



# **TECHNICAL SPECIFICATION**

Name of work: **“WORKSHOP FOR UNIT 3 AND 4 EXPANSION PROJECT AT IB THERMAL POWER STATION OF OPGC”**

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- 1) The construction materials such as Cement, sand, chips etc. if felt necessary will be subjected to test at the cost and risk of the agency.
- 2) Any defective material brought to site should be removed by the agency at the instance of department.
- 3) Agency has to arrange all construction materials such as Cement, Sand, Chips, MS reinforcement bars, colours, paints etc required for the work as per the item specifications.
- 4) The quantity mentioned in the schedule of quantities is purely tentative. At any point of time agency may be asked to execute any quantity of work as per the site requirement.
- 5) All the items mentioned in detail items of the work may be executed at any location and at any height.
- 6) All the materials are to be approved by concerned Engineer-in-charge in written before use.
- 7) All work is to be carried out without causing hindrance to day-to-day activity of people.
- 8) Agency has to make his own arrangement of construction water for the works from available points only.
- 9) Contractor has to make his own arrangement dewatering to reach the required level of excavation.
- 10) Electricity if required by the agency is to be arranged by deploying a DG set.. Contractor has to make all necessary arrangement for safe supply of electricity.
- 11) Ordinary Portland Cement of Ultratech, Konark, ACC make of 53 grade, confirming to corresponding IS code shall be utilized in the work before the expiry date.
- 12) TMT reinforcement and structural steel must be of TATA/SAIL/JINDAL make conforming to corresponding IS code.
- 13) Construction materials such as sand, bricks, chips, bazri etc. should be stacked and kept sufficient in stock at the Construction site. The area is to be fenced properly by the contractor with best housekeeping.
- 14) Fly Ash Bricks will be supplied free of cost from OPGC Ash Brick Manufacturing Plant. The contractor has to make his own arrangement for transportation of bricks to the construction site. Balance Ash Bricks after completion of work must have to be returned back at the Ash Brick Plant, failing which double the prevailing cost of the fly ash brick will be deducted from the Party's Final Bill.
- 15) Proper scaffolding (MS scaffolding) as per OPGC standard must be done while working at height.

- 16)The contractor must have to keep sufficient steel scaffolding material for work at heights and staging for roof shuttering work.
- 17)Construction debris must have to be disposed to a designated place as allowed by EIC. The Place will be leveled and dressed time to time by the contractor in this own cost.
- 18)Parties have to deploy minimum two number full time Supervisors (Minimum Qualification- Matriculate) having minimum 5 years of working experience in supervising Civil Construction / Maintenance jobs and one number civil engineer (Diploma engineer.) having minimum 5yr of experience in civil and structural works.
- 19)Enclosed with all the relevant drawing related to the aforementioned job.

## **A. Technical Specification – Civil**

### **SECTION – 1 - GENERAL**

#### **1.0 GENERAL**

##### **1.1 Application of Specification**

This specification shall be read in conjunction with other documents forming the Contract.

1.2 The construction work shall be carried out in such a manner that where some existing features/structures are to be integrated with the new work, work shall proceed without upsetting the existing situation. Construction shall be carried out in a coordinated manner with the work of other contractors in the area.

1.3 During work on and/or in the vicinity of existing rail tracks the Contractor shall take all necessary precautionary measures. Watchmen shall be engaged with red lights/flags on either side of the working place with caution board during the period of working to caution the men working regarding approaching of any rolling stock. Warning signals during day and red lamps during night shall be provided to the watchman.

1.4 Available soil Investigation report for the site shall be deemed to be studied by the Contractor prior to submission of his tender. Additional soil investigation work, if required for the purpose of the work, shall be done by the Contractor of their own.

1.5 The Contractor, before submitting his tender shall visit the site and ascertain the local conditions, labour rules, availability of construction materials, traffic restrictions, all obstructions in the area and also ascertain all site conditions including sub-soil conditions and shall allow for any extras likely to be incurred due to all such conditions in his quoted prices. No claim shall be entertained from the Contractor on any such account under any circumstances whatsoever.

## 1.6 **Setting Out and Leveling**

The Contractor shall set out and level the works and will be responsible for the accuracy of the same. He is to provide all instruments and proper qualified staff with labour for getting his work checked by the Engineer/Consultant. Such checking, if any shall not, however, relieve the Contractor in any way of his responsibility for correct setting out.

## 1.7 **Safety**

The Contractor shall take adequate precautions to ensure complete safety and prevention of accidents at site. The safety precautions shall conform to the following IS codes wherever applicable.

IS:3696 .. Safety code for scaffolds and ladders  
(Part-1& 2)

IS:3764 .. Safety Code for Excavation Work

IS:4014 .. Code of practice for steel tubular scaffolding.  
(Part-1)

IS:4014 .. Safety Regulations for Scaffolding.  
(Part-2)

IS:4082 .. Recommendations on stacking and  
storage of construction materials at site

IS:4130 .. Safety Code for Demolition of Buildings

IS:4138 .. Safety Code for Working in Compressed Air

IS:5121 .. Safety code for piling and other deep foundations

IS:7293 .. Safety Code for Working with Construction  
Machinery

The Contractor shall also abide by the safety regulations of the Employer and other directives given by the Engineer/Consultant from time to time.

#### **1.8 Keeping Works Free from Water**

The Contractor shall provide and maintain at his own cost, pumps and other equipment to keep the works free from water and continue to do so until the handing over of the Works.

#### **1.9 Rubbish**

The Contractor shall clear all trees, rubbish, vegetation, sod, brickbats etc and dispose them suitably in allotted areas at his own cost.

#### **1.10 Bench Marks, Reference Pillars etc**

The Contractor shall protect surveyor's bench marks and reference lines, ground water gauges and control points from damage or movement during work. In case of any damage, the Contractor shall have to restore them to original condition at his own cost.

#### **1.11 Standards (Latest edition)**

Unless specifically mentioned otherwise, all applicable codes and standards published by the Bureau of Indian Standards, IRC (Indian Road Congress) Codes, specification for road and bridge works under Ministry of Road. Transport and Highways (MORTH), (4<sup>th</sup> Revision), Indian Railway Standard Specification by Ministry of Railways and all other such documents as published on the date of award of contract shall govern design, workmanship, quality and properties of materials, method of field and laboratory testing, method of measurement for different items of work and other pertinent features etc.

In case of variance between this specification and the various standards mentioned above, the provisions of this specification shall prevail upto the extent of such variance, except as mentioned in specific section.

#### **1.12 Secrecy of Information**

The Contractor shall not divulge any information that he may obtain regarding this project to any other party.

1.13 All obligations of the Contractor as specified shall be carried out by the Contractor within contract price and no additional payment will be due beyond the contract price for carrying out all such work. Wherever it is stipulated in the specification that Contractor will carry out a work at his own cost or expense or without any extra cost to the Employer or similar, it must be clearly understood that such stipulation has been made only for the sake of emphasis but such stipulation will not in construed to mean that any additional amount will be payable for carrying out any work as specified where no such stipulation has been made.

1.14 All the civil work shall be carried out as per the drawings, Bill of Quantities, specification and as directed by Engineer/Consultant.

## **SECTION - 2 - DISMANTLING/DEMOLITION WORK**

### **2.1 Planning**

Before starting the actual dismantling work, the Contractor shall carefully study the structures/ buildings/equipment to be dismantled/demolished and of the manner in which various parts are supported and also how far the stage by stage demolition will affect the safety of the adjoining structures, if any. The Contractor shall then prepare a definite plan of the procedure for systematic demolition and submit to the Engineer/Consultant for his approval. The plan of procedure as approved by the Engineer/Consultant shall be rigidly followed in actual execution of the demolition work.

### **2.2 Working Condition**

The dismantling operations if required to be carried out in an operating plant shall be done without any hindrance to the plant operation activities.

All dismantling work shall be carried out in a phased manner as approved by the Engineer/Consultant.

### **2.3 Safety**

The Contractor shall take adequate precautions to ensure complete safety of all installations and the operational personnel working in the region, while carrying out the dismantling work and transportation.



All safety codes as prescribed by the Employer for working in the plant area and the safety codes prescribed by other mandatory bodies shall be followed by the Contractor while dismantling.

On all demolition works, safety signals like danger boards, red lights, safety net etc as needed and/or as directed shall be conspicuously exhibited and the area of demolition shall be kept barricaded or kept manned to prevent trespassing by unauthorised persons.

First-aid equipment shall be kept at the site of demolition work of any magnitude for emergency use.

Personal safety equipment as mentioned hereunder shall be made available for the use of persons employed on the demolition work and maintained in good condition.

- i) Safety helmets and shoes to workmen entering into dismantling site.
- ii) Goggles preferably made of celluloid lens to workmen employed on demolition of walls, floors, etc to protect the eyes from flying pieces, dirt, dust etc,
- iii) Gloves to workmen engaged on demolishing RCC work, removing steelwork etc.
- iv) Safety belts, fall arrestor to workmen working at height.

## 2.4 **Tools and Tackles**

2.4.1 All tools and tackles and equipment viz diamond sawing machine for cutting floor panels, chipping guns, hydraulically operated rock and concrete splitter, rock breaker, pneumatic/paving breaker, core cutter, gas cutting set, movable/crawler crane etc as required for dismantling/demolition shall be arranged by the Contractor.

## 2.5 **Scope of Dismantling/Demolition**

2.5.1 On being given the clearance for dismantling of building/structure/equipment, the Contractor shall take over the area for dismantling and shall shut-off all utility lines and disconnect power lines etc. The Contractor shall then check up all the closed valves of the utility lines like gas lines, oil lines, compressed air line, water line, steam line etc. All these lines shall then be provided with suitable blanking arrangements at the tapping points or at suitable points approved by the Engineer/Consultant before the dismantling work is undertaken.

2.5.2 Similarly, all the power cables, bus bars, control cables, instrument cables, earthing etc shall be disconnected from the supply sources at suitable locations as approved by the Engineer/Consultant.

2.5.3 **Structural:** All columns, supports, platforms, covers, railings, ladders, stairs, roofs, girders etc shall be dismantled from their erected position without any damage. In case existing structures require to be cut, the Contractor shall take prior permission of the Engineer/Consultant. All rivets and welding shall be burnt out to dismantle the structures. All bolts and nuts shall be opened out to the extent possible.

2.5.4 **Refractory and insulation work:** All the refractory and other insulation work shall be dismantled. Care shall be exercised to see that the steel shells and/or structures are not unduly damaged.

Muck arising out of dismantling of refractory shall be transported out, dumped and leveled in the dumping area allotted by the Engineer/Consultant for the purpose.

Bricks which are not burnt out or which have not lost shape and size shall be separately stacked in the areas allotted by the Engineer/Consultant within a lead of 3 km inside the plant boundary.

2.5.5 **Electrical equipment:** Electrical equipment like motors, distribution board, push button station control devices, limit switches, cabling etc shall be dismantled in identifiable pieces without any damage.

All the dismantled cables, wires etc shall be made into suitable rolls, packed.

2.5.6 **Instruments and controls:** All instruments and controls including connecting cables installed shall be dismantled without damaging the same.

2.5.7 **Utility piping and equipment:** All instruments and controls including connecting cables installed shall be dismantled without damaging the same.

2.5.8 **Demolition of civil works:** All concrete and other civil construction works shall be dismantled up to a level 500 mm below the existing ground level if and where no new foundations are interfering. In case the new foundations/structure interfere then the concrete and other civil construction work will have to be dismantled fully.

2.5.9 **Disposal:** All the equipment dismantled under clauses **2.5.1 to 2.5.8** above (both inclusive) shall be transported to the disposal yard or scrap and salvage stores of VSP to the stores as directed by Engineer/Consultant.

All dismantled muck shall be transported out, dumped and leveled in the dumping place allotted by the Engineer/Consultant.

Dismantled muck shall not be allowed to be heaped up in the operating area of the plant and hence the muck shall be disposed off expeditiously.

During dismantling care shall be exercised to see that the dust arising out of dismantling is kept down by the frequent spraying of water.

### **SECTION-3 - EARTHWORK IN EXCAVATION FOR FOUNDATIONS, TRENCHES, BASEMENTS, DRAINS, CULVERTS ETC**

#### **3.1 Codes and Standards**

IS:1200 .. Method of Measurement of Building and (28 parts) Civil Construction Works.

IS:1498 .. Classification and Identification of Soils for General Construction Purposes.

IS:3764 .. Safety Code for Excavation Work

#### **3.2 Classification of Soil**

The soil shall be classified for payment according to IS:1200 and/or as per the item descriptions. All types of soil/rock excluding hard rock requiring blasting shall mean all soil and rock which can be excavated by axes, shovel or Spades or earth moving equipment such as excavator, power shovels, paving/pneumatic breaker etc or quarried/split by crowbars without recourse to blasting and/or other quarrying methods such as chiseling, wedging, heating etc.

#### **3.3 Setting Out**

The work shall be set out to exact dimensions as shown on the approved drawings and excavation shall be commenced only after prior approval of the Engineer/Consultant.

Side slopes, beams or shoring/strutting etc for excavation work shall be as directed by the Engineer/Consultant. Prior approval of the Engineer/Consultant shall be obtained for a suitable method of protection before excavation work is commenced.

#### **3.4 Cleaning and Grubbing Up**

The Contractor shall at his own cost grub up old roots, break up and remove old concrete or brick foundations, drains or manholes, empty and cleanse all old wells, cesspools and ponds found prior to/during progress of excavation, seal up water, sewerage and other connections where required, remove all contaminated earth and fill in voids with approved materials and ram well.

### **3.5 Stripping**

The Contractor at his own cost shall strip the surface of the site prior to the commencement of excavation to remove vegetable soil and carry such soil to separate soil heaps on the allotted site within 500 m.

The Contractor shall not remove any tree without the permission of the Engineer/Consultant.

Stripping work is deemed to have been included in the rate for earthwork in excavation and no extra will be paid.

### **3.6 Excavation**

The Contractor shall excavate by mechanical means to remove materials of any nature or description which may be encountered and excavate to depths, widths and inclinations as directed. The bed of the excavation shall be made level and firm by watering and ramming. While carrying out excavation for drain work, the sides and the bottom shall be cut to the exact shape, slope and gradient. The surface shall be properly dressed. Excavated material shall not be placed within 1.5 m from the edge of any excavation.

#### **3.6.1 Excavation and Transportation by Mechanical means**

The Contractor shall excavate the earth by mechanical excavator and transport the excavated earth by using dumpers/tipper. Levelling/grading of earth shall be done by using dozer or by any other mechanical means. Before commencement of mechanical excavation/grading Contractor shall obtain clearance from Engineer/Consultant to ensure about underground facilities. Wherever excavation by normal excavator is difficult due to shortage of space/approach, smaller/mini excavator shall be used to avoid manual excavation. Contractor shall have sufficient numbers of wheel barrows to handle earth for small lead where disposal of earth by dumper is not suitable and difficult due to site constraint. The excavated earth required for backfilling, the

minimum lead distance considered as 500 metre. The balance earth shall be disposed off within plant boundary up to a distance of 3 km. If dumping is not possible within plant boundary, then dumping to be made outside plant boundary in salt pan area of lead approx. 10 km.

### 3.8 **Variation in Excavation**

3.8.1 **Bad ground:** Should the bottom of any excavation appear to be soft, unsound or unstable, the Contractor shall report the matter to the Engineer/Consultant and if the Engineer/Consultant so directs, shall excavate the same to indicated depths. In case of such extra excavations the extra depth shall be filled up with lean concrete or such other materials as the Engineer/Consultant shall direct, such extra excavations and fillings shall be valued and paid for as an authorised extra item.

3.8.2 **Excavation too deep:** If the Contractor excavates to levels lower than actual level for any unauthorised reason he shall fill it up at his own expense to the proper level with concrete or such other materials as directed. No payment will be made for such excavation taken down to depths lower than actual level and for the filling carried out as directed.

3.8.3 **Slips and falls:** Every precaution shall be taken against slips and falls of earth, clay, sand or other materials in the excavations, but in the event of any such occurring, the Contractor shall at his own expense make good the space affected by the slips or falls, even if the affected area may be outside the dimension of the work ordered.

The Engineer/Consultant will determine in each case whether such affected area is to be filled up in whole with concrete, brickwork or masonry of the quality used in the adjoining work or where only a part is to be so filled, the materials to be used for this part.

If in the opinion of the Engineer/Consultant there is a possibility of the newly constructed work having been damaged or disturbed by such a collapse, the work shall be laid bare at the expense of the Contractor for inspection. Any damage shall be made good by the Contractor at his expense.

### 3.9 **Keeping Works Free from Water**

The excavation for foundation and building area shall be kept free from water by the Contractor at his own expense either by bailing out water with buckets manually or by pumping. Bailing out or pumping of water shall be carried out either directly from the

excavation or from sumps made outside the excavation as directed. Adequate care shall be taken to prevent movement of water through freshly laid concrete or masonry work.

3.9.1 **Pumping:** The Contractor shall provide and operate pumps of adequate capacity or other equipment necessary to drain and keep all excavation pits, trenches etc free from water at all times during the continuance of the Contract at his own expense.

3.9.2 **De-silting:** If any excavation for foundation gets filled up with water due to rain, seepage or for any other reason, the water shall be removed and the bottom of the excavation shall be cleared of all silt/slush by the Contractor at his own expense.

3.9.3 **Disposal of water:** All water pumped or bailed out during dewatering of pits and trenches shall be disposed of to the nearest sewer or natural drains or ponds through properly laid channels or pipes by the Contractor as directed at his own cost. Disposal of water shall be carried out in such a way that no inconvenience or nuisance is caused to the work in progress in the area or to other agencies working in the area or cause damage to property and structures nearby.

### 3.10 **Protection of Work**

3.10.1 The Contractor shall support and maintain adjoining and abutting property and structures to render work safe to persons, property and structures/installations during the course of construction activity. The Contractor shall plank and strut as may be required on the sides of all excavation. The Contractor shall replace or repair at his own cost in an approved manner, all work damaged through removal of such temporary work or improper protective work.

The Contractor shall provide necessary decking, guard, fences, planking with red flags and red lights at night to maintain safe pedestrian and vehicular traffic near all open excavations at his own cost.

3.10.2 **Shoring and strutting:** Shoring and strutting shall be used as directed when excavation is to be carried out in soft, slushy or filled up soil which is likely to collapse during the excavation work. The shoring shall be either open or close boarded type or sand bag shoring depending on the nature of the soil and depth of excavation and the type adopted shall be as directed by the Engineer/Consultant. While excavating in a very unstable ground requiring support throughout the period of excavation, runner rail shall be used and shall be driven always in advance of the excavation. The size and spacing of different members to be

used in shoring shall be as directed by the Engineer/Consultant, depending on the site conditions.

- 3.10.3 **Open boarded shoring:** The work shall be carried out as specified in clause 3.10.2 but the poling boards shall be placed in such a way that the spacing between the poling boards should not exceed 500 mm and should at least cover 50% of the surface area of the excavations shored.
- 3.10.4 **Runners rails:** Runners rails shall be driven slightly in advance of the excavation to form a close vertical support to the sides of the excavation. The runners shall be lowered one at a time by digging away the ground below the toe and tapping the runner down after loosening the wedges. The wedges shall be tightened again after lowering the runner in position. All the runners shall be lowered in a similar manner by about 150 mm to 225 mm and excavation shall be carried out to the required depth by continuously lowering the runners as stated above always keeping the toes of the runner into the ground to prevent earth from slipping in.
- 3.10.5 **Protecting railway track:** All running tracks in the areas of excavations shall be protected/supported as directed in order to maintain the operation traffic. Permission from appropriate authorities shall be taken prior to commencing any work on a running rail track.

#### **SECTION-4 - PLAIN AND REINFORCED CEMENT CONCRETE WORK**

##### **4.1 Codes and Standards**

###### **General**

IS:1200 - Method of Measurement of Building and Civil  
(28 Parts) Engineering Works

###### **Cement**

IS:269 - 33 grade ordinary portland cement  
IS:8112 - 43 grade ordinary portland cement  
IS:12269 - 53 grade ordinary portland cement  
IS:8041 - Rapid hardening portland cement  
IS:455 - Portland Slag Cement  
IS:1489 - Portland puzzolana cement (fly ash based)  
(Part-1)

- IS:1489 - Portland puzzolana cement (Calcined  
(Part-2) clay based)
- IS:8043 - Hydrophobic cement
- IS:12600 - Low heat portland cement
- IS:12230 - Sulphate resisting portland cement

### **Aggregate**

- IS:383 - Coarse and Fine Aggregates from Natural Sources  
for Concrete
- IS:2386 - Methods of Test for Aggregates for concrete  
(8 parts)
- IS:2430 - Method of Sampling of Aggregates for concrete

### **Plain and Reinforced Concrete**

- IS:456 - Code of Practice for Plain and Reinforced  
Concrete
- IS:1199 - Method of sampling and Analysis of concrete
- IS:516 - Method of Test for Strength of concrete
- IS:460 - Test Sieves  
(3 parts)
- IS:1607 - Method for Test Sieving
- IS:1834 - Hot Applied Sealing Compounds for Joint in  
Concrete
- IS:2204 - Code of Practice for Construction of Reinforced  
Concrete Shell Roof
- IS:10262 - Recommended Guide Lines for Concrete Mix  
Design
- IS:4925 - Concrete Batching and Mixing Plant
- IS:3370 - Code of practice for concrete storage  
(4 parts) structures for the storage of liquids

### **Steel**

- IS:2062 - Steel for general structural purposes
- IS:432 - Mild Steel and Medium Tensile Steel Bars and  
(2 parts) Hard-drawn Steel Wire for Concrete  
Reinforcement
- IS:1566 - Hard-drawn Steel Wire Fabric for Concrete



- Reinforcement
- IS:1568 - Wire Cloth for General Purpose
- IS:1786 - High Strength Deformed Steel Bars and Wires for  
Concrete Reinforcement
- IS:2502 - Code of practice for bending and fixing of Bars for  
Concrete Reinforcement
- IS:2751 - Welding of Mild Steel Plain and Deformed Bars  
for Reinforced Construction

## 4.2 **Materials**

4.2.1 **Cement:** The cement used shall be any of the above, mentioned in clause 4.1 and the type selected shall be appropriate for the intended use. The Contractor shall carry out the required tests at his own cost in an approved testing laboratory, at the direction of the Engineer, for all cements supplied by him or by the Employer and submit the test report for the approval of the Engineer, before using the cement in the works. Cement shall be stored on raised platforms inside stores covered on all sides and roof with provision for ample ventilation. Different types of cement shall be stored separately and more than ten bags (10) of cement shall not be stacked one above the other in the stack. Sufficient space shall be left around the stacks for approach. Stacking shall be so arranged that bags from the oldest consignment in the stack can be conveniently removed first for use following the principle of first in first out (FIFO) basis. For this proper label tag indicating date of supply shall be displayed over the stack of stored cement received in a consignment (Batch). Cement which has hardened, clodded or deteriorated due to over stacking or long storage shall not be used in the works and shall be removed from the site immediately with intimation to Employer and Engineer.

4.2.2. **Aggregates:** All aggregates shall conform to IS:383. Coarse aggregates shall be approved crushed stone or gravel, washed clean. Fine aggregates shall be river or pit sand. Coarse and fine aggregates shall be stored at site separately on clean and hard base or in separate compartments/hoppers. Samples of aggregates to be used shall be submitted to the Engineer for approval before commencement of work. No aggregate shall be used without prior approval of the Engineer. The Contractor shall ensure that over the entire period of construction all consignments of coarse and fine aggregates brought to the site conforms to the quality and grading as approved in the mix design by the Engineer before the commencement of work. If necessary, grading of aggregates shall be maintained by blending of different sizes of aggregates which shall be brought to site and stacked in separate stock piles. Whenever directed by the Engineer, the Contractor shall perform tests at his own cost to satisfy the Engineer that the grading and quality approved for coarse and fine aggregates are being maintained. Sampling of aggregates shall conform to IS:2430 and tests shall conform to IS:2386. The percentage to flaky and elongated pieces should not exceed 15%.

- 4.2.3 **Reinforcement:** MS and medium tensile steel bars shall conform to IS:432 ( Part-I & II) or hard drawn steel wire fabric reinforcement shall conform to IS:1566, high strength deformed steel bars shall conform to IS:1786. All reinforcements shall be free from oil, paint, loose rust, mill scale, mud or other matter likely to weaken or destroy their bond with the concrete.
- 4.2.4 **Binding wire:** Binding wire shall be approved 16 SWG annealed iron wire.
- 4.2.5 **Joint filler:** Expansion joint fillers shall be approved non-extruding, resilient fillers as shown in the drawings.
- 4.2.6 **Water stops:** For all movement joints water stops used shall be of rubber, PVC or metallic sheets as indicated in the bill of quantities or drawings.
- 4.2.7 **Waterproofing:** The waterproofing compound/water- proofing membrane materials and treatment shall be of a type shown on the drawings and/or described in the bill of quantities.
- 4.2.8 **Water:** Water shall be clean and reasonably free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.
- 4.2.9 **Chemical Admixtures :** These are material other than water, aggregates and cement (any selected type mentioned in clause 1.1 above), used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state. Dosages of retarders, plasticisers and super-plasticisers shall be restricted to 0.5, 1.0 and 2.0 percent respectively by weight of cementitious materials and unless a higher value is approved by Engineer-in-Charge only after obtaining performance test from the manufactures. They shall conform to either IS:9103 or ASTM Designation C494-RS. Admixture are generally of the following types and are used depending on the requirement or as specified in the Bill of Quantities.
- 4.2.9.1 **Water reducing Admixture :** As per IS:9103 or ASTM C-494, which improves workability, accelerates the setting and early strength development of concrete.
- 4.2.9.2 **Retarding Admixture:** As per IS:9103 or ASTM C-494, which retards the setting of concrete.
- 4.2.9.3 **Water Reducing Admixture, High Range:** As per ASTM C- 494, which reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater.

- 4.2.9.4 **Water Reducing and Accelerating Admixture:** As per ASTM C-494, which reduces the quantity of mixing water required to produce concrete of a given consistency and accelerates the setting and early strength development of concrete.
- 4.2.9.5 **Water Reducing and Retarding Admixture:** As per ASTM C-494, which reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.
- 4.2.9.6 **Water Reducing, High Range and Retarding Admixture:** As per ASTM C-494, which reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater and retards the setting of concrete, increase in both early and ultimate strengths.

### 4.3 **Concrete Mix**

- 4.3.1 All the concrete unless otherwise indicated on drawings or in the Bill of Quantities shall be 'Controlled Concrete' as defined by IS:456. The grades of concrete shall be as indicated on the drawings and/or bill of quantities. The Contractor shall at his own cost, grade the aggregate and control the water cement ratio, to design the different mixes of required strength and workability. The designed mix shall conform to the requirements of IS:456 and recommended guidelines for concrete mix design in IS:10262 and SP-23. The 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 in concrete work shall conform to Table 5 of IS:456. Adjustments to minimum cement contents for aggregates other than 20 mm nominal maximum size will be as per Table 6 of IS:456. All concrete (whether nominal or controlled) shall be machine mixed and no hand mixing will be allowed. Chemical admixtures may be used in the manufacture of concrete. The content, type, method and control of use and the locations and the products in which they are used shall be subject to the written approval of the Engineer in each and every case.

The maximum size of aggregates used shall be as indicated in the drawings and/or bill of quantities. Where reinforcement is too closely spaced for the maximum size of stone in a range, the largest suitable range will be used with the approval of Engineer. Before commencement of work the Contractor shall submit to the Engineer for his approval complete details of the mix design

calculations along with test results of different ingredients, grading analysis of the aggregates, the cube test results etc according to IS:10262. No concrete shall be placed on site until the Engineer has approved the mix design. The concrete shall be of such consistency that it can be readily worked into the corners and angles of the formwork and

around reinforcements without segregation of the materials or bleeding of free water at the surface.

If any change is made in the source and grading of the aggregates, strength of cement used, water content of the mix, manner of making, compacting the concrete or any other deviation from the preliminary test procedure, the Engineer may instruct for fresh preliminary test which shall be carried out by the Contractor at his own cost. Over the full period of construction the Contractor shall carry out work/laboratory tests as per Clause 4.6 of this specification at his own cost to satisfy the Engineer that correct grade of concrete is being used.

4.3.2 Where 'Nominal Mix Concrete' in case of M20 or lower as defined by IS:456 is permitted by the Engineer for any specific reason, the proportion of materials shall be as indicated in Table-9 of IS:456. The water cement ratios shall not exceed those specified in Table-9. If the quantity of water is required to be increased for better workability the cement content also shall be proportionately increased so that the limit specified in Table-9 of IS:456 is not exceeded.

#### 4.4 **Mixing**

#### 4.5 **Workability of Concrete**

4.5.1 The concrete mix proportions chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS:1199 are given below:

Placing Conditions ( 1 )	Degree of workability ( 2 )	Slump ( 3 )
Blinding concrete; Shallow sections; Pavements using pavers	Very low	See 1.5.2
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; floors; Hand placed pavements; Canal lining; Strip footings	Low 25-75	

Placing Conditions ( 1 )	Degree of workability ( 2 )	Slump ( 3 )
Heavily reinforced sections In slabs, beams, walls,	Medium Columns;	50-100
Slipform work; Pumped concrete	Medium	75-100
Trench fill; In-situ piling	High 100-150	
Tremie concrete }	Very high	see 1.5.3

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.

4.5.2 In the 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (see IS:1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

4.5.3 In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS:9103).

#### 4.6 **Work/Laboratory Test**

The Contractor shall carry out work/laboratory tests at his own cost. Sampling, making up, curing and testing of specimen shall conform to IS:456, IS:516 and IS:1199 and other test of the ingredients to be carried out periodically shall conform to IS:2386. Unless otherwise instructed by the Engineer, frequency of work tests shall be as indicated below. The number of specimen to be tested and their criteria for acceptance shall be as per relevant clauses of IS:456. Report of the test results shall be submitted weekly to the Engineer.

#### 4.7 **Frequency of Test**

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following :

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Quantity of Concrete in the work, cum	Number of samples
1 – 5	1
6 – 15	2
16 – 30	3
31 – 50	4
51 & above	4 plus one additional sample for each additional 50 cum or part thereof

Note : At least one sample shall be taken from each shift. Where concrete is produced at continuous production unit, such as ready-mixed concrete plant, frequency of sampling may be agreed upon mutually by suppliers and purchasers.

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#### 4.7.1 **Test Specimen**

Three test specimens shall be made for each sample for testing at 28 days. Additional specimen may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional specimen may also be required for testing specimens cured by accelerated methods as described in IS:9013. The specimen shall be tested as described in IS:516.

#### 4.7.2 **Test Results of Sample**

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than  $\pm 15\%$  of the average. If more, the test results of the sample are invalid.

#### 4.8 **Heat Resistant Concrete**

4.8.1 This specification lays down requirements of heat-resisting concrete of grade M30 to withstand temperature upto 700<sup>0</sup>C.

4.8.2 M30 grade of concrete for temperatures upto 700<sup>0</sup>C shall be made up of (1) blast furnace slag cement, (ii) basalt coarse aggregates and (iii) basalt sand. The mix shall be designed as per IS:10262 and IS:456 for severe exposure conditions.

Blast furnace slag cement shall conform to IS:455 and slag content should not be less than 50%.

Basalt sand shall be fresh and good quality. Grain composition shall conform to IS:383.

### **Basalt Coarse Aggregate**

Basalt coarse aggregate shall be 20 mm and down- graded aggregate obtained from freshly quarried basalts and free from dust and foreign materials and shall satisfy the requirements of IS:383.

4.8.3 Heat resisting concrete of grade M30 shall possess the following physical and mechanical properties to meet duty conditions:

- a) Limit temperature of concrete .. 700<sup>0</sup>C  
service with one-sided heating
- b) 28 days' characteristic .. 30 N/mm<sup>2</sup>  
strength on 15 cm cube
- c) Minimum permissible residual .. 40%  
strength which is the ratio  
of R700 to R100, expressed  
as a percentage

4.8.4 Work tests on heat resisting concrete shall be conducted to find:

- a) Residual compressive strength after heating upto 700<sup>0</sup> and subsequently cooling upto 100<sup>0</sup>C
- b) Compressive strength of concrete specimens hardened in normal conditions for 7 and 28 days and those heated to 105<sup>0</sup>C and subsequent cooling to 27<sup>0</sup>C ± 2<sup>0</sup>C at normal humidity.

10 cm<sup>3</sup> specimens of concrete shall be provided for tests as follows:

- a) Tests for compression at the natural humidity after 7 days .. 3 Nos.
- b) Tests for compression after drying at 105°C after 7 days .. 3 Nos.
- c) Tests for compression after drying at 105°C and with subsequent heating upto 700°C after 7 days .. 3 Nos.
- d) Tests for compression under normal conditions after 28 days .. 3 Nos.

Compaction of concrete mixture in the moulds should be made on the vibrating platform. The laying and vibration of concrete mixture in moulds shall be completed not later than 25 minutes after mixing. Duration of vibration shall not exceed 1.5 minutes. Then the moulds with concrete shall be kept covered with moist cloth for 48 hours. Then the specimens shall be taken from the moulds and kept in a chamber with 90% humidity at temperature 27°C ± 2°C prior to testing. The specimens shall be taken from the chamber not earlier than 1 hour before testing.

#### 4.8.5 Test Procedures

4.8.5.1 **Test for compression at the natural humidity after 7 (seven) days:** These tests shall be carried out in accordance with IS:516.

4.8.5.2 **Tests for compression after drying at 105°C after 7 (seven) days (strength before firing):** After curing the concrete cubes for 7 days at 27°C ± 2°C at 90% humidity, the cubes shall be dried at 100°C to 105°C in a drying oven. Normally 30-32 hours of drying at 100°C to 105°C is sufficient to dry out the combined water. The rate of raising the temperature shall be gradual and should not exceed 50°C per hour, which are as follows:

<u>Time</u> (hrs)	<u>Temperature</u> (°C)
0 ..	20
1 ..	60
2 ..	100



- .. 100  
32 .. 100

After the drying is complete, the cubes shall be gradually cooled to 24°C to 30°C and crushed in a compression testing machine. At least 3 samples shall be tested for determining the mark of concrete before firing and shall be recorded as R100 (in N/mm<sup>2</sup>).

Studies have established that drying the concrete for 30-32 hours at 100°C to 105°C, after 7 days of normal curing will almost result in 28 days' strength.

4.8.5.3 **Test for compression after drying at 105°C and with subsequent heating upto 700°C after 7 (seven) days (strength after firing):** After curing the concrete cubes for 7 days at 27°C ±2°C at 90% humidity and drying for 30-32 hours at 105°C to constant weight in a drying oven, the cubes shall then be fired in a muffle furnace to a temperature of 700°C. The raising of temperature shall be gradual and shall not exceed 200°C per hour as follows:

<u>Time</u> (hrs)	<u>Temperature</u> (°C)
0	20
1	200
2	400
3	600
4	700
5	700
6	700
7	700
8	700

The cubes which have been heated through the above temperature shall be cooled down gradually to the room temperature. After cooling, the cubes shall be again cured for 7 days at 24°C to 30°C at 90% humidity (or the cubes may be steam cured for 7 hours under normal atmospheric pressure and again gradually cooled down to room temperature). The cubes shall be measured for dimensions, weight and carefully examined for any surface cracks and then shall be crushed to determine the strength which shall be recorded as R700 (in N/mm<sup>2</sup>).

The residual strength which is the ratio of R700 to R100, expressed as a percentage, should not be less than 40%.

4.8.5.4 **Tests for compression under normal condition after 28 twenty eight) days:** These tests shall be carried out in accordance with IS:516.

4.8.6. All the test results of 10 cm<sup>3</sup> specimens shall first be multiplied by a coefficient 0.90 to get the equivalent values for 15 cm<sup>3</sup> specimens. The average corrected strength of the three specimens in each set shall not be less than the specified strength, subject to the condition that only one out of the three consecutive tests may give a corrected value less than the specified strength but this shall not be less than 90% of the specified strength.

The 7 days' compressive strength of M30 concrete shall be minimum 20 N/mm<sup>2</sup> on 15 cm<sup>3</sup> specimens. This applies for specimens cured under normal conditions and also those heated to 105°C. Residual compressive strength of the specimens heated to 700°C and air-cured for 10 days shall be calculated as above and expressed as a percentage of the actual compressive strength of specimens heated to 105°C, subject to the condition that the three specimens heated to 105°C themselves have passed the criteria. Residual compressive strength of specimens heated to 700°C, as calculated above shall be minimum 40%.

4.8.7 Samples of concrete shall be collected from the actual concreting of the work to prepare cube-specimens for all the tests once for every 50 m<sup>3</sup> pour of concrete or part thereof or as directed by the Engineer. Concrete may be accepted if all the test results comply with the stipulations. If the specimens heated to 700°C and then cooled and cured show deep cracks outside, the concrete must be rejected even if other strength criteria are satisfied. Engineer's opinion regarding the nature of the cracks shall be final.

4.8.8 Preliminary tests shall be conducted, in the same manner as described above for work tests, before commencement of concreting operation for the purpose of designing the concrete mix. However, preliminary test shall indicate 28 days' compressive strength of at least 38 N/mm<sup>2</sup> for 15 cm<sup>3</sup> cubes and the seven days compressive strength shall be 25 N/mm<sup>2</sup> for 15 cm<sup>3</sup> cubes.

The final composition of concrete, gradation of aggregate, water cement ratio etc, shall be ascertained by means of a series of preliminary tests.

4.8.9 **Vacuum Dewatered Reinforced Cement Concrete Flooring**

4.8.9.1 **Purpose:** The purpose of providing vacuum dewatered flooring is to increase the compressive strength and wear resistance of the concrete floor by reducing the water cement ratio of the concrete substantially. Finishing the top surface of the concrete by floating and

trowelling with a skim floater fitted with a floating disc and/or trowelling blades ensures a water impermeable concrete surface. The workmanship for laying the floor is given below.

#### 4.8.9.2 **Workmanship**

**Preparation of sub-base:** A lean concrete (PCC) layer should be laid as sub-base as shown on the drawings.

**Formwork:** M.S. channels of approved sizes will have to be used for formwork. Suitable holes will have to be provided in the channels for passing reinforcement rods and dowels. The channels should be straight and placed firmly on sub-base to proper level and the bottom edge of the channel should be sealed properly to avoid entry of air. No channels should be removed earlier than 24 hours after the floor is cast.

**Placing of concrete and compaction:** Concrete should be distributed evenly and should be vibrated with an immersion vibrator in order to remove entrapped air and voids and make the concrete homogeneous. Surface vibrator should be used after immersion vibrator in order to make level and smooth concrete surface as directed by the Engineer. The thickness of the floor should be kept more than the required thickness, as directed by the Engineer, to compensate for the shrinkage effect.

**Vacuum dewatering:** After leveling the concrete surface by surface vibrators, the floor is dewatered by using filter mat and suction pump of approved make as per manufacturer's specification. The dewatering time should be based on site conditions and as directed/approved by the Engineer.

**Floating and trowelling:** Immediately after the floor is vacuum dewatered, floating and trowelling operation shall commence by using a skim floater with floating disc and trowelling blades of approved make.

#### 4.9 **Formwork**

4.9.1 **Shuttering for concrete:** The term 'Shuttering' shall include all centering and formwork required to support the concrete during the process of laying, compacting and setting and all items such as planking, lagging, walling, moulds, covers, cross-bearers, struts, props, bracings etc shall be covered by the term.

Shuttering shall be strong and rigidly constructed so that there may not be any deformation under weight and pressure of wet concrete, constructional loads, wind and/or other forces. It shall be constructed in such a manner that it can be easily removed afterwards.

The shuttering shall have smooth and even surface and so constructed as to remain sufficiently rigid during the placing and compacting of concrete and shall be sufficiently tight to prevent loss of liquid from the concrete.

Devices shall be provided in the shuttering for forming openings, holes, pockets, chases, recesses etc where required. Cutting of holes etc in the concrete after casting shall be avoided. Corner fillets shall be provided in the formwork to obtain chamfered edges to beams, columns, etc wherever required and the rate quoted shall be inclusive of the cost of carrying out such work.

Shuttering shall conform to IS:456 and IS:14687. Forms shall be prefabricated standard e.g. Doka system or approved equivalent or shop-built panels or built-in-place units, stiffened and braced. A smearing of oil release agent shall be given on the faces of the shuttering in contact with the concrete or mortar. Forms shall be cleaned from all dust and loose materials before applying oil

release agent over it. Formwork with brick lining may be done for structures below ground level on earth face with prior permission of the Engineer. Bricks shall be thoroughly wetted before laying concrete and the brick lining may be left in position, if so desired by the Contractor.

The shuttering shall be such that after its removal the exposed concrete surface shall be smooth and even. If any unevenness is found, the bulged portion of the concrete shall be chipped off and plastered with 6 mm thick cement plaster 1:4. No extra payment will be made for this.

4.9.2 **Stripping Time:** Forms shall not be released until the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected at the time of removal of form work. The strength referred to shall be that of concrete using the same concrete, aggregates and admixtures, if any, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work.

4.9.2.1 While the above criteria of strength shall be the guiding factor for removal of formwork, in normal circumstances where ambient temperature does not fall below 15°C and where ordinary portland cement is used and adequate curing is done, following striking period may deem to satisfy the guideline given in clause 4.9.2.

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Type of Formwork before Striking Formwork

Minimum Period

- |    |  |           |
|----|--|-----------|
| a) | Vertical Formwork to columns, walls,<br>Beams  | 16 – 24 h |
| b) | Soffit formwork to slabs (Props to be<br>refixed immediately after removal<br>of formwork) | 3 days    |
| c) | Soffit formwork to beams (Props to be<br>refixed immediately after removal<br>of formwork) | 7 days    |
| d) | Props to slabs :   |           |
|    | 1) Spanning upto 4.5 m   | 7 days    |
|    | 2) Spanning over 4.5 m   | 14 days   |
| e) | Props to beams and arches :  |           |
|    | 1) Spanning up to 6 m  | 14 days   |
|    | 2) Spanning over 6 m   | 21 days   |

For other cements and lower temperature, the stripping time recommended above, may be suitably modified.

4.9.3 **Supports:** Formwork shall be so designed that the side of beams and slabs can be removed without disturbing soffit forms and their supports. Props and supports shall allow accurate adjustment of the formwork true to line and level and be capable of being removed in an approved sequence without injury to the concrete. Provision shall be made for removal of formwork without disturbing props required for supporting hardened concrete.

4.9.4 **Setting:** Panels and units shall be set to true dimensions and alignment and rigidly tied, walled and braced to prevent distortion and displacement during concreting. All joints shall be tight and close fitting to prevent leakage. At all construction joints, formwork shall be tightly secured against previously cast or hardened concrete. When fixing formwork for beams and slabs tight fitting collars shall be provided around the heads of columns and the joints shall be made grout tight. Slip forms where used shall provide smooth even surface true to dimension and alignment and shall be free of unsightly off-sets, fins and bulges.

4.9.5 **Ties:** Standard form ties, clamps, bolts, inserts etc shall be of adequate strength. Spreaders, either removable or embedded type shall be used to maintain the wall thickness. The material and position of any tie passing through the formwork shall be as approved by the Engineer. All tie members which will remain embedded in the concrete shall be fixed in a manner that will provide a minimum cover of 12 mm at both the ends. Any holes left after removal of ties shall be filled with concrete or mortar as approved by the Engineer. Provision shall be made for forming holes and chases for services and for providing pipes, conduits and other fixing as shown in the drawing and/or as directed by the Engineer.

4.9.6 **Cleaning and treating of forms:** All rubbish shall be removed from the interior of the formwork and inside of the formwork shall be wetted with water before commencing of concreting. Mould oil or other approved release agent shall be used to all panels. Care shall be taken to prevent contact of release agent with reinforcement.

#### 4.10 **Reinforcement**

Workmanship shall conform to IS:2502. All reinforcements shall be free from loose mill scale, rust, oil, grease, mud and paint. Reinforcement shall not be bent or straightened in a manner that will injure the materials and all bars shall preferably be bent cold. Hot bending shall not be permitted for bars whose strength have been increased by cold working. Cutting and bending of reinforcement bars shall be made by using appropriate machine. No manual cutting and bending shall be allowed.

Reinforcement bars shall be placed and maintained accurately in position as shown in the drawings. The correct cover to the reinforcement shall be maintained by use of precast concrete blocks.

All intersections of longitudinal and transverse bars or stirrups and all laps shall be securely tied together with approved binding wire. The binding wire shall be so placed that it touches all the four corners of the intersection and the two ends shall be looped with pliers and the ends shall be turned into the body of the concrete. The cost of the binding wire and spacer/cover blocks shall be included by the Contractor in his rate for reinforcement work.

Welded joints may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding shall be done in accordance with IS:2751 and special precautions shall be adopted for cold worked bars. Butt welding between the ends of a rod in line, whereby stress is transferred across the section may be adopted only for mild steel bars. In case of tack welding for fixing reinforcements in their position, no special precaution need be taken.

#### 4.11 **Embedments**

All embedments shall be accurately set and rigidly fastened. Anchor bolts shall be set to template and firmly secured in vertical and horizontal line at required positions. Water stops shall be secured against displacement during the placing of concrete. The joints for G.S sheet water stops shall be soldered water-tight and those of PVC and rubber shall be joined by cementing and vulcanising. Expansion joint fillers shall be for the full depth of slabs or full width in walls and shall be cemented with a bituminous cement against previously placed concrete. The ends shall be butted tight and the upper edge set flush with finished slabs.

Anchor holes and anchor bolts shall be protected by covering suitably with brickwork in lean cement mortar after thorough cleaning.

#### 4.12 **Placing of Concrete**

4.12.1 **Transporting concrete:** Concrete shall be transported from the Batching Plant by transit mixers to the forms as rapidly as possible by means that will prevent segregation or flash set in the concrete during hot weather. The containers shall be such as to prevent heavy evaporation. At the time of placing concrete in very hot weather, care shall be taken to see that the temperature of wet concrete does not exceed 38°C. Before placing the concrete, all formwork, embedments and reinforcement shall be checked for completeness, location, dimension, square and plumb. All chips and saw dust or other foul matter shall be removed from within the forms. The base surface shall be well moistened and puddles wiped up. Placing equipment and accessories shall be kept clean and free of partially set grout and concrete, and maintained in proper working order.

4.12.2 **Placing aids:** In general, placing shall be done by concrete pump. Wherever required, concreting shall be done by direct pouring from transit mixer and also of approved chute. Concreting shall also be done with the help of bottom open bucket wherever required. No head load of concrete pouring is allowed and use of wheel barrow is mandatory wherever direct pump concrete or other mechanical means are not suitable.

4.12.3 **Conveying Equipment :** Conveying equipment shall be approved and shall be of size and design such that detectable setting of concrete shall not occur before adjacent/next layer concrete is placed. Conveying equipment shall be cleaned at the end of each operation or work day. Conveying equipment and operation shall conform to the following additional requirements.

- 4.12.3.1 Truck mixers, agitators and agitating units and their manner of operation shall conform to the applicable requirements of ASTM C 94.
- 4.12.3.2 Belt conveyors shall be horizontal or at a slope which will not cause excessive segregation or loss of ingredients. Concrete shall be protected against under drying or rise in temperature. An approved arrangement shall be made at the discharge end to prevent apparent segregation. Mortar shall not be allowed to adhere to the return length of the belt. Long runs shall be discharged in to a hopper or through a baffle.
- 4.12.3.3 Chutes shall be metal or metal-lined and shall have a slope not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal, chutes more than 6 mtrs. long and chutes not meeting the slope requirements may be used provided they discharge into a hopper before distribution.
- 4.12.3.4 Pumping or pneumatic conveying equipment shall be of a suitable kind with adequate pumping capacity. Pneumatic placement shall be controlled so that segregation is not apparent in the discharged concrete. The loss of slump pumping or pneumatic conveying equipment shall not exceed 50 mm.
- 4.12.3.5 Concrete shall not be conveyed through pipe made of aluminium or aluminium alloy.
- 4.12.4 **Construction joints & cold joints:** In general construction joints shall be limited to those indicated on the drawings. In mass concrete, construction joints may not be indicated in the drawings but shall be made at breaks, offsets or other convenient levels as controlled by volume, plant capacity, time factors etc. Such construction joints shall be so located that they do not impair the strength of the structure and prior approval of the Engineer are to be taken. In walls and column height of each lift shall not generally exceed 1.5 m unless otherwise specified in the drawings or directed by the Engineer. Method of forming all construction joints shall conform to the provisions of IS:456. The surface of previously placed concrete at the construction joint shall be thoroughly hacked to expose the coarse aggregates of previously placed concrete and cleaned with wire brush or any other approved means and high pressure water jet to remove all laitance and loose aggregates. Immediately before placing fresh concrete, such prepared surface shall be coated with a thin layer of cement slurry. Where high shear resistance is required at the construction joint, shear keys shall be provided.
- 4.12.5 **Compaction:** Concrete shall be thoroughly compacted and fully worked around the reinforcement, around embedded fixtures and into corners of the form work. Concrete shall be compacted by mechanical vibration using high frequency mechanically driven vibrators



comply with IS:2505, IS:2506, IS:2514 & IS:4656. Concrete shall be placed in layers at least 300 mm deep in walls and approximately 450 mm in mass pours. Vibrators shall not penetrate more than into the surface of previously placed layer but shall completely vibrate the working layer. Care shall be taken not to over-vibrate any concrete and especially those with higher slumps. Under no circumstances vibrators shall be attached to or allowed to touch reinforcement. Spare vibrators in good operating condition shall be on hand during placing operation.

4.12.6 **Special concreting:** The placing of under water concrete shall follow IS:456 in all respects for the method employed. Special types of concrete shall be placed by methods most suitable for the particular conditions.

4.12.7 **Grouting bases of machines, columns, foundations bolts etc.**

4.12.7.1 **Level pads:** For preparing the level pads, the top of the foundation concrete shall be chipped off to remove laitance formed on the concrete surface and all loose materials shall be thoroughly cleaned and the surface wetted before the grouting. In case level pads are constructed they shall be cement concrete with grade M25 or M20 in conformity with the grouting requirement with 6 mm size ballast. The top of the level pads shall be finished fine, true to level and be of size as indicated by the Engineer.

4.12.7.2 **Grouting:** Before placing the grout, the concrete surface shall be thoroughly cleaned, preferably with compressed air and the surface shall be thoroughly wetted with water for several hours. Before placing the grout all free water shall be removed and the flat surface shall be coated with thin cement slurry. The quantity of mixing water should be minimum commensurate with the workability, compaction and filling of the grout in all corners and crevices. The grout shall be evenly spread and compacted by rodding or a vibrator. The grout shall be carefully observed for initial settlement. If any settlement is observed further grout is to be poured and rodded. For base plates having ribs underside the base plate, proper care is to be taken to ensure filling of the cavities between the ribs. In case of wide base plates of bed plates having ribs under- side it may be necessary to do pressure grouting.

4.12.7.3 **Curing:** The grout must not dry out after it is placed in position. The surface shall be kept moist with wet sacks for at least seven days.

4.12.7.4 **Admixtures:** If any admixtures is to be used with the grout, it shall be as approved by the Engineer.

4.12.7.5 **Non-shrinking grout:** Non-shrinking grout where indicated or directed shall be placed in accordance with the method specified by the manufacturer. Material shall be as approved by the Engineer.

4.12.8 **Waterproofing:** Waterproofing of concrete with approved waterproofing compound shall be carried out strictly in accordance with the manufacturer's specification.

4.13 **Curing and Protecting:** Curing of concrete with water shall comply with IS:456. The Contractor shall keep the exposed surfaces of concrete in a constantly wet condition for at least 7 days from the date of placing the concrete. Curing compound may be used subject to approval by the Engineer. Finished floors and concrete shall be protected carefully until conditions shall comply with the code.

4.14 **Repairing and Patching:** Pockets, honey combing and other defects which may be formed due to segregation, improper vibration and any other reason whatsoever shall be completely repaired to the satisfaction of the Engineer. The voids, if any, shall be properly keyed and reinforced, if necessary. The face shall be tightly formed and arranged for providing a head in the concrete. The cavity shall be filled with the same concrete as used for the structure and thoroughly rodded or vibrated where possible. The concrete sets sufficiently to stay in place. While still 'alive', the upper part of form hopper shall be removed and excess concrete struck off and finished with wood flat or trowel to match existing concrete. Any fins or unsightly grout runs or bulges shall be removed from

surfaces exposed to view. The rod holes shall be finished with cement or grouted to match the existing surface as closely as possible. No cement wash shall be used unless particularly called for in the drawings.

4.15 **Tolerances for Formwork**

The Formwork shall be designed and constructed so as to remain sufficiently rigid during placing and compaction of Concrete and shall be such as to prevent loss of slurry from the Concrete. The tolerances on the shape, line and dimensions as shown in the drawing shall be within limits as given in the Table of clause no 11.1 of IS:456

4.16 **Tolerances for Placing of Reinforcement**

Unless otherwise specified, the Reinforcement shall be placed within the following tolerances :

a) For effective depth 200 mm or less  $\pm 10$  mm

- b) For effective depth more than 200 mm  $\pm 15$  mm

## **SECTION - 5 - MORTAR FOR MASONRY AND PLASTER WORK**

### **5.0 Work Included**

The Contractor shall furnish materials, labour, plant, equipment and tools to complete the work as specified herein.

### **5.1 Materials**

5.1.1 **Cement:** As per Section-4.

5.1.2 **Sand:** The sand shall be of approved river or pit sand and it shall conform to IS:1542 for plaster and to IS:2116 for masonry mortar. Sand for the mortar shall be evenly graded from coarse to fine, free from loam, clay, dust or organic matter etc.

5.1.3 **Water:** Water shall be clean and reasonably free from deleterious materials such as oils, acids, alcohol, salts, sulphate and vegetable growth as per clause No. 5.4 of IS:456.

### **5.2 Mortar Proportion**

The proportion of cement and sand for mortar shall be for masonry work is 1:6 and for plaster work is 1:4.

### **5.3 Workmanship**

The workmanship shall conform to IS:2250 for preparation of masonry mortars and to IS:1661 for plaster mortars. The cement and sand shall be thoroughly mixed dry in specified proportion to obtain a uniform colour. The water shall be added by sprinkler just sufficient to make a stiff and workable paste. In case of mechanical mixing the mortar shall be mixed for at least 3 minutes and for hand mixing the mortar shall be mixed back and forth for 10 to 15 minutes with additions of water. Mortar that has stiffened because of evaporation of water may be re-tamped by adding water as frequently as necessary to restore consistency but this re-tempering

will be permitted only within one (1) hour from time of addition of cement. Inner end of the scaffolding poles shall rest in a hole provided in a header course only. Only one header for each pole shall be left out. Holes, if provided shall be filled in and made good by the Contractor at his own cost to the satisfaction of the Engineer/Consultant.

#### 5.4 **Curing**

After the completion of plaster work, it shall be cured by adequate watering for a period of seven (7) days. The plaster shall be protected during that period from extreme temperature and weather condition.

### **SECTION - 6 - BRICK AND STONE MASONRY WORK**

#### 6.0 **Work Included**

The Contractor shall furnish materials, labour, plant, equipment and tools to complete the work as specified herein.

#### 6.1 **Codes and Standards**

IS:2212 .. Code of Practice for Brickwork

IS:1077 .. Common Burnt Clay Building Bricks

IS:2691 .. Burnt Clay Facing Bricks

IS:3495 .. Methods of Test for Burnt Clay Building Bricks

IS:2750 .. Steel Scaffoldings

IS:4014 .. Code of Practice for Steel Tubular Scaffolding  
(Part 1)

IS:3696 .. Safety Code for Scaffolds and Ladders  
(Part 1 & 2)

IS:1127 ... Recommendation for Dimensions and Workmanship of Natural  
Building Stones for Masonry Work

IS:1129 .. Recommendation for Dressing of Natural  
Building Stones

IS:1124 .. Methods of Test for Determination of Water  
Absorption Apparent Specific Gravity and  
Porosity of Natural Building Stones

IS:1597 .. Code of Practice for Construction of Stone  
(Part 1 & 2) Masonry

IS:12894 ... Code of practice for flyash lime Bricks.

## 6.2 Materials

6.2.1 **Cement mortar:** Cement mortar shall be as specified in Section-5 of this specification.

6.2.2 **Water:** Water shall be clean and reasonably free from deleterious materials such as oils, acids, alcohol, salts and vegetable growth.

6.2.3 **Burnt clay Bricks:** The bricks used shall be conforming to IS:1077. Bricks shall be whole, sound, well burnt, free from cracks, flaws and nodules of free lime. Brick shall have rectangular faces with sharp corners and shall be uniform in colour and shall emit a clear ringing sound when struck. The compressive strength of brick shall be minimum of 50 kg/sq cm or 5 N/sq. mm.

6.2.4 **Stone:** Building stone shall conform to IS:1127. Rubble stone shall be strong, dense, compact, close grained and uniform in texture and colour with reasonable facility of working. It shall be free from cracks, flaws, decay and sand holes and shall be taken from approved quarries. A fresh fracture of stone shall be bright, clean and sharp without loose grains and free from any dull earthy appearance. The stone shall be properly dressed in conformity with IS:1129 after quarrying before they are put to use in the structure.

6.2.5 **Flyash Lime Brick (Falg):** The bricks are made of quarry dust, fly ash, cement, lime and gypsum. The water absorption shall not be more than 10% after immersion in cold water for 24 hours. The brick shall conform to IS:12894.

6.2.6 **Wire Netting:** Woven, hexagonal wire shall conform to type N3 of IS:3150 and be galvanized. The width shall suit the thickness of the wall.

## 6.3 Scaffolding

Generally, scaffolding shall conform to IS:4014 and shall be designed to withstand the required loads and to ensure complete safety of workmen and materials. The scaffolding shall be double, i.e. it shall have two sets of stands. Where this is not possible, the inner end of the scaffolding poles shall rest in a hole provided in a header course only. Only one header for each pole shall be left out. Holes, if provided shall be filled in and made good by the Contractor at his own cost to the satisfaction of the Engineer/Consultant.

## 6.4 Lifting and Handling of bricks at height

All bricks shall be lifted at height with the help of builder hoist or any other approved mechanical means.

## 6.5 **Cleaning**

The Contractor shall carry out work in as clean a manner as possible and shall remove excess material and mortar droppings and rubbish daily. Where brick walls and stone masonry are to receive plaster, the joints shall be cleaned of excess mortar and raked to a depth of 12 mm and the surface shall be brushed clean. During cleaning operations, adjacent work shall be protected and any damage resulting from improper protection shall be made good by the Contractor at his own cost.

## 6.6 **Brickwork**

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

The Contractor shall lay bricks in full mortar beds with shoved joints. The joints shall not exceed 10 mm in thickness and shall be full of mortar, close, well finished and neatly struck. The vertical joints in any course shall not be nearer than a quarter of brick length from those in the course below. All joints shall be of same width except for small variations to maintain the bond. The brickwork shall be laid plumb and true to line and level. No portion of brickwork shall be raised more than 1 meter above another in a day. If the mortar in any course has begun to set, the joints shall be raked out before another course is laid. The top course of brickwork in reinforced concrete frame structure shall be wedged against reinforced concrete surface and joint well filled with mortar.

The Contractor shall flush up all the joints thoroughly with mortar as the work proceeds. Where brickwork is to receive plaster, the joints shall be raked to a depth of 12 mm to provide proper bond. The brickwork as it progresses shall be thoroughly watered on its faces and top. New work shall be properly bonded with old work. New work surface of unfinished work shall be cleaned and thoroughly watered before joining new work to it.

Any work in which the mortar deteriorates shall be dismantled and rebuilt by the Contractor at his own expense.

6.6.2 **Curing:** The Contractor shall keep wet all brickwork for 7 days after laying.

## 6.7 **Uncoursed Random Rubble Masonry**

6.7.1 Workmanship for stone masonry shall conform to IS:1597. No stone shall be less than 250 mm in thickness or less than 300 mm in each horizontal dimension. If the thickness be more than 300 mm the least horizontal dimension must not be less than the thickness.

6.7.2 **Dressing:** The stones after being fully cleaned and wetted are to be set in the work as received from the quarry and without further dressing of any sort except that of knocking off weak corners and edges with the mason's hammer.

6.7.3 **Bond and laying :** The stones shall be carefully laid so as to break joints by at least 75 mm and solidly bedded with close joints. No joint shall exceed 20 mm in thickness. Chips of stones and spalls shall be wedged into the work, wherever necessary so as to avoid thick bed or joints of mortar. No dry work or hollow spaces shall be allowed in the masonry anywhere. Every stone whether large or small shall be set flush in mortar, smaller stones used in the filling being carefully selected to fit into interstices between the larger ones roughly. The outside and the inside faces of masonry in walls must be carried out in the same plane as the faces of the preceding length.

6.7.4 **Face stones :** The face stones shall be laid as far as possible without pinnings in front and they shall be selected from the mass or quarry stone for greater size, good beds and uniform colour. They shall be laid so that they shall tail back and bond well into the work and shall not be of greater height than either the breadth on face or length of tail in the work.

6.7.5 **Bond or header stones :** At least one-fifth of stones in the face shall be through stones evenly distributed throughout the wall. The through stones will fulfil all the conditions of the face stone except as regards their length which must be not less than 450 mm and must run right through the wall when the wall is not more than 450 mm thick. In thicker walls a line of two or more through stones must be laid from face to back overlapping each other at least 150 mm. Through stones should not be in the same vertical plan in successive courses. For facility of checking they shall be marked and the marks shall be capable of being easily rubbed out.

6.7.6 **Quoins :** Quoins must be of the same height as the course in which they occur and should be formed of header stones from 220 mm to 450 mm long according to the height of the course and laid lengthwise alternatively along each face. They should be laid square on their beds

which should be dressed to a depth of at least 100 mm. The corner of each quoin should have a chisel draft of 25 mm on each side to facilitate checking the vertical alignment.

6.7.7 **Finishing** : Where lime mortar is used, the exposed faces of work shall be cement flush pointed, unless otherwise specified. When cement mortar is used the joints may be flushed as the work proceeds. Where stone work is to receive plaster or to be pointed other than flush pointing, the joints shall be raked to a minimum depth of 12 mm to provide proper bond. Any work in which mortar perishes shall be dismantled and rebuilt by the Contractor at his own expense.

6.7.8 **Curing** : Curing shall be done for a period of 7 days.

## 6.8 **Coursed Random Rubble Masonry**

The specification shall be same as in [clause 6.7](#) above excepting that the work shall be roughly levelled upto courses at intervals varying from 300 mm to 900 mm.

## 6.9 **Coursed Rubble Masonry**

6.9.1 **Height of courses** : The stones after being cleaned and wetted shall be laid in horizontal courses of equal depth of not less than 150 mm and shall be set full in mortar.

6.9.2 **Dressing** : The joint between two continuous face stones in the same course shall be truly vertical and the two stones shall be hammer or chisel dressed so as to be in proximity for at least 75 mm depth from the face of the wall. The beds of face stones shall also be hammer or chisel dressed for at least 75 mm depth.

6.9.3 **Bond and laying** : The stone shall be laid on their broadest face in mortar and beaten into position with mallet, care being taken that the mortar is well filled into the joint. The vertical joints in each course must break joint at least 75 mm with those in the courses above and below. No joint shall exceed 12 mm in thickness. The interior of the wall is to be carefully constructed with proper sized stones and not filled up with spalls and/or chips. Spalls may however be used to wedge into the mortar to avoid thick bed or joints of mortar.

6.9.4 **Face stones** : The face stones shall be squared on all joints and beds. No face stone shall be narrower or shorter than its depth. Its length tailing into the wall shall not be less than their height and at least one-third of the face stones shall tail into the work for a length twice their height or in the quick walls three times their height.

The width of the face stones in plan shall not be less than 150 mm for walls 400 mm thick, 200 mm for walls, 450 mm thick and 250 mm for walls 600 mm thick or more respectively. No



stone less than 150 mm in height shall be used on the face. The face stones shall be laid headers and stretchers alternatively.

6.9.5 **Bond or header stones** : Through stones for headers shall fulfil all the conditions of face stones, except as regards their length which must not be less than the width of the wall or 450 mm whichever is less. Through stones shall be inserted approximately 1.5 metre apart in every course. Other details shall be same as for bond or header stones for random rubble masonry.

6.9.6 **Quoins** : The same specification shall be followed as detailed for random rubble masonry.

6.9.7 **Finishing** : The exposed surface of the work shall be flush pointed. Unless the interior face is to be plastered, it shall be of the same finish as that of exterior face.

6.9.8 **Curing** : Curing shall be done for a period of 7 days.

## **SECTION - 7 - PLASTER WORK**

### **7.0 Work Included**

The Contractor shall furnish materials, labour, plant, equipment and tools to complete the work as specified herein.

### **7.1 Codes and Standards**

IS:1542 .. Sand for plaster

IS:1661 .. Code of practice for application of cement  
and cement-lime plaster finishes

IS:2250 .. Code of practice for preparation  
and use of masonry mortars.

### **7.2 Materials**

All materials, cement mortar etc shall be as specified under Section-4 and 5 of this specification.

### **7.3 Plastering in One and Two Operations**

7.3.1 **Proportion**: All plaster work shall be carried out according to IS:1661 with 1:4 cement sand mortar.

7.3.2 **Workmanship**: The surface to be plastered shall be cleaned of all extraneous matter and rubbish. In brickwork the joints shall be raked and concrete surface roughened

by chipping or hacking. Any shuttering material adhering to the concrete shall be removed. The surface shall be thoroughly watered and soaked, aerated and all log holes shall be closed before starting plastering operation. Plaster pads of required thickness of plaster for correctness of plumb, line and level shall be established before starting plaster work.

For one coat plaster work, the plaster shall be laid slightly thicker than the specified thickness and the surface then leveled with flat wooden rule to the required thickness. The plaster shall be well pressed into the joints and the surface finished as specified.

Where two coats of plaster work is specified, the first coat shall be applied as described above except that the surface shall be left rough and keys formed for the application of second coat. The second coat shall be applied a day or two after the first coat has set, but the first coat shall not be allowed to dry. The second coat shall consist of mortar ground very fine and shall be laid on with a wooden rule to a specified thickness, rubbed smooth and leveled and the surface plastered completely the same day. The leveling shall be continued till the plaster is quite dry and all moisture which exudes from the plaster shall be wiped off with fine cloth. The surface shall be kept dry until exudation of moisture ceases, during the process of rubbing.

#### 7.4 **Plastering (Rough Cast Finish)**

7.4.1 **Proportion:** The first coat shall consist of 1 part of cement and 4 parts of sand. The proportion of second coat (rough cast finish) shall be 3 parts of cement, 6 parts of fine sand and 4 parts of shingle or crushed stone not exceeding 10 mm size.

7.4.2 **Workmanship:** The workmanship shall conform to two coats plaster as indicated in IS:1661 and surface preparation shall be as specified under Clause 7.3.2. The first coat shall be dashed on to the prepared surface with a trowel to fill up all unevenness in the surface. The surface shall not be smoothed but left rough. A wet plastic mix of second coat as specified above shall be thrown on the first coat by means of a scoop or plasterer's trowel while the first coat is still soft. The thickness of the second coat shall not exceed 12 mm.

#### 7.5 **Plastering (Pebble-dash Finish)**

7.5.1 **Proportion:** The first coat of plaster shall consist of 1 part of cement and 4 parts of sand.

The second coat (i.e. pebble-dash finish) shall consist of 1 part of cement, 4 parts of sand upon which shingle is thrown. The second coat shall not exceed 10 mm in thickness.

7.5.2 **Workmanship:** The workmanship shall conform to two coat plaster as indicated in IS:1661 and the surface preparation shall be as specified under Clause 7.3.2.

The first coat of plaster shall be dashed on to the prepared surface to the specified thickness with a trowel to fill up all unevenness in the surface, but the surface shall not be smoothed. The first coat shall be allowed to dry and shrink properly before the second coat is applied. A wet plastic mix of second coat as specified above shall be applied upon which selected shingle which has been well washed shall be thrown while it is still soft.

7.5.3 **Curing**

After the completion of plaster work, it shall be cured by adequate watering for a period of seven (7) days. The plaster shall be protected during that period from extremes of temperature and weather at no additional cost to the Employer.

## **SECTION - 8 - WATERPROOFING AND DAMP-PROOFING**

### **8.1 WATERPROOFING OF UNDERGROUND STRUCTURES BY PRESSURE GROUTING WITH NON-SHRINKING POLYMERIC WATERPROOFING GROUTING COMPOUND**

The Contractor shall furnish materials, labour, plant, equipment and tools to complete the work as specified herein.

#### **8.1.1 Codes and Standards**

IS:2645 .. Integral cement waterproofing compounds  
IS:9103 .. Admixtures for concrete

#### **8.1.2 Materials**

8.1.2.1 **Cement:** As mentioned in Section-4.

- 8.1.2.2 **Aggregates:** All aggregates shall conform to IS:383. Fine aggregates shall be approved river or pit sand. Coarse aggregates shall be approved crushed stone. Aggregates shall be clean and free from any foreign material.
- 8.1.2.3 **Cement waterproofing compound:** All cement waterproofing compound shall conform to IS:2645 and shall be of approved brand and quality.
- 8.1.2.4 **Acrylic Polymer Modified Cementitious Coating:** Acrylic Polymer Modified Cementitious Coating to form a thick resilient and flexible membrane on concrete/plastered surfaces with high resistance to oil and water shall be of approved brand and quality.
- 8.1.2.5 **Nozzle:** Nozzles shall be 15 mm dia threaded G.S. pipes of suitable length plugged at both ends and of approved quality.
- 8.1.2.6 **Super plasticiser:** High range water reducing admixture and integral cement waterproofer for concrete shall be of approved brand and quality. Super plasticiser shall conform to ASTM C-494 Type F or IS:9103 and IS:2645.
- 8.1.2.7 **Non-shrink polymeric waterproofing grouting compound:** The non-shrink polymeric waterproofing grouting compound shall be of approved brand and quality.

### 8.1.3 **Workmanship**

Waterproofing of underground structures shall be carried out as per approved manufacturer's specifications and as stated below:

- 8.1.3.1 **Raft:** The sub-base (PCC) of the underground structure shall be cleaned of all dirt and kept dry by continuous pumping of water.

The surface shall then be painted with two (2) coats of approved acrylic polymer modified cementitious compound to form a thick resilient and flexible membrane over the sub base.

Threaded nozzles of 15 mm dia and of suitable length shall be placed and fixed in a grid pattern of maximum 1.5 m center to center over the whole raft, prior to casting of RCC raft. Similar nozzles will also be placed along the construction joints, if any, at regular intervals not exceeding 1.5 m c/c. Adequate precautions shall be taken to keep the nozzles plugged at both ends to prevent them from getting clogged by concrete. Similar nozzles shall also be post fixed at critical points, if required. Approved super plasticiser-cum-cement waterproofer shall be added to the concrete

for the raft as per manufacturer's specification. The concrete shall be at least M25 grade as defined by IS:456 and the water cement ratio of the concrete shall not exceed 0.50. Adequate precaution shall be taken to keep the nozzles vertical while concreting.

Approved non-shrink polymeric waterproof grouting compound mixed with cement slurry shall be injected through the nozzle (after removal of plugs) under pressure by pump as per the instructions of the manufacturer. When the injection operation is over the nozzles shall be sealed with a sealing compound as per manufacturer's specification and instruction.

#### **8.1.3.2 Vertical Wall**

15 mm dia threaded nozzles of suitable lengths (about half of the thickness of the wall) shall be placed and fixed in a grid pattern of maximum 1.5 m center to center over the entire surface prior to concreting of the vertical wall. Similar nozzles are to be also fixed at construction joints, if any, at regular intervals not exceeding 1.5 m c/c. Adequate precaution shall be taken to keep the nozzle plugged at both the ends to avoid clogging of the nozzles by concrete.

Similar nozzles shall also be post fixed at critical points, if required.

The concrete for the vertical wall shall be at least M25 grade as defined by IS:456 having a maximum water cement ratio of 0.50. Approved super plasticiser-cum-cement waterproofer shall be mixed with the concrete as per the manufacturer's specification. Adequate precaution shall be taken to keep the nozzles horizontal during concreting.

The exterior surface of the concrete shall be finished smooth and painted with two (2) coats of approved acrylic polymer modified cementitious coating to form a thick resilient and flexible membrane over the surface.

Approved non-shrink polymeric waterproof grouting compound mixed with cement slurry shall be injected through the nozzles (after removal of plugs) under pressure by pump as per the manufacturer's instruction. When the injection operation is over the nozzles shall be sealed with a sealing compound as per manufacturer's specification and instruction.

#### **8.1.3.3 Guarantee for Waterproofs**

The Contractor shall furnish a guarantee of at least ten (10) years for the waterproofs of the underground structures (in a bone dry condition) treated by him by pressure grouting as specified above.

## **8.2.0 Waterproofing with Liquid Waterproofing Membrane**

### **8.2.1 Materials**

8.2.1.1 **Liquid waterproofing membrane:** It shall be of approved make and quality.

8.2.1.2 **Thinner:** Approved quality thinner as per manufacturer's recommendation shall be used.

8.2.1.3 **Water:** Water shall be clean and of potable quality.

### **8.2.2 Workmanship**

8.2.2.1 **Surface preparation:** The surface shall be dry and free from dust, grease, oil and loose particles. The roof surface shall be regarded to required levels and slope prior to waterproofing with screed concrete or cement mortar. If laitance is found it shall be removed by acid etching using a mixture of 1 part muriatic acid to 3 parts of water by volume. The acid solution shall be scrubbed into the surface with a shift broom while it effervescence for approximately two minutes. The surface shall then be thoroughly washed with fresh water and broomed to remove acid solution and slurry residue and allowed to dry completely. When dry the surface shall be finally broomed to remove all dust and dirt.

8.2.2.2 **Application:** The surface shall be completely dry. A coat of primer as recommended by the manufacturer shall be evenly sprayed/ poured or brushed on the surface. It shall then be allowed to air dry undisturbed for about 24 hours.

The liquid waterproofing compound shall be stirred well before use and thinner/liquidizer shall be added if necessary as per the recommendations of the manufacturer only. The first coat of the liquid waterproof membrane shall then be applied on the primed surface by sprayer/wide thin hair brush. The coat shall then be allowed to air dry for 24 hours before the final coat is applied. The final coat shall then be applied in a manner same as that of the first coat and allowed for air dry undisturbed for 24 hours.

At perimeter cave or in other areas where vertical wall and horizontal slab meets the primer and the liquid membrane coating shall be turned up and finished in a groove.

The membrane shall then be finally protected by providing a suitable cover to prevent it getting physically damaged.

8.2.3 **Guarantee:** The Contractor shall provide guarantee against leakage of treatment for a minimum period of ten (10) years from the date of handing over of the structure.

### 8.3 **ROOF WATER PROOFING**

8.3.1 The waterproofing work shall be done in four (2) layers. The details of two (2) layers including surface preparations are as follows:

#### 8.3.1.1 **Surface preparation:**

Surface shall be dry and free from dust, any laitance, grease, oil and other loose and deleterious materials.

The roof surface shall be graded to required slopes and levels with screed concrete or cement mortar and rendered smooth prior to waterproofing work. For water proofing of existing roof surfaces, the concrete surfaces

Any laitance found shall be removed by acid etching using a mixture of one (1) part muriatic acid to three (3) parts of water by volume. The acid solution shall be scrubbed into the surface with a hard brush while it effervesces for approximately two minutes. The surface shall then be thoroughly washed with clean water and broomed to remove the acid solution and slurry residue from the surface and allowed to dry completely. When dry the surface shall be finally broomed to remove all dust and dirt.

#### 8.3.1.2 **Bottom Layer**

Exactly over the prepared roof surface, a coat of XIPEX shall be applied over new concrete surfaces.

#### 8.3.1.5 **Top Layer**

The top layer shall be of 50 mm thick plaster with 1:4 cement mortar. The top layer shall be covered for at least seven (7) days prior heading over the same.

### 8.4 **HYDRO AND THERMAL INSULATION TO ROOF**

8.4.1 The hydro and thermal insulation (CFC free) to roof shall be done in multiple layers. The details of all these layers including surface preparations are given below:

8.4.1.0 **Surface Preparation**

Similar to roof water-proofing with fibre glass cloth.

8.4.1.1 **First Layer/Bottom Layer**

Exactly over the prepared roof surface one coat of primer @ 0.3kg/sqm suitable for polypropylene waterproofing membrane to be applied.

8.4.1.2 **Second Layer**

Approved make white granular polymer modified polypropylene membrane "MOPLY FP-3 MM" with 160 gsm polyester non oven mat reinforcement over the prime surface of M/s Texa India Pvt Ltd or other approved equivalent, shall be laid over the first layer.

8.4.1.3 **Third Layer**

Providing and laying PVC/polyester sheet of 150 gsm as separating layer (vapor barrier).

8.4.1.4 **Fourth Layer**

Providing and laying 50 mm thick extruded polystyrene slab, having density 30 kg/cu m, thermal conductivity 0.023 Kcal/mh degree C "ROOF MATE TG" of M/s Texa India Pvt Ltd or other approved equivalent.

8.4.1.5 **Fifth Layer**

Providing and laying PVC/polyester sheet of 150 gsm as vapor barrier (all joints to be sealed with self adhesive tape).

8.4.1.6 **Sixth Layer**



Providing and laying PCC(1:2:4), average 40mm thick laid to slope 1:20 with chicken wire mesh of 20 mm x 26 swg as reinforcement. The PCC to be done in panels of size 1m x 1.5m ( max ) with joints sealed with mastic sealant.

#### 8.4.1.7 **Seventh Layer**

On top of PCC panels having control joints, 40mm thick top cover with “ broken China mosaic” to be laid. The broken China mosaic tiles shall be broken pieces of ceramic tiles 8 mm thk, solar reflectance 0.7 ( min ) of approved make and colour fixed on top of PCC panels with 1:3 bedding cement sand mortar.

### 8.5 **DAMP-PROOF COURSE**

#### 8.5.1 **Work Included**

The Contractor shall furnish materials, labour, plant, equipment and tools to complete the work as specified herein.

#### 8.5.2 **Materials**

**Cement:** As mentioned in Section-4.

**Aggregates:** All aggregates shall conform to IS:383. Fine aggregates shall be approved river sand or pit sand. Coarse aggregate shall be approved stone chips of size not exceeding 6 mm. Aggregate shall be clean and free from any foreign material.

**Water:** Water shall be clean and of potable quality of PH value ranges from 8 to 6.

**Bitumen:** Bitumen shall conform to IS:3384.

#### 8.5.3 **Proportion:**

The proportion of cement and aggregates (fine and coarse) and thickness of the damp-proof course shall be 1:1.5:3 & 40 mm as per requirement.

#### 8.5.4 **Workmanship**

The masonry surface shall be leveled and joints shall be raked to receive the damp proof course. Damp proof course shall be provided at required positions. It shall be laid for the full width of the wall. The top surface shall be kept rough or ribbed for proper adhesion with the mortar for masonry coming over it. All other surfaces of the damp proof course shall be finished fair and smooth. After the surface has partially set hot bitumen shall be applied in two coats at the rate of 1.7 kg per sq m per coat and dry sand spread over it.

## **SECTION-9 - FLOORING AND FLOOR FINISHES**

### **9.0 Work Included**

The Contractor shall furnish labour, plant, equipment and tools to complete the work as specified herein.

### **9.1 Codes and Standards**

- IS:653 .. Specification for Linoleum sheets and tiles
- IS:809 .. Rubber Flooring Materials for General Purposes
- IS:1197 .. Code of Practice for Laying of Rubber Floors
- IS:1195 .. Specification for Bitumen Mastic for Flooring
- IS:1196 .. Code of Practice for Laying Bitumen Mastic Flooring
- IS:1198 .. Code of Practice for Laying, fixing and Maintenance of Linoleum Floors
- IS:1237 .. Specification for Cement Concrete Flooring Tiles
- IS:1443 .. Code of Practice for Laying and Finishing of Cement Concrete Flooring Tiles
- IS:1580 .. Bituminous compounds for water-proofing and caulking purposes
- IS:2114 .. Code of Practice for Laying in-situ Terrazzo Floor Finish
- IS:2571 .. Code of Practice for Laying in-situ Cement concrete flooring
- IS:3462 .. Specification for unbaked flexible PVC flooring
- IS:3464 .. Method of Test for Plastic Flooring and Wall Tiles
- IS:4443 .. Code of practice for use of Resin type

Resistant mortars.  
IS:4457 .. Ceramic Unglazed Vitreous Acid Resisting  
Tiles  
IS:4832 .. Specification for Chemical resistant mortar  
(Part-II) (Resin type)  
IS:5318 .. Code of Practice for Laying of PVC sheet and  
Tile Flooring  
IS:5491 .. Code of Practice for Laying in-situ Granolithic  
Concrete Floor for Topping

## 9.2 **Cast-in-Situ Concrete Flooring**

### 9.2.1 **Materials**

**Cement:** Cement shall be as per Section-4.

**Sand:** The sand shall be of river sand or from approved pits and shall conform to IS:383.

**Aggregates:** The aggregates shall conform to IS:383. The coarse aggregate shall generally be of the following sizes:

Base concrete .. Graded from 40 mm and below

Cement concrete topping of thickness 25 mm ..  
Graded from 10 mm and below

Cement concrete topping of thickness 40 mm ..  
Graded from 10 mm and below.

#### **Cement concrete topping in two layers:**

i) Under layer .. Graded from 10 mm and below

ii) Top layer.. Graded from 6 mm and below

Grading of coarse aggregates shall conform to Table-1 of IS:2571. The fine aggregates shall be either of grading zone 1 or 2 of Table-2, IS:2571.

**Water:** Water shall be clean and reasonably free from deleterious materials such as oils, acids, alcohols, salts and vegetable growth.

**Aluminium and glass divider:** Strips used shall be 2 mm thick and the depth shall be equal to the overall thickness of the flooring.

**Colouring pigment:** Pigments, synthetic or otherwise, used for colouring shall have permanent non-fading colour and shall not contain matters detrimental to concrete. The pigment shall be of approved brand and tints shall be uniform. All pigments used shall conform to the relevant Indian Standards.

## 9.2.2 **Workmanship**

9.2.2.1 **Plain cement concrete flooring:** Generally workmanship shall conform to IS:2571. If the floor finish is to be laid over consolidated ground or a layer of hard core, cement concrete of approved mix shall be poured as a base layer to the required thickness. In the case of structural slabs, the slab itself will form the required base.

The area requiring floor finish shall be divided into suitable panels to reduce the risk of cracking. No dimension of a panel shall exceed 4 m in case of floor finish laid monolithically with base concrete and 2 m in case of floor finish laid separately on a hardened base. Length of the panel shall not exceed one and half times its breadth.

Paneling shall be done by fixing glass or aluminium strips of depth equal to the combined thickness of base concrete and topping. Before being fixed in position these strips shall be coated with a thick coat of lime wash. Flooring shall be laid in alternate panels, the intermediate panels being filled in after one or two days.

9.2.2.2 **Floor finish laid monolithically with base concrete:** The sub-base shall be properly wetted and divided into panels. For structural slabs, the formwork shall be erected to the finished thickness of floor finish and structural concrete shall be deposited in the forms and finished below the top edge of the form to accommodate the required thickness of the topping. The base concrete shall be poured and tamped and screeded to levels suitable to accommodate topping and to give the desired slope. The surface shall be left rough to provide bond with the topping.

On the green surface of the base concrete, topping shall be placed in position as soon as the base has stiffened enough to allow workmen to tread over it by placing planks on the surface. The mix for the topping shall be as stiff as possible consistent with workability so as to prevent accumulation of excess water or laitance. Should any water rise to surface during compaction and screeding, it

shall be mopped up. The topping shall be then floated with a wooden float to render the surface even.

- 9.2.2.3 **Floor Finish laid separately on hardened concrete base:** The sub-grade shall be properly wetted and the base concrete laid, if possible over the whole area at a stretch. The surface shall be left rough to provide adequate bond for the topping by wire brushing two to three hours after its laying.

Before the topping is laid, the surface of the base shall be thoroughly cleaned of loose materials, dirt and laitance by wire brushing. Where this is not possible, chipping or hacking shall be done. The surface shall be soaked with water for 12 hours before laying the topping. The surplus water shall be mopped up, 1:1 sand cement slurry spread and the concrete for the topping deposited in suitably divided panels. The mix for the topping shall be as stiff as possible consistent with workability so as to prevent accumulation of excess water or laitance. After thorough consolidation the topping shall be struck off level and surface floated with a wooden float. It shall be tested with a straight edge and mason's spirit level to detect any inequalities and any undulations found shall be made good immediately.

- 9.2.2.4 **Laying topping in two layers:** Where it has been specified that the topping is to be laid in two layers to obtain very smooth and dense finish, the base concrete and underlayer of topping shall be laid as above with the exception that the surface of the concrete in the underlayer of topping shall not be finished smooth but left rough after tamping and leveling.

Before placing the top layer, any water or laitance which may have worked up to the surface of the underlayer shall be removed. The top 15 mm thick top layer of 1:1.5:3 cement concrete of consistency stiffer than that of underlayer of concrete shall then be immediately laid over the rough but green surface of underlayer and thoroughly tamped, struck off level and the surface floated with a wooden float. The surface shall then be tested with a straight edge and mason's spirit level to detect any undulations and if any, these shall be made good and then the surface finished smooth as specified below.

- 9.2.2.5 **Finishing the surface by troweling of floating:** After the concrete has slightly hardened it shall be finished by troweling or floating. Finishing operations shall start shortly after the compaction of concrete and shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled three times at intervals so as to produce a uniform and hard surface. Immediately after laying, just sufficient

troweling, the duration being guided by temperature and rate of set of cement, the surface shall be retroweled to close any pores in the surface and to draw out and mop up any excess water in the concrete and laitance. The final troweling shall be done well before the concrete has become too hard but at such a time that considerable pressure is required to make any impression on the surface. Trowelling with dry cement mix on the surface shall not be permitted.

9.2.2.5.1 **Curing:** As soon as the surface has hardened beyond damage, it shall be kept continuously moist for at least 15 days by impounding water on the finished surfaces.

9.2.2.6 **Finishing the surface by grinding and polishing:** Where grinding and polishing is indicated, the topping shall be laid in two layers as specified in Clause 1.2.2.4. After the concrete has slightly hardened, it shall be finished with steel trowel but the trowelling shall be light to avoid excessive laitance coming up on the surface.

9.2.2.6.1 **Curing:** Immediately after final trowelling, the surface shall be laid for drying, and as soon as it has hardened sufficiently, water shall be sprinkled over it and kept wet continuously for at least fifteen (15) days.

9.2.2.6.2 **Grinding:** When the floor has sufficiently hardened and cured for 3-4 days after laying, initial grinding with a coarse grade of carborundum stone shall be carried out and all pits or airholes observed shall be filled up with cement grout of creamy consistency. The surface shall be saturated with water during grinding. After a further curing of 3-4 days, the second grinding shall be carried out with medium grade carborundum stone. The final grinding shall be carried out with fine grade carborundum stone after curing of the floor finish in complete.

9.2.2.6.3 **Polishing:** The finished floor shall be thoroughly cleaned and then polished with approved wax polish.

9.2.2.7 **Coloured cement concrete flooring:** Where coloured finish is indicated, the top shall be finished with coloured cement as specified. If coloured cement is not available pigment shall be mixed in the proportion, one part of pigment with three parts of cement.

The colouring material and cement shall first be mixed dry. Special attention shall be paid to the mixing of colour, which should be screened twice with a fine screen and again through fine muslin before use. All the colour required for one room shall be mixed in one lot. For red colour, mixture shall consist of 1 part of iron oxide to 3 parts of cement. For green colour mixture shall consist of 1 part of

chromium oxide to 3 parts of cement. After dry mixing , the minimum quantity of water required for workability shall be added gradually until a paste of the required consistency is obtained. Dry colour shall not be used to finish the surface of coloured concrete floor. Coloured paste shall be applied with wooden floating boards and English trowels. The quantity of colour mixture shall be 0.06 cu m for every 10 sq m of surface.

Any cracks, ruts, disfiguration or discolouring of surface shall be made good by the Contractor at his own cost. The finished portion of the floor shall be kept wet for at least 15 days.

### 9.3 **Granolithic Finish and Floor Hardener Finish**

#### 9.3.1 **Materials**

9.3.1.1 **Cement:** Cement shall conform to IS:455 or IS:8112 or IS:12269.

9.3.1.2 **Aggregate:** It shall be approved granite, basalt, trap or quartzite chippings and the grading shall conform to Table-1 of IS:5491.

9.3.1.3 **Sand:** The sand shall be approved river sand and shall conform to IS:383. The grading shall conform to Table-2 of IS:5491.

9.3.1.4 **Water:** Water shall be clean and reasonably free from deleterious materials such as oils, acids, alcohols, salts and vegetable growth.

9.3.1.5 **Floor Hardener:** It shall be approved quality metallic/non-metallic hardener of approved make.

9.3.2 **Proportion of Mix:** The proportion of mix for granolithic flooring shall be 1 part of cement, 1.5 part of sand and 3 parts of stone chips.

The proportion of mix for floor hardener shall be according to the manufacturer's instructions.

#### 9.1.3.3 **Workmanship**

9.3.3.1 **General:** The floor topping shall be laid in suitable panels. While laying the topping on structural slab monolithically, no dimension of panel shall exceed 4 m and when the topping is laid on hardened base, no dimension shall exceed 2 m. In

case of ground floor the dimensions of the topping panels shall match those of the base concrete, length of panel shall not exceed one and half time its breadth.

9.3.3.2 **Laying granolithic topping monolithically with base concrete:** The topping shall be laid within two to three hours of laying the base concrete. At the time of laying the topping the base shall be still green but sufficiently firm to enable the workmen to tread over it by placing planks on the surface. The topping shall be laid on suitable panels and thoroughly compacted to the finished thickness. The surface shall be checked for undulation and made even using wooden floats. When the surface has slightly hardened it shall be finished smooth.

9.3.3.3 **Laying topping on hardened base and hardened structural slab:** The base concrete shall be thoroughly cleaned of all dirt, loose particles etc and roughened by chipping or hacking at close interval. The surface shall then be soaked in water for several hours and the excess water removed by mopping immediately before laying the topping. Cement sand (1:1) slurry shall be spread on the prepared surface of the base concrete and the topping laid in suitable panels as described in [clause 9.3.3.1](#).

9.3.3.4 **Laying floor hardener finish:** The thickness of the floor hardener topping shall be 15 mm or as indicated on the drawings and shall be laid over the granolithic finish when it has partially dried as per instructions of the manufacturer. The surface shall be leveled and finished smooth.

The finished surfaces after hardening beyond damage shall be cured for a period of seven (7) days by impounding water on the finished surfaces.

## 9.4 **In-situ Terrazzo Flooring**

### 9.4.1 **Materials**

9.4.1.1 **Cement:** The cement shall conform to IS:455 or IS:8119 or IS:12269. White cement of approved quality may be used for the topping.

9.4.1.2 **Sand:** The sand shall be of river sand or from approved pits and shall conform to IS:383.

9.4.1.3 **Aggregates:** The aggregates used in the topping shall be of marble chips. The size shall be as approved in accordance with clause 5.2 of IS:2114. Marble powder used in the topping shall pass through IS sieve 30. Aggregates for the under layer and base concrete shall conform to IS:383.



9.4.1.4 **Pigments:** Pigments to be incorporated shall be of permanent colour and shall conform to Appendix A of IS:2114.

9.4.1.5 **Dividing strips:** Dividing strips shall be of aluminium, glass or plastic of thickness not less than 1.5 mm and width not less than 25 mm.

9.4.1.6 **Water:** Water shall be as specified in Section-4.

**Mix proportion and thickness:** The base concrete when terrazzo finish is laid over ground shall be lean cement concrete mix 1:2:4. The thickness of base concrete shall not be less than 100 mm. The cushioning layer, when terrazzo finish is laid over structural slab shall preferably be of lime concrete. The thickness of cushioning layers shall not be less than 75 mm.

The underlayer shall be cement concrete of mix 1:1.5:3 and the maximum size of aggregate shall not exceed 10 mm. The mix for the topping shall have cement, marble, powder and marble aggregate and water in the proportion as specified in clause 5.3.2 of IS:2114.

If coloured terrazzo finish is indicated, the proportions in which pigments are mixed with ordinary portland cement or white cement to obtain different colours shall be as specified in Table 1 of IS:2114. The complete quantities of cement and pigment required for one operation shall be mixed at the beginning of work and stored properly to avoid variation in colour.

9.4.3 **Preparatory Work:** All inside walls and ceiling shall be plastered, doors frames and windows shall be fixed in place and all heavy work in the room/area shall be completed before commencing terrazzo flooring work. Clean and dry storages shall be provided at the site for all the materials conforming to the provisions of relevant Indian Standards.

9.4.4 **Workmanship:** The base concrete shall be finished to a reasonably true plane surface and to a level which is lower than the level of the finished floor by the depth specified for the thickness of the terrazzo flooring. Any slope indicated for the finished floor shall be incorporated in this base course.

To prevent chances of cracking, the floor shall be divided into suitable panels, not exceeding 2 sq m in area. If dividing strips are indicated, these shall be fixed over the base concrete to the full depth of the terrazzo finish.

The coloured cement shall be mixed thoroughly in the dry state with marble power. The binder so obtained and chips mixed in the required proportions shall then be mixed dry together. Water shall then be added in a fine spray while the materials are worked to a consistency which is plastic but does not flow. The mix shall be used in the work within half an hour of the addition of water.

The base over which flooring is to be laid shall be cleaned of all dirt, laitance and loose material and then well wetted without forming any water pools on the surface. It shall then be smeared with cement slurry and immediately thereafter the underlayer shall be spread and leveled with a screeding board.

Terrazzo topping shall be laid while the underlayer is still plastic, about 20 hours after the underlayer is laid. A cement slurry preferably of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. The terrazzo mix shall then be placed on the screed bed and compacted thoroughly by tamping and trowelled just sufficient to give a level surface.

The surface shall then be rammed in order to consolidate the terrazzo, preferably with a piece of smooth marble stone of size 15 cm x 15 cm x 2.5 cm. This may be followed by trowelling. In trowelling, pressure rather than rotary action shall be used to achieve a smooth surface.

9.4.5 **Curing:** The surface shall be left dry for air-curing for a duration of 12 to 18 hours depending upon temperature conditions. It shall then be cured by impounding water for at least four (4) days.

9.4.6 **Grinding:** Four (4) days shall be allowed to elapse after completion of laying for grinding to commence manually. If machine grinding is specified this period shall be seven (7) days.

The first grinding shall be done with carborundum stone of 60 grit size. The surface shall then be washed clean and grouted with neat cement grout of cream like consistency. It shall then be allowed to dry for 24 hours and wet cured for four days again. The second grinding shall be done with 80 grit stone. After another surface grouting, a third grinding with 120 to 150 grit size stone shall be done. The surface shall then be washed clean, allowed to dry for 12 hours and wet cured again for four days. After a final grinding with carborundum stone 320 to 400 grit size, the surface shall be washed clean after rubbing hard with felt and slightly moistened with oxalic acid powder. When all construction work and finishing work are completed and just before handing over the area the floor shall be washed clean with dilute oxalic acid solution and dried. Floor shall then be

finally polished with machine fitted with felt and with approved floor polish until the floor shines clean and dry. Saw dust shall then be spread over the floor and the polishing machine again applied to remove excess floor polish.

## 9.5 **Terrazzo Skirting and Dados**

For terrazzo finish on vertical surfaces the underlayer shall consist of a layer of stiff cement sand mortar 1:3 finished rough to provide keying.

The combined thickness of underlayer and terrazzo shall not be less than 25 mm and the terrazzo topping shall not be less than 6 mm.

Other details shall be the same as for in-situ terrazzo flooring in clause 1.4 except that grinding shall be manual.

## 9.6 **Terrazzo Flooring with Tiles**

### 9.6.1 **Materials**

**Plain or coloured terrazzo cement tiles:** The tiles shall conform to IS:1237. They shall be of the type, quality, colour and size indicated on the drawings or in the bill of quantities and shall be approved by the Engineer/Consultant. The type, quality, distribution and size of marble chips shall be as approved by the Engineer/Consultant.

**Cement:** The cement shall conform to IS:455 or IS:8112 or IS:12269. White and coloured cement shall also conform to the requirements specified for ordinary portland cement in the above specification.

**Sand:** The sand shall be approved river or pit sand and shall conform to IS:383.

**Aggregate:** Aggregate used in the mortar for fixing the tiles and in the backing layer of tiles shall conform to IS:383. For the top layer of tiles, unless otherwise specified, marble chips, marble powder or a mixture of the two, shall be used.

**Pigment:** Pigment, synthetic or otherwise, shall conform to the relevant Indian Standards.

9.6.2 **Preparatory Work:** Before commencement of tiling work, all inside walls and ceiling shall be plastered, door frames and windows shall be fixed in place and all

heavy work in the rooms shall be completed. All the materials at site shall be stored in clean and dry storage space.

### 9.6.3 **Workmanship for laying concrete tiles**

9.6.3.1 Generally workmanship for laying tiles shall conform to IS:1443.

9.6.3.2 **Bedding:** The surface of the sub-floor shall be thoroughly cleaned of dirt, loose particles and laitance (in case of cement slabs) by scrubbing with a wire brush. The surface shall then be thoroughly cleaned and well wetted but without forming any water pools on the surface. Screed pads shall be set up to indicate required levels on the clean damp surface of the sub-floor and cement sand mortar shall then be evenly spread. The mortar for the setting bed for tiles shall consist of cement and coarse sand in the proportion of 1:3. The thickness of the bedding mortar shall normally be not less than 10 mm and not more than 20 mm.

9.6.3.3 **Fixing:** When the bedding mortar acquires sufficient hardness to provide a fairly rigid cushion for the tiles, neat cement slurry of honey like consistency shall be spread over an area at a time, as would accommodate about 20 tiles. The tiles shall then be fixed in this grout one at a time and gently tamped with a wooden mallet to set properly on the bedding at the level of the adjoining tiles. In areas adjoining walls, the tiles shall extend about 10 mm inside the plaster, skirting or dado as the case may be. The joints between tiles shall be straight and shall not exceed 1.5 mm in width.

9.6.3.4 After fixing the tiles, the joints shall be refilled on the following day with cement paste or grout of the same shade as that of the matrix of the tile. Before the joints are filled, they shall be cleaned with wire brush or with the point of a trowel and any loose cement, dirt or dust in the joints shall be removed.

9.6.3.5 **Polishing:** After fixing of tiles the flooring shall be allowed to mature undisturbed for seven (7) days. Then the floor shall be polished by machine using carborundum stones of the following grit:

- a) For leveling (where the tiles are supplied ungrounded) .. 24 to 60
- b) For second grinding (for removal of filling of plaster on the surface of the tile) .. 120 to 150

c) For final grinding .. 220 to 350

Floor surface shall be kept watered continuously while polishing so as to prevent scratching. After polishing the floor shall be thoroughly washed clean and dried. Prior to handing over the buildings to the Employer, the floor shall be washed, clean with dilute oxalic acid solution and dried. Floor shall then be finally polished with machine filled with hessian bobs or felts and approved floor polish until the floor shines. Clean and dry saw dust shall then be spread over the floor and the polishing machine again applied to remove all excess floor polish, leaving glossy non-slippery surface.

9.6.3.6 **Skirting and Dado Work** : Skirting and dado shall be fixed only after laying the tiles on the floor. The portion of the wall where tiles are to be fixed, shall be left unplastered.

Before fixing tiles on brick or concrete wall, the surface of the wall shall be first wetted with clean water. Thereafter, it shall be evenly and uniformly covered with a coating of cement sand mortar about 10 mm thick. Before the cushioning mortar has hardened, the back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tamped against the cushion with a wooden mallet. Fixing of tiles shall be done from the bottom upwards. Each tile shall be fixed as close as possible to the one adjoining, and any difference in the thickness of the tiles shall be evened out in the cushioning mortar or cement paste so that all the tile faces are set in conformity with one another.

Skirting and dado shall be ground and polished as for floor by machine suitable for the purpose. Skirting and dado may also be polished by hand by rubbing down with suitable polishing stones evenly and without scratching the surface.

Upon completion of polishing, it shall be thoroughly washed clean and dried. Before handing over the building the skirting and dado shall be cleaned with dilute oxalic acid and polished as specified in clause 9.6.3.5.

## 9.7 **Vitreous tile Flooring**

### 9.7.1 **Materials**

9.7.1.1 **Vitreous tiles**: The vitreous tiles shall be flat and glazed on the top surface and completely free from glaze on the underside. Size of the tiles shall be as shown in the drawings or as approved by the Engineer/Consultant. Unless otherwise

specified the thickness of the tiles shall be minimum 8 mm thick. They shall conform to IS:777 in all other respects. The Contractor shall submit to the Engineer/Consultant for his approval samples of tiles to be used in the work and all tiles shall be similar to the approved sample.

9.7.1.2 **Cement:** The cement shall conform to IS:455 or IS:8112 or IS:12269 .

9.7.1.3 **Sand:** Sand shall be river sand, or sand from approved pit and shall conform to IS:383.

9.7.14 **Water:** Water used shall be as specified in **Section-4.**

## 9.7.2 **Workmanship**

The workmanship shall conform to clause No. **9.6.3.2 and 9.6.3.4** of this section.

9.7.3 **Skirting and dado work:** Bedding and fixing of vitreous tiles in skirting and dado shall conform to clause 1.6.3.6 of this section.

Upon completion of tiling work in floor and skirting/dado, it shall be thoroughly cleaned with a scrubbing brush, coarse cloth or broom and allowed to mature undisturbed for seven (7) days and then cleaned with soap and water.

## 9.8 **Acid/Alkali Resistant Ceramic Unglazed Tile Flooring**

### 9.8.1 **Materials**

9.8.1.1 **Ceramic tiles:** The tiles shall be glazed/unglazed vitreous ceramic tiles of approved make and shall conform to IS:4454 & IS:4457. Size of tiles shall be as shown on drawings or as approved by the Engineer/Consultant. The thickness of the tile shall be 25 mm for flooring and 6/8/12 mm for dado as per the requirement.

9.8.1.2 **Joint Filler:** Epoxy polyester resin type mortar conforming to IS:4832 (Part-II).

9.8.1.3 **Bedding mortar:** Bedding mortar shall be 1:3 cement:sand mortar.

### 9.8.2 **Workmanship**

The bedding & fixing shall be as per **clause No. 9.6.3.2 & 9.6.3.3** of this section.

The epoxy/polyester resin shall be prepared according to manufacturers specifications.

When the surface is dry, the joints in tiles shall be cleaned and well raked. The joints shall be sealed with resin type mortar conforming to IS:4832 (Part-II) and finished flush with the surface of tiles.

9.8.3 **Skirting and Dado Work** : The work shall be carried out as per clause No. 9.6.3.6.

## 9.9 **PVC Flooring**

### 9.9.1 **Materials**

9.9.1.1 **Semi Flexible tiles**: The tiles shall generally be rigid, plain or mottled, 200 mm, 250mm or 300 mm square, 2.0 or 3.0 mm thick, smooth surfaced homogeneous PVC floor tiles. The size and thickness of the tiles shall generally be as specified above. These shall be of a fast, uniform colour as approved by the Engineer/Consultant and shall comply with all relevant requirements associated with tests specified in IS:3464.

9.9.1.2 **Fully Flexible Rolls**: The sheets or rolls and tiles shall be homogeneous, flexible material of thickness 2 mm, conform to the requirements of IS:3462 when tested in accordance with IS:3464.

9.9.1.3 **Antistatic PVC tiles** : The sheets or rolls and tiles shall be as specified in clause 9.9.1.2 above. In addition to complying the requirements of IS:3462 and tests as per IS:3464 the surface resistance (electrical resistance) should be limited as per relevant clause of Indian Standard.

9.9.1.4 **Underlay**: The underlay shall be in-situ **trowelled screeding** to the sub-floor.

9.9.1.5 **Adhesives**: For fixing rigid and flexible tiles/rolls the adhesives used shall generally be rubber based of approved make like Fevicol S 505 or approved equivalent and shall conform to the recommendation of the flooring manufacturer. In case of fixing of antistatic flooring, 100 gms of 99.99% purity copper powder is to be mixed with 1 kg. of rubber based adhesive to make the adhesive conductive.

### 9.9.2 **Workmanship**

9.9.2.1 Workmanship shall generally comply with IS:5318.

9.9.2.2 **Preparation of sub-floors:** Concrete sub-floors shall be laid in two layers with an effective damp-proof course located in between. The top of the lower layer shall be finished smooth and when set and sufficiently hard, painted with two coats of bitumen conforming to IS:1580 applied at the rate of 1.5 kg/m<sup>2</sup>. The sub-floor concrete shall be finished using a power float.

Six (6) weeks time shall be allowed for the water to dry completely from the concrete floor. Then if power floating has not already been adopted, the finish required for laying PVC flooring shall be produced with a trowel on a screed applied to the sub-floor concrete.

For old concrete surfaces cleaning and degreasing shall suffice if the existing floor is even. If unevenness exists, the surface shall be scraped free of all foreign materials, swept clean and wetted for 24 hours by sprinkling water. Then screed topping of 3 mm thickness shall be provided over the concrete.

9.9.2.3 **Setting out:** The surface to be floored shall be cleaned with a dry cloth and checked for sufficient dryness in accordance with Appendix A of IS:5318. The flooring shall not be laid under high humidity conditions (>70%) as this affects the adhesive strength.

The tiles shall be spread on the floor, without any adhesive, from the center of the room towards the walls. While placing the tiles, the sides of each tile shall be cut and finished as necessary to make a uniform setting. The alignment shall be checked after setting out each row. Cut pieces of tiles, if necessary, shall be set along the walls, subject to Engineer/Consultant's approval. To minimise the shade variations of tiles of different batches shall not be used.

9.9.2.4 **Fixing:** The adhesive shall be applied according to the recommendation of the manufacturer. It shall be applied uniformly on the back of tiles as well as on the floor. After application, sufficient time (about half an hour) shall be allowed for the adhesive to become tacky.

The tiles shall then be placed in position on the floor along one edge and rolled out to remove any entrapped air bubbles. After laying all the tiles, a 5 kg wooden roller shall be used to ensure full contact between tiles and the underlay. Work shall be constantly checked against guidelines to ensure that all the four edges of adjacent tiles meet accurately.



In case of antistatic flooring normally a copper foil approximate size 50 mm X 0.15 mm thick shall be laid first in a grid pattern of 1.0 m X 1.5 m with proper earthing connection, over which the tiles shall be fixed by using adhesives mixed with copper powder. The copper grid shall be properly earthed, generally at one point per 30 sqm of floor surface.

Any adhesive that may squeeze up between tiles shall be removed with a wet cloth before it hardens. Adhesives and scuff marks shall be removed first by scrubbing with '00' grade steel wool. Hardened adhesive shall be removed with a solvent consisting of one part of commercial butyl-acetate and three parts of turpentine oil.

The floor shall not be put to service within 72 hours of laying. After the tiles are fully bonded, they shall be cleaned with wet cloth soaked in warm soap solution (two spoons of soap in 5 liters of warm water).

## 9.10 **Kota Stone, Marble and Granite flooring**

### 9.10.1 **Materials**

9.10.1.1 **Kota stone:** The kota stone slabs shall be of approved shade in tile or slab forms of various sizes.

The stone slabs shall be machine-cut, polished on top surface and machine cut edges and bottom shall be rough. Stone tiles should be free from cracks and other defects. Bedding mortar shall be same as for terrazzo tile flooring.

9.10.1.2 **Cement:** Cement used shall conform to IS:455 or IS:8112 or IS:12269.

9.10.1.3 **Sand:** The sand shall be of approved river or pit sand and shall conform to IS:383.

9.10.1.4 **Pigment:** Pigments used for colouring cement shall conform to IS:2214.

9.10.1.5 **Water:** Water used shall be as specified in **Section-4**.

9.10.2 **Preparatory Work:** Before commencement of stone flooring work, all inside walls and ceiling shall be plastered, door frames and windows shall be fixed in place and all heavy work in the rooms shall be completed.

### 9.10.3 **Workmanship for Laying Kota and Marble Stone Slabs**

9.10.3.1 **Bedding:** The surface of the base concrete shall be thoroughly scraped to remove dirt, loose particles and laitance by scrubbing with a wire brush. The surface shall then be thoroughly cleaned and well wetted but without forming any water pools on the surface and any excess water shall be removed. Screed pads shall be set up to indicate finished floor level on the clean damp surface of the base concrete and setting mortar bed shall then be evenly spread. The proportion of setting bed shall be one (1) part of cement and three (3) part of coarse sand. The thickness of this bedding shall normally be not less than 10 mm and not more than 15 mm.

9.10.3.2 **Fixing:** When the bedding mortar acquires sufficient hardness to provide a fairly rigid cushion for the tiles/slabs, neat cement slurry for honey like consistency shall be spread over an area at a time, as would accommodate about 10 stone slabs. The stone slabs shall then be fixed in this grout one at a time and gently tamped with a wooden mallet to set properly on the bedding and in level with the adjoining stone slabs. The joints between slabs shall be straight and shall not exceed 1.5 mm width. The top surface of the slabs shall be laid true to plane with levels and/or slopes. After the slabs have been laid, the surplus cement grout that may have come out of the joints, shall be cleaned off. In areas adjoining walls, the slabs shall extend about 10 mm inside the plaster, skirting or dado as the case may be.

The day after the stone slabs have been fixed, the joints shall be re-filled with cement paste or grout mixed with pigment to match the shade of the slabs. Before the joints are filled, they shall be cleaned with wire brush or with the point of a trowel and any loose cement, dirt or dust in the joints shall be removed.

9.10.3.3 **Polishing:** After fixing the stone slabs, the flooring shall be allowed to mature undisturbed for a period of seven (7) days. Polishing should start only after the floor as well as joints have dried out. The floor shall be polished by machine using carborundum stones of 200 to 350 grit. Sufficient quantity of water shall always be continuously used during polishing operation. Duration of polishing or number of operation will depend on joint condition. Normally one operation should be enough for properly laid machine polished stone slabs. After polishing, the floor shall be washed clean and dried. Prior to handing over, the saw dust shall be removed and floor shall be washed clean with dilute oxalic acid solution and dried out. Floor shall then be finally polished with machine fitted with hessian bobs or felts until the floor shines.

9.10.3.4 **Fixing of kota stones /marble/granite in skirting and dado:** Skirting and dado shall be fixed only after laying the tiles of the floor. Where the portion of the wall is to be so tiled it shall be left unplastered.

The kota/marble stone slab/tile shall be fixed on masonry/concrete wall surface in the same manner as followed for stone flooring. The polishing work shall be done by hand polishing with carborundum stone of 200 to 350 grit etc.

#### 9.11 **Parquet Flooring / Skirting**

Parquet floor / skirting to be provided over a leveled floor / wall surface which is sufficiently free from dampness and moisture. The floor / wall surface has to be painted with anti termite paint.

9.12 **Ordinary Parquet Floor:** 0.6mm thick HDPE sheet to be laid over anti termite painted surface to act as a moisture barrier and 4 mm high density foam is spread over it uniformly. 15 mm thick rubber wood /agro wood/certified wood strips of approved size and quality tongue and groove jointed and laid over foam with the help of approved adhesives. All work to be carried out as per approved manufacturer's specification and workmanship.

9.13 **Sports Type Parquet Floor :** 75mm thick & 50mm wide hardwood battens to be fixed rigidly over 10mm thick rubber pads at 460mm c/c with floor. 21 mm thick wooden strip to be fixed over the battens tongue and groove jointed with approved quality adhesive. All work to be carried out as per manufacturer's specification.

9.14 **Parquet Skirting:** 15 mm thick Rubber wood/ Agrowood/Certified wood strips of approved size and quality tongue and groove jointed laid over anti-termite painted surface with the help of approved adhesives. All work to be carried out as per approved manufacturers' specifications.

#### 9.15 **Glass mosaic facia tiles to external finishes**

Coloured glass mosaic tile 20mm X 20mm X 4mm thick in 305 mm X 305 mm paper sheet and to be fixed to the plastered wall surface by adhesive as per manufacturer's specification.

#### 9.16 **External quality ceramic tiles**

'Eurocon' or approved equivalent external wall cladding ceramic tiles to be fixed as per manufacturer's specification.

## **SECTION - 10 – METAL DOORS AND WINDOWS AND MISCELLANEOUS STEELWORK**

### **10.0 METAL DOORS AND WINDOWS**

#### **10.1 Codes and Standards**

IS:1038	..	Steel Doors, Windows and Ventilators
IS:1081	..	Code of Practice for Fixing and Glazing of Metal (Steel and Aluminium) Doors, Windows and Ventilators.
IS:1361	..	Steel Windows for Industrial Buildings
IS:1948	..	Aluminium Doors, windows and Ventilators
IS:1949	..	Aluminium Windows for Industrial Buildings
IS:6248	..	Metal Rolling Shutters and Rolling Grills

#### **10.2 Materials**

**10.2.1 Structural steel:** All structural steel materials shall conform to IS:1977 or IS:2062.

**10.2.2 Steel doors, windows and ventilators:** Steel doors, windows, ventilators and their fittings for residential and office buildings shall conform to IS:1038.

Steel windows for industrial buildings shall conform to IS:1361.

External doors shall be provided with threshold as shown in IS:1081 and the doors required for internal use shall be provided with an approved size base tie-bar in lieu of threshold.

Unless otherwise specified, coupling sections shall be of mild steel and handles, peg stays and pivots of centre hung ventilators shall be of lead-tin-bronze alloy (gun metal). Hinges for side hung shutter shall be projecting non-friction type. Weather bars shall be provided as per requirement. The type, size, number and position of fixing lugs shall conform to IS:1038. The steel doors shall be painted with one coat of zinc chromate primer conforming to IS:2074 before they are supplied. Final painting shall be done with two coats of ready mixed approved

synthetic enamel paint of approved colour. Glazing clips shall be provided where pane sizes exceed 600 x 300 mm and shall be of shape as shown in IS:1038.

### 10.2.3 **Glazing for door, window, structural glazing**

10.2.3.1 **Single Glazing** : Where single glazing is specified for the work, it shall be of float glass of specified thickness, with permissible tolerance. Float glass shall be clear or tinted as per requirement. For some specific purpose this may even be toughened. Float glass shall have solar low e, UV resistant, light transmittance (min) 55%, U-value 0.32 BTU/sqft<sup>0</sup>F, solar efficiency 0.44.

10.2.3.2 **Insulated Double Glazing**: Insulated double glazing shall comprise of two (2) numbers of float glasses (clear/tinted/ toughened as per requirement) as specified for single glazing above, hermitically factory sealed together with a specified argon gas gap in between. The glazing shall be kept in position using aluminium spacers, primary & secondary sealant for water, air tightness and structural integrity respectively. The argon gas gap in between the glass panes shall be kept dry using proper desiccant.

10.2.4 **Glazing putty**: The Glazing putty shall conform to IS:419.

### 10.3 **Workmanship**

All steel doors, windows and ventilators shall be fixed true to line and level. Fixing and glazing of metal doors, windows and ventilators shall be in accordance with IS:1081.

### 10.4 **Rolling shutters**

Rolling shutters shall be fabricated from 18 gauge steel sheet and machine rolled with 75 mm rolling centers with effective bridge depth of 12 mm lathe sections, interlocked with each other and ends locked with malleable cast iron clips.

The guides shall be either rolled or pressed deep channel sections fitted with necessary fittings and fixtures. The size of the guide channel shall conform to IS:6248.

The suspension shaft of the roller shall be made of steel pipe of heavy duty conforming to IS:1161, and of sufficient diameter so as to resist deflection due to the weight of the rolling shutter. The deflection shall not exceed 5 mm per meter width. The shaft shall be provided with C.I. pulleys and helical spring for counter balancing the weight of the shutter adequately. The spring shall be made of high tensile spring steel wire conforming to grade 2 of IS:4454. For large size rolling shutters, the roller shall be provided with double row self-aligning ball bearings. For wire opening the roller shall be of fabricated cage type. The roller assembly

shall be designed so as to be capable of producing sufficient torque to ensure easy operation of the rolling shutter in any position. The spring tension shall be adjustable by means of suitably adjustment holes drilled on the rims of the pulleys.

The hood cover shall be made of 20 gauge galvanized steel sheets with necessary stiffeners and framework to prevent sag. The bottom lock plate shall be made of mild steel sheet not less than 3.15 mm thick and 95 mm wide reinforced with angle/T iron of suitable section with 6 mm dia M.S. rivets interlocked with last stride of curtain. The locking arrangement shall consist of hasp and staple on the bottom plate lockable from both sides.

Unless otherwise specified, for overall area of rolling shutters up to 8 sq m, pull and push type hand operated shutters shall be used, for area between 8 and 12 sq m, pull and push type shutters shall be provided with ball bearings, for area larger than 12 sq m, mechanical gear type or electrically operated shutters shall be supplied.

All rolling shutters shall be of reputed make as approved by the Engineer/Consultant. Rolling Shutters shall be painted with one coat of zinc chromate primer conforming to IS:2074 before they are supplied and two coats of ready mixed synthetic enamel paint after erection.

## 10.5 **Steel Grills**

The grills for windows, verandahs, balconies etc shall be of mild steel. The edges, angles and corner shall be cleaned and true to shape. The joints shall be mechanically interlocked and overlapping and neatly spot welded in such a way that the grill is rigid. Where moulded grills are specified, the moulded work shall be carried out shall have clear, straight and sharply defined profile.

All necessary cutting, fitting, drilling, tapping, scrubbing etc shall be done to fix grills to the opening adjacent surfaces. The grills shall be fixed plumb in line and level.

The grills shall be painted with one coat of zinc chromate primer conforming to IS:2074 before they are fixed and two coats of ready mixed synthetic enamel paint after erection.

## 10.6 **Tubular Railings**

Steel tubes for railing shall conform to IS:1161. Electrodes used for welding shall conform to IS:814. Fabrication and erection of railing shall be in accordance with IS:806 and IS:800. Railings shall be painted with one coat of zinc chromate primer conforming to IS:2074 after fabrication and two coats of ready mixed synthetic enamel paint after erection.

## 10.7 **Collapsible Gates**

The gates shall be manufactured out of M.S. channel pickets of size 20 x 10 mm and flats 20 x 6 mm.

The top runner flat shall be at least 50 x 12 mm in section. The bottom guide shall consist of a channel or two angles of specified size laid in the flooring to guide the free movement of the gate. The gate shall move in the guide channel on rollers of adequate size fixed at the top and bottom of the gate. The gate shall be painted with one coat of zinc chromate primer conforming to IS:2074 before fixing in position and two coats of ready mixed synthetic enamel paint after erection.

## 10.8 **Subsidiary Gates**

The subsidiary gates, unless otherwise specified, shall be made of 'A' grade pipe of 38 mm nominal bore and 3 mm weld mesh fabric at 50 mm centers both ways and shall be fully welded. The corners shall be square. The gate shall be additionally reinforced with flats.

## 10.9 **Steel Wire Fencing**

Chain link fencing shall be 75 mm square mesh size of 4 mm nominal dia galvanised steel wire conforming to IS:2721. The barbed fencing wire shall consist of 2 ply, 12 gauge galvanised wires with 4 point thick set barbs at 75 mm centers.

Fencing posts shall be either of M.S. or reinforced concrete or pre-stressed concrete or timber as per requirement. The post shall be fixed in position in a concrete block. Corner posts shall be suitably strengthened by struts or ties to resist the forces acting on them.

Wire shall be fully stretched and securely tied to the posts. The fixing shall be done in a workmanlike manner without leaving any kinks etc. The wire shall be held tight in a position by eye bolts etc.

All steelwork shall receive one coat of zinc chromate paint conforming to IS:2074. wooden posts shall be treated with fungus resisting approved paint before fixing. Concrete posts shall be painted with two coats of cement wash.

## 10.10 **Welded mesh and Expanded Metal Partitions**

Welded mesh shall be of make approved by the Engineer/Consultant. Expanded metal shall conform to IS:412. The framing shall be of M.S. angle or tees, with additional stiffening by M.S.

flats. The frame shall be of fully welded construction. The connection of the weld mesh or expanded metal to the frame shall be with standard bolts & nuts.

#### 10.11 **Fire check doors**

Fire check doors shall be fabricated from 6 mm thick M.S. plate, conforming to Grade St 32.0 of IS:1977, stiffened all round at one face at the edges with T-bars not less than ISNT 80. The door shall be further divided into panels not exceeding 0.8 M2 each with ISNT 80. They shall be riveted together with rivets not less than 8 mm in diameter and spaced not more than 150 mm centres.

The double leaf doors shall be so constructed that a riveted joint not less than 12 mm wide is formed at the meeting stiles when the door is closed. The door or leaf shall not be sub-divided into parts hinged together.

Construction features of fire check doors shall conform to Clause 6.1 of IS:3614 (Part-1) except as stated above.

All leaf-type fire check doors shall be hinged type, openable from either side and shall be provided with hydraulic door closers.

The doors shall be provided with bolts at top and bottom of the leaf and a central latch and lock arrangement.

#### 10.12 **Aluminium double swing door with floor spring**

The door frame section shall be UV resistant powder coated/ anodized aluminium made from 101.6 mm x 44.45 mm x 3.18 mm thick anodized aluminium section of approved make INDAL or any other approved equivalent.

Door stiles, top and bottom rails etc shall be made as per approved drawing with anodised aluminium box section having wall thickness of not less than 2.5 mm. Glazing shall be fixed to the shutter frame with snap on bead of approved quality and make and neoprene gaskets. The door shall be fixed with double action floor spring (IS:6315) securedly anchored to floor and pivotted for swing action.

All necessary fittings and fixtures like anodised aluminium door handle, weather strips, bolting and locking arrangements with keys in duplicate of approved quality and make shall be provided.

#### 10.13 **Aluminium window**



The top, bottom, intermediate and side frame of the window shall be 101.6 mm x 44.45 mm x 3.2 mm thick anodized aluminium section of approved make (INDAL or any other approved equivalent) respectively and side hung 18 mm x 18 mm x 0.75 mm thick anodized aluminium bead shall be fixed to glass on both faces. The window shall be fixed as per IS:1948.

#### 10.14 **Aluminium Double Glazed Doors, Windows & Ventilators**

The frame section shall be anodized aluminium extruded built-up standard and other sections of approved make conforming to IS:733 and IS:1285. Extruded anodised aluminium box sections having wall thickness not less than 2.5 mm to accommodate two numbers 6 mm thick toughened float glasses of approved quality with an air gap of 12 mm hermetically factory sealed shall be used. Glazing shall be fixed to the shutter framings with snap on beads and approved quality neoprene gaskets.

The frames shall be securedly fixed to masonry work with rawl plugs and screws or with fixing clips or with expansion hold fasteners including necessary filling up of gaps at junctions at top, bottom and sides with required sealant. Aluminium sections shall be smooth, rust free, straight, mitered and jointed wherever required including cleat angles, Chromium Plated brass/Stainless Steel screws all complete for shutters of doors, windows and ventilators including provision double/single action floor spring (IS:6315)/hinges, handles, weather strips, bolting and locking arrangements, all materials and method of fixing as per manufacturer's specifications.

#### 10.15 **Aluminium Joinery**

Anodized Aluminium joinery shall conform to the requirements specified in IS:1948 and IS:1949 and shall be of INDAL or equivalent reputed make. The average thickness of nodic coat shall not be less than 20 microns (IS: 7088) and shall be matt finished.

Aluminium doors, windows, ventilators shall be made of Aluminium alloy conforming to IS: 733 and sections shall generally conform to IS: 1948. Coupling members forming composite sections shall be of extruded true right angle. For side hung shutters. hinges shall normally be of projecting type made of Aluminium alloy and riveted / machine jointed to frame and shall have stainless steel / Aluminium alloy pins. Irrespective of the hinges being anodized or not. the Aluminium alloy pins shall be anodised to a minimum film thickness of 25 microns and shall be sealed with oil or wax.

Handles, peg stays shall be of approved heavy-duty quality Aluminium or its alloy conforming to IS specifications.

The door frame and shutters shall be single action or double action as per requirement with hydraulic door closer in the floor. The doors shall be provided with anodized Aluminium door handles for full width of door inside and outside. The door frame shall be provide with approved anchors spaced not more than 900mm centres.

Before erecting, frames coming into contact with concrete masonry, plaster or dissimilar metals, shall be coated with a thick layer of clear transparent lacquer based on methacrylates or cellulose butyrate, which is compatible with zinc chromate to protect the surface from wet cement during installation. This lacquer coating shall be removed after installation is completed. Before handling over, the Aluminium work shall be washed with mild solution of non-alkali soap and water.

Gaskets to be used shall be made of neoprene/EDPM of approved make and shall be approved by the Engineer/Consultant before fixing in position. The sealant shall be of approved make and shall be duly approved before application. Aluminium doors, windows and ventilators after fixing in position shall be watertight and airtight.

Aluminium material used shall be specially anodized for protection against corrosion in marine environment in approved shade. The anodic coating shall conform to IS: 1868 and shall be of AC25 grade with minimum thickness of 20 microns when measured as per IS 660/2 and density shall be at least 32 MG/sq m. The anodic coating shall be double sealed or alternatively sealed with steam and shall be of minimum thickness of 50 microns. The anodic coating shall be tested in a laboratory by Eddy current method as per IS: 6012 for thickness. Sulphuric acid shall be used as the electrolyte for the anodic process.

#### 10.15.1 **Hydraulic Door Closer**

These shall conform to IS: 3564 and be of brand approved by the Engineer/Consultant for both left and right hand openings.

All hardware and fixtures shall be made able to withstand repeated use. Door closer shall be suitable for doors weighing 61-80 kg. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the closer replaced free of charge. Concealed door closures shall be either floor mounted or transoms sounded suitable for installation with metal doors. It shall conform to the performance requirements and endurance test stated in IS:3564.

#### 10.16 **Pressed Steel Door Frame**

The frame shall be 105 x 60 x 1.67 mm thick pressed steel having best material as per IS:513. All joints shall be welded and necessary fittings and fixtures shall be as per IS:4351 and

IS:1341 for holding the door frame in position. The frame shall be provided with UV resistant powder coated paint finish of approved make and shade over galvanization (as per IS:1477).

#### 10.16.1 **Pressed Steel Door Shutter**

The top and intermediate rail of the panel door shall be 100 mm x 35 mm x 1.25 mm thick CRCA steel section and stiles. The bottom rail is made up of 200 mm x 35 mm x 1.25 mm thick CRCA sheet section. In case of flush door the shutter shall be made of 1.25 thick CRCA sheet on both sides welded over 35 mm x 18 mm x 1.25 mm thick pressed steel channels @ 300 c/c both ways.

Pressed steel doors shall be made from materials as per IS:513 and shall be provided with UV resistant powder coated paint finish of approved make and shade over galvanization as per IS:277.

The handles, locks, hinges, bolts and lugs shall be of approved make as per IS:4351.

#### 10.17 **Pressed Steel Window**

Providing and fixing pressed steel glazed windows fabricated from roll formed sections made of galvanised steel colour coated/powder coated (Base steel as per IS:513 'D' quality, galvanised as per IS:277 with zinc of 120 GM/sq mtr) with total coated thickness of 0.6 mm. All the pressed steel window shall be fabricated and painted at shop.

##### 10.17.1 **Paint Specifications**

Primer coat with epoxy primer of 5-7 microns thick, finish painted with a polyester paint of 12-16 microns thick and back coated with alkyd lacker of 5-7 microns or powder coated with pure polyester powder upto 50-60 microns thick.

##### 10.17.2 **Dimensions**

Sections for shutter should be 46 mm x 46 mm and external frame should be 46 mm x 52 mm. Section for glass beading should be of 18 mm x 25 mm and centre mullion should be of 46 mm x 70 mm.

##### 10.17.3 **Accessories**

Handle made of high grade aluminium powder coated and with nylon receiver. Gaskets made of Ethyl Propylene Diamine Monomer (EPDM). Corner brackets made of CRCA with zinc phosphating. Mullion caps made of glass filled nylon.

#### 10.17.4 **Fixing Details**

The section are to be cut to length, mitre joined with corner bracket. Centre mullions are to be fixed using mullion cap.

The above frames should be fixed to the concrete/masonry walls by means of self expanding screws.

#### 10.18 **uPVC door**

10.18.1 **Door frame:** Door frame shall be made up of factory made extruded PVC section having overall dimension of 48 mm x 40 mm, with wall thickness 2.0 mm. The corners of the door frame shall be mitred and joined by means of plastic/M.S. galvanised brackets and stainless steel self tapping screws. The hinge side, vertical of the frames shall be reinforced by galvanised M.S. tube of size 19 mm x 19 mm with wall thickness of 1 mm. At least three (3) Nos. hinges shall be fixed to one side of the door frame with stainless steel self tapping screw.

10.18.2 **Shutter:** Shutter shall be 30 mm thick factory made extruded PVC door shutter made of styles and rails of a uPVC hollow section of size 60 mm x 30 mm with wall thickness of 2 mm having decorative moulding edging on one side. The styles and rails shall be mitred and joined at the corners by means of MS galvanised/plastic brackets of size 75 mm x 220 mm having wall thickness 1.0 mm and self tapping stainless steel screws. The styles of the shutter shall be reinforced by inserting galvanised M.S. tube of size 25 mm x 20 mm and 1 mm wall thickness. The lock rail shall be made up of PVC hollow section of size 100 mm x 30 mm with wall thickness of 2 mm, fixed to the shutter by styles by means of plastic/galvanised MS 'U' cleat. The shutter frame shall be filled with a uPVC multi chambered single panel of size not less than 620 mm having overall thickness of 20 mm and wall thickness of 1 mm. The panels filled vertically and tie bar at two places by inserting horizontally 6 mm galvanised MS rod and fastened with nuts and washers. All the job shall be carried out as per relevant IS code and as directed by Engineer/Consultant.

10.19 **FRP door:** The doors are made up of 1.5 mm thick FRP skin and moulded using high quality polyester/isothalic gel coat and resin. Sufficient number of layers of fibre glass are to be applied for development of high strength of the door. The interiors of the door is filled with light weight close celled foam and compacted under pressure for solidity and strength of the door. Wooden stiffeners are provided for hinges and locks to be fitted. Fitting can also be screwed as directed by Engineer/Consultant. The standard door thickness shall be 35 mm.

#### 10.20 **Galvanised link chain for hand railing**

Galvanised link chains used for handrailing shall be of mild steel made from 6 mm dia. Rounds electrically welded. Outside length and width of links should not exceed 6 times and 3½ times the diameter of the material respectively.

## 10.21 Aluminium Structural Glazing

The aluminium structural glazing shall be designed as per IS : 875 ( Part - 3 ) with the glass facade outside the building elevation.

### Frame Work

The frame work shall be of aluminium extruded sections made of alloy confirming to I.S.: 63400, with UV resistant powder coating/anodisation of approved make and shade as directed by the Engineer/Consultant..

The frame work shall consist of Mullion, Transome and sub frame, and shall withstand a wind load of 200 kg/sq m.

The aluminium sections will have the following properties:

#### a) PHYSICAL

E-Value of aluminium	=	68950 N / Sq.mm.
Poisson ratio	=	0.33
Density	=	26.603 KN / Cum.

#### b) MECHANICAL

Ultimate Tensile Strength	=	21 Kg / Sq.mm.
Corresponding Percentage	=	10
Elongation		
Alloy	=	T6
Temper	=	6063

### Glazing

Glazing may be single or insulated double glazing depending on the use. For details of glazing, refer specifications "Glazing for doors, window, structural glazing".

### Sealant

The structural grade support to the glass panels should be DOW CORNING or equivalent.

The sealant should have the following properties:

Excellent adhesion to glass, aluminium glazing gaskets, stone, R.C.C. and to the painted and exposed surfaces.

Dynamic movement capacity shall be  $\pm 50\%$

Shore (A) hardness will be 35.

Tensile strength should be 300 psi as per ASTM 412.

### **Anchoring**

All anchoring of the frame to the super structure will be done using HIL TI or equivalent make HVU type adhesive anchoring system.

The anchoring should have the following properties:

It should consist of flexible foil capsule of vinyl urethane, matheuxylate resin and stain free hardness in pre-weighted pack condition and HAS-E (HIL TI version), high tensile fully threaded anchor rod of 5.8 grade steel.

The anchor shall be highly resistant to moisture, chemical and atmospheric gas and should be suitable for horizontal, vertical and overhead application.

### **Hardwares**

All gaskets to be used shall be Ethylene Propylene Diene Monomer based and resistant to all kinds of weathering. It shall have the ability to recover from compression or deformation and shall have the property to allow joint movement.

All brackets shall be of 6mm thick M. S. Galvanised bent at 90 degree with round or oval slots for manoeuvrity,

Full or half threaded stainless steel screws ( self tapping type) with counter sunk or Pan-head shall be used.

High tensile 8.8 grade M. S. Galvanised bolt (TVS or equivalent make) shall be used.

## **Air And Water Tightness**

The structural glazing system shall be designed to prevent Air and Water penetration as per relevant Indian standards.

## **Load**

The structural glazing system shall be capable of accommodating dead load, wind load, seismic force, thermal movement and any other forces without reducing its performances or causing permanent damages.

However maximum permissible deflection should not exceed 1/200 and no permanent deformation shall be permitted.

## **Static / Structural Performance**

The system shall be strong enough to withstand a positive and negative pressure from any particular designated section.

Structural Glazing system with glazed panels would be factory made to the unit size as shown in the drawing and as directed by the Engineer/Consultant.

## **Poly-carbonate Roof Cover**

Polycarbonate sheets for roof cover shall be of minimum 6 mm thick, UV resistant, hard coated, heat strengthened, clear or tinted, fixed to suitable aluminium alloy or steel frame work. The framework shall be of UV resistant powder coated/anodised or other approved finished rigid frame capable of withstanding extreme climatic conditions.

The shape of the roof cover may be pyramidal, dome, vault or any other approved shape. The polycarbonate covering sheet shall be solar low e, low thermal conductive and of high light transmittant. Proper sealant, washers and gaskets shall be provided to assure complete water tightness.

## **Stainless Steel Modular Balustrade/ Handrail**

Stainless Steel Modular Balustrade/ Handrail of Technorail or any other approved equivalent made of 38mm dia, top mounted tubular handrail over balustrade at 1000-1500 mm c/c of anticorrosive high grade AISI 304-18/8 stainless steel with 6 mm thick clear toughened glass between the balusters fixed by glass holders at suitable points and 3 nos. 19 mm dia. stainless

steel tubular intermediate horizontal/angular members fixed between the balusters approximately 200 c/c.

The mounting of balusters shall be with Grub Bolt and Anchor Fasteners and System should be assembled with Allen Key fixing ( no welding allowed for assembling the handrail ). All materials and fixing shall be done as per manufacturer's specifications.

## **SECTION-11 - PIPEWORK, SANITARY AND PLUMBING WORK**

### **11.1 General**

All water supply, drainage and sanitary work shall be executed by a licensed or authorised plumbing supervisor or a licensed or authorised plumber and shall be in accordance with the requirements of relevant bye-laws of Municipal or other Authorities in whose jurisdiction the work is being carried out.

For items such as earthwork, excavation, concrete, brickwork, stonework, pointing etc relevant specifications for these shall apply, unless specified otherwise.

Unless otherwise specified, all exposed work such as cisterns, brackets etc shall be painted with one coat of red oxide paint and two coats of oil paint of approved colour and make.

The diameter of pipes and fittings wherever mentioned shall mean the internal diameter, unless otherwise specified.

The job shall include the cost of making the necessary chases, holes etc in walls, floors and in other places and also making good on completion of the works. Any damage caused to floors, walls etc during the sanitary and plumbing works shall be made good by the Contractor at his own cost to the satisfaction of the Engineer/Consultant.

### **11.2 Codes and Standards**

#### **Roof drainage system**

- IS:1230 - Cast iron rain water pipes and fittings
- IS:2527 - Code of practice for fixing rainwater gutters and downpipes for roof drainage
- IS:1742 - Code of practice for building drainage

#### **Pipes and fittings for sanitary, plumbing and drainage**



- IS:404 - Lead pipes for other than chemical purpose
- IS:405 - Lead sheet and strips
- (2 Parts)
- IS:458 - Precast Concrete pipes (with or without Reinforcements)
- IS:651 - Salt-glazed-stoneware pipes and fittings
- IS:771 - Glazed fire clay sanitary appliances
- IS:3597 - Methods of test for concrete pipes
- IS:774 - Flushing cisterns for water closets and urinals (other than plastic cistern)
  
- IS:775 - Cast iron brackets and supports for wash basins and sinks
- IS:781 - Cast copper alloy screw down bip taps and stop valves for water services
- IS:782 - Caulking lead
- IS:783 - Code of practice for laying of concrete pipes
- IS:804 - Rectangular pressed steel tanks
- IS:1239 - Mild steel tubes, tubular and other wrought steel fittings
- (2 Parts)
- IS:1703 - Copper alloy float valves (Horizontal plunger type) for water supply fittings
- IS:1711 - Self closing taps for water supply purposes
- IS:1726 - Cast iron manhole covers and frames
- IS:1729 - Sand cast iron spigot and socket, soil, waste and ventilating pipes, fittings and accessories
- IS:1795 - Pillar taps for water supply purposes
- IS:2065 - Code of practice for water supply in buildings
- IS:2104 - Water meter boxes (domestic type)
- IS:2326 - Automatic flushing cisterns for urinals
- IS:779 - Water meters (domestic type)
- IS:1536 - Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
- IS:1537 - Vertically cast iron pressure pipes for water, gas and sewage
- IS:2470 - Code of practice for design and construction of septic tanks
- (2 Parts)
- IS:2548 - Plastic seats and covers for water closets
- (2 Parts)
- IS:2556 - Vitreous sanitary appliances (vitreous China)
- (Parts 1 to 5)

- IS:2963 - Copper alloy waste fittings for wash basins and sinks
- IS:3004 - Plug cocks for water supply purposes
- IS:3006 - Chemically resistant glazed stoneware pipes and fittings
- IS:3114 - Code of practice for laying of cast iron pipes
- IS:3311 - Waste plug and its accessories for sinks and wash basins
- IS:4127 - Code of practice for laying of glazed stoneware pipes
- IS:4346 - Washers for use with fittings for water services
- IS:778 - Copper alloy gate, globe and check valves for water works purposes
- IS:4984 - Specification for high density polyethylene pipes for portable water supply
- IS:7634 - Code of practice for plastic pipes work for portable (3 Parts) water supplies
- IS:8008 - Specification for injection moulded HDPE (7 Parts) fittings for portable water supplies

### 11.3 **Materials**

11.3.1 **Materials, fittings and appliances for sanitary and plumbing work:** The materials, fittings and appliances used in the work shall be as specified hereunder. The type, quality, class, size, finish and make shall be specified. The Contractor shall submit to the Engineer/Consultant samples of all materials, fittings and appliances for approval well in advance of starting the work. All materials, fittings and appliances used in the work shall conform to the approved samples.

11.3.2 UPVC pipes & fittings are to be provided.

11.3.5 **Bottle trap:** Brass traps shall be of approved quality heavy brass chromium plated trap and made particularly smooth on the inside and shall have minimum 50 mm water seal and cleaning screw at bottom.

11.3.7 **High density polyethylene pipes and fittings:** High density polyethylene pipes and fittings shall be of tested quality and shall conform to IS:4984 and IS:8008.

11.3.8 **Cast iron pipes and accessories:** Cast iron pipes with socket and spigot ends shall conform to IS:1230 and IS:1729.

- 11.3.9 **Manhole covers:** Manhole covers shall conform to IS:1726.
- 11.3.10 **Heavy Duty Cast Iron Gratings :** The grade of raw materials shall conform to FG - 150 of IS : 210 . The size will be as indicated in the approved drawings. The guarantee will be given by the supplier to withstand a minimum applied load of 20 tons.
- 11.3.11 **Concrete pipes:** Concrete pipes shall be non-pressure type and shall conform to IS:458 and the type of joints shall be as indicated in the approved drawings. The class of pipe shall be NP-2/NP-3/NP-4 as per the design requirement of sewer pipe & shall be tested as per IS:3597.
- 11.3.12 **Salt glazed stoneware appliances and pipes:** Salt glazed stoneware appliances and pipes shall conform to IS:651 and IS:3006.
- 11.3.13 **Sanitary appliances and non-ferrous fittings:** All sanitary appliances and non-ferrous fittings shall be of tested quality and shall conform to the relevant Indian Standards.
- 11.3.14 **uPVC Pipes and Fittings:**

**Pipes:** All uPVC soil, waste, ventilating and overflow pipes, accessories and fittings shall comply with the requirements of IS: 4985. All uPVC rainwater pipes and fittings shall be circular and grey in colour and shall comply with the requirements of IS:7834.

**Joining Materials:** Joining materials for pipe runs shall be as recommended by the pipe manufacturer.

**Holder bats:** Holderbats shall be of PVC coated steel and shall be sized to suit the various diameters of pipes.

**Brackets and Clips:** Hanger brackets and clips shall be fabricated from 50 x 6 mm thick flat bar of sufficient length to suit particular requirements and shall be holed for fixing to steel or concrete surfaces and ends shall be cranked where necessary. Pipe clips shall be semi-circular with cranked ends holed for bolting together and to hanger brackets. All hanger brackets and clips shall receive a 0.5 mm thick PVC coating after fabrication.

## 11.4 **Joints**

- 11.4.1 **Cast iron pipes:** The type of jointing for CI pipes shall be either socket and spigot with molten lead or lead wool or flanged type with nuts, bolts and gasket.

If the joints used are spigot and socket type, the spigot shall be carefully centered in the socket by one or more laps of clean white hemp spun yarn with about 25 mm overlap. Sufficient yarn only shall be forced into the socket to leave a correct depth of lead for caulking. The pipe shall then be examined again for line and level and the proper depth of each joint shall be tested before running the molten lead. For pouring of molten lead a ring of hemprope shall be rapped around the pipe at the end of the socket and the joint shall be covered with stiff damp clay. The rope shall then be removed carefully leaving a V-shaped large hole at the top of the joint to pour the molten lead. Lead shall be poured in one operation only. After a section of convenient length of pipe has been laid, lead shall be caulked sufficiently with a hand hammer and the joint shall be made neat and clean.

The type of jointing C.I. pipes conforming to IS:1230 shall be socket and spigot with cement and sand mortar (1:1) and gasket yarn.

The spigot shall be carefully inserted and centered in the socket by one or more laps of thin clean hemp spun yarn and shall be forced into the socket to leave a correct depth of 30 mm all round for cement mortar. The pipe shall then be examined again for line and level and the proper depth of each joint shall be tested before inserting the cement mortar. The joints shall then be carefully filled with stiff cement and sand mortar (1:1) and the joints shall be leveled to the edge of the socket. Each joint shall be adequately cured by covering with wet cloth and pouring water at frequent intervals.

The packing ring or washer for the flanged joints shall be rubber for the full diameter of the flange with proper pipe hole and bolt holes cut out suitably. The packing shall be smeared with graphite paste or a mixture of red lead and white lead and shall be introduced between the flanges of both the pipes and nuts tightened in opposite pairs keeping the longitudinal axes and adjoining pipe lines in exactly the same straight line. Lead washers shall be provided along with bolts to prevent any leakage through bolt holes.

11.4.2 **Stoneware pipes:** The type of jointing for stoneware pipes shall be socket and spigot. The inside of the socket shall be first painted with a thin layer of cement mortar 1:2 and a gasket of yarn dipped in cement slurry shall be inserted in the socket of the pipe with a wooden caulking tool and wooden mallet in such a way that the gasket shall fully encircle the spigot with a slight overlap. Where the spigot end received the gasket, it shall be wrapped round with two or three turns of treated spun yarn at its end before being inserted into the socket. The rest of the joint shall then be completely filled with cement sand mortar (1:1) having very little water and the joint shall be leveled to form a splayed fillet at an angle of 45°. All excess cement mortar left inside the pipe joint shall be neatly cleaned off and the joint shall be adequately cured by covering with wet gunny bags and pouring water at frequent intervals. In jointing stoneware pipes, care shall be taken that the pipes are kept concentric and the socket, specially on the underside, shall be completely filled with cement mortar.

Where settlement of earth is envisaged, the joints shall be made with bitumastic filler or any other materials as approved by the Engineer/Consultant.

11.4.3 **Concrete pipes:** The type of jointing for concrete pipes shall be with loose concrete collars and the joints shall be packed from either side with spun yarn dipped in cement slurry as specified for jointing stoneware pipes. For higher diameter of pipe, joints shall be of socketing type & jointing shall be as per clause No.11.4.2 mentioned above. Stiff cement mortar (1:1) shall be filled from both sides and splayed at an angle of 45° on both sides. The joints shall be adequately cured as specified for joints in stoneware pipes.

## 11.5 **Laying of Pipes**

11.5.1 **Cast iron pipes:** The laying of cast iron pipelines shall commence only after the bottom of the trench at various points have been leveled and aligned. The sides of the trenches shall be as vertical as possible, and the width at the bottom shall be 450 mm wider than the diameter of the pipe. Where joints are made, the trench shall be widened suitably to provide room for caulking joints. Shoring and timbering shall not be used without prior approval of the Engineer/Consultant. For pipes buried in the ground, the Contractor shall take care to maintain always the minimum cushion of earth over the pipes. All pipes, water mains, cables etc met within the course of excavation shall be carefully protected and supported. All pipes and fittings shall be sounded with a light hammer to detect any cracks before laying. The excavated materials shall be placed on one side of the trench and the pipes stacked on the other side. The inside of socket and the outside of spigot shall be thoroughly cleaned of all foreign matter before laying. The pipes shall be laid with their socket ends facing the direction of the flow. The pipes shall be lowered in the trenches by a method as approved by the Engineer/Consultant. The pipes shall then be jointed by caulking as specified in clause 11.4.1. After each section of the pipeline has been laid it shall be tested for water-tightness before backfilling the trench. On successful completion of testing, the trench shall be backfilled with the excavated earth in layers of 200 mm and shall be watered and rammed. Any subsidence occurring in the line of trenches after backfilling shall be repaired by the Contractor at his own cost. Where the pipelines cross roads, the sides of the trenches shall be suitably shored.

11.5.2 **Concrete pipes:** The laying of concrete pipes shall conform to Clause 9 of IS:783. Pipes shall be laid true to line and grade. Laying of pipes shall always proceed upgrade in a slope.

11.5.3 **Stoneware pipes:** The laying of stoneware pipelines shall commence only after the bottom of the trench at various points have been leveled. The center line of the trench shall first be marked out on the ground and excavation done correct to depth and width at all points. The pipes shall be carefully laid to the alignment, levels and gradients. The trench shall be excavated wide enough under the sockets to allow hands to pass for making joints. The pipes

between manholes shall be laid truly in straight lines and without any vertical or horizontal deviations on a bed of concrete. While laying pipes, portion of concrete under each socket shall be dug and taken off so that barrel of the pipe gets full support on the concrete bed. Pipes shall be haunched with concrete up to a depth of half the diameter of the pipe. When it crosses under a road, the pipes shall be fully encased in concrete. The Contractor shall take precautions to maintain always a minimum cushion of earth over the pipes. All pipes shall be carefully examined with a light hammer for soundness before laying. After each section of the pipeline has been laid, the joints shall be allowed to set properly and shall be inspected and tested as directed by the Engineer/Consultant. Backfilling of the trench shall be carried out only after approval of the Engineer/Consultant. After testing, the trench shall be backfilled with selected earth in layers of 200 mm and shall be watered and thoroughly rammed. All pipes, water mains, cables etc met within the course of excavation shall be carefully protected and supported.

When the pipelines cross roads, the trenches shall have vertical sides with suitable shoring. Any subsidence in the line of trenches after backfilling shall be repaired by the Contractor at his own cost.

#### 11.5.4 **Cast iron rainwater pipes:** Cast iron rainwater pipes shall conform to IS:1230.

Cast iron rainwater pipes fixed to the external walls shall conform to IS:1230 and shall be blocked out at least 25 mm from the plastered surface by means of cast iron bobbins. The rainwater pipes at the roof level shall be fitted with cast iron bell mouth roof outlet bend or a cast iron bend with a masonry bell mouth of suitable size fitted with a cast iron grating. The bottom of the down pipe shall be fitted with a shoe fixed 150 mm above ground/apron level of the building. The sockets and spigots of pipes and fittings shall be jointed using hemp spun yarn and cement mortar (1:2).

Cast iron rainwater pipes embedded in concrete or masonry shall conform to IS:1230 and shall be securely fixed to wall with wooden plugs and nails. Joints of the sockets and spigots of pipes and fittings shall be with hemp spun yarn and lead caulking.

#### 11.5.5 **HDPE rainwater pipes:** HDPE rainwater pipes shall conform to IS:4984 and IS:8008.

HDPE rainwater pipes shall be fixed to the external walls and blocked out at least 25 mm from the plastered surface. The rainwater pipes at the roof level shall be fitted with bell mouth roof outlet bend or a bend with a masonry bell mouth of suitable size fitted with a grating. The bottom of the down pipe shall be fitted with a shoe fixed 150 mm above ground/apron level of the building. The sockets and spigots of pipes and fittings shall be jointed using hemp spun yarn and cement mortar (1:2).

HDPE rainwater pipes embedded in concrete or masonry shall be securely fixed to wall with wooden plugs and nails.

#### 11.5.6 **PVC Pipework**

All pipes and supports shall be sufficiently strong to carry the various systems when fully charged. Vertical pipes stacks shall be erected perfectly straight and shall be jointed and sealed at each connection and shall include expansion joints as shall be positioned on all vertical stacks.

Vertical stacks shall be supported by holder bats under each collar and where pipe lengths are in excess of 2000 mm. The stacks shall be supported at centres not exceeding 2000 mm.

Horizontal pipe runs shall be erected without 'kinks' or 'sags' to even gradients of 1 in 120 for 100 mm dia pipes and 1 in 200 for 150 mm dia pipes. Pipes shall be joined and sealed at each connection and shall include expansion joints as and when recommended by the pipe manufacturer. Cleaning eyes shall be positioned at each change in direction and pipes shall be supported by clips and brackets at each connection and at centres not in excess of 1250 mm.

The thickness of fittings used in uPVC System shall not be less than that of the pipes with which they are used. Care shall be exercised in the fixing of all pipes to ensure that pipes and fittings are not damaged by fixing which have been bolted to tightly but when erected the pipe and fixing shall be provide a secure component. The screws used in concrete block work, concrete walls and the soffits of concrete slabs or beam casings shall be non-ferrous screws not less than 50 mm long with appropriately sized rawlplugs.

#### 11.6 **Inspection Pit and Trap Pits**

Construction of pits shall commence only after the pipes have been laid in position true to line and levels to the satisfaction of the Engineer/Consultant.

11.6.1 **Inspection pit:** All inspection pits shall be constructed with brick masonry in cement mortar (1:4). Half round channels of size suitable for the inlet and outlet pipe diameters shall be formed on the floor of the pit with PCC M10. The floor of the pit shall be haunched towards the channel. Inside of pit shall be finished with cement-sand plaster (1:4) and finished smooth with cement punning. Invert level after finishing shall be as directed by the Engineer/Consultant.

11.6.2 **Intercepting/master trap pit:** The construction and finishing of the pit shall be as described for inspection pit. The floor of the pit shall be haunched towards the intercepting/master trap.

11.6.3 **Gully trap pit:** The Construction and finishing of the pit shall be as described for inspection pit. The cast iron grating shall be set flush with the finished ground/apron level.

### 11.7 **Testing of Cast Iron, Soil and Waste Pipelines**

On completion of laying, the cast iron, soil, waste and ventilation pipelines shall be tested by the Contractor at his own cost to detect leakages and any other defects in the pipelines.

Test shall be conducted using proper apparatus with attachments for smoke making machine for applying smoke to the pipe lines under pressure. Only cotton waste or brown paper soaked in creosote shall be used and fired to obtain dense and pungent smoke. While conducting smoke test, top of soil, waste and ventilation pipes shall be kept open till smoke starts coming out of the openings. The openings shall then be securely plugged with expanding rubber or any other approved plug. The entire pipeline shall be tested in suitable sections as directed by the Engineer/Consultant. The entire length of the pipeline including all joints under test shall be closely observed for any sign of smoke leakage. Any leakage and defects detected shall be rectified by the Contractor at his own cost to the satisfaction of the Engineer/Consultant.

### 11.8 **Testing of Underground Sewer lines**

The drainage system shall be tested in accordance with the provision of IS:1742. All defects and deficiencies detected during the test shall be promptly rectified by the Contractor at his own cost to the satisfaction of the Engineer/Consultant.

### 11.9 **Water Supply**

11.9.1 **Jointing and laying of galvanised steel water supply pipes:** Threaded galvanised steel pipes shall be jointed with threaded socket joints and threaded fittings of the same materials as that of the pipes. Any burrs remaining on the pipe ends after the threads are cut shall be removed. An approved jointing compound together with a few strands of fine yarn shall be used for jointing pipes and fittings. Any pipe threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved bituminous compound to prevent corrosion.

The service pipe passing into or beneath the building shall be laid at least 200 mm below the ground floor level and accommodated in the previously laid sleeve in the structure where it enters the building. The space between the sleeve and the pipe at its entry into and exit from the building shall be filled with a bituminous material for a minimum length of 150 mm at both ends.



Piping shall not be buried in walls or floors as far as possible. However, when unavoidable, piping shall be buried for the shortest distance necessary and adequate protection shall be provided against damage.

Galvanised steel piping shall be secured by iron or steel clamps and hooks when fixed on walls.

All pipework shall be completely watertight and the joints shall be such that there are no projections of jointing materials or the like in the interior of pipes. Before the pipeline is commissioned, all piping and fittings shall be flushed clean.

11.9.2 **Jointing and laying of high density polyethylene water supply pipes:** All high density polyethylene pipes shall have screwed ends and shall be jointed with screwed fittings of the same materials as that of the pipes. Any burrs remaining on the pipe ends after cutting threads shall be removed. If necessary, an approved jointing compound with a few strands of fine yarn may be used for jointing pipes and fittings. All exposed high density polyethylene pipes shall be installed with PVC saddles screwed on 25 mm thick wooden blocks securely fixed on walls at suitable intervals, not exceeding 1 m. Pipes wherever installed in well chasing shall be of fixed as in the case of galvanised steel pipes.

11.9.3 **Testing:** After the laying and fixing of all galvanised steel and high density polyethylene water supply pipes and fittings are completed, the line shall be slowly and carefully charged with water to a test pressure of 5 kg per sq cm or the specified working pressure plus 50% as may be prescribed by the Engineer/Consultant. Care shall be taken that air in pipelines is completely exhausted while filling the pipelines with water. This pressure shall be maintained for at least one hour, unless otherwise specified. The pipes and fittings shall then be inspected for any leakage of water. Defects in pipes and fittings, if detected, shall be remedied by the Contractor at his own cost.

11.9.4 **Jointing of lead pipes:** Joints in lead pipes shall be wiped solder joints. Joints shall be wiped in a continuous circular motion in one direction so as to leave a neatly formed elliptical shaped joint free from tears, burrs, droppings etc. All exposed lead pipes, exceeding 25 mm in diameter shall be secured to walls by iron clips or lead ears. The spacing of the clips shall not exceed 900 mm.

11.9.5 **Storage of water:** All tanks for storage of water shall be completely watertight and properly covered with dust, light and mosquito proof cover of approved type. They shall be fitted with a heavy duty (10 kg/cm<sup>2</sup>) ball valve of approved type, securely fixed to the tank independent of the inlet pipe. A mosquito proof overflow pipe shall be fixed to the tank with the pipe invert about 25 mm above the top of water line. Approved type of stop valve shall be

provided for every outlet pipe. Inside surface of the HDPE tanks shall be painted with anti-corrosive drinking water paints.

11.9.6 **Cleaning and disinfection:** All storage tanks, water supply fittings and pipes before being put into commission, shall be disinfected by the Contractor at his own cost.

#### 11.10 **Installation of Sanitary Appliances**

All sanitary appliances shall be fixed in position rigidly on floor and walls as directed by the Engineer/Consultant.

11.10.1 **Water closet - squatting type:** Squatting type water closet shall be fitted on the trap and shall be jointed with gasket yarn and cement mortar. Rim of the pan shall be leveled properly and set flush with the finished floor. The pan shall be connected to cast iron high level pull and let go or cast iron low level push down type flushing cistern of capacity. The flushing cistern shall be supported on a pair of CI cantilever brackets firmly embedded in the wall in cement mortar (1:4) or screwed to wall with suitable plugs. The flush pipe from the cistern shall be 32 mm dia tested quality galvanised steel pipe (light) or HDPE pipe and connected to the pan inlet by means of hemp and putty joint.

11.10.2 **Water closet - pedestal type:** Pedestal type water closet shall be rigidly fixed on the finished floor by means of 75 mm long brass screws with suitable plugs. The flushing cistern shall be of porcelain or cast iron low level push down cistern. The cistern shall be supported on a pair of cast iron or rolled steel cantilever brackets firmly fixed on wall with brass screws and suitable plugs. The flush pipe from the cistern shall be 40 mm dia chromium plated brass bend and fitted to the closet by means of rubber adopter. The closet shall be provided with double black plastic seat cover and chromium plated hinges.

11.10.3 **Urinals:** Standing type urinals shall be firmly fitted on finished wall by means of 50 mm long brass screws and suitable plugs. Urinals shall be fitted with cast iron automatic flushing cistern. Flushing pipes shall be of galvanised steel pipes of required sizes and connected to the urinal with 15 mm dia lead connector fitted with brass cap and lining at one end. The joint to the inlet of urinal shall be neatly finished with putty joints.

The arrangement of waste pipes and discharge to the floor trap shall be as directed by the Engineer/Consultant. For single urinal the discharge may be direct to the floor trap through a 40 mm dia lead pipe. For a range of urinals, the discharge may be collected in a common galvanised steel or HDPE pipe of 50 mm dia leading to the floor trap. Each urinal shall be connected to the common discharge pipe by 40 mm dia lead or HDPE pipes. Alternatively, the discharge from each urinal through 40 mm dia lead pipe shall be led to half round channel laid on the floor leading to the floor trap.

- 11.10.4 **Wash hand basin:** Wash hand basin shall be fitted in position on true level on a pair of cast iron brackets rigidly fixed on wall with 50 mm long brass screws and suitable plugs. The basin shall be fitted with 15 mm dia approved quality chromium plated pillar tap and 32 mm dia waste fittings. The type of waste pipes and their connections shall be as directed by the Engineer/Consultant.
- 11.10.5 **Sink:** White glazed percolin sink of standard make shall be fitted in position on a pair of cast iron cantilever brackets firmly embedded in the wall in cement mortar (1:4). The sink shall be fitted with chromium plated brass waste fittings of standard size. The type of waste pipes and their connections shall be as directed by the Engineer/Consultant.
- 11.10.6 **Other miscellaneous fittings (e.g. mirror, towel rails, soap case etc):** All such fittings shall be of type and sizes of approved manufacturer and shall be fitted in position true to line, level and plane to the satisfaction of Engineer/Consultant..

## **SECTION-12 - ROAD WORK**

### **12.1 ROAD WORK**

#### **12.1.1 General**

All road works ie. Quality of material, construction of roads and quality of execution shall conform to specification for road and bridge works under Ministry of Road Transport and Highways (MORTH) (4<sup>th</sup> Revision). Road work shall be executed in a most professional way by deploying all mechanical equipment like vibratory rollers, smooth wheeled roller, hydraulic excavators, batch mixer, rock breaker, mobile crusher (if applicable), self propelled paver finisher or motor grader, hot mix plant, tipper vehicles, plate compactor, bitumen pressure sprayer, compressor air cleaner etc. No additional amount shall be payable on account of using any mechanical equipment not listed above or may be directed further by the Engineer/Consultant for deployment during the construction work. Provided where any provision of the specification stated hereinafter is contrary to provision of specification for road and bridge works under Ministry of Road Transport and Highways (MORTH) (4<sup>th</sup> Revision), provision of the later shall prevail to the extent of such contradiction unless otherwise directed by the Engineer/Consultant.

#### **12.1.2 PREPARATION OF SUB-GRADE**

Bottom of excavation before laying of sub-base shall be prepared, watered and re-rolled for compaction with minimum six (6) passes of 80-100 kN power roller to

the specified lines and cross fall (camber), to get the required CBR value of 4%/6% as per requirement. Any ruts or soft yielding places shall be corrected in an approved manner and rolled with minimum two passes of 80 – 100 kN smoothed wheeled roller with sprinkling of water to achieve the required dry density. Haulage of materials over the formed surface shall not be permitted.

The sub-grade shall comply with the following requirements to receive the granular sub-base course:

- a) No soft spots shall be present.
- b) It shall be properly drained during construction.
- c) The minimum compaction shall not be less than 97 per cent of maximum laboratory dry density as per IS:2720 (Part VIII). This should be ensured by taking sample from finished top and tested in laboratory.
- d) CBR value at sub-grade level shall not be less than specified value as mentioned above. This should be ensured by taking undisturbed sample from finished top and tested in laboratory as per IS:2720 (Part XVI). Field CBR test shall also be done as per IS:2720 (Part XXXI) at a depth of about 500 mm to ascertain the CBR value.

## 12.2 **SUB-BASES (NON-BITUMINOUS) AND SHOULDERS**

### 12.2.1 **Scope**

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications. The material shall be laid in one or more layers as lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades, camber and cross-sections as directed by the Engineer/Consultant.

### 12.2.2 **Granular lower sub-base (with granulated BF slag and gravel)**

The material recommended for lower subbase layers is gravel (60%) mixed with Granulated Blast Furnace slag (GBFS) (40%) by weight. The requisite quantities of materials shall be spread over the prepared sub-grade and thoroughly mixed preferably by using mechanical mixers like 'rotillor' and compacted in layers with compacted thickness of 150 mm each layer with optimum moisture content to 100 per cent of the maximum laboratory density as per IS:2720 (Part-VIII).

The gravel from approved quarry is to be collected and the gravel-GBFS are to be mixed as per the Grading-1 as shown in TABLE-1 on the next page and the materials will be used in the lower layers of roads.

The mixed material shall be free from organic or other deleterious constituents.

**TABLE -1 - GRADING FOR GRANULAR  
LOWER SUB-BASE MATERIALS**

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading I	Grading II	Grading III
80 mm	100	100	100
63 mm	90-100	90-100	90-100
4.75 mm	35 - 70	40 -90	50 - 100
75 micron	0-20	0-25	0-30
CBR Value (Minimum)	30%	25%	20%

**Note:** The material passing 425 micron sieve for all the three gradings when tested according to IS:2720 (Part V) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

#### 12.2.2.1 **Physical requirements**

The fraction of material passing 22.4 mm sieve shall give a CBR value not less than 30%, when tested in accordance with IS:2720 (Part-XVI) after preparing the samples at maximum dry density and optimum moisture content corresponding to IS:2720 (Part VIII) and soaking the same in water for a period of 4 days prior of testing.

#### 12.2.2.2 **Construction Operations:**

##### 12.2.2.2.1 **Preparation of subgrade**

Immediately prior to the laying of sub-base, the sub-grade already finished as per clause 1.2, shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80-

100 kN smooth wheeled roller to attain CBR value of 4%/6% as per the requirement.

#### 12.2.2.2.2 **Spreading and compacting**

The sub-base material of grading specified in Table-1 shall be mixed mechanically by mix in place method and spread on the prepared sub-grade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and maintain the required slope and grade during the operation or other means as approved by the Engineer/Consultant.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved

equipment capable of mixing the material to the desired degree. If so desired by the Engineer/Consultant, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS:2720 (Part-II) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer/Consultant so that at the time of compaction it is from 1 percent above to 2 per cent below the optimum moisture content corresponding to IS:2720 (Part VIII). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means if so directed by the Engineer/Consultant until the layer is uniformly wet.

Immediately thereafter, rolling shall start, if the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 kN/sq m or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 97 per cent of the maximum dry density for the material determined as per IS:2720 (Part VIII). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or other defective areas shall be made good to the full thickness of layer and re-compacted.

### 12.2.3 **Granular upper sub-base (Gravel or Crushed Stone)**

The material to be used for the work shall be gravel, crushed stone or combination thereof depending upon the grading required. The material shall be free from organic or other deleterious constituents and conform to Grading-1 as shown in Table-2/3.

Grading-1 in Table-2 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding Grading-1 for the coarse-graded materials for each of three maximum particle sizes are given in Table -3.

#### 12.2.3.1 **Physical requirements**

The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part III). The water absorption value of the coarse aggregate shall be determined as per IS:2386 (Part III); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS:383.

**TABLE -2 - GRADING FOR CLOSE-GRADED GRANULAR SUB-BASE MATERIALS**

<b>IS Sieve Designation</b>	<b>Per cent by weight passing the IS sieve</b>		
	<b>Grading I</b>	<b>Grading II</b>	<b>Grading III</b>
75.0 mm	100	-	-
53.0 mm	80-100	100	-

26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30%	25%	20%

*TABLE -3 - GRADING FOR COARSE-GRADED  
GRANULAR SUB-BASE MATERIALS*

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	-	100	-
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	<10	<10	<10
CBR Value (Minimum)	30%	25%	20%

**Note:** The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS:2720 (Part V) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

### 12.2.3.2 Construction Operations

#### 12.2.3.2.1 Preparation of lower sub-base

The upper sub-base shall be laid over the prepared lower sub-base in moist condition as enumerated in Clause 2.2 and prepared as per Clause No. 2.2.2.1.



### 2.3.2.2 **Spreading and compacting**

The upper sub-base material of grading as per Table 2/3 shall be spread and compacted as per Clause No. 2.2.2.2.

### 12.2.4 **Strength of sub-base**

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR not less than 30% and other physical requirements when compacted and finished.

When directed by the Engineer/Consultant, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the "quality" of materials, as may be necessary as per IS:2720 (Part-XVI).

### 12.3.0 **WET MIX MACADAM BASE**

12.3.1 This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared granular sub-base. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections as directed by the Engineer/Consultant.

The thickness of a single compacted Wet Mix Macadam layer shall not less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the wet mix macadam course may be increased to 200 mm upon a approval of the Engineer/Consultant. The tested CBR value of wet mix macadam shall be 60% (minimum).

### 12.3.2 **Materials**

#### 12.3.2.1 **Aggregates**

**Physical requirements:** Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 4 below:

**TABLE 4 - PHYSICAL REQUIREMENTS OF  
COARSE AGGREGATES FOR WET MIX MACADAM  
FOR SUB-BASE/BASE COURSES**

Method	Requirements	Test	Test	
1.	* Los Angeles Abrasion value	IS:2386 (Part-4)	40 per cent (Max)	
	or			
2.	* Aggregate (Part-4) or	IS: 2386 IS:5640 **	30 per cent (Max)	Impact
3.	Combined Flakiness and Elongation Indices (Total)	IS:2386 (Part-1)	30 per cent (Max)**	

\* Aggregate may satisfy requirements of either of the two tests.

\*\* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particle divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

If the water absorption value of the course aggregates is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

12.3.2.2 **Grading requirements:** The aggregates shall conform to the grading given in Table 5 below:

**TABLE 5 - GRADING REQUIREMENTS OF AGGREGATES FOR WET MIX MACADAM**

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<i>IS Sieve</i>	<i>Designation</i>	<i>Per cent by weight passing the IS sieve</i>
53.00	mm	100
45.00	mm	95-100
26.50	mm	-
22.40	mm	60-80
11.20	mm	40-60
4.75	mm	25-40
2.36	mm	15-30
600-00	micron	8-22
75.00	micron	0-8

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Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice-versa.

12.3.3 **Kerb stones:** The work shall consist of constructing cement concrete (M25) kerb stone along the central median (if road width is more than 11 m) and shoulder. The kerb stone shall be cast in continuous length with kerb casting machine in central median portion and shoulder portion. At the place of bend/curve, pre-cast kerb stone may be placed as per the direction of Engineer/Consultant. The base of the kerb stone of suitable size shall be laid over 150 mm thick M10 cement concrete or extended width of pavement with proper anchorage. Saw cut groove shall be provided at an interval of 5 m or as directed by Engineer/Consultant. Vertical and horizontal tolerances with respect to true line shall be  $\pm 6$  mm.

#### 12.3.4 **Construction Operations**

12.3.4.1 **Formation of shoulders:** While constructing Wet Mix Macadam (WMM) arrangement shall be made for lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of matching thickness of wet mix macadam layer. The pavement layer shall be compacted first. The corresponding layer in shoulder portion shall be compacted thereafter with watering and rolling using 80 kN vibratory roller. During all stages of shoulder construction, the required cross fall shall be maintained to drain off water.

12..4.2 **Preparation of mix:** Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pug mill or pan type mixer of concrete batching plant.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-VIII) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance shall be made for evaporation losses. However, at the time of compaction, water in the wet mix shall not vary from the optimum value by more than agreed limits. The mixed material shall be uniformly wet and no segregation is permitted.

12..4.3 **Spreading of mix:** Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared granular sub-base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread either by a Paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer/Consultant shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specific slope and grade.

The paver finisher shall be self-propelled, having the following features:

- i) Loading hoppers and suitable distribution mechanism.
- ii) The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.
- iii) The Paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The

layer may be tested by depth blocks during construction. No segregation of larger and the fine particles shall be allowed. The aggregates as spread shall be of uniform gradation with no pockets of fine materials.

12.3.4.4 **Compaction:** After the mix has been laid to the required thickness, grade and cross fall/camber the same shall be uniformly compacted to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single

layer upto 250 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km/hr.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the center line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions of camber, rolling shall begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface shall be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and cross-fall. In no case the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS:2720 (Part-8). The exact number of passes required for achieving the desired result should be established before hand by test rolling over a test bed over similar sub grade.

After completion, the surface of the any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompactd.

12.3.4.5 **Setting and drying:** After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours. No vehicular traffic of any kind shall be

allowed on the finished wet mix macadam surface till it is dried and next course laid.

#### **12.4 PRIME COAT OVER GRANULAR SUB-BASE/BASE COURSE**

**12.4.1 Scope of work:** The work shall consist of the application of a single coat low viscosity liquid bituminous primer over weight mix macadam cause preparatory to the superimposition of bituminous treatment or mix.

**12.4.2 Material:** The low viscosity bituminous primer shall comply with the requirement of IS:8887 with kinematic viscosity at 60°C is 30 – 60 centistokes when tested. The quantity of primer for road surface is 6 to 9 kg per 10 sq m.

#### **12.4.3 Construction**

**12.4.3.1 Preparation of road surface:** Prior to application of primer the road surface shall be free of dust, loose particles and kept moist (lightly sprayed with water and the surface allowed to dry) until the primer is applied.

**12.4.3.2 Equipment and application:** The primer distributor shall be self propelled or towed bitumen sprayer equipped for spraying the primer uniformly at specified rates and temperatures. The method of application of the primer shall depend on type of equipment used, size of nozzles, pressure of the spray bar and speed of forward movement.

**12.4.3.3 Curing:** The primed surface shall be allowed to air cure for at least for 24 hours as directed by Engineer/Consultant.

#### **12.5.0 TACK COAT**

**12.5.1 Scope of work:** Same as that of prime coat and over existing/new bituminous road surface.

**12.5.2 Material:** Material shall be same as that of prime coat and the quantities shall be as per Table 6 on the next page.

**TABLE – 6 – RATE OF APPLICATION OF TACK COAT**

<b>Sl. No.</b>	<b>Type of surface</b>	<b>Quantity of liquid bituminous Materials in</b>
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		<b>Kg per sq m area</b>
1.	Normal bituminous surfaces	0.20 to 0.25
2.	Dry and hungry bituminous surface	0.25 to 0.30
3.	Granular surfaces treated with primer	0.25 to 0.30
4.	Non-bituminous surfaces:	
	a) Granular base (non primed)	0.35 to 0.40
	b) Cement concrete pavement	0.30 to 0.35

### 12.5.3 **Construction**

12.5.3.1 **Preparation of road surface:** The road surface shall be free from dust, road particles, any extraneous materials etc and immediately before application of primer, the road surface shall be swept clean with the mechanical broom and high pressure air jet as directed by Engineer/Consultant.

12.5.3.2 **Equipment and application:** Same as that of prime coat.

12.5.3.3 **Curing:** Same as that of prime coat.

### 12.6.0 **BITUMINOUS MACADAM**

12.6.1 **Work Included:** The work shall consist of construction, in a single course, of compacted crushed aggregates premixed with a bituminous binder, laid immediately after mixing, on a base prepared previously in accordance with the requirement of this specification and in conformity with the lines, grades and cross-sections as directed by the Engineer/Consultant.

### 12.6.2 **Materials**

**Bitumen:** The bitumen shall be paving bitumen of suitable penetration grade (30/40) as per IS:73.

**Aggregates:** The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones retained on 2.36 mm sieve. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. If crushed shingle/gravel is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The fine aggregates shall pass 2.36

mm sieve and retained on 75 micron sieve. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, the bitumen shall preferably be treated with anti-stripping agents of approved quality in suitable dose as directed by the Engineer/Consultant. The aggregates shall satisfy the physical requirements set forth in Table 7.

**TABLE-7 - PHYSICAL REQUIREMENTS FOR COARSE AGGREGATES FOR BITUMINOUS MACADAM**

<b>Property</b>	<b>Test</b>	<b>Specification</b>
Cleanliness	Grain size analysis <sup>1</sup>	Max 5% passing 0.075 mm sieve
Particle shape	Flakiness and Elongation Index (Combined) <sup>2</sup>	Max 30%
Strength*	Los Angeles Abrasion Value <sup>3</sup>	Max 40%
	Aggregate Impact Value <sup>3</sup>	Max 30%
Durability	Soundness <sup>4</sup> Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
Water Absorption	Water absorption <sup>5</sup>	Max 2%
Stripping	Coating and stripping of bitumen aggregate mixtures <sup>6</sup>	Minimum retained coating 95%
Water Sensitivity <sup>7</sup>	Retained tensile strength	Min. 80%

- Notes:**
1. IS:2386 Part 1
  2. IS:2386 Part 1  
(the elongation test to be done only on non-flaky aggregates in the sample)
  3. IS:2386 Part 4\*
  4. IS:2386 Part 5
  5. IS:2386 Part 3
  6. IS:6241
  7. The water sensitivity test is only to be carried out if the minimum retained coating in the stripping test is less than 95%.

\* Aggregate may satisfy requirements of either of these two tests.



12.6.3 **Proportioning of materials:** The bitumen content for pre-mixing shall be 3.1 to 3.5 per cent by weight of the total mix except when otherwise directed by the Engineer/Consultant. The composition of bituminous macadam shall conform to one of the two grading in Table-8 on the next page.

**TABLE-8 - COMPOSITION OF BITUMINOUS MACADAM**

Mix designation Nominal aggregate size Layer thickness IS Sieve (mm)	Grading I 40 mm 80 - 100 mm	Grading 2 19 mm 50 - 75 mm
	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0.8	0.8
Bitumen content, % By weight of total Mixture	3.1-3.4	3.3-3.5
Bitumen grade	35 to 90	35 to 90

The maximum compacted thickness of a layer shall be 100 mm.

The quantities of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

**Variation in proportioning of material:** The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content  $\pm 0.3$  per cent by weight of total mix shall, however, be permissible for individual specimens taken for quality control tests.

**Tack Coat:** Tack coat shall be as per Clause No. 5.0 of this Section.

#### 12.6.4 **Workmanship**

12.6.4.1 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10°C or less.

12.6.4.2 **Preparation of the base:** The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross-sections and a priming coat where needed shall be applied as directed by the Engineer/Consultant.

12.6.4.3 **Preparation and transportation of mix:** Bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates.

Hot mix plant shall be of suitable capacity preferably of batch mix type. The total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, deployed by the Contractor must be capable of meeting the overall specification requirements under stringent quality control.

The temperature of binder at the time of mixing shall be in the range of 150°C to 163 °C and that of the aggregate in the range of 155 °C to 163 °C provided that the difference in temperature between the binder and aggregate at no time exceeds 14 °C.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly, and the discharge temperature of mix shall be between 130 °C to 160 °C.

The mixture shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and be covered in transit if so directed by the Engineer/Consultant. Any tipper causing excessive segregation of materials by its spring suspension or other contributing factors or that which shows undue delay shall be removed from the work until such conditions are corrected.

12.6.4.4 **Spreading:** The mix transferred from the tipper at site to the paver shall be spread immediately by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mix true to the specified lines, grades and cross-sections. The manufacturing and rolling temperature shall be as per Table-9.

**TABLE-9 – MANUFACTURING AND ROLLING TEMPERATURES**

Bitumen Penetration	Bitumen Mixing (°C)	Aggregate Mixing (°C)	Mixed Material (°C)	Rolling (°C)	Laying (°C)
35	160-170	160-175	170 Max.	100 Min.	130 Min.
65	150-165	150-170	165 Max.	90 Min.	125 Min.
90	140-160	140-165	155 Max.	80 Min.	115 Min.

However, in restricted locations and in narrow widths where the available plant cannot be operated in the opinion of the Engineer/Consultant, he may permit manual laying of the mix.

The temperature of the mix at the time of laying shall be in the range of 120 °C to 160 °C. In multi-layer construction, the longitudinal joint in one layer shall offset that in the layer below by about 150 mm. However, the joint in the top-most layer shall be at the lane line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating line parallel to the center line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material. Longitudinal and transverse joints shall be offset by at least 250 mm from those in the lower courses and the joint on the top most layer shall not be allowed to fall within the wheel path. All transverse joints shall be cut vertically to the full thickness of the previously laid mix with asphalt cutter/pavement breaker and surface painted with hot bitumen before placing fresh material. Longitudinal joints shall be preferably hot joints. Cold longitudinal joints shall be properly heated with joint heater to attain a suitable temperature of about 80 °C before laying of adjacent material.

12.6.4.5 **Compaction:** After the spreading of mix, rolling shall be done by 80 - 100 KN rollers or other approved equipment. Rolling shall start as soon as possible after the material has been spread deploying a set of rollers as the rolling is to be completed in limited time frame. The roller shall move at a speed not more than 5 km/hr. Rolling shall be done with care to avoid unduly roughening of the pavement surface.

Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, the rolling shall commence at the edges and progress towards the center longitudinally.

The initial or break-down rolling shall be done with 80 - 100 kn. static weight smooth wheel roller (3 wheels or tandem), as soon as it is possible to roll the mix without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the break-down rolling with vibratory roller of 80 to 100 kn. static weight or pneumatic tyred roller of 150 to 250 kn. weight, with minimum 7 wheels and minimum tyre pressure of 0.7 MPa as closely as possible to the paver and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while material is still workable enough for removal of roller marks, with 60 - 80 kn. tandem roller. During the final rolling, vibratory system shall be switched off. The joints and edgers shall be rolled with a 80 to 100 kn. static roller.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding mix material. The rolling shall then be continued till the entire surface has been rolled to 95 per cent of the average laboratory density (obtained from Marshall specimens compacted as defined in Table-10), there is no crushing of aggregates and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. The roller wheel shall be kept damp if necessary to avoid bituminous material from sticking to the wheels and being picked up. In no case shall fuel, lubricating oil be used for this purpose, nor excessive water poured on the wheels.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 100 °C.

Roller(s) shall not stand on newly laid material while there is a risk that surface will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case, as the case may be, without any delay.

#### **TABLE - 10 - REQUIREMENT OF BITUMINOUS MACADAM**

<b>Sl. No.</b>	<b>Description</b>	<b>Requirement</b>
1.	Marshall stability (ASTM Designation D-1559) specimens compacted by 75 compaction blows on each end	820 kg determined on Marshall minimum
2.	Marshall flow (mm)	2 mm to 4 mm
3.	Per cent Air voids in mix	3% to 5%
4.	Minimum voids in mineral aggregates (VMA)	10 % to 12 %
5.	Per cent voids in mineral aggregates filled by bitumen (VFB)	65% to 75%
6.	Binder content per cent by weight of total mix	Minimum 4.0%

### **12.7.0 DENSE GRADED BITUMINOUS MACADAM (DBM)**

#### **12.7.1 Scope**

This clause specifies the construction of Dense Graded Bituminous Macadam (DBM) for use as road surface material. This work shall consist of construction in a single or multiple layers of DBM on a base. The thickness of a single layer shall be 50 mm to 100 mm.

#### **12.7.2 Materials**

**12.7.2.1 Bitumen:** The bitumen shall be paving bitumen of penetration Grade (60/70) complying with Indian Standard Specifications for "Paving Bitumen" IS:73.

**12.7.2.2 Coarse Aggregates:** The coarse aggregate shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable or cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in Table-11 for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

12.7.2.3 **Fine aggregates:** Fine aggregates shall consist of crushed stone or naturally occurring mineral material or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust and soft or friable matter, organic or other deleterious matter.

The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part-XXXVII).

The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4 when tested in accordance with IS:2720 (Part V).

**TABLE 11 - PHYSICAL REQUIREMENTS OF COARSE AGGREGATE FOR DENSE GRADED BITUMINOUS MACADAM**

<b>Property</b>	<b>Test</b>	<b>Specification</b>
Cleanliness (dust)	Grain size analysis <sup>(1)</sup>	Max 5% passing 0.075 mm sieve.
Particle shape	Flakiness and elongation index (combined) <sup>(2)</sup>	Max 30%
Strength*	Los Angeles Abrasion Value <sup>(3)</sup> Aggregate Impact Value <sup>(4)</sup>	Max. 35% Max. 27%
Durability	Soundness <sup>(5)</sup> : Sodium sulphate Magnesium sulphate	Max. 12% Max. 18%
Water absorption	Water absorption <sup>(6)</sup>	Max. 2%
Stripping	Coating and stripping of bitumen aggregate mixtures <sup>(7)</sup>	Minimum retained coating 95%
Water sensitivity**	Retained tensile strength <sup>(8)</sup>	Min. 80%

**Notes:** 1.IS:2386 Part I

2. IS:2386 Part I  
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS:2386 Part 4\*
4. IS:2386 Part 4\*
5. IS:2386 Part 5
6. IS:2386 Part 3
7. IS:6241
8. IS:AASHTO T283\*\*

\* Aggregate may satisfy requirements of either of these two tests.

\*\* The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

12.7.2.4 **Filler:** filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer/Consultant.

The filler shall be graded within the limits indicated in Table- 12.

**TABLE 12 - GRADING REQUIREMENTS FOR MINERAL FILLER**

<u>IS Sieve (mm)</u>		<u>Cumulative per cent passing by weight of total aggregate</u>
0.6	..	100
0.3	..	95 -100
0.075	..	85 - 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table -11, then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

12.7.3 **Aggregate grading and binder content:** When tested in accordance with IS:2386 Part I (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in Table-13 for dense bituminous macadam grading 1 or 2. The type and quantity of bitumen, and appropriate thickness are also indicated for each mixture type.

**TABLE 13 - COMPOSITION OF DENSE GRADED BITUMINOUS MACADAM PAVEMENT LAYERS**

Grading	1	2
Nominal aggregate size	40 mm	25 mm
Layer Thickness	80 – 100 mm	50 – 75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	100	-
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7.21
0.15	-	-
0.075	2-8	2-8
Bitumen content % by mass of total mix <sup>2</sup>	Min 4.0	Min 4.5
Bitumen grade (pen)	65 or 90	65 or 90

- Notes:**
1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
  2. Determined by the Marshall method.

#### 12.7.4 Mixture Design



12.7.4.1 **Requirement for the mixture:** Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table – 14.

**TABLE 14 - REQUIREMENTS FOR DENSE GRADE**

**BITUMINOUS MACADAM**

Minimum stability (kN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3.6
Per cent voids in mineral aggregate (VMA)	See Table 15 below.
Per cent voids filled with bitumen (VFB)	65-75

**TABLE 15 - MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)**

Nominal Maximum Particle Size <sup>1</sup> (mm)	Minimum VMA, Per cent Related to Design Air Voids, Per cent <sup>2</sup>		
	3.0	4.0	5.0
9.5	14.0		16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

- Notes:**
1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent.
  2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

12.7.4.2 **Binder content:** The binder content shall be optimised to achieve the requirements of the mixture set out in Table-14 and the traffic volume. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer/Consultant. Where 40 mm dense bituminous macadam mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures, particularly the minimum stability values in Table -14 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

12.7.4.3 **Job mix formula:** The Contractor shall inform the Engineer/Consultant in sufficient advance before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details:

- i) Source and location of all materials.
- ii) Proportions of all materials expressed as follows where each is applicable:
  - a) Binder type and percentage by weight of total mixture.
  - b) Coarse aggregate/fine aggregate/mineral filler as percentage by weight of total aggregate including mineral filler.
- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The individual gradings of the individual aggregate fractions, and the proportion of each in the combined grading.
- v) The results of tests enumerated in Table-14 as obtained by the Contractor.
- vi) Where the mixer is a batch mixer, the individual weights of each type of aggregates and binder per batch.
- vii) Test results of physical characteristics of aggregates to be used;

viii) Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer/Consultant for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer/Consultant.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded to the Engineer/Consultant for approval before the placing of the material without any additional payment to contractor.

12.7.5 **Plant trials – permissible variation in job mix formula:** Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentage of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table-16. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Clause 11 of this Section.

**TABLE 16 - PERMISSIBLE VARIATIONS FROM THE  
JOB MIX FORMULA**

Description	Permissible variations	
	Base/binder course	Wearing course
Aggregate passing 19 mm sieve or larger	± 8%	± 8%
Aggregate passing 13.2 mm, 9.5 mm	± 7%	± 6%
Aggregate passing 4.75 mm	± 6%	± 5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5%	± 4%

Aggregate passing 0.3 mm , 0.15 mm	± 4%	± 3%
Aggregate passing 0.075 mm	± 2%	± 1.5%
Binder content	± 0.3%	± 0.3%
Mixing temperature	± 10°C	± 10°C

Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer/Consultant shall require additional testing of the product to establish the reliability and consistency of the plant.

12.7.5.1 **Laying Trials:** Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid and compacted all in accordance with Clause 6.4.5. The laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing by the Engineer/Consultant.

The area of the laying trials shall be a minimum of 100 sq m of construction similar to that of the project road and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer/Consultant of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material of the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer/Consultant, who may at the discretion require further laying trials.

## 12.7.6 **Workmanship**

12.7.6.1 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or the base course is damp or free standing water is present on the surface or atmospheric temperature is less than 10°C.

12.7.6.2 **Preparation of base:** The base on which Dense Graded Bituminous Material is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross sections. The surface shall be thoroughly swept, cleaned by a mechanical broom, and the dust removed by compressed air. In locations, where mechanical broom cannot access, other approved methods shall be used as directed by the Engineer/Consultant. A prime coat shall be applied as directed by the Engineer/Consultant. The type and viscosity of the primer shall comply with requirements of IS:8887.

12.7.6.3 **Preparation and transportation of mix:** Dense bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. **Hot mix plant shall be of suitable capacity preferably of batch mix type. The total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, deployed by the Contractor must be capable of meeting the overall specification requirements under stringent quality control.**

The temperature of binder at the time of mixing shall be in the range of 150°C to 163 °C and that of the aggregate in the range of 155 °C to 163 °C provided that the difference in temperature between the binder and aggregate at no time exceeds 14 °C.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly, and the discharge temperature of mix shall be between 130 °C to 160 °C. **The mixture shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and be covered in transit if so directed by the Engineer/Consultant. Thin coating of diesel or lubricating oil may be applied to the interior of vehicles to prevent sticking and to facilitate easy discharge of the materials. Any tipper causing excessive segregation of materials by its spring suspension or other contributing factors or that which shows undue delay shall be removed from the work until such conditions are corrected.**

12.7.6.4 **Spreading:** The mix transferred from the tipper at site to the paver shall be spread immediately by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mix true to the specified lines, grades and cross-sections. However, in restricted locations and in narrow widths where the available plant cannot be operated in the opinion of the Engineer/Consultant, he may permit manual laying of the mix.

The temperature of the mix at the time of laying shall be in the range of 120 °C to 160 °C. In multi-layer construction, the longitudinal joint in one layer shall offset that in the layer below by about 150 mm. However, the joint in the top-most layer shall be at the lane line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating line parallel to the centre line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material. Longitudinal and transverse joints shall be offset by at least 250 mm from those in the lower courses and the joint on the top most layer shall not be allowed to fall within the wheel path. All transverse joints shall be cut vertically to the full thickness of the previously laid mix with asphalt cutter/pavement breaker and surface painted with hot bitumen before placing fresh material. Longitudinal joints shall be preferably hot joints. Cold longitudinal joints shall be properly heated with joint heater to attain a suitable temperature of about 80 °C before laying of adjacent material.

12.7.6.5 **Compaction:** After the spreading of mix, rolling shall be done by 80 - 100 kN rollers or other approved equipment. Rolling shall start as soon as possible after the material has been spread deploying a set of rollers as the rolling is to be completed in limited time frame. The roller shall move at a speed not more than 5 km/hr. Rolling shall be done with care to avoid unduly roughening of the pavement surface. **Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, the rolling shall commence at the edges and progress towards the centre longitudinally.**

**The initial or break-down rolling shall be done with 80-100 kN static weight smooth wheel roller (3 wheels or tandem), as soon as it is possible to roll the mix without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the break-down rolling with vibratory roller of 80 to 100 kN static weight or pneumatic tyred roller of 150 to 250 kN weight, with minimum 7 wheels and minimum tyre pressure of 0.7 MPa as closely as possible to the paver and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while material is still workable enough for removal of roller marks, with 60 - 80 kN tandem roller. During the final rolling, vibratory system shall be switched off. The joints and edgers shall be rolled with a 80 to 100 kN static roller.**

**When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding mix material. The rolling shall then be continued till the entire surface has been**

rolled to 95 per cent of the average laboratory density (obtained from Marshall specimens compacted as defined in Table-10), there is no crushing of aggregates and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. The roller wheel shall be kept damp if necessary to avoid bituminous material from sticking to the wheels and being picked up. In no case shall fuel, lubricating oil be used for this purpose, nor excessive water poured on the wheels.

Rolling operations shall be completed in every respect before the temperature of the mix falls below 100 °C.

**Roller(s) shall not stand on newly laid material while there is a risk that surface will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.**

**The dense bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, without any delay.**

## 12.8.0 BITUMINOUS CONCRETE

12.8.1 **Work included:** The work shall consist of constructing in a single layer, bituminous concrete of thickness 40 mm on previously prepared Bituminous Macadam (open/dense) course to the requirements of the specification.

### 12.8.2 Materials

12.8.2.1 **Bitumen:** The bitumen shall be paving bitumen of Penetration Grade (60/70) as per IS: 73 supplied from approved manufacturer in properly sealed drums to the satisfaction of the Engineer/Consultant.

12.8.2.2 **Coarse aggregates:** The coarse aggregates shall consist of crushed rock/stone, crushed gravel/shingle or other stones retained on 2.36 mm sieve. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. The aggregates shall satisfy the physical requirements set forth in Table 17.

## TABLE 17 - PHYSICAL REQUIREMENTS FOR COARSE

**OF AGGREGATES FOR  
BITUMINOUS PAVEMENT LAYERS**

<b>Property</b>	<b>Test</b>	<b>Specification</b>
Cleanliness	Grain size analysis <sup>1</sup>	Max 5% passing 0.075 mm sieve
Particle shape	Flakiness and Elongation Index	Max 30% (Combined) <sup>2</sup>
Strength*	Los Angeles Abrasion Value <sup>3</sup>	Max 30%
	Aggregate Impact Value <sup>4</sup>	Max 24%
Polishing	Polished Stone Value <sup>5</sup>	
Durability	Soundness <sup>4</sup> Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
Water Absorption	Water absorption <sup>7</sup>	Max 2%
Stripping	Coating and stripping of bitumen aggregate mixtures <sup>9</sup>	Minimum retained coating 95%
Water Sensitivity**	Retained tensile strength <sup>8</sup>	Min. 80%

- Notes:**
1. IS:2386 Part 1
  2. IS:2386 Part 1  
(the elongation test to be done only on non-flaky aggregates in the sample)
  3. IS:2386 Part 4\*
  4. IS:2386 Part 4\*
  5. BS:812 Part 114
  6. IS:2386 Part 5
  7. IS:2386 Part 3
  8. AASHTO T283\*\*
  9. IS:6241

\* Aggregate may satisfy requirements of either of these two tests.

\*\* The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

**TABLE 18 – COMPOSITION OF BITUMINOUS  
CONCRETE PAVEMENT LAYERS**



<b>Grading</b>	<b>1</b>	<b>2</b>
<b>Nominal aggregate size</b>	<b>19 mm</b>	<b>13 mm</b>
<b>Layer Thickness</b>	<b>50-65 mm</b>	<b>30-45 mm</b>
<b>IS Sieve (mm)</b>	<b>Cumulative % by weight of total aggregate passing</b>	
45		
37.5		
26.5	100	
19	79-100	100
13.2	59-79	79-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by Mass of total mix <sup>2</sup>	5.0 – 6.0	5.0 – 7.0
Bitumen grade (pen)	65	65

**Notes:** 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

12.8.2.3 **Fine aggregates:** Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crusher-run screening, gravel, sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

**TABLE 19 – REQUIREMENT FOR BITUMINOUS  
PAVEMENT LAYERS**

Minimum stability (kN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4

Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3-6
Per cent voids in mineral Aggregate (VMA)	See Table 15
Per cent voids filled with Bitumen (VFB)	65-75
Loss of stability on immersion In water at 60°C (ASTM D 1075)	Min. 75 per cent retained strength

12.8.2.4 **Filler:** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer/Consultant.

The filler shall be graded within the following limits as per Table 20.

**TABLE 20 - GRADING LIMIT OF FILLERS**

**IS Sieve Per cent passing by weight**

600 micron	..	100
300 micron	..	95-100
75 micron	..	85-100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by mass of total aggregate of portland cement or hydrated lime shall be added and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the gravel is limestone.

12.8.2.5 **Aggregates gradation:** The mineral aggregates, including mineral filler shall be so graded or combined as to conform to the grading set forth in Table-18.

**12.8.3 Mix Design**

12.8.3.1 **Requirement of mix:** Apart from conformity with the grading and quality requirements of individual ingredients, the mix shall meet the requirements as per Table-19.

12.8.3.2 **Binder content:** The binder content shall be so fixed as to achieve the requirements of the mix set forth in Table 18. Marshall method for arriving at the binder content shall be adopted.

12.8.3.3 **Job mix formula:** The Contractor shall intimate to the Engineer/Consultant in writing, at least 20 days before the start of the work, the job mix formula proposed to be used by him for the work and shall give the following details:

(i) Source and location of all materials.

(ii) Proportions of all materials expressed as follows where each is applicable.

(a) Binder, as percentage by weight of total mix;

(b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;

(iii) A single definite percentage passing each sieve for the mixed aggregate;

(iv) The results of tests as enumerated in Table 19 as obtained by the Contractor;

(v) Test results of physical characteristics of aggregates to be used.

(vi) Mixing temperature and compacting temperature.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these specifications.

For obtaining approval of the job mix formula, if required, samples of all ingredients of the mix shall be furnished by the Contractor to the Engineer/Consultant.

The approved job mix formula shall remain effective unless and until modified by the Engineer/Consultant. Should a change in the source of materials be proposed, a

new job mix formula shall be established and approved from the Engineer/Consultant before actually using the materials.

#### 12.8.4 **Workmanship**

12.8.4.1 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10° C or less.

12.8.4.2 **Preparation of base:** The base on which bituminous concrete is to be laid shall be prepared, shaped and conditioned to the specified levels, grade and cross fall (camber) as directed by the Engineer/Consultant.

Prior to the application of tack coat, all dust, dirt, loose and foreign materials etc shall be removed and the interstices of the stone aggregates in wet mix macadam shall be exposed upto a depth of 12 mm by wire brushing. Finally the surface shall be brushed with soft brushes and the dust which gets accumulated shall be thoroughly removed by dusting with gunny bags. In case the bituminous work laid on an old bituminous road the old surface shall be scarified by close application of picks, upto a depth of 12 mm for the entire area of the road.

12.8.4.3 **Tack coat:** The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction over it. The binder used for tack coat shall be a bituminous material and as approved by the Engineer/Consultant and spread on the base. The binder shall be applied uniformly with nozzles having constant volume or pressure system, capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. Work should be planned so that no more than the necessary tack coat for the day's operation is placed on the surface. After application and prior to succeeding construction the tack coat shall be allowed to cure, without being disturbed, until the water/cutter has completely evaporated, as determined by the Engineer/Consultant.

12.8.4.4 **Preparation of mix:** The bituminous concrete mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates.

Hot mix plant shall be of suitable capacity preferably of batch mix type. The total system deployed by the Contractor for crushing of stone aggregates and feeding of the aggregate fractions in required proportions to achieve the desired mix,

deployed by the Contractor must be capable of meeting the overall specifications requirements under stringent quality control.

The temperature of binder at the time of mixing shall be in the range of 150°C to 163 °C and that of the aggregate in the range of 155°C to 163 °C provided that the difference in temperature between the binder and aggregate at no time exceeds 14°C.

Mixing shall be thorough to ensure that a homogenous mixture is obtained in which all particles of the aggregates are coated uniformly, and the discharge temperature of mix shall be between 130°C to 160°C.

The mixture shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and be covered in transit if so directed by the Engineer/Consultant. Any tipper causing excessive segregation of materials by its spring suspension or other contributing factors or that which shows undue delay shall be removed from the work until such conditions are corrected.

12.8.4.5 **Spreading:** The mix transported from the hot mix plant to the site shall be spread by means of a self-propelled paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, lines and cross-section. However, in restricted locations and in narrow widths where the available equipment cannot be operated in the opinion of the Engineer/Consultant, manual laying of the mix may be permitted. Similarly for smaller jobs, mechanical paver may be used with the approval of the Engineer/Consultant.

The temperature of the mix at the time of laying shall be in the range of 120° C - 160 ° C.

Mixes with a temperature of less than 120° C shall not be put into paver spreader. Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the center line of the road. Longitudinal and transverse joints shall be offset by at least 250 mm from those in the lower courses and the joint on the top most layer shall not be allowed to fall within the wheel path. Longitudinal joints shall be preferably hot joints.

12.8.4.6 **Rolling:** After spreading the mix by paver, it shall be thoroughly compacted by rolling with a set of rollers moving at a speed not more than 5 km/h, immediately following close to the paver. Generally rolling shall be done with 80 to 100 KN static weight smooth-wheeled roller. The exact pattern of rolling shall be

established after trial compaction as approved by the Engineer/Consultant. Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good. The rollers shall not be permitted to stand on pavement which has not been fully compacted and where temperature is still more than 70°C. Necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of roller shall be kept moist to prevent the mix from adhering to them. But in no case shall fuel/lubricating oil be used for this purpose nor excessive water poured on the wheels.

Rolling shall commence longitudinally from edges and proceed towards the center, except that on superelevated and unidirectional cambered portions, it shall progress from the lower to upper edge parallel to the center line of the pavement. The roller shall proceed on the fresh material with rear or fixed wheel leading so as to minimise the pushing of the mix and each pass of the roller shall overlap the preceding one by half the width of the rear wheel.

Rolling shall be continued till the density achieved is at least 98 per cent of that of laboratory Marshall specimen (compacted as defined in Table 10) and all roller marks are eliminated. Skin patching of an area that has been rolled will not be permitted. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100° C.

## 12.9.0 **OPEN-GRADED PREMIX CARPET USING BITUMEN**

12.9.1 **Work Included:** This work shall consist of laying and compacting an open-graded carpet of 20 mm thickness in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of this specification, to serve as a wearing course.

### 12.9.2 **Materials**

12.9.2.1 **Binder :** The binder shall be bitumen of a suitable grade of 60/70 grade as per IS:73.

12.9.2.2 **Aggregates:** The coarse aggregates shall consist of crushed rock, crushed stone, crushed gravel or other hard material. The aggregates shall satisfy the quality requirement mentioned in Table-21. The Stone Polishing Value as measured by BS:812-(Part 114) shall not be less than 55.

**TABLE - 21 - PHYSICAL REQUIREMENTS OF AGGREGATES FOR  
OPEN GRADED PRE-MIX CARPET**

<b>Sl. No.</b>	<b>Test</b>	<b>Test Method</b>	<b>Requirement</b>
1.	Los Angeles Abrasion Value *	IS:2386 (Part-4)	40 per cent Maximum
2.	Aggregate Impact Value *	IS:2386 (Part-4)	30 per cent Maximum
3.	Flakiness and Elongation ** Indices (Total)	IS:2386 (Part-1)	30 per cent Maximum
4.	Water absorption	IS:2386 (Part-3)	1% (Maximum)

\* Aggregates may satisfy requirements of either of the two tests as given in Sl.Nos 1 and 2.

\*\* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

12.9.2.3 **Proportioning of materials:** The materials shall be proportioned as per quantities given in Table 22.

**TABLE 22 - QUANTITIES OF MATERIALS REQUIRED FOR  
10 M<sup>2</sup> OF ROAD SURFACE FOR 20 MM THICK  
OPEN-GRADED PREMIX CARPET USING BITUMEN**

Aggregates for Carpet

- (a) Nominal stone size - 13.2 mm size (passing 22.4 mm sieve and retained on 11.2 mm sieve) .. 0.18 m<sup>3</sup>
- (b) Nominal stone size - 11.2 mm size (passing 13.2 mm sieve and retained on 5.6 mm sieve) .. 0.09 m<sup>3</sup>

Total  
.. 0.27 m<sup>3</sup>

**Binder (quantities in terms of straight run bitumen)**

- (a) For 0.18 m<sup>3</sup> of 13.2 mm nominal stone size at 52 kg per m<sup>3</sup> .. 9.5 kg
- (b) For 0.09 m<sup>3</sup> of 11.2 mm nominal stone size at 56 kg per m<sup>3</sup> .. 5.1 kg

Total .. 14.6 kg

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**12.9.3 Workmanship**

**12.9.3.1 Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or the base course is damp or free standing water is present on the surface or atmospheric temperature is less than 10°C.

**12.9.3.2 Preparation of base:** The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-section. A prime coat where needed shall be applied as directed by the Engineer/Consultant.

**12.9.3.3 Preparation of premix:** Hot mix plant of appropriate capacity and type shall be used for the preparation of mix material. The hot mix plant shall have separate dryer arrangement for heating aggregates and pugmill for mixing aggregates and binder.

The temperature of binder at the time of mixing shall be in the range of 150°C to 163°C and that of the aggregates in the range of 155°C to 163°C provided that the difference in temperature between the binder and aggregates at no time exceeds 14°C. Mixing shall be thorough to ensure that a homogeneous mixture is



obtained in which all particles of the aggregates are coated uniformly and the discharge temperature of mix shall be between 130°C and 160°C.

The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and the mix being transported covered in transit if so directed by the Engineer/Consultant.

12.9.3.4            **Spreading and rolling** : The mixed material shall be spread by suitable means. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 80-100 KN rollers, preferably of smooth wheel tandem type, or other approved equipment. Rolling shall begin at the edge and progress toward the centre longitudinally, except that on the super elevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Excess use of water for this purpose shall be avoided.

Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby. Rolling operations shall be completed in every respect before the temperature of the mix falls below 100°C.

The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

#### 12.10.0            **SEAL COAT**

12.10.1            **Work included:** The work shall consist of application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber). Seal coat shall be pre-mixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

#### 12.10.2            **Material**

12.10.2.1 **Bitumen:** The bitumen shall be paving bitumen of Penetration Grade 60/70 as per IS: 73. The quantity of bitumen shall be 6.8 kg per 10 sq m area .

12.10.2.2 **Aggregates for seal coat:** The aggregates shall be sand or grit and shall consist of clean, hard, durable uncoated dry particles and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregates pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cu m per 10 sq m area.

### 12.10.3 **Construction operations**

12.10.3.1 **Weather & seasonal limitations:** The requirements of clause 9.3.1 shall apply.

12.10.3.2 **Preparation of surface:** The seal coat shall be applied immediately after the laying of bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other extraneous matter.

12.10.3.3 **Preparation and application of seal coat:** A mixer of appropriate capacity and type approved by the Engineer/Consultant shall be used for preparation of the mixed material. The plant shall have separate arrangement for heating aggregate.

The binder shall be heated in a boiler to a temperature conforming to the grade of bitumen used and as directed by the Engineer/Consultant. The aggregate shall be equally heated to a temperature 150°C to 160°C, before these components are placed in the mixer. Mixing of binder with aggregates to the specified proportion shall be continued till both are thoroughly mixed.

The mix shall be immediately transported to the point of use and spread uniformly on bituminous surface to be sealed.

As soon as sufficient length is covered with pre-mixed material, the surface is rolled with 80-100 KN smooth wheeled roller. Rolling shall be continued until pre-mix material completely seals the void in the bituminous course and smooth uniform surface is obtained.

12.10.3.4 **Opening to traffic:** Traffic may be allowed soon after final rolling when pre-mixed material has been cooled down to the surrounding temperature.

### 12.11.0 **TRAFFIC SIGNS:**

The colour, configuration, size of location of all traffic signs for highways is in accordance with IRC 67-1977, or as shown in drawings. The signs shall be either reflectorised or non-reflectorised as shown on the drawings or as directed.

12.11.1 **Materials:**

The various materials and fabrication of the Traffic Signs shall conform to Ministry of Surface Transport, Specifications for roads and bridge works – (fourth revision).

12.11.2 **Installation:**

Sign posts, their foundations and sign mountings shall be as indicated in the drawings.

12.12.0 **ROAD MARKINGS:**

The colour width and layout of road markings shall be in accordance with the code of practice for road markings with paints IRC – 35 – 1970.

12.12.1 **Lane Markings:**

Traffic lane lines shall be single broken lines, their width shall be 10 cm (4 inches) and the length of segments and gaps shall be as under:

On straight reaches	1.5 metres segments and 4.5 metres gaps
On curves and Approaches to intersection	1.5 metres segments and 1.5 metres gaps

12.12.2 **Arrow Markings:**

The size and location shall be as indicated in the drawings.

12.13.0 **QUALITY CONTROL FOR ROAD WORK**

12.13.1 **General:** All materials to be used, all methods adopted and all works performed shall be strictly in accordance with the requirement of these specification. The Contractor shall set up a field laboratory at locations approved by the Engineer/Consultant and equipment at the same with adequate and personnel in

order to carry out all required tests and quality control work as per specification/as directed by Engineer/Consultant.

12.13.2 The method of sampling and testing of materials shall be as required by the “Handbook of Quality Control for Construction of Roads and Runways” (IRC:SP:11) and as per this specification.

12.13.3 All materials which the Engineer/Consultant has determined as not conforming to the requirements of the specification shall be rejected and removed from the site with immediate effect as directed. Materials which have been subsequently corrected, shall not be used in the work unless otherwise approval is accorded from Engineer/Consultant.

#### 12.13.4 **Control of Alignment, Level and Surface Regulations**

12.13.4.1 **Horizontal Alignment:** The edges of the carriage way shall be correct within a tolerance of  $\pm 10$  mm and  $\pm 25$  mm from the central line of the road and lower layer of the road respectively.

12.13.4.2 **Surface Level:** The tolerance limit of the surface level is mentioned in the Table-23 on the next page.

**TABLE 23 – TOLERANCES IN SURFACE LEVELS**

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1.	Subgrade	+20 mm
		-25 mm
2.	Sub-base +10 mm	
	(a) Flexible pavement	-20 mm
3.	Base-course for flexible pavement	
	(a) Bituminous course	+6 mm
		-6 mm
	(b) Other than bituminous	+10 mm
	(i) Machine laid	-10 mm
		+15 mm
	(ii) Manually laid	-15 mm
4.	Wearing course for flexible pavement	
	(a) Machine laid	+6 mm

	-6 mm
(b) Manually laid	+10 mm
	-10 mm

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For checking compliance with the above requirement for subgrade, sub-base and base courses, measurements of the surface levels shall be taken on a grid of points placed at 6.25 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

12.13.4.3 **Surface Regularity of Pavement Courses:** The maximum number of surface irregularities shall be as per Table-24 on the next page.

**TABLE 24 - MAXIMUM PERMITTED NUMBER OF SURFACE IRREGULARITIES**

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Irregularity	4 mm		7 mm		4 mm		7 mm	
Length(m)	300	75	300	75	300	75	300	75
Roads of lower Category*	40	18	4	2	60	27	6	3

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The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer/Consultant shall be:

(a) For pavement surface .. 3 mm

(bituminous)

- (b) For bituminous base courses .. 6 mm
- (c) For granular sub-base/base courses.. 8 mm

#### 12.13.5 **Quality Control Tests during Construction**

12.13.5.1 **Tests on Earthwork for Embankment:** Grid the area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for proper identification of suitable sources of material. The following tests on representative samples shall be carried out:

- (a) Sand Content (IS:2720 (Part-4): 2 tests per 3000 cubic metres of soil.
- (b) Plasticity Test (IS:2720 (Part-5): Each type to be tested, 2 tests per 3000 cub, metres of soil.
- (c) Density Test (IS:2720 (Part 8): Each soil type to be tested, 2 tests per 3000 cube metres of soil.
- (d) Deleterious Content Test (IS:2720 (Part-27): As and when required by the Engineer/Consultant.
- (e) Moisture Content Test (IS:2720 (Part-2): One test for every 250 cubic metres of soil.
- (f) CBR Test on materials to be incorporated in the sub-grade on soaked/unsaturated samples (IS:2720 (Part-16): One CBR test for every 3000 cu m atleast or closet as and when required by the Engineer/Consultant.

12.13.5.2 **Compaction Control:** Control shall be exercised on each layer by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS:2720 (Part-28). Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 6 (if non-destructive tests are carried out, the number of tests shall be doubled) as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between

individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus.

$$1.65 - \frac{1.65}{(\text{No. of samples})^{0.5}} \text{ times the standard deviation}$$

However, for earthwork in shoulders (earthen) in the subgrade, at least one density measurement shall be taken for every 500 square metres for the compacted area provided further that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

12.13.5.3 **Formation Control:** Same as that of Clause No. 11.5.2.

12.13.6 **Tests on Granular Sub Base:** This shall be done as per Table-25.

**TABLE 25 – CONTROL TESTS AND THEIR MINIMUM  
FREQUENCY FOR SUB-BASES AND BASES  
(EXCLUDING BITUMEN BOUND BASES)**

Sl. No.	Type of Construction	Test	Frequency (min.)
1.	Granular	i) Gradation	One test per 200 m <sup>3</sup>
		ii) Atterberg limits	One test per 200 m <sup>3</sup>
		iii) Moisture content prior to compaction	One test per 250 m <sup>2</sup>
		iv) Density of compacted layer	One test per 500 m <sup>2</sup>
		v) Deleterious constituents	As required
		vi) C.B.R	As required
2.	Wet Mix Macadam	i) Aggregate Impact Value	One test per 200 m <sup>3</sup> of aggregate
		ii) Grading	One test per 100 m <sup>3</sup> of aggregate
		iii) Flakiness and Elongation Index	One test per 200 m <sup>3</sup> of aggregate
		iv) Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100 m <sup>3</sup> of aggregate

v) Density of compacted layer One test per 500 m<sup>2</sup>

The acceptance criteria for the test is that the main value is not less than the specified value + 1.65 - 1.65

$$\left[ \frac{\text{No. of samples}}{0.5} \times \right]$$

standard deviation.

### 12.13.7 Tests on Bituminous Work

**TABLE 26 - CONTROL TESTS FOR BIOTUMINOUS WORKS, AND THEIR MINIMUM FREQUENCY**

Sl. No.	Type of Construction	Test	Frequency (min.)
1.	Prime Coat/Tack Coat	i) Quality of binder	Number of samples per lot and tests as per IS:73, IS:217 & IS:8887 as applicable.
		ii) Binder temperature	At regular close intervals for application
		iii) Rate of spread of binder	One test per 500 m <sup>2</sup> and not less than two tests per day.
2.	Seal Coat	i) Quality of Binder	Same as mentioned under Serial No. 1.
		ii) Aggregate Impact Value/Los Angeles Abrasion Value	One test per 50 m <sup>3</sup> of aggregate
		iii) Flakiness Index and Elongation Index	- do -
		iv) Stripping value of	Initially one set of 3



aggregates (Immersion Tray Test) representative specimens for each source of supply. Subsequently when Warranted by changes in the quality of aggregates.

v) Water absorption of aggregates - do -

vi) Water sensitivity of mix Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates (if required).

vii) Grading of aggregates One test per 25 m<sup>3</sup> of aggregate.

viii) Soundness (Magnesium and Sodium Sulphate) source of supply, then as Initially, one determination by each method for each warranted by change in the quality of the aggregates.

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Sl. No.	Type of Construction	Test	Frequency (min.)
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ix) Polished stone value As required.

x) Temperature of binder at application At regular close intervals

xi) Rate of spread of materials One test per 500 m<sup>2</sup> of work, and not less than

two tests per day.

xiii) Percentage of fractured facestest per 50 m<sup>3</sup> of aggregate      When gravel is used, one

3. Open-graded/  
Dense-graded  
Premix carpeting
- i) Quality of binder      Same as mentioned under Serial No. 1.
  - ii) Aggregate Impact Value/Los Angeles Abrasion Value      Same as mentioned under Serial No. 2.
  - iii) Flakiness Index and Elongation Index.      - do -
  - iv) Stripping value      Same as mentioned under Serial No. 2.
  - v) Water absorption of aggregates under      Same as mentioned under Serial No. 2.
  - vi) Water sensitivity of mix      Same as mentioned under Serial No. 2.
  - vii) Grading of aggregates under Serial No. 2      Same as mentioned under Serial No. 2.
  - viii) Soundness (Magnesium and Sodium Sulphate)      Same as mentioned under Serial No. 2.
  - ix) Polished stone value      As required.
  - x) Temperature of binder intervals      At regular close      at
  - xi) Binder content      One test per 500m<sup>3</sup> and not less than two tests per day.

	xii) Rate of spread of mixed material	Regular control through checks of layer thickness	
	xiii) Percentage of fractured faces	Same as mentioned under Serial No. 2	
4.	Bituminous Macadam	i) Quality of binder	Same as mentioned under Serial No. 1
		ii) Aggregate Impact Value	Same as mentioned under Serial No. 2
		iii) Flakiness Index and Elongation Index	Same as mentioned under Serial No. 2
			Value/Los

Sl. No.	Type of Construction	Test	Frequency (min.)
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	iv) Stripping Value	Same as mentioned under Serial No. 2
	v) Water sensitivity of mix	- do -
	vi) Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer.
	vii) Water absorption of aggregates	Same as in Serial No. 2
	viii) Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No. 2
	ix) Percentage of fractured faces	Same as mentioned under Serial No. 2.
	x) Binder content and	Periodic, subject to

	aggregate grading	of two tests per day per plant
	xi) Control of temperature intervals of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close
	xii) Rate of spread of mixed material	Regular control through checks of layer thickness
	xiii) Density of compacted layer	One test per 2.50m <sup>2</sup> of area
5.	Dense Bituminous Macadam/Bituminous Concrete	i) Quality of binder Same as mentioned under Serial No. 1
	ii) Aggregate Impact Value/Los Angeles Abrasion Value	Same as mentioned under Serial No. 2
	iii) Flakiness Index and Elongation Index	- do -
	iv) Stripping Value	Same as mentioned under Serial No. 2
	v) Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No. 2

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Sl. No.	Type of Construction	Test	Frequency (min.)
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vi) Water absorption of aggregates	As in Serial No. 2.	
vii) Sand equivalent test	As required.	
ix) Polished stone value	As required, for Semi Dense Bituminous Concrete/Bituminous Concrete	
x) Percentage of fractured faces	Same as mentioned under Serial No. 2.	
xi) Mix grading	One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests	per
plant per day.	xii) Stability of Mix	For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being tested per plant per day.
xiii) Water sensitivity of mix (Retained Tensile Strength)	Same as mentioned under Serial No. 2	
xiv) Swell test on the mix	As required for the Bituminous Concrete.	
xv) Control of temperature of binder in boiler, aggregate in	At regular close intervals	

the dryer and mix at the time of laying and rolling.

- xvi) Control of binder content and grading of the mix      One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
- xvii) Rate of spread of mixed material      Regular control through checks on the weight of mixed material and layer thickness
- xviii) Density of compacted layer      One test per 250 m<sup>2</sup> area

The acceptance criteria shall be as per 13.6.

12.13.8 **Rectification:** The rectification work (if required) shall be done as per the direction of Engineer/Consultant and/or as per the specification for road and bridge works under Ministry of Road Transport and Highways (MORTH) (4<sup>th</sup> Revision).

**LIST OF APPROVED MAKES OF MATERIALS**

SL.	ITEM OF WORK	APPROVED MAKES		
<b>A</b>	<b>CIVIL</b>			
1	CEMENT	ACC	ULTRATECH	KONARK
2	STEEL	SAIL	TATA TISCON	JINDAL
3	VITRIFIED TILES	SOMANY	KAJARIA	NITCO
4	CERAMIC TILES	SOMANY	KAJARIA	NITCO
5	GLAZED TILES	SOMANY	KAJARIA	NITCO
6	CLADDING CONCRETE TILES / CONCRETE TILE FOR PAVING / INTERLOCKING BLOCKS	AMAN	EUROCON	PAVIT
7	WALL PUTTY	LATICRETE	BIRLA	JK WALL PUTTY

8	PLASTIC EMULSION PAINTS-LOW VOC	ASIAN	BERGER	DULUX
9	WEATHER COAT PAINT- LOW VOC	ASIAN	BERGER	DULUX
10	ENAMEL PAINT	ASIAN	BERGER	DULUX
11	TEXTURED PAINT	ASIAN	BERGER	DULUX
12	EPOXY PAINT	ASIAN	BERGER	DULUX
13	WATER PROOFING	SIKA	FOSROC	PIDILITE
14	MS/SS SECTIONS	SAIL	TATA TISCON	JINDAL
15	UPVC WINDOWS	TORFENSTER	REHAU	FENESTA
17	FLUSH DOOR	GREEN	SONEAR	MERINO
18	LAMINATES	SONEAR	GREEN	MERINO
19	LOCKS/HANDLES/HARDWARE	DORMA	DORSET	HAFELLE
20	GLASS	SAINT GOVIN	MODIGUARD	EQUIVALENT
21	EPOXY GROUT	LATICRETE	DOW	EQUIVALENT
22	POLYCARBONATE SHEETS	DUNPALON	GE	EQUIVALENT

#### WATER SUPPLY & SANITARY INSTALLATION

SL no	Material	Make
1	Sanitary ware	Jaquar/ Parryware/Kohler
2	Toilet Accessories	Jaquar/ Parryware/Kohler
3	CP fittings	Jaquar/ Parryware/Kohler
4	Water closet seats & Cisterns	Jaquar/ Parryware/Kohler
5	Mirrors	Saint Gobain / Modi/Atul
6	Kitchen sink	Franke / Diamond / Nirali
7	uPVC pipes & fittings	Astral /supreme/Ashirbad

8	Manhole frame & cover in Fiber reinforced concrete	Southern Concrete Industries / Approved Equivalent
9	Manhole PVC steps	Southern Concrete Industries / Approved Equivalent
10	CPVC Pipes & Fittings	Astral /Supreme /Ashirvad
11	polyethylene TANKS	SINTEX/RHINO/SUDHAKAR

**Note: OPGC decision regarding the MAKE shall be final.** However if due to non-availability or any other technical reasons, the alternative make is allowed, it shall be subject to prior approval of the Project Manager.

**1. The contractor shall produce all samples including natural stones, before procurement of the materials, for approval of the OPGC/Architects/Project Managers.**

## **PART B: TECHNICAL SPECIFICATION for STRUCTURAL STEELWORK & CLADDING**

### **1.0 DESIGN PARAMETERS AND CONSIDERATIONS FOR STRUCTURAL STEELWORK & CLADDING**

#### **1.1 General**

1.1.1 This section covers the design criteria for structural steelwork and provides guidelines for the design of steel structures for various units. The design of the steel structures shall provide for the appropriate conditions of loading, stresses, deflection and stability requirements, effect of both static and dynamic loads, effect of weather, provisions for thermal expansion, natural lighting and ventilation, roof drainage system etc. The design shall also cater to repair and service facilities with access for maintenance of cranes, cladding and other services. Moreover, the design shall take into account facilities for fabrication, transportation, storage, erection, maintenance and construction. The objective of the design shall be function, service, economy and safety.

1.1.2 The design of steel structures in general shall be according to IS:800. The provisions of "Factory Rules" and/or as stipulated by the local authorities shall be followed. The design shall also conform to the statutes laid down by Central Pollution Control Board, New Delhi and/or any other regulatory bodies.



1.1.3 A list of relevant IS Codes of latest edition is indicated in Annex-1 enclosed. All work shall be based on the latest Codes.

## **1.2 Architectural Planning**

1.2.1 Any addition of unplanned annexes such as lean-to to the main buildings at a later stage is not recommended and shall be avoided as far as possible.

1.2.2 Roof with 1:5 slope shall generally be adopted for pitched roof buildings. Adequate measures to be taken to prevent ingress of rain water through the side and end laps of roof and side cladding.

### 1.3 Height of Premises

1.3.1 Sufficient head room shall be kept above the crane rail for the passage of the crane and height above the crane top to the bottom part of roof structure shall not be less than 200mm. However, minimum headroom of 2000mm to be kept above any platform on the crane to underside of structural member or any other permanent object.

1.3.2 In general, for all buildings minimum clear height between floors to be kept as 3.5m unless more height is required from some other considerations.

### 1.4 Material

1.4.1 **Structural steel:** Rolled steel sections and plates up to 20mm thickness shall be semi-killed and conform to IS:2062 Grade E 250 (Fe 410W), Quality A. Plates above 20 mm thickness shall be killed and conform to IS:2062 Grade E 250 (Fe 410W) Quality B. Sections and plates made of medium or high tensile steel shall conform to IS:8500 or equivalent. Abrasion resistant steel liner plates shall be TISCRAAL upto 12mm thick and SAIL HARD for more than 12mm thick. Chequered plates shall conform to IS:3502/IS :2062 Grade E 250(Fe 410W), Quality A. All plates 40mm thick and above used in crane girders and similar dynamically loaded structures shall be of UT grade. Plates below 40mm thick for such application shall be ultrasonically tested at site. Weathering Steel (SAILCOR) may be used for areas such as roof over slag yard pits. Crane rails shall conform to IS:3443 or equivalent. Steel Tubes shall conform to grade Yst 240 of IS:1161. Cold formed Structural Hollow steel sections shall conform to Grade Yst 310 of IS:4923. All structural steel shall be free from rust, scales, laminations, cracks, fissures and other surface defects.

Material of gutters, collector pipes and downpipes shall be

Gutters - Mild steel of minimum 6mm thickness

Collector pipe - Mild steel of minimum 5mm thickness

ERW pipes may be used subject to minimum thickness requirements.

1.4.2 **Bolts and Nuts:** All bolts and nuts shall conform to IS:1363 or IS:1364 as applicable. Nuts shall have property class conforming to IS:1367 compatible to the property class of the mating bolts. High strength structural bolts and nuts shall conform to IS:3757 and IS:6623 respectively.

1.4.3 **Washers:** Plain washers shall conform to IS:2016 unless otherwise specified. Each bolt shall be provided with one washer and in case of special type of bolts more than one washer as needed for the purpose shall be provided. An additional double coil helical spring washer conforming to IS:6755 shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Taper washers conforming to IS:5372 and IS:5374 shall be used for channels (MC) and I-beams (MB) respectively. Washers for high strength structural bolts and nuts shall conform to IS:6649.

## 1.5 Roof and Side Coverings

**General:** Roof and walls of structural buildings and galleries shall be covered with Pre-coated sheets and matching FRP sheets/Polycarbonate sheets on walls. Additional FRP sheets on roof, matching with Pre-coated sheets, shall be used for buildings. Suitably designed safety guard, made of structural steel, shall be used below FRP sheet on roof in order to avoid accident due to breakage of FRP sheets during roof maintenance.

**Pre-Coated Sheets:** Pre-colour coated sheets used in roof and walls shall be of trapezoidal profile with galvanized processed steel substrate. Stainless steel self tapping screws, having washers built monolithically with the screw head and with bonded EPDM washers shall be used for fastening the sheets.

## 1.6 Minimum Thickness of Metal

1 For minimum thickness of metal provisions under IS:800 shall generally be followed.

1.6.2 Sealed tubes and sealed hollow box sections used for external construction exposed to weather shall not be thinner than 4mm and for construction not exposed to weather shall not be thinner than 3.2mm. Where structures are not readily accessible for maintenance the minimum thickness shall be 5mm. However, for secondary members like handrails 2.5mm thickness may be adopted.

## 1.7 Type of Structures

1.7.1 **Shop construction:** All steel structures shall be designed and constructed as welded, conforming to guidelines of IS:816 and IS:9595.

1.7.2 **Site connection:** Site connection shall be made welded or bolted with high strength structural bolts for connections of all important structural elements carrying heavy loads, moments or dynamic loads. For secondary members carrying static loads of small magnitude e.g. purlins, side runners, hangers, handrails, stairs, ladders, small platforms, gangways etc., ordinary unfinished bolts may be used. All unfinished bolts under direct tension and vibration shall be provided with lock nuts/spring .

washers. Where site connections are developed by welding, necessary erection bolts, minimum two numbers at each end, shall be provided. However, number of bolts provided shall be sufficient to carry the dead load prior to welding.

### 1.7.3 Splices in structures

1.7.3.1 **Shop splice:** Where shop splices in plates are necessary due to non-availability of members in required lengths, full penetration defect free sound butt welds shall be made. Shop splices in rolled steel angles, joists and channels shall preferably be developed by fillet welding and cover plates, angles etc. In case butt welds in rolled sections are called for, complete detail of face preparation and procedure of welding to achieve defect free weld shall be furnished in the drawings.

1.7.3.2 **Site splice:** Site splices for members required due to transportation, assembly and erection facilities shall be developed by fillet welds or high strength structural bolts with necessary cover plates and angles etc. In case butt welding in plates is employed for site splice, the same shall be sound, defect free and of full penetration and shall be carried out with run-on and run-off plates having same edge preparation. After welding run-on and run-off plates shall be removed.