid for separately. The bottom surface of the frame shall be checked and corrected to true plans and slopes.
13.16.3 Mild Steel Screws
Screws shall be got approved from the Engineer-in-Charge before fixing. They shall be of the slotted counter sunk head type of length not less than the thickness of the board plus 20 mm. The designation number shall not be less than 9 for screws of length 40 to 50 mm and shall not be less than 6 for screws of length 25 to 35 mm.

13.16.4 Fixing
The outer lines of boards shall be accurately fixed, parallel and close to the wall. Each subsequent plank shall be carefully jointed up. The boards shall be fixed to the frame scantling above with two screws at each of frame and one at every intermediate joist. The screws shall be counter sunk and the screw holes filled with putty or sloping out wax.
The unexposed faces of planks shall be painted with wood preservative before fixing.

13.16.5 Finishing
The exposed side of the boards shall be truely level and plane. The joints shall be truely parallel and/or perpendicular to the walls.
Beadings shall then be fixed to the ceiling, to the size and pattern required. These shall be measured and paid for separately unless specifically included in the description of the ceiling item.

13.16.6 Measurements
Length and breadth shall be measured correct to a cm. Areas shall be worked out to nearest 0.01 sqm. The superficial area of the finished work ceiling shall be measured in square metres.
No deduction in measurements shall be made for openings of areas upto 40 square decimetre.
Nothing extra shall be payable either for any extra material or labour involved in forming such openings.
For openings exceeding 0.40 sqm in area, deductions in measurements for the full opening will be made and in such case any labour involved in making these openings shall be paid for separately in running metres.
Wooden ceiling of boardings fixed to curve surfaces in narrow widths shall be measured and paid for separately and shall include making the joints to proper splay.
Circular cutting and waste shall be measured and paid for separately in running metres.

13.16.7 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above.

13.17 CEILING WITH FIBRE INSULATING BUILDING BOARDS
13.17.1 Insulating Building Boards
The insulating building boards shall be of approved quality as per IS code 3348 and, unless otherwise specified, shall have square edges. The dimension shall be subjected to the tolerances given in the Table 13.6 below:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Type of Board</th>
<th>Nominal Thickness mm</th>
<th>Tolerance on Thickness mm</th>
<th>Length cm</th>
<th>Width cm</th>
<th>Tolerance on length and width</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Fibre insulation board, ordinary or flame retardant type</td>
<td>9</td>
<td>± 0.75</td>
<td>365, 300</td>
<td>180,150</td>
<td>120 cm and below ± 3 mm Above 120 cm ± 6 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>± 0.75</td>
<td>270, 240</td>
<td>120,100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>± 1.00</td>
<td>210,180</td>
<td>90, 60</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>± 1.25</td>
<td>150,120</td>
<td>45 and 30</td>
<td></td>
</tr>
</tbody>
</table>
13.17.2 Frame
Frame of the class of timber and section specified in the description of the relevant item or as ordered by the Engineer-in-Charge shall be provided. The width of the scantlings provided shall be sufficient to provide a minimum nailing surface of 50 mm. The longitudinal and header scantlings shall be so arranged that (a) the boards can be fixed to form the panel arrangements required as per drawings or as ordered by the Engineer-in-Charge (b) the longitudinal scantling to which the boards are mainly fixed are spaced at 30 to 45 cm centres, the actual spacing selected depending on the width of the cut board in the panel arrangement, (c) all edges of the cut board units are supported either on the longitudinal scantlings or on the header scantlings or on both.
The frame shall be given two coats of approved preservative paint (to be paid for separately) before the board is nailed on. M.S. angles or other sections shall be used for suspending the frame and will be paid for separately.
Where the joints in the board are to be covered with beadings the frames should allow 3 to 6 mm for space between boards.
The frame and painting thereof shall be paid for separately unless specifically included in the description of the ceiling item.
The bottom surface of the frame shall be checked and corrected to true planes and slopes.

13.17.3 Nails
The sheets shall be fixed to the frame scantling with G.I. headless nails 2.24 mm dia when the joints are to be left exposed. Where the joints will be covered with beadings, the sheets are to be fixed to the frames scantlings with G.I. felt headed (clout) nails 2.5 mm dia. The length of the nails shall generally be equal to thickness of sheet plus 25 mm so that their grip on the framing members will not be less than 25 mm.

13.17.4 Fixing
The boards shall be laid with lengths parallel to all joints centered over the framing members. Where joints are to be covered, the boards may be spaced 3 to 6 mm apart as described in the respective manufacturers’ specifications. Where joints are to be left exposed the sheets shall be butt laid with their edges abutting in moderate contact, but without having to force them into place. The boards shall be supported and held tight to the frame with timber pieces the later being moved outwards as the nailing proceeds. The boards are first nailed to the intermediate framing member proceeding from the centre of the board outwards, the edges being nailed last.
Where the joints are to be left exposed, the outer rows of nails are placed at 10 cm centres and about 12 mm from the edge of the sheet. In the rows in the middle of the sheets, the nails are placed 20 cm apart. The nails should be counter sunk in the under side of board with a suitable punch. Care shall be taken in driving the nails so that the sheets are not marked by hammer blows.
Where the joints are to be covered with beadings, felt headed (clout) nails shall be used instead of nails without head. The spacing of the nails in the interior rows in boards shall be the same as in the preceding para. In the outer rows at edges to be covered by beadings, the nails will be spaced at 20 cm centres in each row with the nails staggered. The beadings will then be fixed over the sheets with screws at 20 cm centres in each row with the screws in the two rows staggered and passing through beading, sheet and framing so that ultimately the spacing of the fixing (nails and screws taken together) in each row will be at 10 cm centres so far as the sheets and frames are concerned.

13.17.5 Finishing
The exposed side of the board shall be truely level and plane without any local bulges or sags. The joints shall be truely parallel and/or perpendicular to the walls. The width of joints shall be uniform. Care shall be taken to see that the uniformity of colour of the sheets is not spoilt during the fixing operations.
Where the joints are required to be covered, beadings of size, pattern and material as approved by Engineer-in-charge be fixed with screws. These shall, however, be measured and paid for separately,
unless specifically included in the description of the ceiling item. The ceiling shall be treated with distemper or painting if so required but such surface treatment will be paid for separately, unless specifically included in the description of the ceiling item.

13.17.6 Measurements and Rate
These shall be the same as described in 13.16.6 and 13.16.7.

13.18 PARTICLE BOARD /MULTIPURPOSE CEMENT BOARD CEILING

13.18.1 Boards
13.18.1.1 Particle Board: Particle board flat pressed 3 layers medium density shall be graded particle board grade-1 conforming to IS 3087 of specified thickness. The specifications for particle board shall be same as in sub head 9.0 of wood work and PVC work.

13.18.1.2 Multipurpose Cement Board: (High Pressure Steam cured). This shall be conforming to IS 14862 and of thickness specified in the item.

13.18.2 Frame
The specifications as described in 13.17.2 shall apply except that the maximum spacing of the longitudinal scantlings shall be 40 cm centres. The specifications for cutting and chamfering etc. will be same as in 13.17.2.

13.18.3 Nails
The specifications shall be the same as in 13.17.3.

13.18.4 Fixing
The specifications as in 13.17.4 shall apply.

13.18.5 Finishing
The specifications as in 13.17.5 shall apply except that normally no surface treatment like painting, varnishing, etc. is necessary.

13.18.6 Measurements and Rate
These shall be the same as under 13.17.6.

13.19 PLAIN/SEMI PERFORATED PARTICLE BOARD TILES CEILING

13.19.1 Frame
The frame work shall consist of anodized aluminium T sections for main runners /cross runners of size specified in the item with anodic coating of 15 micron and perimeter wall angle of anodized aluminium section of size specified by the Engineer-in-charge with anodic coating of 15 micron fixed to the wall with M.S. screws 50 mm long and PVC raw plugs. The frame work shall be executed in a manner so as to form a grid of 600 mm x 600 mm as specified in the item. The frame work shall be suspended from ceiling by level adjusting hangers made of 6 mm dia. M.S. rods fixed to slab by means of MS ceiling cleats. The ceiling cleats shall be fixed to the slab by means of mechanical dash fasteners 6 mm dia and 50 mm long. MS hangers and ceiling cleats shall be painted with a coat of yellow zinc chromate primer and two coats of synthetic enamel paint.

13.19.2 Ceiling Tiles
Ceiling tiles shall be of 12 mm plain/semi perforated or with design BWP type phenol formaldehyde synthetic resin bonded particle board conforming to IS 3087 of required size. Tiles shall be finished with a coat of aluminium primer on both side and edges and two coats of synthetic enamel paint of approved quality and shade on exposed faces of the tiles.
13.19.3 Fixing of Ceiling Tiles
The ceiling tiles shall be placed over the aluminium frame and fixed to the frame with help of 25 mm long CP brass screws with minimum 2 screws on each side of the grid. The CP brass screws shall be counter sunk star head screws.

13.19.4 Measurements
Length & breadth of the finished ceiling shall be measured correct to a centimetre. The area shall be calculated in square metre correct to two decimal places. No deduction shall be made for making openings for electrical, air conditioning, fire fighting fixtures nor shall extra payment be made either for extra materials or labour involved in making such openings.

13.19.5 Rate
The rate shall include the cost of all the materials and labour involved in all the operation described above including scaffolding etc. Aluminium frame work mentioned in para 13.19.1 will be paid for separately unless otherwise stipulated in the description of the items.

13.20 TRANSULCENT WHITE ACRYLIC PLASTIC (PMMA) SHEET CEILING
13.20.1 Frame
It shall be as para 13.19.1

13.20.2 Ceiling Tiles
These shall be made of translucent white acrylic plastic sheet conforming to IS 14753 of thickness specified in the item.

13.20.3, 13.20.4, 13.20.5 Fixing, Measurements & Rate
Same as per paras 13.19.3, 13.19.4, 13.19.5 respectively.

13.21 PLASTER OF PARIS (GYPSUM ANHYDROUS) CEILING OVER WOODEN STRIPS
13.21.1 Frame
The frame work shall be of the specified wood. In case of sloping roofs, wooden battens of suitable section (depending upon the span and load to be carried) shall be firmly fixed as main supports, to the under side of the tie beams of the trusses at required spacing by means of bolts and nuts of proper size. In case of flat roofs, the battens shall be securely fixed to the walls and pillars by holding down bolts and shall be fastened to the slabs above with iron straps of suitable sections and encroached therein. Cross battens of 50 x 40 mm sections at 40 cm centres or so, shall then be fixed at right angles to the main battens. The frame work shall be treated with approved wooden preservative before fixing. The underside of the frame work shall be true to planes and slopes. The frame work for ceiling shall be paid for separately unless specifically included in the description of the ceiling item.

13.21.2 Wooden Strips
Wooden strips of size 25 x 6 mm of first class kailwood, (unless otherwise stipulates specifically in the description of the item) shall be fixed to the cross battens, in the parallel rows with gaps of 10 mm in between adjacent rows, by means of felt headed (clout) nails. The strips shall be fixed butt jointed and not overlapped. The joints shall be staggered. The minimum length of strips to be used shall be 1.5 m depending upon the length of strips required.

13.21.3 Rabbit Wire Mesh
Rabbit Wire mesh shall then be fixed to the underside of wooden strips and their junctions with the battens with nails at pitch of 15 to 20 cm as ordered by the Engineer-in-Charge. The rabbit wire mesh shall be straight, tight and perfectly true to planes and slopes and without any sagging and shall be slightly below the underside of the laths to allow the plaster to encase the metal round.
13.21.4 Plaster of Paris
The plaster of Paris shall be of the calcium-sulphate semi-hydrate variety. Its fineness shall be such that when sieved through a sieve of IS sieve designation 3.35 mm for 5 minutes the residue left on it after drying shall be not more than 1% by weight. It shall not be too quick setting. Initial setting time shall not be less than 13 minutes. The average compressive strength of material determined by testing 5 cm cubes after removal from moulds, after 24 hours and drying in an oven at 40 degree C till weight of the cubes is constant, shall not be less than 84 kg per square metre.

13.21.5 Applications
The material will be mixed with water to a workable consistency. Plaster of Paris shall be applied to the underside of the laths over the rabbit wire mesh in suitable sized panels and finished to a smooth surface by steel trowels. The plaster shall be applied in such a manner that it fully fills the gaps between the laths and the thickness over the laths is as specified in the description of the item. The joints shall be finished flush to make the ceiling in one piece. The finished surface shall be smooth and true to plane, slopes or curves as required.

13.21.6 Measurements
13.21.6.1 Length and breadth of superficial area of the finished work shall be measured correct to a cm. Area shall be calculated in square metre correct to two places of decimal. No deduction will be made to openings of areas up to 40 square decimetre nor shall extra payment be made either for any extra material or labour involved in forming such openings.

13.21.6.2 For openings exceeding 40 square decimetre in area, deduction in measurements shall be made but extra payment will be made for any extra material or labour involved in making such openings.

13.21.6.3 Curved surfaces shall be measured and paid for separately from flat surfaces. The work shall be deemed to comprise of flat surfaces only unless specifically stated otherwise in the description of the item.

13.21.6.4 Any sunk or raised mouldings in the plaster shall be measured and paid for separately, deductions being made from plastering on ceiling only if the width exceeds 15 cm. Ceiling at a height greater than 5 metres shall be so described and measured separately stating the height.

13.21.7 Rate
The rate shall include the cost of all materials and labour involved in all the operations described above including all scaffolding, staging etc. The frame work mentioned in para 13.21.1 supporting the ceiling will be paid for separately unless otherwise stipulated in the description of the item. The rate does not include for any raised or sunk mouldings or for any patterned finishing of the surface which will be measured and paid for extra over the plaster work.

13.22 RAIN WATER SPOUTS
13.22.0 The sectional area of rain water spouts provided shall be generally at the rate of 1 square cm per 70 to 80 square decimetre 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.

13.22.1 Stone Ware Spouts
The spouts shall be 100 mm in diameters and 60 cm long.

13.22.1.1 The stone ware pipe shall be perfectly sound, free from fine cracks, imperfections of glazing etc. They must be straight cylindrical and of standard nominal diameter and length and depth of socket as given in IS 651. Full length of pipes shall be used on the work. They must be thoroughly salt glazed inside and outside shall generally conform to IS 651.
**13.22.1.2 Fixing**: 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 around the pipe and socket shall be thoroughly wetted and the holes shall be given a coat of cement mortar around. The S.W. pipe shall then be inserted and fixed with a surround of mortar. In case the hole has become 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 the annular space. The spouts shall slope downward at the rate 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. Care 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.

**13.22.1.3 Measurements**: Spouts shall be measured in numbers.

**13.22.1.4 Rate**: The rate shall include the cost of all materials and labour involved in all the operations described above including scaffolding.

**13.23 CAST IRON RAIN WATER PIPES**

**13.23.1 Cast Iron Pipes**

Pipes shall conform to IS 1230 and shall be perfectly, smooth and cylindrical, their inner and outer surfaces being as nearly as practicable concentric. These shall be sound and of 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.

**13.23.2 Dimensions**

C.I. rain water pipes shall be of the dia 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.

The pipes supplied shall be factory painted (with a tar base composition) both inside and outside which shall be smooth and tenacious.

Every pipe shall ring clearly when struck all over with a light hand hammer. When shorter pipes are cut from full lengths they shall be cut with a hacksaw. The sizes, weights, sockets and tolerances of pipes shall be as shown in Table 13.7.

<table>
<thead>
<tr>
<th>Nominal size of pipes (Internal diameter in mm)</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>125</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PIPE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) External diameter in mm</td>
<td>53</td>
<td>79</td>
<td>104</td>
<td>130</td>
<td>156</td>
</tr>
<tr>
<td>Tolerance in mm</td>
<td>± 3</td>
<td>± 3</td>
<td>± 3.50</td>
<td>± 3.50</td>
<td>± 4.00</td>
</tr>
<tr>
<td>(b) Thickness in mm</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Tolerance in mm</td>
<td>± 1</td>
<td>± 1</td>
<td>± 1</td>
<td>± 1</td>
<td>± 1</td>
</tr>
<tr>
<td>(c) Nominal weight of 1800 mm long pipe without ears in kg</td>
<td>7.50</td>
<td>11.00</td>
<td>14.00</td>
<td>20.00</td>
<td>26.00</td>
</tr>
<tr>
<td>Tolerance in weight</td>
<td>(~) 10%</td>
<td>(~) 10%</td>
<td>(~) 10%</td>
<td>(~) 10%</td>
<td>(~) 10%</td>
</tr>
<tr>
<td>Tolerance in length in mm</td>
<td>± 13.00</td>
<td>± 13.00</td>
<td>± 13.00</td>
<td>± 13.00</td>
<td>± 13.00</td>
</tr>
</tbody>
</table>
2. **SOCKET**

<table>
<thead>
<tr>
<th></th>
<th>63</th>
<th>89</th>
<th>114</th>
<th>139</th>
<th>167</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a) Internal diameter in mm Tolerance in mm</strong></td>
<td>± 3.00</td>
<td>± 3.00</td>
<td>± 3.00</td>
<td>± 3.00</td>
<td>± 3.00</td>
</tr>
<tr>
<td><strong>(b) Thickness in mm Tolerance in mm</strong></td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td><strong>(c) Internal depth in mm Tolerance in mm</strong></td>
<td>± 1.00</td>
<td>± 1.00</td>
<td>± 1.00</td>
<td>± 1.00</td>
<td>± 1.00</td>
</tr>
<tr>
<td>60</td>
<td>65</td>
<td>65</td>
<td>75</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>± 10</td>
<td>± 10</td>
<td>± 10</td>
<td>± 10</td>
<td>± 10</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** 1. All dimensions are in mm.
2. Pipes weighing 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.
4. For pipes and fittings which are to be embedded in masonry, specifications shall correspond with those of pipes for soil, waste, and vent pipes. For their weights, specifications under chapter 19.0 shall be referred to.

**13.23.3 Fixing and Jointing**

**13.23.3.1** Pipes shall be either fixed on face of wall or embedded in masonry, as required in the description of the item.

**13.23.3.2** 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 dia M.S. bolt on one side and provided with flanged ends on the other side with hole to fit by 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, rivetted to the ring at the centre of one semi circular 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. 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.

**13.23.3.3** 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 be 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.

**13.23.3.4** 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 portion 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. The depth of lead from the lip of socket shall be 25 mm minimum. In case of 100 mm dia. 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. In 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. 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 variation includes allowances of wastage also.

13.23.3.5 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 as described in detail under jointing of S.C.I soil, waste and vent pipes.

13.24 CAST IRON ACCESSORIES FOR RAIN WATER PIPES

13.24.1 C.I. Fittings
C.I. accessories such as bends of various degrees, heads, offsets of different projections, branches and shoes shall conform to IS 1230. Bends shall be of the nearest standard degree as actually required at site. Heads shall be of the flat or corner type as required. Offsets shall be of the projection 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 dia., 205 mm for 100 mm dia and 275 mm for 150 dia sized pipe from top of socket to lowest tip of shoe. Shoes of longer lengths if used shall be in lengths 300 mm, 375 mm, 450 mm, or 600 mm from top of socket to lowest tip of shoe of as actually required at site.

12.24.2 Dimensions
The fittings shall be of the diameter specified in the description of the item. 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 13.8.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Description</th>
<th>75 mm dia (weight in kg)</th>
<th>100 mm dia (weight in kg)</th>
<th>150 mm dia (weight in kg)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bends (Plain)</td>
<td>3.20</td>
<td>4.50</td>
<td>9.10</td>
<td>Each</td>
</tr>
<tr>
<td>2.</td>
<td>Offsets (Plain)</td>
<td>2.70</td>
<td>5.00</td>
<td>8.20</td>
<td>Each</td>
</tr>
<tr>
<td></td>
<td>(a) 55 mm projection</td>
<td>3.20</td>
<td>5.50</td>
<td>9.10</td>
<td>Each</td>
</tr>
<tr>
<td></td>
<td>(b) 75 mm projection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13.8.
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>(c) 115 mm projection</td>
<td>4.10</td>
<td>5.90</td>
<td>9.50</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>(d) 150 mm projection</td>
<td>4.50</td>
<td>6.40</td>
<td>10.40</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>(e) 225 mm projection</td>
<td>5.00</td>
<td>7.30</td>
<td>11.80</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>(f) 300 mm projection</td>
<td>6.00</td>
<td>8.60</td>
<td>12.70</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>3. Branches (Plain)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>5.00</td>
<td>7.30</td>
<td>14.50</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>6.80</td>
<td>10.00</td>
<td>19.10</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>4. Standard shoes (Plain)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer shoes (Plain)</td>
<td>3.20</td>
<td>4.10</td>
<td>8.60</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>(a) 300 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) 375 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) 450 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) 600 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Heads</td>
<td>6.40</td>
<td>6.80</td>
<td>11.30</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>7. Extras:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) For ears cast on any fitting and short pipes</td>
<td>0.90</td>
<td>0.90</td>
<td>1.35</td>
<td>Each</td>
<td></td>
</tr>
<tr>
<td>(b) For inspection doors fitted on any fitting</td>
<td>1.80</td>
<td>1.80</td>
<td>2.25</td>
<td>Each</td>
<td></td>
</tr>
</tbody>
</table>

**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.

**13.24.3 Fixing and jointing shall be as specified in 13.23.3.**

**13.24.4 Measurements**
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 dia, 100 mm dia and 150 mm dia respectively in number and the extra lengths of the shoes shall be measured and paid for under the corresponding size of pipes.

**13.24.5 Rate**
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.

**13.25 THERMAL INSULATION FOR ROOFING**

**13.25.1 With Cellular Concrete**

**13.25.1.1 Types and Grades:** Cellular concrete is a light weight concrete formed by producing gas or air bubbles in cement slurry or a cement sand slurry. Cellular concrete shall conform to IS 6598 and shall be of following two types depending on the manner of manufacture.

(i) Type I: High pressure steam cured (auto-claved) materials in the form of precast blocks.
(ii) Type II: Materials cured under natural conditions (that is under ambient pressure and temperature) by water. The material may be either cast in situ or may be in the form of precast
blocks.
Grades - Each of these two types of the material shall have three grades, namely:
Grade A - Light weight cellular concrete;
Grade B - Medium weight cellular concrete and;
Grade C - Heavy weight cellular concrete.

13.25.1.2 Materials
(a) Aggregate: A variety of sillicious fines, such as ground quarts sand shale, flyash and granulated slag may be used in the manufacture of cellular concrete.
(b) Water and binder shall conform to para 3.1.1 and 3.1.2 of CPWD Specifications 2009.
(c) Gassing Agents: Organic foaming agents based on resin soap, glue, surface active agents, or fine aluminium powder, zinc, dust, calcium carbide, calcium by pocheride etc. may be used for gassing the concrete.

13.25.1.3 Dimensions: The dimensions of the type I and type II precast cellular concrete block shall be either 50 or 60 cm in length, 20, 25 or 30 cm in width and 7.5, 10, 15, 25 or 40 cm in thickness.

13.25.1.3.1 Tolerance: A tolerance of ±3 percent shall be allowed on width and height and ±1 percent on thickness.

13.25.1.4 Requirement for Cellular Concrete

| TABLE 13.9 |
|------------------|---|---|---|---|---|
| S. No. | Characteristics | Grade | Grade | Grade | Test reference |
|       |                 | A     | B     | C     |               |
| 1.    | Density in kg/cum | Upto  | 320   | 400   | 500           | IS 5688     |
| 2.    | Crushing Strength in kg/sq. cm. | (type I) | 7.0   | 12.0  | 20.0          | -do-        |
|       | (type II)        | 2.5   | 4.5   | 8.0   |               |             |
| 3.    | Thermal conductivity in kw/cm deg c at 50 deg. c mean Temperature | 0.7   | 0.85  | 1.0   | IS 3346       |
| 4.    | Capillary absorption not to exceed 20% in case of type I cellular concrete when tested as per Appendix A of IS 6598. |

13.25.1.5 Sampling: In a consignment, cellular concrete of the same type and grade and manufactured approximately in the same period shall be grouped to form a lot. If it is in the form of blocks, a lot shall be made up of not more than 1000 blocks. If the material is in situ, not more than 10 tons of materials shall constitute a lot.
If the material is transported in lorries and received as such, the material in lorry (or vehicle load) & may conveniently be termed as lot.
Each lot shall be tested for all the requirements separately.
If the lot is made up of precast blocks, the number of sample blocks to be tested shall be selected at random as per the following Table 13.10.
Table 13.10.

<table>
<thead>
<tr>
<th>Lot Size</th>
<th>Sample size (block to be sampled) (n)</th>
<th>Permissible No. of defectives (visual and dimensional requirements) (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>101 to 300</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>301 to 500</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>501 to 1000</td>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

13.25.1.6 General: Cellular concrete if done with precast blocks shall be laid on terrace slab after thoroughly cleaning the surface. The blocks shall be laid over a layer of 12 mm average thick cement mortar 1:4 (1 cement : 4 coarse sand) and the joints shall also be filled properly with neat cement slurry. The joints shall be staggered. Thickness of joints shall be as minimum as possible and not more than 5 mm.

13.25.1.7 Measurements: Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work. No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but nothing extra will be paid for any extra material or labour involved in forming such openings.

13.25.1.8 Rate: The rate shall include the cost of all materials and labour required in providing cellular concrete.

13.25.2 With Resin Bonded Fibre Glass Wool (Bonded Mineral Wool)
13.25.2.1 Material: The material shall be mineral wool made from rock slag or glass processed from a molten state into fibrous form and shall be bonded with a suitable binder. Bonded mineral wool shall conform to specifications of group I of IS 8183.

13.25.2.2 Dimensions: The bonded mineral wool shall be supplied in width of 50, 60, 75 and 100 cms, and length of 100, 120 and 140 cms and the thickness of the bonded mineral wool shall be 25, 40, 50, 65 or 75 mm.

13.25.2.3 Tolerances: For width and length, the dimensional tolerances of the bonded mineral wool slabs shall be -½%. For nominal thickness in the range 25 to 75 mm the tolerance shall be -2 mm. An excess, in all dimensions is permitted.

13.25.2.4 Requirements for Fibre Glass Wool

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Characteristics</th>
<th>Group I</th>
<th>Test Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bulk density</td>
<td>12 to 15 kg/cum</td>
<td>IS 3144</td>
</tr>
<tr>
<td>2.</td>
<td>Recovery after compression</td>
<td>not less than 90% of original thickness</td>
<td>Annex. A of IS 8183</td>
</tr>
<tr>
<td>3.</td>
<td>Shot content max</td>
<td>500 micron - 5% 250 micron - 15%</td>
<td>IS 3144</td>
</tr>
<tr>
<td>4.</td>
<td>Moisture content and</td>
<td>not more than 2%</td>
<td>IS 3144</td>
</tr>
</tbody>
</table>
5. Incombustibility & IS 3144

6. Thermal Conductivity 0.49 mw/ cm oC & IS 3346

7. Sulphur Content Not more than 0.6% & IS 3144

13.25.2.5 General: Bonded mineral wool insulation can be either laid over false ceiling or alternatively it can be fixed to the ceiling when the space above false ceiling is being used for carrying return air. In the first case the bonded mineral wool can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled over the suspended false ceiling. In the second case when space above false ceiling is to be used for carrying return air 1.5” x 1.5” slotted angle (3” length) shall be fixed to the ceiling by means of rawl plugs at 2’0” spacing. Draw 14 gauge tie wires from the slots. Make a mat of mineral wool insulation backed with scrim cloth with a light coating of Plaster of Paris or polythene faced hessian and 24g x 1” wire mesh netting. The joints of wire netting should be butted and tightly laced down with G.I. wire. Stretch the mat tightly across the angles holding it in place by means of tie wires.

13.25.2.6 Measurements: Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work. No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings. Boarding fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately in running metres.

13.25.2.7 Rate: The rate shall include the cost of all materials and labour required in providing bonded mineral wool.

13.25.3 With Expanded Polystyrene

13.25.3.1 Material: Expanded polystyrene shall conform to IS 4671. It is of two types as given below:
(a) Type N - Normal
(b) Type SE - It shall be of self extinguishing type when tested in accordance with Appendix E of IS 4671.

13.25.3.2 Dimensions: The size of the finished boards shall be 1.0 x 0.5 m or as specified and having a thickness of 15, 20, 25, 40, 50, 60, 75 or 100 mm.

13.25.3.2.1 Tolerances: The tolerances on length, width and thickness of the finished board shall be ±2 mm.

13.25.3.3 Requirements for Expanded Polystyrene for General Use:
TABLE 13.12

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Characteristics</th>
<th>Requirements at various nominal apparent densities in kg/cum</th>
<th>Test Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15 20 25 30 35</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Thermal conductivity (K. value)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) at 0ºC</td>
<td>0.34 0.32 0.30 0.29 0.28</td>
<td>IS 3346</td>
</tr>
<tr>
<td></td>
<td>(b) at 10ºC</td>
<td>0.37 0.35 0.33 0.32 0.3</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Compressive strength at 10% deformation in Kg/sq.cm Min.</td>
<td>0.7  0.9 1.1 1.4 1.7</td>
<td>IS 4671 Appendix A</td>
</tr>
<tr>
<td>3.</td>
<td>Cross breaking strength in kg/sq. cm Min.</td>
<td>1.4 1.6 1.8 2.2</td>
<td>IS 4671 Appendix A</td>
</tr>
<tr>
<td>4.</td>
<td>Water vapour permeance in g/sqm 24 hrs. Max.</td>
<td>50 40 30 20</td>
<td>IS 4671 Appendix B</td>
</tr>
<tr>
<td>5.</td>
<td>Thermal stability Percent Max.</td>
<td>1 1 1 1</td>
<td>IS 4671 Appendix D</td>
</tr>
<tr>
<td>6.</td>
<td>Water absorption</td>
<td>less than 0.5% by volume (after 24 hrs. immersion)</td>
<td>IS 4671 Appendix E</td>
</tr>
</tbody>
</table>

13.25.3.4 **Sampling**: In a single consignment all the items of the same type, shape and dimensions belonging to the same batch of manufacture shall be grouped together to constitute a lot. For the purpose of judging conformity to the requirements each lot shall be considered separately. The number of sample items for this purpose shall depend on the size of the lot and shall be in accordance with col. 1 & 2 of Table No. 13.13 given below. The sample shall be taken at random from the lot.

**TABLE 13.13**

<table>
<thead>
<tr>
<th>No. of items in the lot</th>
<th>No. of sample items</th>
<th>Permissible number of defective sample items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Upto 25</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>26 to 100</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>101 to 300</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>301 to 1000</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>1001 to 3000</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>3001 and above</td>
<td>32</td>
<td>2</td>
</tr>
</tbody>
</table>

All the sample items selected from the lot shall be tested for all requirements of the specifications. Any item failing in one or more of the requirements shall be regarded as defective.

13.25.3.5 **General**: Expanded polystyrene can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled over the suspended false ceiling.

13.25.3.6 **Measurements**: Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work. No deduction shall be made for openings of areas up to 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area deduction for the full opening will be made, but nothing extra will be paid for any extra material/labour involved in forming such openings.
13.25.3.7 Rate: The rate shall include the cost of material and labour in providing and fixing the polystyrene boards.

13.25.4 With Exfoliated Vermiculite
13.25.4.1 Material: Exfoliated vermiculite consists of vermiculite mineral which has been expanded many times of its original volume after being subjected to high temperature (700 degree C to 1000 degree C).
It is utilised as a thermal insulation material after mixing it with a cementitious material.

13.25.4.2 Requirements of Exfoliated Vermiculite for General Use
13.25.4.2.1 Exfoliated vermiculite in loose fill condition should conform to following:

**TABLE 13.14**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Characteristics</th>
<th>Type-I</th>
<th>Type-II</th>
<th>Type-III</th>
<th>Type-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Density in kg/m</td>
<td>Min.</td>
<td>56</td>
<td>64</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max.</td>
<td>12</td>
<td>128</td>
<td>144</td>
</tr>
<tr>
<td>2.</td>
<td>Thermal conductivity at mean temp. 25 deg. C in mw/cm deg.C</td>
<td>0.72</td>
<td>0.72</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>3.</td>
<td>Guarding: As per following table.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accumulated % age retained on sieves having square holes, by wt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 13.15**

<table>
<thead>
<tr>
<th>Size</th>
<th>9.51 mm</th>
<th>4.76 mm</th>
<th>2.38 mm</th>
<th>1.19 mm</th>
<th>595 mcn</th>
<th>297 mcn</th>
<th>149 mcn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-I</td>
<td>0</td>
<td>40</td>
<td>30</td>
<td>90</td>
<td>65</td>
<td>98</td>
<td>85</td>
</tr>
<tr>
<td>Type-II</td>
<td>-</td>
<td>0</td>
<td>95</td>
<td>20</td>
<td>80</td>
<td>75</td>
<td>99</td>
</tr>
<tr>
<td>Type-III</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>Type-IV</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

13.25.4.2.2 Exfoliated vermiculite after being mixed with a cementitious material should conform to Following:

**TABLE 13.16**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Characteristics</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Consistency</td>
<td>35 to 45% or 178 to 229 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34 sqm</td>
</tr>
<tr>
<td>2.</td>
<td>Dry covering capacity in sqm of 100 kg of material 1 cm thick</td>
<td>103.5 KN/sqm</td>
</tr>
<tr>
<td>3.</td>
<td>Compressive strength at 5% deformation min.</td>
<td>3%</td>
</tr>
<tr>
<td>4.</td>
<td>Liner shrinkage after 24 hrs. at 1800 Deg. F max.</td>
<td>1.37 mw/cm deg.C</td>
</tr>
<tr>
<td>5.</td>
<td>Thermal conductivity max. at mean temperature 95 deg.C.</td>
<td></td>
</tr>
</tbody>
</table>
13.25.4.3 **Sampling & Testing**: If any of the test date obtained on the samples tested fail to conform to the requirements given above, the material shall be rejected.

13.25.4.4 **General**: Exfoliated vermiculite along with cementitious material is mixed with water in the required proportion (as specified by manufacturers). This mix is to be immediately spread over the terrace slab in prescribed thickness. No curing need be done. After laying the insulation, the entire surface shall be cement plastered with cement mortar 1:4 of 20 mm thickness.

13.25.4.5 **Measurements**: Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work. No deduction shall be made for openings of areas up to 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but nothing extra will be paid for any extra material or labour involved in forming such openings. Boarding fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately in running metres.

13.25.4.6 **Rate**: The rate shall include the cost of all materials and labour in providing exfoliated vermiculite.

### 13.26 UNPLASTICISED POLYVINYL CHLORIDE PIPES AND FITTINGS

13.26.1 **UPVC Pipes**

Pipes shall conform to Type A pipes of IS 13592. The internal and external surfaces of the pipes shall be smooth and clean and free from groovings and other defects. The end shall be clearly cut and shall be square with the axis of the pipe. The end may be chamfered on the plain sides. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible provided the wall thickness remains within the permissible limit.

13.26.2 **Colour of Pipe**

Surface colour of the pipes shall be dark shade of grey or as specified.

13.26.3 **Marking**

Each pipe shall be clearly and indelibly marked with the following information at intervals not more than 3 meter.

(a) Manufacturer’s name or trade mark.
(b) Nominal outside dia of pipe.
(c) Type ‘A’
(d) Batch number.

13.27.4 **Dimensions**

13.26.4.1 **Diameter and Wall Thickness**: Mean outside diameter, outside diameter at any point and wall thickness for type –A manufactured plain or with socket shall be as given in Table-1 of IS 13592. UPVC rain water pipes shall be of the dia, specified in the description of the item and shall be in nominal lengths of 2, 3, 4 or 6 metres either plain or with sliding/grooved socket unless shorter lengths are required at junctions with fittings. Tolerances on specified length shall be ± 10 mm and – 0 mm.

13.26.5 **Fixing and Jointing**

Pipes shall be either fixed on face of wall or embedded in masonry as required in the description of the item.

Plain pipes shall be secured to the walls at all joints with PVC Pipes clips by means of 50 x 50 x 50 mm hard wood plugs, screwed with M.S. screws of required length i/c cutting brick work and fixing in cement
mixture of 1:4 (1 cement : 4 coarse sand). The clips shall be kept about 25 mm clear off finished face of wall, so as to facilitate cleaning of pipes. Pipes shall be fixed perfectly vertical or to the lines as directed. The pipes shall be fitted to fittings with seal ring conforming to IS 5382 allowing 10 mm gap for thermal expansion.

13.26.6 Installation in Wall/Concrete
The walls/concrete slots should allow for a stress free installation. Pipes and fittings to be inserted into the slots without a cement base have to be applied first with a thin coat of PVC solvent cement followed by sprinkling of dry sand (medium size). Allow it to dry. The process gives a sound base for cement fixation. This process is repeated while joining PVC material to CI/AC materials.

13.26.7 Fittings
Fittings used shall be of the same make as that of the PVC pipes Injection moulded or fabricated by the manufacturer and shall have a minimum wall thickness of 3.2 mm. The fittings shall be supplied with grooved socketted ends with square grooves and provided with Rubber Gasket conforming to IS 5382. The plain ends of the fittings should be chamfered. The fittings shall be joined with the help of Rubber lubricant. The details of fittings refer IS 13592.

13.26.8 Measurements
The fittings shall be measured by numbers. The pipes shall be measured net when fixed correct to a cm. excluding all fittings along its length.

13.26.9 Rate
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 PVC clips which shall be paid for separately.

Note: These pipes shall be used only in shaft or unexposed location to avoid damage to these pipes due to willful act.
A-1 Dimensions
A-1.0 Sizes of plain Sheet: The plain sheets shall be supplied in any combination of the following lengths, widths and thickness.
(a) Length : 2500 and 3000 mm
(b) Width : 900 and 1000 mm
(c) Thickness : 0.50, 0.63, 0.80, 1.00 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 tonne.
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 side 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 within the limit specified in table below:

TABLE I
Mass of Coating (Total Both Sides)

<table>
<thead>
<tr>
<th>Grade of coating</th>
<th>Minimum average coating</th>
<th>Minimum coating single spot test g/sqm*</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>600</td>
<td>510</td>
</tr>
<tr>
<td>450</td>
<td>450</td>
<td>380</td>
</tr>
<tr>
<td>350</td>
<td>350</td>
<td>300</td>
</tr>
<tr>
<td>275</td>
<td>275</td>
<td>235</td>
</tr>
</tbody>
</table>

* minimum individual value obtained in triple spot test.

A-3 Mass
The mass of sheets and coils shall be calculated as given in Table II on the basis of nominal dimensions and mass of zinc coating.

TABLE II
Calculation of Mass of Sheets or Coils

<table>
<thead>
<tr>
<th>Type of materials</th>
<th>Order of calculation</th>
<th>Method of calculation</th>
<th>Number of Numerals in resultant value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet</td>
<td>Mass of single sheet</td>
<td>Nominal mass of single sheet plus mass of zinc coating</td>
<td>Rounded off to 4 effective figures</td>
</tr>
<tr>
<td>Total mass</td>
<td>Mass of single sheet (kg) x number of sheets</td>
<td></td>
<td>Rounded off to integral value of kg</td>
</tr>
</tbody>
</table>
Coil | Unit mass of coil | Unit mass of sheet (kg/m²)x width (mm) x10^-3 | Rounded off to 3 effective figures
---|---|---|---
Mass of single coil | Unit mass of coil (kg/m)x length (m)
Total mass (kg) | Total mass of each coil | Integral number of kg

**Note:**
(i) 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.
(ii) Mass of the coating shall be calculated by multiplying the surface area of single sheet with indicated inominal coating mass (g/square metre) as shown for triple spot test (Table I).
(iii) For calculation of corrugated sheet mass, the width before corrugation shall be considered while calculating the area.

**A-4 Corrugations**
The depth and pitch of corrugation shall be as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Depth of Corrugation (mm)</th>
<th>Pitch of Corrugation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17.5</td>
<td>75</td>
</tr>
<tr>
<td>B</td>
<td>12.5</td>
<td>75</td>
</tr>
</tbody>
</table>

The number of corrugations shall be 8, 10, 11 or 13 per sheet. The overall width of the sheets before and after corrugation shall be as given in Table below.

**TABLE III**
Details of Corrugations

<table>
<thead>
<tr>
<th>Number of corrugations</th>
<th>Grade</th>
<th>Nominal overall width of sheet measured between crowns of outside corrugations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before corrugation mm</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>750</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>900</td>
</tr>
<tr>
<td>11</td>
<td>A</td>
<td>1000</td>
</tr>
<tr>
<td>13</td>
<td>A</td>
<td>1200</td>
</tr>
<tr>
<td>8</td>
<td>B</td>
<td>750</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>900</td>
</tr>
<tr>
<td>11</td>
<td>B</td>
<td>1000</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
<td>1200</td>
</tr>
</tbody>
</table>
APPROVED MAKES FOR CIVIL WORK
# LIST OF APPROVED MAKES / BRANDS FOR CIVIL WORKS

<table>
<thead>
<tr>
<th>S.No</th>
<th>Item</th>
<th>Makes / Brands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CEMENT (ORDINARY PORTLAND / PORTLAND POZZOLANA)</td>
<td>ACC / GRASIM / AMBUJA / BIRLA / ULTRA TECH. / LAFARGE / KONARK</td>
</tr>
<tr>
<td>2</td>
<td>TMT / TOR STEEL</td>
<td>SAIL / TISCO / RINL / JINDAL</td>
</tr>
<tr>
<td>3</td>
<td>STRUCTURAL STEEL</td>
<td>SAIL / TISCO / RINL / JINDAL</td>
</tr>
<tr>
<td>4</td>
<td>CERAMIC TILES</td>
<td>NITCO / ORIENT / SOMANY / KAJARIA / ANGEL / NAVEEN / EVRO</td>
</tr>
<tr>
<td>5</td>
<td>VITRIFIED TILES</td>
<td>NITCO / ORIENT / SOMANY / KAJARIA / NAVEEN / EURO</td>
</tr>
<tr>
<td>6</td>
<td>RCC PIPES</td>
<td>AKSHAY / KK / HINDUSTAN / PRAGATI / ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>7</td>
<td>MANHOLE COVERS (SFRC)</td>
<td>KK / HINDUSTAN / ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>8</td>
<td>KERB STONE (PRECAST CC)</td>
<td>NIMCO PREFAB / SUBHASH FERRO CONCRETE / HINDUSTAN TILES / ANY OTHER MAKE LOCALLY AVILABLE DULY APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>9</td>
<td>CHAINLINK WIREFIEMESH</td>
<td>MITTAL / SHAKTI – WELD MESH / ANY OTHER MAKE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>10</td>
<td>PVC PIPES / FITTINGS</td>
<td>SUPREME / PRAKASH / ORI PLAST / FINOLEX / PRINCE</td>
</tr>
<tr>
<td>11</td>
<td>FLOAT GLASS AND MIRROR</td>
<td>MODIGUARD / ASAHI / SAINT GOBAIN / GUARDIAN</td>
</tr>
<tr>
<td>12</td>
<td>WATER-PROOFING COMPOUND</td>
<td>CICO / CHEMISTIK / FOSROC / MBT / DEGUSSA / CONCARE / PIDILITE</td>
</tr>
<tr>
<td>13</td>
<td>CEMENT/ CONCRETE ADHESIVES</td>
<td>CICO / CHEMISTIK/ FOSROC/MBT/ DEGUSSA/ FOSROC/ SIKA / ARALDOTE/PIDILITE</td>
</tr>
<tr>
<td>14</td>
<td>DISTEMPER-DRY/ OIL BOUND/PAINT</td>
<td>ICI/ASIAN / BERGER/ NEROLAC</td>
</tr>
<tr>
<td>15</td>
<td>ALUMINIUM SECTIONS FOR DOORS/ WINDOWS</td>
<td>HINDALCO / JINDAL/ INDAL/ BANCO/INDOALUSIS(MAHAVIR)</td>
</tr>
<tr>
<td>16</td>
<td>FLOOR HARDNER</td>
<td>CHEMISTIK/FOSROC/SIKA</td>
</tr>
<tr>
<td>17</td>
<td>CEMENT PAINT</td>
<td>SNOWCEM / ICI/NEROLAC/ BERGER / ASIAN</td>
</tr>
<tr>
<td>18</td>
<td>PRIMER FOR STEEL</td>
<td>ICI /ASIAN / BERGER/ NEROLAC</td>
</tr>
<tr>
<td>19</td>
<td>SYNTHETIC ENAMEL PAINT</td>
<td>ICI / ASIAN / BERGER / NEROLAC</td>
</tr>
<tr>
<td>20</td>
<td>PLASTIC EMULSION</td>
<td>ICI/ASIAN/BERGER/NEROLAC</td>
</tr>
<tr>
<td>21</td>
<td>WATERPROOF PLY&amp; BOARD</td>
<td>DURO /GREENPLY/ CENTURY/KITPLY/ ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>22</td>
<td>FLUSH DOOR SHUTTER</td>
<td>KITPLY / SWASTIK / DURO/ GURJAN / UNNPLY / SITAPUR OR ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>23</td>
<td>ROLLING SHUTTER</td>
<td>DIANA/ RAYMUS / RAMA/ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>24</td>
<td>BITUMENOUS SEALENT</td>
<td>STP / LLOYD/ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>25</td>
<td>PVC DOOR SHUTTER</td>
<td>RAJSHRI/SINTEX/ ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>26</td>
<td>PVC TANK</td>
<td>SINTEX/ ELECTROPLAST/ STAR /LOTUS</td>
</tr>
<tr>
<td>27</td>
<td>WC/WASH BASIN</td>
<td>CERA/PARRYWARE/HINDUSTAN</td>
</tr>
<tr>
<td>No.</td>
<td>Material/Component</td>
<td>Supplier Options</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>28</td>
<td>C.P. FITTINGS</td>
<td>PARKO / HINDUSTAN / SEIKO / ORIENT / JAQUAR</td>
</tr>
<tr>
<td>29</td>
<td>S.C.I. PIPES</td>
<td>RIF / NICCO / BENGAL IRON / IISCO</td>
</tr>
<tr>
<td>30</td>
<td>WHITECEMENT</td>
<td>BIRLAWHITE / JKWHITE / ASIAN</td>
</tr>
<tr>
<td>31</td>
<td>OXIDIZED ALUMINIUM FITTINGS</td>
<td>EBCO / DOOR LINE / ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>32</td>
<td>GYPSUM FALSE CEILING</td>
<td>INDIAGYPSUM / BORAL / ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>33</td>
<td>FUSION BONDED EPOXY COATINGS (FBEC)</td>
<td>TO BE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>34</td>
<td>IRONMONGERY</td>
<td>AS PER ARCHITECTURAL DRAWINGS / BOQ &amp; SUBJECT TO PRIOR APPROVAL FROM ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>35</td>
<td>HYDRULIC DOOR CLOSER</td>
<td>HARDWYN / TRIUM / EGL / EVERITE</td>
</tr>
<tr>
<td>36</td>
<td>FLOOR SPRING</td>
<td>HARDWYN / GARNISH / TRIUM / OMEGA / EVERITE</td>
</tr>
<tr>
<td>37</td>
<td>UNPLASTICISED PVC</td>
<td>ORIPLAST / ONPLAST / SUPREME / ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>38</td>
<td>ANCHOR FASTENERS</td>
<td>HILTI / FISCHER / ANY OTHER MAKE LOCALLY AVAILABLE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>39</td>
<td>WATER HEATER (GEYSER)</td>
<td>TO BE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>40</td>
<td>WATER PURIFIER</td>
<td>TO BE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>41</td>
<td>STEAM – AERATED CONCRETE BLOCK.</td>
<td>SIPOREX / BILTACH OR ITS EQUIVALENT TO BE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>42</td>
<td>POLY CARBONATE SHEETS</td>
<td>LEXAN OR ITS EQUIVALENT TO BE APPROVED BY ENGINEER IN CHARGE</td>
</tr>
<tr>
<td>43</td>
<td>PE-AL-PE PIPE</td>
<td>KITEC OR EQUIVALENT TO BE APPROVED BY ENGINEER IN CHARGE.</td>
</tr>
</tbody>
</table>
APPROVED MAKES
<table>
<thead>
<tr>
<th>S.No</th>
<th>Plant &amp; Equipment</th>
<th>Makes / Brands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AMMONIA REFRIGERATION COMPRESSOR</td>
<td>KIRLOSKAR/FRICK/SUPERFREEZE/MYCOM</td>
</tr>
<tr>
<td>2</td>
<td>ELECTRIC MOTOR</td>
<td>KIRLOSKAR/CROMPTON/GEC</td>
</tr>
<tr>
<td>3</td>
<td>MOTOR STARTER</td>
<td>MEI/KILBERN/L&amp;T</td>
</tr>
<tr>
<td>4</td>
<td>ATMOSPHERIC CONDENSER</td>
<td>TATA/JINDAL/PRAKASH SURYA</td>
</tr>
<tr>
<td>5</td>
<td>WATER LING B CLASS PIPE</td>
<td>TATA/JINDAL/PRAKASH SURYA MS</td>
</tr>
<tr>
<td>6</td>
<td>AIR COOLING UNITS</td>
<td>ALFALAVA/ICL/STARCOOLER/FRICK OR EQUIVALENT MAKE</td>
</tr>
<tr>
<td>7</td>
<td>PUF COMPOSITE SANDWICH PANNEL INSULATION</td>
<td>LOYD OR EQUIVALENT MAKE</td>
</tr>
<tr>
<td>8</td>
<td>PLUMBING &amp; SANITARY</td>
<td>HINDWARE/CERA/PARRYWARE/SUPREME/ASTRAL/ASHIRVAD</td>
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<tr>
<td>9</td>
<td>CONSTRUCTION OF RAIN WATER HARVESTING PIT</td>
<td>SUPREME/ASTRAL/ASHIRVAD</td>
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<tr>
<td>10</td>
<td>WATER TRANSFER PUMP FROM DOMESTIC WATER TANK UGR TO OVERHEAD TANK</td>
<td>SUPREME/ASTRAL/ASHIRVAD</td>
</tr>
<tr>
<td>11</td>
<td>DG SET</td>
<td>WILSON/CUMMINS/CATTERPILLAR/VOLVO/PERKINS</td>
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<tr>
<td>12</td>
<td>UPS</td>
<td>EMRERSON, PANASONIC / ROCKET / AMARON QUANTA</td>
</tr>
<tr>
<td>13</td>
<td>MCCB</td>
<td>L&amp;T / SIEMENS / SCHNEIDER/ ABB/C&amp;S</td>
</tr>
<tr>
<td>14</td>
<td>TPN SWITCHES &amp; HRC FUSES</td>
<td>L&amp;T/ SIEMENS/ HAVELLS/ SCHNEIDER/ ABB/C&amp;S &amp; EQUIVALENT</td>
</tr>
<tr>
<td>15</td>
<td>STARTER</td>
<td>L &amp; T / SIEMENS / BCH / ABB / MEI / GE POWER CONTROL</td>
</tr>
<tr>
<td>16</td>
<td>MCBS / ISOLATORS &amp; DISTRIBUTION BOARD</td>
<td>INDO ASIAN / HAVELLS / INOKUPP / HAGER/SIEMENS/ STANDARD/ CROMPTON/ MDS/C&amp;S</td>
</tr>
<tr>
<td>17</td>
<td>AMMETER/VOLTMETER</td>
<td>UNIVERSAL/ RISHABH/ AE/ IMP/ MECO/ ENERCOM</td>
</tr>
<tr>
<td>18</td>
<td>CABLES</td>
<td>POLYCAVB / FINOLEX / HAVELLS / PLAZA/ UNIVERSAL/ASIAN/ GLOSTER</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Brand</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>19</td>
<td>PVC INSULATED COPPER CONDUCTOR WIRE</td>
<td>ANCHOR/ POLYCAB/ FINOLEX/ PLAZA</td>
</tr>
<tr>
<td>20</td>
<td>SANDWICH TYPE BUS BAR</td>
<td>SCHNEIDER/ ABB/C&amp;S</td>
</tr>
<tr>
<td>21</td>
<td>AMF &amp; ELECTRICAL PANELS</td>
<td>KALPAKA, POWER &amp; INSTRUMENTATION LTD.</td>
</tr>
<tr>
<td>22</td>
<td>BUS TRUNKING</td>
<td>KALPAKA, POWER &amp; INSTRUMENTATION LTD.</td>
</tr>
<tr>
<td>23</td>
<td>LIGHTING FIXTURES</td>
<td>WIPRO, PHILIPS, HAVELS, GE</td>
</tr>
<tr>
<td>24</td>
<td>DBS</td>
<td>SIEMENS / SCHNEIDER/ HAVELS, INDOASIAN, LEGRAND/ HAGGER/ MDS</td>
</tr>
<tr>
<td>25</td>
<td>SWITCHES &amp; PLUGS</td>
<td>ANCHOR/ PANASONIC, MK, GM, CPL, CG, SCHNEIDER &amp; EQUIVALENT</td>
</tr>
<tr>
<td>26</td>
<td>CFL</td>
<td>WIPRO, PHILIPS, HAVELS, GE &amp; EQUIVALENT</td>
</tr>
<tr>
<td>27</td>
<td>COMPOUND LIGHT</td>
<td>BAJAJ, PHILIPS, CROMPTON &amp; EQUIVALENT</td>
</tr>
<tr>
<td>28</td>
<td>FIRE ALARM CONTROL PANEL</td>
<td>SECUTRON / NOTIFIER / EDWARD / BOSCH / COOPER/ SIEMENS / MORLEY</td>
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<tr>
<td>29</td>
<td>REPEATER PANEL</td>
<td>SECUTRON / NOTIFIER / EDWARD / BOSCH / COOPER/ SIEMENS / MORLEY</td>
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<tr>
<td>30</td>
<td>ADDRESSABLE SMOKE DETECTOR</td>
<td>SECUTRON / NOTIFIER / EDWARD / BOSCH / COOPER/ SIEMENS / MORLEY</td>
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<tr>
<td>31</td>
<td>ADDRESSABLE SOUNDER / HOOTER</td>
<td>SECUTRON / NOTIFIER / EDWARD / BOSCH / COOPER/ SIEMENS / MORLEY &amp; EQUIVALENT</td>
</tr>
<tr>
<td>32</td>
<td>ADDRESSABLE MONITOR MODULE</td>
<td>SECUTRON / NOTIFIER / EDWARD / BOSCH / COOPER/ SIEMENS / MORLEY &amp; EQUIVALENT</td>
</tr>
<tr>
<td>33</td>
<td>ADDRESSABLE CONTROL MODULE</td>
<td>SECUTRON / NOTIFIER / EDWARD / BOSCH / COOPER/ SIEMENS / MORLEY</td>
</tr>
<tr>
<td>34</td>
<td>FRLS ARMoured CABLE</td>
<td>FINOLEX / NEOLEX / POLYCAB / KEI / RAVIN / THERMOFLEX / RPG / RR KABEL / LAPP &amp; EQUIVALENT</td>
</tr>
<tr>
<td>35</td>
<td>PUMP</td>
<td>KIRLOSKAR, CROMPTON, GRUNDFOSS, BEACON, KSB</td>
</tr>
<tr>
<td>36</td>
<td>MS PIPE</td>
<td>JINDAL/TATA/SAIL/ ZENITH</td>
</tr>
<tr>
<td>37</td>
<td>VALVES (BUTTERFLY, SLUICE, BALL)</td>
<td>AUDCO /C&amp;R/ADVANCE/LEADER</td>
</tr>
<tr>
<td>38</td>
<td>AIR VENT</td>
<td>ANERGY, ITAP, HONEYWELL</td>
</tr>
<tr>
<td>39</td>
<td>GI SHEET</td>
<td>SAIL/TATA/BHUSHAN</td>
</tr>
<tr>
<td>----</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>40</td>
<td>VALVES &amp; CONTROLS (MIXING VALVES, DIVERTING VALVES, ETC)</td>
<td>SIMENS, HONEYWELL, JOHNSON CONTROL, ALCO, BELIMO</td>
</tr>
</tbody>
</table>
NOTES:
1. Depth of Foundation 2.5 M from NGL (SBC will be reviewed at site condition).
2. Footing to be cast on soil of SBC = 230 Kgf / sq M.
3. Concrete Mix shall be M-25 unless specified otherwise.
4. Use Fe-500 HYSD Steel.
5. Clear cover to main reinforcement bars shall be:
   i) for footing - 75 mm
   ii) for column - 40 mm (above 200 mm)
6. Shuttering plates for column sides shall not be removed before 24 hours after casting.
7. Height of fall of concrete shall not be more than 1.8 m.
8. Proper key shall be left at the end of concreting in each lift of columns.
9. Not more than half of the column R/F shall be lapped at a section.
LEGEND:

- a - 2 ISA 90X50X6
- b - 2 ISA 50X50X6

NOTE:
1. SIZE OF WELD AT LEAST 4MM IN ALL JOINTS
2. THICKNESS OF GUSSET PLATE 4MM
3. ALL SURFACES WHICH ARE TO BE PAINTED WITH RED OXIDE SHALL BE DRY AND THOROUGHLY CLEANED
4. THE SUITABILITY AND CAPACITY OF ALL PLANTS AND EQUIPMENT USED FOR ERECTION SHALL BE TO THE SATISFACTION OF THE SITE ENGINEER. HOWEVER THE CONTRACTOR IS FULLY RESPONSIBLE FOR THE SUITABILITY AND CAPACITY OF ERECTION EQUIPMENT.
5. THE POSITIONING AND EXECUTING OF ALL STEEL WORK SHALL BE IN ACCORDANCE WITH THE DRAWING.
7. DURING ERECTION THE STEEL WORK SHALL BE TEMPORARILY BRACED TO AVOID THE TANGLED OF TRUSSS AND TO MAKE THE ERECTED TRUSSS STABLE UNTIL FINAL BRACING IS COMPLETED AS PER DRAWING.
8. MINIMUM CLEAR GAP OF GUSSET PLATE MEMBER SHALL BE 12MM AND SHOULD BE WELDED ALL AROUND.
9. ALL CONNECTING PLATES SHOULD BE WELDED TO MEMBERS BEFORE ERECTION OF TRUSS

ODISHA STATE AGRICULTURAL MARKETING BOARD

PRIMUS AGRIDPROJECTS PVT. LTD.

CONSULTANT:

SUB CONSULTANT:

ACREATION COMPUTING SOLUTIONS P. LTD

PACKAGE DESCRIPTION:

PROPOSED MULTI CHAMBER WITH MULTI COMMODITY FOR ODISHA STATE MARKETING BOARD AT BHUBANESHWAR (ODISHA)

DESIGN

DRAWN

CHKS

APPROVED

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