

VOLUME II - A

Technical specification

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Sub-Section - C1
**Technical specification for excavation and
filling**

Sub-Section - C1
Technical specification for excavation and filling

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Section - C1: Technical specification for excavation and filling

1. Scope

- 1.1 This section of the specification covers the technical requirements for excavation and filling for industrial plots in & around structures, buildings, pipes, foundations, trenches, pits, drains, channels, cable ducts, underground facilities & similar works. It also covers filling areas and plinths with selected materials, conveyance and disposal of surplus soils and/or stacking them properly as directed by the Engineer.
- 1.2 The contractor shall be fully responsible for getting necessary permission from government authorities to excavate soil from the sources mentioned in the tender and should pay necessary seignorage charges to government authorities as per rules.
- 1.3 The Contractor shall be fully responsible for proper setting out of works, profiling in excavation, stacking, etc., taking adequate safety measures etc. The Contractor shall carry out all works meant within the intent of this specification even if not explicitly mentioned herein. All work shall be executed to the satisfaction of the Engineer.
- 1.4 Existing trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, drains, sewers, or other surface or subsurface systems/drains/facilities within or adjacent to the works being carried out which are not to be disturbed, shall be protected from damage by the Contractor shall provide and install suitable safeguards approved by the Engineer for this purpose.
- 1.5 During excavation, the Contractor shall take all necessary precautions against soil erosion, water & environmental pollution and where required to undertake additional works to achieve this objective. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan and the procedure he intends to follow for disposal of waste materials etc. and the schedule for carrying out temporary and permanent control works. However, the approval of the Engineer to such plans and procedures shall not absolve the Contractor of his responsibility for safe and sound work.

2. General requirements

- 2.1 The Contractor shall make his own surveying arrangements for locating the coordinates and positions of all work and establishing the reduced levels (RL's) at these locations based on two reference grid lines and one benchmark which will be furnished by the Owner. The Contractor has to provide at site all the required survey instruments, along with qualified surveyors, to the satisfaction of the Engineer so that the work can be carried out accurately and according to the specification and drawings.
- 2.2 The Contractor shall furnish all skilled and unskilled labour, plant, tools, tackle, equipment, men, materials required for complete execution of the work in accordance with the drawings and as described herein and/or as directed by the Engineer.

- 2.3 The Contractor shall control the grade in the vicinity of all excavations so that the surface of the ground will be properly sloped or dyed to prevent surface water from running into the excavated areas during construction.
- 2.4 All materials obtained from excavation shall remain owner's property. All salvaged materials of archeological importance or of value (in the opinion of the Engineer) shall be segregated from the other materials and both stacked separately and in regular manner at locations indicated by the Engineer.
- 2.5 Excavation shall include removal of trees including roots & organic remains, vegetation, grass, bushes, shrubs, plants, poles, fences, etc. that are in the area to be excavated as well as beyond the excavation line so as to ensure safety of the excavated side slopes, and of men and equipment operating in the area. Before start of excavation work, joint measurements of ground level shall be taken after cleaning all grass, vegetation, etc.
- 2.6 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance as decided by the Engineer to permit the placing and setting of forms, inspection and completion of all works to the satisfaction of the Engineer for which the excavation was done.
- 2.7 Wherever reference is made to 'drawings' in this specification it shall mean the latest issue of the approved drawings.

3. Codes and standards

- 3.1 All standards, specifications, acts, and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.
- 3.2 In case of conflict between this specification and those (IS standards, codes etc.) referred to herein (in para 3.3) the former shall prevail.
- 3.3 Some of the relevant Indian standards, Acts and Codes are referred to here below:

IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:2720 (Part-II, IV to VIII, XIV, XXI, XXIII, XXIV XXVII to XXIX, XL)	Methods of tests for soils - determination of water content etc.
IS:3764:	Safety code for excavation work
IS:4081:	Safety code for blasting and related drilling operations
IS:4701:	Code of Practice for earth work on canals

IS:9759:	Guide lines for Dewatering during construction.
IS:10379:	Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.
IS:3812	Pulverised fuel ash – specification part 2 for use as admixture in cement mortar and concrete

4. Excavation

- 4.1 Excavation in all types of soils, soft and disintegrated rock (ordinary rock), and hard rock shall be done up to the required level. Excavation shall also include breaking of existing concrete RCC, Masonry work, tar and bitumen surfaces, and paving works etc. In case blasting is required the same shall be subject to the approval of Engineer. Sides and bottoms of excavation shall be cut sharp and true to line and level. Undercutting shall not be permitted. When machines are used for excavation, the last 300 mm before reaching the required level shall be excavated manually or by such equipment that soil at the required final level will be left in its natural condition. Suitability of strata (at the bottom of excavations) for laying the foundation thereon shall be determined by the Engineer.
- 4.2 Excavation for foundations shall be to the bottom of lean concrete and as shown on drawings or as directed by the Engineer. The bottom of all excavations shall be trimmed to required levels and when excavation is carried below such levels, by error, it shall be brought back to specified level by filling with concrete of nominal mix 1:3:6/1:4:8 (cement & Fly ash (20% replacement ratio of cement with fly ash): coarse sand : 20mm down aggregates) as directed by the Engineer.
- 4.3 The Contractor shall ascertain for himself the nature of materials to be excavated and the difficulties, if any, likely to be encountered in executing this work. Cofferdams, Sheeting, shoring, bracing, maintaining suitable slopes, draining etc. shall be provided and installed by the Contractor, to the satisfaction of the Engineer.
- 4.4 All excavation for installation of underground facilities, such as piping, sewer lines, drain lines, etc. shall be open cuts. For deep and huge excavations and in other excavations, if required by the Engineer, the Contractor shall submit for Engineer's approval (as already mentioned under Clause 1.5) an "Excavation scheme" showing the methodology to be adopted for excavation in order to maintain the stability of side slopes, means for ensuring safety of existing facilities nearby, dewatering as required etc. However, the Contractor shall be fully responsible for the scheme irrespective of any approvals granted. Benching shall be provided for deeper excavation wherever required.
- 4.5 When excavation requires bracing, sheeting or shoring etc., the Contractor shall submit drawings to the Engineer, showing arrangements and details of proposed installation. The Contractor shall also furnish all supporting calculations as called for and shall not proceed until he has received written approval from the Engineer. However, the responsibility for adequacy of such bracing, sheeting, shoring etc. will

rest with the Contractor, irrespective of any approval of the Engineer. All precautions shall be taken while excavations near existing structures are to be carried out till the backfilling is completed.

- 4.6 The Contractor shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, ground water, springs etc. and maintain dry working conditions at all times until the excavation, placement of reinforcement, shuttering, concreting, backfilling is completed. The Contractor shall remove all slush/muck from the excavated areas to keep the work area dry. Sludge pumps, if required, shall be employed by the Contractor for this purpose.
- 4.7 The Contractor shall remove all materials arising from excavations from the vicinity of the work either for direct filling, stacking and subsequent filling or for ultimate disposal as directed by the Engineer. In no case shall the excavated soil be stacked within a distance of 1.5m from the edge of excavation or one third the depth of excavation whichever is more. Material to be used for filling shall be kept separately as directed by the Engineer.

5. Filling

5.1 Materials

- a) Materials to be used for filling purposes shall be stone, sand or other inorganic materials and they shall be clean and free from shingle, salts, organic, large roots and excessive amount of sod. Lumps concrete or any other foreign substances which could harm or impair the strength of the substructure in any manner. All clods shall be suitably broken to small pieces. When the material is mostly rock boulders, these shall be broken into pieces not larger than 150mm size. Sand used for filling shall be clean, medium grained and free from impurities. Fines less than 5 microns shall not be more than 20%. In any case, the materials to be used for filling purposes shall have the prior written approval of the Engineer.
- b) If excavated materials are to be used for filling, then the Contractor shall select the materials from the stockpile, load and transport this material and execute the filling. This shall include excavation of earth which may become hard due to laying in stack yard for a long period of time.
- c) In case the materials have to be brought from pits/quarries, then it shall be the Contractor's responsibility for identification of such quarry areas, obtaining approval for their use from concerned authorities, excavation/quarrying, loading and carriage of such material, unloading and filling at specified locations. The Contractor shall pay any fees, royalties etc. that may have to be paid for utilization of borrow areas.

5.2 Filling procedure

- a) After completion of foundation, footings, walls and other construction below the elevation of the final grades, and prior to filling, all temporary shoring, timber, etc.

shall be sequentially removed and the excavation cleaned of all trash, debris and perishable materials. Filling shall begin only with the written approval of the Engineer. Also, areas identified for filling shall be cleared of all soft pockets, vegetation, bushes, slush etc. In case of plinth and similar filling the ground shall be dressed and consolidated by ramming and light rolling.

- b) Fill materials shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage. Filling shall be started after the concrete/masonry has fully set and shall be carried out in such manner so as not to cause any undue lateral thrust on any part of the structure.
- c) All space between foundation (concrete or masonry) and the sides of excavation shall be filled to the original surface after making allowance for settlement. Fill shall be placed in horizontal layers not exceeding 200mm loose thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction/density as specified. Trucks or heavy equipment for depositing or compacting fill shall not be used within 1.5 metres of building walls, piers or other facilities which may be damaged by their weight or operations. The methods of compaction shall be subject to the approval of the Engineer. Pushing of earth for filling shall not be adopted under any circumstances.
- d) Fill adjacent to pipes shall be free of stones, concrete, etc. and shall be hand placed and compacted uniformly on both sides of the pipe and where practicable upto a minimum depth of 300mm over the top of pipes. While tamping around the pipes, care should be taken to avoid unequal pressure.
- e) Filling shall be accurately finished to line, slope, cross section and grade as shown on the drawings. Finished surface shall be free of irregularities and depressions and shall be within 20mm of the specified level.
- f) Where filling with stone from excavated materials is required, as per design and functional requirements, it shall be from broken pieces of boulders. At first a 75mm thick cushion of selected earth shall be laid over which the 200mm thick graded stones shall be laid in loose layers of 200mm and then the interstices filled with properly graded fine materials consisting of selected earth brought from borrow areas. Each layer shall be watered and compacted to the required density as per design and functional requirements before the next layer is laid. However, no cushion shall be required where filling is over non-rocky surface.
- g) Where clean stone fill is required as per design and functional requirements it shall consist of clean selected stone metal of 40mm nominal size. It shall be laid in layers not exceeding 150mm (loose) and lightly tamped before the next layer is laid. No compaction shall be required for this type of stone filling.

5.3 **Compaction**

- a) Where compaction of 90% Standard Proctor Density is called for, such compaction shall be by mechanical means but the contractor may be permitted to adopt manual means only if the Engineer finds that the desired compaction is achievable in the field.
- b) Where compaction to 95% Standard Proctor Density is called for, it shall be by mechanical means only. Where access is possible, compaction shall be 12 tonne rollers smooth wheeled, sheep foot or wobbly wheeled and directed by the Engineer. A smaller weight roller may be permitted by the Engineer in special cases, but in any case not less than 10 passes of the roller will be accepted for each layer. Each layer shall be wetted or the material dried by aeration to a moisture content of 3-5% above the Optimum Moisture Content to be determined by Contractor. Each layer shall be watered, rammed and compacted to the density as specified in the Schedule of Quantities.
- c) For compacting each sand layer, water shall be sprayed over it to flood it and it shall be kept flooded for 24 hours to ensure maximum compaction. Vibro-compactors shall also be used if necessary to obtain the required degree of compaction. Any temporary works required to contain sand under flooded condition shall also be undertaken. The surface of the consolidated sand shall be dressed to required levels or slope.
- d) After the compacted fill has reached the desired level, the surface shall be flooded with water for 24 hours, allowed to dry and then rammed and consolidated to avoid any settlement, at a later date. The compacted surface shall be properly shaped, trimmed and consolidated to an even gradient or level. All soft spots shall be excavated, filled and consolidated.
- e) The degree of compaction of compacted fill in place will be subject to tests in accordance with relevant Indian Standards as desired by the Engineer. As the work progress, the Contractor shall provide the necessary facilities to make such tests. If any test indicates that the compaction achieved is less than the required as per design and functional requirements degree of compaction, the Engineer may require all fill placed subsequent to the last successfully test to be removed and re-compacted by the Contractor. Compaction procedure shall be amended as necessary to obtain satisfactory results.
- f) When semi-compacted fill is required as per design and functional requirements by the Engineer, the Contractor shall fill up such areas with available earth from stock piles or borrow pits or directly from excavation without special compaction except that obtained by moving trucks, etc.

6. Sampling testing and quality control

6.1 General

- a) The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards and shall conduct such

tests as are called for by the Engineer. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer. Tests shall be done in the field and at a laboratory approved by the Engineer and the Contractor shall submit to the Engineer, the test results in triplicate within three days after completion of a test. The Engineer may, at his discretion, waive some of the stipulations given below, for small and unimportant operations.

- b) Work found unsuitable for acceptance shall be removed and replaced by the Contractor. The work shall be redone as per specification requirement and to the satisfaction of the Engineer.
- c) Only as a very special case and that too in non-critical areas, the Engineer may accept filling work which is marginally unacceptable as per the criteria laid down. For such accepted work, payment shall be made at a reduced rate prorate to the compaction obtained against that stipulated.

6.2 Quality assurance programme

The Contractor shall submit and finalize a detailed field Quality Assurance Programme within 30 days from the date of award of the Contract according to the requirements of the specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of format for record, Field Quality Plan, etc. On finalized field quality plan, the owner shall identify customer hold prints beyond which work shall not proceed without written approval from the Engineer.

- 6.3 Frequency of sampling and testing including the methods for conducting the tests are given in **Annexure B**. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out or call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications.

6.4 Acceptance criteria

Following acceptance criteria shall be followed.

- a) All individual samples collected and tested should pass without any deviation when only one set of sample is tested.
- b) For re-test of any sample two additional samples shall be collected and tested, and both should pass without any deviation.
- c) Where a large number of samples are tested for a particular test than 9 samples out of every 10 consecutive samples tested shall meet the specification requirement.

- d) Tolerance on finished levels for important filling areas at approved intervals shall be + 20 mm. However, for an unimportant area, tolerance upto + 57 mm shall be acceptable at the discretion of the Engineer. However, these tolerances shall be applicable for localized areas only.

For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

Sub-Section - C2

Technical specification for properties, storage and handling of common building materials

Sub-Section - C2**Technical specification for properties, storage and handling of common building materials****Contents**

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Section - C2: Technical specification for properties, storage and handling of common building materials

1. Scope

- 1.1 The scope of this section of the specification is to specify the properties, storage and handling of common building materials namely, coarse aggregates, cement, water, sand masonry units, reinforcement and structural steel.
- 1.2 Properties of the materials in general have been discussed. Specific requirements of the materials have been stipulated separately under specification for relevant items of work.

2. General requirements

- 2.1 The work shall include, providing of all necessary plants and equipment, providing adequate engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out the entire work as directed by the Engineer to his complete satisfaction.
- 2.2 All materials proposed for use in the work shall conform to the requirements laid down in this section, and also subject to the approval of the Engineer. After specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the Engineer.

Approval of any material by the Engineer shall not relieve the Contractor of his responsibility, for the requisite quality and performance of the material used.

- 2.3 Any material considered to be sub-standard, or not upto satisfaction of the Engineer, shall not be used by the Contractor and shall be removed from the site immediately.
- 2.4 Representative samples shall be procured by the Contractor and submitted to the Engineer, for approval before bulk procurement. The representative samples shall be retained by the Engineer for future comparison and reference.

3. Codes and standards

- 3.1 In the event that state, city or other local governmental bodies have requirements more stringent than those set forth in this specification, the former shall govern.
- 3.2 All applicable standards, acts, specifications, codes of practice, hand books, referred to herein shall be the latest editions, including all official amendments and revisions. In case of discrepancy between this specification and those referred to herein, this specification shall govern.
Any special materials used, but not covered here, shall conform to relevant Indian Standards, if any, or as specified by the Engineer for any special purpose.

3.3 Some of the applicable Indian standards, codes are referred to here below :

IS:226	Specification for structural steel (standard quality).
IS:269	Specification for ordinary Portland cement, 33 grade.
IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432 (Parts 1&2)	Specification for mild steel and medium tensile steel bars and hard-drawn steel wires for concrete reinforcement.
IS:455	Specification for Portland slag cement.
IS:712	Specification for building limes.
IS:1077	Specification for common burnt clay building bricks.
IS:1077 IS:1127	Specification for Burnt clay bricks/Fly ash bricks. Recommendations for dimensions and workmanship of natural building stones for masonry work.
IS:1129	Recommendation for dressing of natural building stones.
IS:1489	Specification for Portland pozzolana cement (Part-I) Fly ash based (Part-II) Calcined clay based
IS:1542	Specification of sand for plaster.
IS:1566	Specification hard-drawn steel wire fabric for concrete reinforcement.
IS:1597	Code of Practice for construction of Stone masonry, rubble stone masonry.
IS:1786	Specification for high strength deformed bars for concrete reinforcement.
IS:2062	Specification for hot rolled medium and high tensile structural steel.
IS:2116	Specification for sand for masonry mortars.
IS:2386	Testing of aggregates for concrete. (Part I to VIII)
IS:3495 (Part-I to IV)	Methods of test of Burnt clay bricks/Fly ash bricks

IS:4031	Methods of physical tests for hydraulic cement.
IS:4032	Methods of chemical analysis of hydraulic cement.
IS:4082	Recommendations on stacking and storage of construction materials at site.
IS:7969	Safety code for handling and storage of building materials.
IS:8112	High strength ordinary portland cement.
IS:8500	Medium and high strength structural steel.
IS:12269	43/53 grade ordinary Portland cement.
IS:12330	Sulphate resisting Portland cement.
IS:12600	Portland cement, low heat.
IS:12894	Fly Ash Lime Bricks - specification.
IS: 3812-2	Specification for pulverized fuel ash for use as admixture in cement mortar and concrete

4. Burnt clay Bricks

- 4.1 Burnt clay bricks, for general masonry work, shall conform to IS:1077 and for face brick work, shall conform to IS:2691. Fly ash lime bricks shall conform to IS:12894
- 4.2 Bricks for general masonry work shall be table moulded/machine made, well burnt without being vitrified, of uniform size, shape, having sharp edges and cherry red colour. These shall be free from cracks, flaws or nodules of free lime and shall emit clear ringing sound (metallic sound) when struck. These shall not show any signs of efflorescence either when dry or subsequent to soaking in water. Fractured surface shall show uniform texture free from girts, lumps, holes etc.
- 4.3 Unless otherwise specified, minimum compressive strength shall correspond to class designation 75 as per IS: 107 with a minimum crushing strength of 75 kg/sq.cm. for general masonry work. However, for non-load bearing walls, bricks pavements, etc. bricks of class designation 50 shall only be used, wherever specified or shown on the drawings. Water absorption after 24 hours immersion shall not exceed 20% by weight for common bricks and 15% for face bricks.
- 4.4 On the basis of finish and dimensional tolerance, the bricks shall be classified as sub class A and B. Dimensional tolerance shall not exceed 3% and 8% of the size, of common bricks for sub-class A & B respectively and 3% for face bricks. All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chip page for

the face bricks shall be 6mm at the edges and 10mm for corners. The face bricks shall show no efflorescence after soaking in water and drying in the shade.

For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

- 4.5 The size of the bricks used shall be either modular size as per IS:1077 or locally available conventional size as approved by the Engineer.
- 4.6 Each brick shall have the manufacturer's identification mark clearly marked on the frog. The colour and texture of face bricks shall be limited to the range of samples submitted. Any brick not found upto the satisfaction of the Engineer shall be removed immediately from site by the Contractor.

5. Fly Ash Bricks

- 5.1 Fly ash bricks (cement bonded) shall be locally made. Bricks shall have smooth rectangular faces with sharp and square corners. Bricks shall be hand or machine moulded and shall be made from the admixture of suitable good quality of fly ash, sand and cement as per the composition mentioned below :

FLY ASH : 50-60%

SAND : 32-40%

CEMENT : 8-12%

- 5.2 The fly ash bricks will be as per latest relevant IS code. The bricks will be of dimension as per standard clay brick, suitable for making 230mm thick full brick wall, 115mm thick half brick wall and 75mm thick minor partition walls, as applicable, as per drawing/specification/BOQ. A maximum tolerance of (+/-) 2mm shall be allowed as the manufacturing tolerance. The bricks shall have frog of 100 mm in length 40 mm in width and 10 to 20 mm deep of one of its flat sides.

The bricks when tested in accordance with the procedure laid down in IS 3495 (part 2) : 1992 after immersion in cold water for 24 hrs., water absorption shall be within 13-15% by weight. Similarly, the porosity of the fly ash bricks shall be within 12-20%. The bricks shall have a minimum crushing strength of 80 Kg/Sqcm.

- 5.3 Fly ash bricks, for general masonry work, shall conform to IS:2212-1991
- 5.4 Unless otherwise specified, minimum compressive strength shall correspond to class designation 80 as per IS: 107 with a minimum crushing strength of 80 kg/sq.cm. for general masonry work. However, for non-load bearing walls, bricks pavements, etc. bricks of class designation 50 shall only be used, wherever specified or shown on the drawings. Water absorption after 24 hours immersion shall not exceed 20% by weight for common bricks and 15% for face bricks.

- 5.5 On the basis of finish and dimensional tolerance, the bricks shall be classified as sub class A and B. Dimensional tolerance shall not exceed 3% and 8% of the size, of common bricks for sub-class A & B respectively. All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chip page for the face bricks shall be 6mm at the edges and 10mm for corners. The face bricks shall show no efflorescence after soaking in water and drying in the shade.

For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

- 5.6 The size of the bricks used shall be either modular size as per IS:1077 or locally available conventional size as approved by the Engineer.
- 5.7 Each brick shall have the manufacturer's identification mark clearly marked on the frog. The colour and texture of face bricks shall be limited to the range of samples submitted. Any brick not found upto the satisfaction of the Engineer shall be removed immediately from site by the Contractor.

6. Stones

- 6.1 All stones shall be from approved quarries. These shall be hard, tough, durable, compact grained, uniform the texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stone with round surface shall not be used.
- 6.2 Stones showing mottled colours shall not be used for face work. A stone shall not absorb more than 5% of its weight of water after 24 hours immersion. The type of stone shall be as specified or shown on drawings and/or as instructed by the Engineer. Stones used for masonry work shall conform to IS:1597 (Part – I) No soft stone shall be used for masonry or for filling purpose.
- 6.3 Any stone not found upto the satisfaction of Engineer shall be removed immediately from site by the Contractor.

7. Lime

- 7.1 Lime shall be stone lime and it shall conform to IS:712. Hydrated lime shall be mixed with water to form a putty. This shall be stored with reasonable care to prevent evaporation of water for atleast 24 hours before use. Quick lime shall be slaked with enough water to make a cream and then stored with reasonable care to prevent evaporation of water for atleast seven days before use. Type of lime to be used for different purposes such as concreting, plastering, white washing etc. shall be according to the satisfaction made hereunder :

Class – A Eminently hydraulic lime used for structural purposes.

Class – B	Semi-hydraulic lime used for masonry mortars, lime concrete and plaster undercoat
Class – C	Fat lime used for finishing coat in plastering, white washing, composite mortars, etc. and with addition of pozzolanic materials for masonry mortar.
Class – D	Magnesium/dolomite lime used for finishing coat in plastering, whitewashing, etc.
Class – E	Kankar lime used for masonry mortar.
Class – F	Siliceous dolomite lime used for undercoat and finishing coat of plaster

8. Cement and Fly ash

8.1 Cement shall be ordinary Portland cement, 43/53 grade conforming to IS 8112/12269. The Engineer may permit the use of Portland pozzolana cement conforming to IS:1489 or Portland slag cement conforming to IS:455 or sulphate resistant cement conforming to IS 12330 as per the specific site condition. However, any lower grade of OPC, PPC and PSC should never be mixed with higher grade cement.

8.2 Fly ash is generated by burning of coal in coal fired power plants. It has the characteristic of pozzolonic additive to cement. Continuous research studies by various engineering research laboratories revealed its varied usefulness as an additive for enhancing the various qualities of concrete including its workability, strength and durability if handled and cared properly. Partial replacement of cement with fly ash in concrete save much of the energy required for production of OPC and also facilitates the economical disposal of millions of tons of fly ash.

At present most of the fly ash blended cements commercially produced in India has 18 to 25% fly ash by weight and addition of fly ash to this extent has a beneficial effect on the workability and economy of concrete. It has been found that in order to improve the other qualities of concrete like resistance of sulfate attack and thermal cracking, larger percentage of fly ash is to be used in concrete.

Indian standard specification No. 3812-2003, Specification for Pulverized Fuel Ash, Part 2: For Use as Admixture in Cement Mortar and Concrete [CED 2: Cement and Concrete] covers the extraction and the physical and chemical requirements of pulverized fuel ash for use as admixture in cement mortar and concrete. Fly ash conforming to this standard shall be used in place of cement.

The chemical, physical requirements and testing of fly ash shall be in accordance with the IS 3812-2003

9. Water

9.1 Water used for cement concrete, mortar, plaster, grout, curing, washing of coarse aggregate, soaking of bricks, etc. shall be clean and free from injurious amount of oil, acids, alkalis, organic matters or other harmful substances in such amounts that may impair the strength or durability of the structure. Potable water shall generally be considered satisfactory for all masonry and concrete works, including curing. The Contractor shall carry out necessary tests in advance to prove the suitability of the water proposed to be used. As a guide, the following concentrations represent the maximum permissible values :

- a. To neutralize 200 ml sample of water, it should not require more than 2ml of 0.1 normal NaOH.
- b. To neutralize 200 ml sample of water, it should not require more than 10ml of 0.1 normal HCL.
- c. Percentage of solids shall not exceed the following :
 - i) Organic 0.02
 - ii) Inorganic 0.30
 - iii) Sulphates 0.05
 - iv) Chlorides 0.10
 - v) Suspended matter 0.20

10. Aggregates

10.1 Aggregates mean both coarse and fine inert materials used in the preparation of concrete. Aggregates shall consist of natural sands, crushed stone and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, hard, strong, durable against weathering, of limited porosity and free from such quantities of deleterious materials as may cause corrosion of reinforcement or may impair the strength and / or durability of the concrete. Total percentage of all deleterious materials, including coal, lignite, clay lumps, materials finer than 75 microns, soft fragments and shale but excluding mica shall not exceed 5%. However, for crushed fine aggregate, total percentage of coal and lignite and clay lumps, shall be limited to 2%. Both coarse and fine aggregates shall conform to IS:383 for concrete, shotcreting etc. unless otherwise mentioned.

10.2 Sample of aggregates for mix design and determination of their suitability shall be sent to the laboratory well in advance in scheduled placing of concrete. Sampling, testing, and interpretation of test results shall be subject to the approval of the Engineer. Aggregates shall be properly graded.

11. Sand

- 11.1 Sand shall be hard, durable, clean and free from adherent coatings of organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale, or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance on mortar, plaster, etc. or to cause corrosion of any metal in contact with such mortar, plaster etc. In no case, the cumulative percentage of Impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Engineer, sand for masonry mortars shall conform to IS:2116 and sand for plaster shall conform to IS:1542. Sand, when used as fine aggregate, in concrete, shall conform to IS:383. For filling, medium grained sand (having fines less than 75 microns not exceeding 20%) shall be used.

12. Reinforcement steel, structural steel (including embedded steel) and wire mesh**12.1 Billet:- (Primary steel)**

A semi-finished product obtained by forging or rolling, usually square and not exceeding 125 x 125 mm in cross section with rounded corners and is intended for further processing into suitable finished product by forging or re-rolling.

Steel shall be manufactured by open hearth, electric, duplex, basic oxygen or a combination of these processes. In case any other process is employed by the manufacturer, prior approval of the purchaser should be obtained.

The ladle analysis of the material when analyzed in accordance with the various parts of IS : 228, shall be confirmed with IS: 8056-1976- Table 1(Cheical composition).

Table 1 Chemical composition (As per IS: 8056-1976 clauses 3.1 & 6.1)	
CONSTITUENT	PERCENT
Carbon	0.45 to 0.80
Silicon	0.15 to 0.35
Manganese	0.40 to 1.00
Sulphur, Max	0.050
Phosphorus, Max	0.050

In case of continuous cast billets, the billet analysis shall be taken as ladle analysis.

Permissible variation in case of product analysis from the limits specified in IS: 8056-1976 clause-6.1 shall be as follows:

CONSTITUENT	Variation Over the Specified Maximum or Under the Minimum Limits in %
Carbon	0.03
Silicon	0.03

Manganese	0.04
Sulphur, Max	0.005
Phosphorus, Max	0.005

NOTE - Variations shall not be applicable both over and under the specified limits in several determinations in a heat.

SAMPLING

At least one ladle sample analysis shall be taken per cast.

If required, the samples for product analysis shall be prepared by forging or rolling down to 30-mm round section.

In case of wire rods the test piece size shall be the size of wire rods.

Drilling shall be taken from the sample representing two-thirds, half and one-third of height from bottom of the billet separately.

In case of continuous cast billets and billets produced from ingots of masses 3 tonnes and more, the sample may be taken from anywhere from the billets.

FREEDOM FROM DEFECTS

The billets and continuous cast billets shall be free from harmful defects, such as pipe, laminations, segregation, inclusions and cracks.

Subject to agreement between the purchaser and the manufacturer, the billets and continuous cast billets may be supplied with suitable surface dressing.

billets shall either be supplied free from harmful segregation, piping, cracks, inclusions, and blow-hole by appropriate top and bottom discard and dressing or supplied with suitable surface dressing only, without top and bottom discard if agreed to between the purchaser and the manufacturer, to ensure the requirements of freedom from defects specified in the relevant product specifications.

If agreed to between the purchaser and the manufacturer the following tests may be carried out from the samples prepared under IS: 8056-1976

DIMENSIONS

The size and tolerance of billets shall be subject to agreement between the purchaser and the manufacturer. However, the nominal sizes of billets generally supplied as per guidance given in IS: 8056-1976

The preferred sizes of billets shall be 50, 63, 71, 80, 90, 100 and 125 mm.

The sizes other than those specified may be supplied by agreement between the purchaser and the manufacturer.

A tolerance of the billets shall be confirmed with IS: 8056-1976

The ends of ingots and billets shall be painted with a suitable colour code conforming to IS : 2049-1963.

Each ingot and billet shall be legibly stamped or painted with the cast number, grade and the name or trade-mark of the manufacturer.

The material may also be marked with the IS1 Certification Mark.

- 12.2 All steel for reinforcement shall be clean and free from loose mill scales, dust, loose rust, oil, grease, paint or other harmful matters which may affect its bond with concrete. Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement shall conform to grade-1 of IS:432 (Part-1). High strength deformed steel bars shall conform to grade Fe 415 of IS:1786. All steel bars shall be of tested quality. Actual grade and type steel, to be used, shall be as specified or shown on drawings.
- 12.3 Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaws, laminations and all other defects. Structural steel shall be of tested quality conforming to IS:226, IS:2062 or IS:8500. These shall be free from lamination defects. Grade and type of steel to be used shall be as specified.
- 12.4 Hard drawn steel wire fabric shall conform to IS:1566. Wire fabric shall be electrically cross welded.

13. Storage and handling of materials

- 13.1 Generally, all materials shall be stacked and stored by the Contractor as described in IS:4082 unless otherwise mentioned and in a manner affording convenient access for identification and inspection at all times. The storage area and arrangements shall be subject to the approval of the Engineer. Any material rendered unserviceable during the Contractor's custody, shall be replaced or repaired by the Contractor as determined by the Engineer.
- 13.2 All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used and shall be removed and the cost thereof, shall be realized from the Contractor's dues. The Contractor shall maintain up-to-date accounts of receipts, issue and balance (stock wise) of all materials.

- 13.3 Bricks shall not be dumped at site. These shall be stacked on dry firm ground in regular tiers even as they are unloaded to minimize breakage and defacement of bricks. Bricks of different class, selected for various categories of use in the work, shall be stacked separately. Each stack shall contain equal number of bricks, preferably not more than 3000.
- 13.4 Dressed stone for all facing, paving etc. shall be stored with special care to avoid defacement of faces and edges or damp and rust stains.
- 13.5 Lime shall be stored in weather-proof sheds. Lime which has been damaged by rain, moisture or air slaking, shall not be used. If the lime is supplied as hydrated lime, it shall be stored in the same manner as cement.
- 13.6 **Cement and fly ash**
- a. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery. Cement held in storage for more than ninety days shall invariably be tested, and only if test results are satisfactory, the Engineer may consider permitting its use.
 - b. Different consignments of different types of cement, i.e. OPC, PPC, PSC shall be stacked separately with clear identifiable stack number.
 - c. The cement shall be stored in dry, leak proof and weather proof are closed sheds. Storage under tarpaulins shall not be permitted. The cement bags shall be stored well away from the walls and insulated from the floor, using
 - d. Planks etc. to avoid contact with moisture. The cement shall be stacked in easily countable stacks and in a place of easy access so as to facilitate proper inspection and removal on a first in first out basis. Not more than 15 bags shall be stacked in any tier to prevent lumping up under pressure. However, in stacks more than 8 bags high, the cement bags shall be arranged alternately lengthwise and crosswise so as to tie the stacks together and minimize the danger of toppling over. The cement bags shall be gently kept to avoid leakage of cement from the bags. Substandard or partially set cement shall be immediately removed from the site as soon as it is detected.
 - e. The Contractor shall make his own arrangements for the storage of adequate quantity of cement. Cement in bulk may be stored in bins or silos which will provide adequate protection against dampness, contamination, etc. The bins or silos, shall be cleaned periodically.
 - f. Pulverized fuel ash (Fly ash) shall be stored in accordance with the recommendation given in IS 4082. Additionally, during bulk storage, the fly ash should be suitably covered to avoid getting airborne.

- g. Supplies of pulverized fuel ash (Fly ash) may be made in bulk in suitable quantities or in bags (jute, jute-laminated, multiple paper or polyethylene lined) bearing the net mass (may be 15 kg, 30 kg, 300 kg, 600 kg as agreed by the Contractor)
- h. Pulverized fuel ash in bulk storage for more than 6 months or in bags for more than-3 months after completion of tests, may be re-tested before use and standard. may be rejected, if it fails to conform to any requirements of this standard.
- i. Pulverized fuel ash may be rejected if it does not comply with any of the requirements stipulated in IS 3812 Part 2 of 2003

13.7 Coarse and fine aggregates/sand

- a. Coarse and fine aggregates shall be stacked separately. Contamination with foreign materials and earth during storage and while heaping the materials shall be avoided. Coarse aggregates shall be stacked in layers not exceeding 120 cm in height such that corning and segregation do not occur. Each layer shall cover the entire area of the stock pile before succeeding layers are placed. Segregated aggregates from stock-pile shall be rejected.
- b. Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance, at any stage. For lifting aggregates from stock piles, rakers shall be used. Aggregates of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Engineer, aggregates from different source shall be stacked separately with proper care to prevent intermixing.

13.8 Reinforcement and Structural Steel (including steel required for embedment)

- a. Reinforcement and structural steel (including steel required for embedment) shall be stored consignment wise and size wise, off the ground by at least 150mm and protected by the suitable cover, or as desired by the Engineer. The steel shall be protected from rusting, oil grease and distortions. The reinforcing steel shall be coated with cement wash before stacking to prevent scale and rust, in areas having accelerating corrosion effect like marine atmosphere. The stacks shall be easily measurable. Steel needed for immediate use only shall be removed from storage. Fabricated steel shall be carefully stored to prevent damage, distortion, corrosion and deterioration.
- b. Reinforcement shall be stored according to the diameter, grade and length in such a place as to permit easy approach for inspection and identification.

- c. The area shall be such that water does not accumulate and reinforcement does not get distorted or corroded. It shall not be stacked directly over ground or near any harmful materials. It shall be cleaned of excessive rust before use.
- d. Steel plates of different specifications shall be stacked separately. Steel of IS:2062 and IS:8500 quality shall be given a grade wise, distinctive identification mark. Passage and space between the stacks shall be sufficient for rigging operations.

14. Testing

- 14.1 All materials provided by the Contractor shall be tested for conformity of the specification and the test results shall be submitted to the Engineer for acceptance. In addition to above, the Contractor shall carry out the relevant tests at site as specified under different items of work.

Section – C24
Technical specifications for
construction of roads, footpath, cycle
track & pipe culverts

Section – C24

Technical specifications for construction of roads, footpath, cycle track & pipe culverts

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Section – C24: Technical specifications for construction of roads, footpath, cycle track & pipe culverts

1 Scope

This specification covers the general requirements for the materials and construction of embankment, preparation of sub grade, stocking & laying of granular sub base, wet mix macadam, dense bituminous macadam and bituminous concrete and walkways and drains and culverts.

2 Applicable codes & specifications

The following specifications, standards and codes are made a part of this specification. All standards, tentative specifications, specifications, codes of practices referred to herein shall be the latest edition including all applicable official amendments and revision. In case of discrepancy between this specification and those referred to herein, this specification shall govern.

IS:73	:	Paving bitumen
IS:215	:	Road tar
IS:217	:	Cutback bitumen
IS:383	:	Specification for coarse and fine aggregate from natural sources for concrete.
IS:458	:	Concrete pipes (with and without reinforcement)
IS:460	:	Test sieves
IS:1077	:	Fly ash bricks/Burnt clay bricks
IS:1124	:	Method of test for water absorption of natural building stones.
IS:1195	:	Specification for Bitumen Mastic for flooring.
IS:1196	:	Code of Practice for laying Bitumen Mastic flooring.
IS:2116	:	Sand for masonry mortars.
IS:2386	:	Methods of test for aggregate for concrete.
(Parts I) through VIII)	:	
IS:3102	:	Classification of Fly ash bricks/Burnt clay bricks
IS:3495	:	Method of sampling and testing of clay building bricks.
IS:1834	:	Sealing compounds, hot applied, for joints in concrete.
IRC:SP:53	:	Modified bitumen
IRC 10	:	Practice for borrow pits for road embankment
IRC 15	:	Spec. and code of practice for construction of CC roads
IRC 16	:	Spec. and code of practice for prime and tack coat
IRC 29	:	Specification for bituminous concrete
IRC 35	:	Code of practice for road marking
IRC 36	:	Construction of earthen embankments and sub grade
IRC 51	:	Guidelines for use of soil-lime mixes in road construction

IRC 89	:	Practice for lime fly ash stabilized soil base/ sub-base in pavement
IRC 94	:	Specification for dense bituminous macadam
IRC 109	:	Guidelines for wet mix macadam
IRC:SP:58	:	Use fly ash in road embankments
IRC:SP:63	:	Guidelines for use of interlocking concrete block pavement
IRC:SP:69	:	Guidelines & specification for expansion joints
IRC:SP:97	:	Guidelines on compaction equipment for road works
Ministry of road transport & highways- Fifth revision	:	Specification for Road & Bridge works

Where the requirements of the above codes differ from this specification or other specifications forming a part of the bid document, the latter shall govern

All earthwork and concrete work shall be according to component specifications “Earthwork in Grading, Excavation & Backfilling” and “Cast-in-Situ Concrete and Allied Works” bearing serial no. C1 & C3 respectively.

3 Construction sequence

It is intent of this specification that the wet mix macadam road be constructed first and surfaced with bituminous surfacing as specified hereunder. This shall be opened to traffic, as directed by the Employer/EIC. After such period of time as decided by the Employer/EIC, when the major construction and/or erection activities within project areas are over, Contractor shall rectify all defects, wear and tear, etc. and surface the road with bituminous treatment (Dense bituminous macadam, Bituminous concrete etc) as specified hereunder.

4 Materials for road & allied structure

4.1. General notes

All materials shall be obtained from local sources and approval of EIC shall be obtained prior to starting of work.

5 Embankment construction

5.1. General

These specifications shall apply to the construction of embankments including sub-grades, earthen shoulders and miscellaneous backfills with approved material obtained from approved source, including material from roadway and drain excavation, borrow pits or other sources. All embankments sub-grades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the

requirements of these specifications and in conformity with the lines, grades, and cross-sections shown on the drawings or as directed by the engineer.

5.2. Physical requirements for embankment materials

The materials used in embankments, sub-grades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material as approved by the engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment.

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

- a) Materials from swamps, marches and bogs;
- b) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS:1498;
- c) Materials susceptible to spontaneous combustion;
- d) Materials in a frozen condition;
- e) Clay having liquid limit exceeding 50 and plasticity index exceeding 25; and
- f) Materials with salts resulting in leaching in the embankment.

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

Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO₃) per litre when tested in accordance with BS: 1377, Part 3, but using a 2:1 water-soil ratio shall not be deposited within 500 mm distance (or any other distance described in the Contract), of permanent works constructed out of concrete, cement bound materials or other cementitious material.

Materials with a total sulphate content (expressed as SO₃) exceeding 0.5 percent by mass, when tested in accordance with BS: 1377, Part 3 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent works.

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

Ordinarily, only the materials satisfying the density requirements given in Table 300-1 shall be employed for the construction of the embankment and the sub-grade.

**As per table 300 – 1:
Density requirements of embankment and sub-grade materials**

Sl. No	Type of work	Maximum laboratory dry unit weight when tested as per IS:2720 (Part8)
1.	Embankment up to 3 m height, not subjected to extensive flooding	Not less than 15.2 kN/cum
2.	Embankments exceeding 3m height or embankments of any height subject to long periods of inundation	Not less than 16 kN/cum
3.	Sub grade and earthen shoulders/verges/backfill	Not less than 17.5 kN/cum

Notes:

- 1) This table is not applicable for lightweight fill material, e.g., cinder, fly ash, etc
- 2) The material to be used in sub-grade shall be non-expansive and shall satisfy design CBR at the specified dry density and moisture content. In case the available materials fail to meet the requirement of CBR use of stabilization methods in accordance with MORTH-5TH REVISION clauses 403 and 404 or by any stabilization method approved by the engineer shall be followed.

The material to be used in sub-grade shall conform to the design CBR value at the specified dry density and moisture content of the test specimen. In case the available materials fails to meet the requirement of CBR, use of stabilization methods in accordance with MORTH-5TH REVISION clauses 403 and 404 or by any stabilization method approved by the Engineer or by the IRC Accreditation committee shall be followed.

The material to be used in high embankment construction shall satisfy the specified requirements of strength parameters.

5.3. General requirements for embankment materials

The materials for embankment shall be obtained from approved sources with preference given to acceptable materials becoming available from nearby roadway excavation under the same contract.

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

5.4. Borrow materials

The arrangement for the source of supply of the material for embankment and sub-grade and compliance with guidelines, and environmental requirements, in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of

Environment and Forests, government of India and the local bodies, as applicable shall be the sole responsibility of the contractor.

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

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

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

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

5.5. Fly-Ash

Use of fly-ash shall conform to the Ministry of Environment and Forest guidelines. Where fly-ash is used the embankment construction shall conform to the physical and chemical properties and requirements of IRC: SP: 38-2001, "Guidelines for Use of Fly-ash in Road Construction." The term fly-ash shall cover all types of coal ash such as pond ash, bottom ash or mound ash.

Embankment constructed out of fly-ash shall be properly designed to ensure stability and protection against erosion in accordance with IRC guidelines. A suitable thick cover may preferably be provided at intervening layers of pond ash for this purpose. A thick soil cover shall bind the edge of the embankment to protect it against erosion. Minimum thickness of such soil cover shall be 500mm.

5.6. Compaction requirements

The contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing program approved by the engineer. It shall be ensured that the sub-grade material when compacted to the density requirements as the table 300-2 shall yield the specified design CBR value of the sub-grade.

As per table 300 - 2: Compaction requirements for embankment and sub-grade

Sl. No	Type of work /material	Relative compaction as percentage of max. laboratory dry density as per IS: 2720 (Part 8)
1)	Sub-grade and earthen shoulders Not less than	97%
2)	Embankment, Not less than	95%
3)	Expansive clays	
	a. Sub-grade and 500mm portion just below the sub-grade	Not allowed
	b. Remaining portion of embankment	90-95%

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

- i) The values of maximum dry density and optimum moisture content obtained in accordance with IS:2720 (Part 8), appropriate for each of the fill materials he intends to use.
- ii) A graph of dry density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

The maximum dry density and optimum moisture content approved by the Engineer shall form the basis for compaction.

5.7. Construction operation

5.7.1. Setting out

After the site has been cleared to MORTH-5TH REVISION clause 201, the work shall be set out to MORTH-5TH REVISION clause 301.2.1 the limits of embankment/sub-grade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/sub-grade shall be built sufficiently wider than the design dimension so that surplus material may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

5.8. Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the Engineer, and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole

responsibility of the Contractor to repair/restore it to original condition or compensate for the damage at his own cost.

If the embankment is to be constructed under water, MORTH-5TH REVISION clause 305.4.6 shall apply.

5.9. Stripping and storing topsoil

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

5.10. Compacting ground supporting embankment/sub-grade

Where necessary, the original ground shall be leveled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling in accordance with MORTH-5TH REVISION clauses 305.3.5 and 305.3.6 so as to achieve minimum dry density as given in MORTH-5TH REVISION - table 300-2.

In case where the difference between the sub-grade level (top of the sub-grade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density (as give in MORTH-5TH REVISION table 300-2), the ground shall be loosened up to a level 0.5 m below the sub-grade level, watered and compacted in layers in accordance with MORTH-5TH REVISION clause 305.3.5 and 305.3.6 to achieve dry density not less than 97 percent relative compaction as given in MORTH-5TH REVISION table 300-2.

Where so directed by the engineer, any unsuitable material occurring in the embankment foundation (500 mm portion just below the sub-grade) shall be removed, suitably disposed and replaced by approved materials laid in layers to the required degree of compaction.

Any foundation treatment specified for embankments especially high embankments, resting on suspects foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the engineer. Where the ground on which an embankment is to be built has any of such material types (a) to (f) in MORTH-5TH REVISION clause 305.2.1.1 at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

5.11. Spreading material in layers and bringing to appropriate moisture content

The embankment and sub-grade material shall be spread in layers of uniform thickness in the entire width with a motor grader. The compacted thickness of each layer shall not be more than 250mm when vibratory roller/vibratory soil compactor is used and not more than 200 mm when 80-100 kN static roller is used. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in MORTH-5TH REVISION table 300-2 and got approved by the Engineer, Each compacted layer shall be finished parallel to the final cross-section of the embankment.

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

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

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1 percent above to 2 percent below the optimum moisture content determined in accordance with IS: 2720 Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

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

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

Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the Engineer, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other construction vehicles. Damage by construction plant and other vehicular traffic shall

be made good by the Contractor with material having the same characteristics and strength of the material before it was damaged.

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

Whenever fill is to be deposited against the face of the natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical to 4 horizontal, such faces shall be benched as per MORTH-5TH REVISION clause 305.4.1 immediately before placing the subsequent fill.

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

5.12. Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Static three-wheeled roller, self-propelled single drum vibratory roller, tandem vibratory roller, pneumatic tyre roller, pad foot roller, etc., of suitable size and capacity as approved by the engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of self-propelled single drum vibratory roller or pad foot vibratory roller of 80 to 100 kN static weight or heavy pneumatic tyre roller of adequate capacity capable of achieving the required compaction. The contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for the site trials shall be submitted to the Engineer for approval.

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

Each layer of the material shall be thoroughly compacted to the densities specified in MORTH-5TH REVISION table 300-2. Subsequent layers shall be placed only after the finished layer has been tested according to MORTH-5TH REVISION clause 903.2.2 and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture/density gauge used in accordance with agreed procedure and provided and gauge is calibrated to give results identical to that obtained from tests in accordance with IS:2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment/sub-grade/earthen shoulders, further compaction shall be carried out as directed by the Engineer. If in spite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted using appropriate mechanical means such as light weight vibratory roller, double drum walk behind roller, vibratory plate compactor, trench compactor or vibratory tamper to the density requirements and satisfaction of the Engineer.

6 Lime treated soil for improved sub-grade/sub-base

6.1. General

This work shall consist of laying and compacting an improved sub-grade / lower sub-base of soil treated with lime on prepared sub-grade in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer, Lime treatment is generally effective for soils which contain a relatively high percentage of clay and silty clay.

6.2. Soil

Except when otherwise specified, the soil used for stabilization shall be the local clayey soil having a plasticity index greater than 8.

6.3. Lime

Lime for lime-soil stabilization work shall be commercial dry lime slaked at site or pre-slaked lime delivered to the site in suitable packing, Unless otherwise permitted by the Engineer, the lime shall have purity of not less than 70 percent by weight of Quick-lime (CaO) when tested in accordance with IS:1514. Lime shall be properly stored to avoid prolonged exposure to the atmosphere and consequent carbonation which would reduce its binding properties.

6.4. Quantity of lime in stabilized mix

Quantity of lime to be added as percentage by weight of the dry soil shall be as specified in the Contract. The quantity of lime used shall be related to its calcium oxide content which shall be specified. Where the lime of different calcium oxide content is to be used, its quantity shall be suitably adjusted with the approval of the Engineer so that equivalent calcium oxide is incorporated in the work. The mix design shall be done to arrive at the appropriate quantity of lime to be added, having due regard to the purity of lime, the type of soil, the moisture-density relationship, and the design CBR/Unconfined Compressive Strength (UCS) value specified in the Contract. The laboratory CBR/UCS value shall be at least 1.5 times the minimum field value of CBR/UCS stipulated in the Contract.

6.5. Water

The water to be used for lime stabilization shall be clean and free from injurious substances. Potable water shall be used.

6.6. Weather limitations

Lime-soil stabilization shall not be done when the air temperature in the shade is less than 10°C.

6.7. Degree of pulverization

For lime-soil stabilization, the soil before addition of stabilizer, shall be pulverized using agricultural implements like disc harrows (only for low volume roads) and rotavators to the extent that it passes the requirements set out in MORTH-5TH REVISION table 400-3 when tested in accordance with the method described in MORTH-5TH REVISION appendix-3

As per MORTH-5TH REVISION table 400 – 3: Soil pulverization requirements for Lime stabilization

IS Sieve designation	Minimum percent by weight passing the IS sieve
26.5 mm	100
5.6 mm	80

6.8. Equipment for construction

Stabilized soil sub-bases shall be constructed by mix-in-place method of construction or as otherwise approved by the Engineer. 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 pulverizing and mixing the soil with additive and water to specified degree to the full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilized material. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for work.

The thickness of any layer to be stabilized shall be not less than 100 mm when compacted. The maximum thickness can be 200 mm, provided the plant used in accepted by the Engineer.

6.9. Mix-in-place method of construction

Before deploying the equipment, the soil after it is made free of undesirable vegetation or other deleterious matter shall be spread uniformly on the prepared sub-grade in a

quantity sufficient to achieve the desired compacted thickness of the stabilized layer. Where single-pass equipment is to be employed, the soil shall be lightly rolled as directed by the Engineer.

The equipment used shall either be of single-pass or multiple pass type. The mixers shall be equipped with an appropriate device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

With single-pass equipment the forward speed of the machine shall be so selected in relation to the rotor speed that the required degree of mixing, pulverization and depth of processing is obtained. In multiple-pass processing, the prepared sub-grade shall be pulverized to the required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits mentioned hereinafter. The lime shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained.

The mixing equipment shall be so set that it cuts slightly into the edge of the adjoining lane processed previously so as to ensure that all the material forming a layer has been properly processed for the full width.

6.10. Construction with manual means

Where manual mixing is permitted, the soil from borrow areas shall first be freed of all vegetation and other deleterious mater and placed on the prepared sub-grade. The soil shall then be pulverized by means of crow-bars, pick axes or other means approved by the Engineer.

Water in requisite quantities may be sprinkled on the soil for aiding pulverization. On the pulverized soil, the lime in requisite quantities shall be spread uniformly and mixed thoroughly by working with spades or other similar implements till the whole mass are uniform. After adjusting the moisture content to be within the limits mentioned later, the mixed material shall be leveled up to the required thickness so that it is ready to be rolled

6.11. Addition of lime

Lime may be mixed with the prepared material either in slurry form or dry state at the option of the Contractor with the approval of the Engineer.

Dry lime shall be prevented from blowing by adding water to the lime or other suitable means selected by the contractor, with the approval of the Engineer.

The tops of windrowed material may be flattened or slightly trenched to receive the lime.

The distance to which lime may be spread upon the prepared material ahead of the mixing operation shall be determined by the Engineer.

No traffic other than the mixing equipment shall be allowed to pass over the spread lime until after completion of mixing.

Mixing or remixing operations, regardless of equipment used, shall continue until the material is free of any white streaks or pockets of lime and the mixture is uniform.

Non-uniformity of colour reaction, when the treated material is tested with the standard phenolphthalein alcohol indicator, will be considered evidence of inadequate mixing.

6.12. Moisture content for compaction

The moisture content at compaction checked vide IS: 2720 (Part 2) shall neither be less than the optimum moisture content corresponding to IS: 2720 (Part 8) nor more than 2 percent above it.

6.13. Rolling

Immediately after spreading, grading and leveling of the mixed material, compaction shall be carried out with approved equipment preceded by a few passes of lighter rollers if necessary. Rolling shall commence at edges and progress towards the centre, except at super elevated portions or for carriageway with unidirectional cross-fall where it shall commence at the inner edge and progress towards the outer edge.

During rolling, the surface shall be frequently checked for grade and crossfall (camber) and any irregularities corrected by loosening the material and removing / adding fresh material. Compaction shall continue until the density achieved is at least 98 percent of the maximum dry density for the material determined in accordance with IS: 2720 (Part 8).

Care shall be taken to see that the compaction of lime stabilized material is completed within three hours of its mixing or such shorter period as may be found necessary in dry weather.

During rolling it shall be ensured that roller does not bear directly on hardened or partially hardened treated material previously laid other than what may be necessary for achieving the specified compaction at the joint. The final surface shall be well closed, free from movement under compaction planes, ridges, cracks or loose material. All loose or segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

6.14. Curing

The sub-base course shall be suitably cured for the minimum period of 7 days after which subsequent pavement courses shall be laid to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over the completed sub-base unless permitted by the Engineer.

6.15. Surface finish and quality control of work

The surface finish of construction shall conform to the requirements of MORTH-5TH REVISION clauses 902.

Control on the Quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

6.16. Strength

When lime is used for improving the sub-grade, the soil-lime mix shall be tested for its CBR value, when lime stabilized soil is used in the sub-base, it shall be tested for unconfined compressive strength (UCS) at 7 days. In case of variation from the design CBR/UCS, in situ value being lower, the pavement design shall be reviewed based on the actual CBR/UCS values. The extra pavement thickness needed on account of lower CBR/UCS value shall be constructed by the Contractor at his own cost.

6.17. Arrangements for traffic

During the period of construction, arrangements for traffic shall be provided and maintained in accordance with MORTH-5TH REVISION clause 112.

6.18. Measurement for payment

Stabilized soil sub-graded sub-base shall be measured as finished work in position in cubic metres.

6.19. Rate

The Contract unit rate for lime stabilized soil sub-graded / sub-base shall be payment in full for carrying out the required operations including full compensation for all components listed in MORTH-5TH REVISION clause 401.7 (i) to (v).

7 Granular sub-base

7.1. General

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

7.2. Materials

The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the grading given in MORTH-5TH REVISION table 400-1 and physical requirements given in MORTH-5TH REVISION table 400-2. Grading III and IV shall preferably be used in lower sub-base. Grading V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

If the water absorption of the aggregates determined as per IS: 2386 (Part 3) is greater than 2 percent, the aggregates shall be tested for wet Aggregate Impact Value (AIV) (IS: 5640). Soft aggregates like Kankar, brick ballast and late rite shall also be tested for Wet AIV (IS: 5640).

As per MORTH-5TH REVISION table 400 – 1: Grading for granular sub-base materials

IS sieve designation	Percent by weight passing the IS sieve					
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75.0 mm	100	-	-	-	100	-
53.0 mm	80 - 100	100	100	100	80 - 100	100
26.5 mm	55 - 90	70 - 100	55 - 75	50 - 80	55 - 90	75 - 100
9.50 mm	35 - 65	50 - 80	-	-	35 - 65	55 - 75
4.75 mm	25 - 55	40 - 65	10 - 30	15 - 35	25 - 50	30 - 55
2.36 mm	20 - 40	30 - 50	-	-	10 - 20	10 - 25
0.85 mm	-	-	-	-	2 - 10	-
0.425 mm	10 - 15	10 - 15	-	-	0 - 5	0 - 8
0.075 mm	<5	<5	<5	<5	-	0 - 3

As per MORTH-5TH REVISION table 400 – 2: Physical requirements for materials for granular sub-base

Aggregate Impact Value (AIV)	IS:2386 (Part 4) or S:5640	40 maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
CBR at 98% dry density (at IS:2720 – Part 8)	IS:2720 (Part 5)	Minimum 30 unless otherwise specified in the Contract

7.3. Preparation of sub-grade

Immediately prior to the laying of sub-base, the sub-grade already finished to MORTH-5TH REVISION clause 301 or 305 as applicable 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.

7.4. Spreading and compacting

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS: 2720 (Part 8). The mix shall be 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 for maintaining the required slope and grade during the operation, or other means as approved by the Engineer.

Moisture content of the mix shall be checked in accordance with IS: 2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 percent below the optimum moisture content.

Immediately after spreading the mix, rolling shall be done by an approved roller. 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 up to 200mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall or on super- elevation. For carriageway having crossfall on both sides, rolling shall commence at the edges and progress towards the crown.

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 98 percent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

7.5. Surface finish and quality control of work

The surface finish of construction shall conform to the requirements of MORTH-5TH REVISION clause 902. Control on the quality of materials and works shall be exercised by the Engineer in accordance with MORTH-5TH REVISION Section 900.

7.6. Arrangements for traffic

During the period of construction, arrangements for the traffic shall be provided and maintained in accordance with MORTH-5TH REVISION clause 112.

7.7. Measurements for payment

Granular sub-base shall be measured as finished work in position in cubic metres.

The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

7.8. Rate

The Contract unit rate for granular sub- base shall be payment in full for carrying out the required operations including full compensation for:

- i) Making arrangements for traffic to MORTRH-5TH REVISION Clause 112 except for initial treatment to verges, shoulders and construction of diversions;
- ii) Supplying all materials to be incorporated in the work including all royalties, fees, rents where applicable with all leads and lifts;
- iii) All labour, tools, equipment and incidentals to complete the work to the Specifications;
- iv) Carrying out the work in part widths of road where directed; and carrying out the required tests for quality control.

8 Wet mix macadam sub-base/base

8.1. General

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 sub-grade/sub- base/ base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm (as per MORTH-5TH REVISION). When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be up to 200 mm with the approval of the Engineer.

8.2. Physical requirements

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent 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 MORTH-5TH REVISION table 400 – 12.

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

As per MORT table 400 – 12: Physical requirements of coarse aggregates for wet mix macadam for sub-base / base courses

S. No.	Test	Test Method	Requirements
1)	Los Angeles Abrasion value Or Aggregate impact value	IS:2386 (Part-4) IS: 2386 (Part-4) or IS:5640	40 percent (Max.) 30 percent (Max.)
2)	Combined Flakiness and Elongation indices (Total)	IS: 2386 (Part-1)	35 percent (Max.)*

**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 values of flakiness index and elongation index so found are added up.*

8.3. Grading requirements

The aggregates shall conform to the grading given in MORTH-5TH REVISION table 400-13.

As per MORTH-5TH REVISION table 400–13: Grading requirements of aggregates for wet mix macadam

IS Sieve designation	Percent by weight passing the IS Sieve
53.00 mm	100
45.00 mm	95 – 100
26.50 mm	–
22.40 mm	60 – 80
11.20 mm	40 – 60
4.75 mm	25 – 40
2.36 mm	15 – 30
600.00 micron	8 – 22
75.00 micron	0 – 5

Material finer than 425 micron shall have plasticity Index (PI) not exceeding 6

The final gradation approved within these limits shall be 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.

8.4. Preparation of base

The surface of the sub-grade/sub-base/base to receive the wet mix macadam course shall be prepared to the specified graded and camber and cleaned of dust, dirt and other extraneous material. Any rust or soft yielding places shall be corrected in an approved manner and rolled unit firm surface is obtained.

Where the WMM is to be laid on an existing metallic road, damage area including depressions and potholes shall be repaired and made good with the suitable material. The existing surface shall be scarified and re-shaped to the required grade and camber before spreading the coarse aggregate for WMM.

As far as possible, laying wet mix macadam course over existing bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous wearing course where wet mix macadam is proposed to be laid over it.

8.5. Provision of lateral confinement of aggregates

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in MORTH-5TH REVISION clause 404.3.3.

8.6. 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. The plant shall have following features:

- i) For feeding aggregates- three/ four bin feeders with variable speed motor
- ii) Vibrating screen for removal of oversize aggregates
- iii) Conveyor Belt
- iv) Controlled system for addition of water
- v) Forced/positive mixing arrangement like pug-mill or pan type mixer
- vi) Centralized control panel for sequential operation of various devices and precise process control
- vii) Safety devices

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of

4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

8.7. Spreading of mix

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. In no case shall 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 by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

- i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed.
- ii) Hydraulically operated telescopic screed for paving width upto to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.
- iii) Automatic leveling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure.

In exceptional cases where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with the prior approval of the Engineer. The motor grader shall be capable of spreading the material uniformly all over the surface.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

The Engineer may permit manual mixing and /or laying of wet mix macadam where small quantity of wet mix macadam is to be executed. Manual mixing/laying in inaccessible/ remote locations and in situations where use of machinery is not feasible can also be permitted. Where manual mixing/laying is intended to be used, the same shall be done with the approval of the Engineer.

8.8. Compaction

After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100kN weight may be used. For a compacted single layer upto 200 mm, the

compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 km/h.

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 in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the center parallel to the center 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 should not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or sub-grade. If irregularities develop during rolling which exceeds 12 mm when tested with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and cross fall. In no case shall the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part – 8).

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

8.9. Setting and drying

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

8.10. Opening to traffic

No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

8.11. Surface finish and quality control of work

8.11.1. Surface evenness

The surface finish of construction shall conform to the requirements of MORTH-5TH REVISION clause 902.

8.11.2. Quality control

Control on the quality of materials and works shall be exercised by the Engineer in accordance with MORTH-5TH REVISION section 900.

8.12. Rectification of surface irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premixed material or removed and replaced with fresh premixed material as applicable and re-compacted in accordance with MORTH-5TH REVISION clause 406.3. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

8.13. Arrangement for traffic

During the period of construction, arrangements for traffic shall be done as per MORTH-5TH REVISION Clause 112.

8.14. Measurements for payment

Wet mix macadam shall be measured as finished work in position in cubic metres.

8.15. Rate

The Contract unit rate for wet mix macadam shall be payment in full for carrying out the required operations including full compensation for all components listed in MORTH-5TH REVISION clause 401.7.

9 Prime coat over granular base

9.1. General

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix. The work shall be carried out on a previously prepared granular/ stabilized surface to MORTH-5TH REVISION clause 501.8.

9.2. Materials

The primer shall be cationic bitumen emulsion SS1 grade conforming to IS::8887 or medium curing cutback bitumen conforming to IS: 217 or as specified in the Contract.

Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as given in MORTH-5TH REVISION table 500-3.

As per MORTH-5TH REVISION table 500 – 3: Quantity of bitumen emulsion for various types of granular surfaces

Type of surface	Rate of Spray (Kg/Sqm)
WMM/WBM	0.7-1.0
Stabilized soil bases/Crusher run macadam	0.9-1.2

Cutback for primer shall not be prepared at the site. Type and quantity of cutback bitumen for various types of granular surface shall be as given in MORTH-5TH REVISION table 500-4.

As per MORTH-5TH REVISION table 500 – 4: Type and quantity of cutback bitumen for various types of granular surface

Type of surface	Type of cutback	Rate of spray (Kg/Sqm)
WMM/WBM	MC 30	0.6-0.9
Stabilized soil bases/ Crusher run macadam	MC 70	0.9-1.2

The correct quantity of primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10 mm.

9.3. Weather and seasonal limitations

Primer shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10OC. Cutback bitumen as primer shall not be applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

9.4. Equipment

The primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

9.5. Preparation of road surface

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose materials and other foreign materials shall be removed completely. If soil/ moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

9.6. Application of bituminous primer

After preparation of the road surface as per MORTH-5TH REVISION clause 502.4.2, the primer shall be sprayed uniformly at the specified rate. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

No heating or dilution of SS1 bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively through the jets of the spray and to cover the surface uniformly.

9.7. Curing of primer and opening to traffic

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

9.8. Quality control of work

For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

9.9. Arrangements for traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of MORTH-5TH REVISION clause 112.

9.10. Measurement for payment

Prime coat shall be measured in terms of surface area of application in square metres.

9.11. Rate

The contract unit rate for prime coat shall be payment in full for carrying out the required operations including full compensation for all components listed in MORTH-5TH REVISION clause 401.7 (i) to (v) and as applicable to the work specified in these Specifications. Payment shall be made on the basis of the provision of prime coat at an application rate of quantity at 0.6 kg per square metre or at the rate specified in the Contract, with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to in MORTH-5TH REVISION clause 502.4.3.

10 Tack coat

10.1. General

The work shall consist of the application of a single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or as instructed by the Engineer. The work shall be carried out on a previously prepared surface in accordance with MORTH-5TH REVISION clause 501.8.

10.2. Materials

The binder used for tack coat shall be either Cationic bitumen emulsion (RS 1) complying with IS: 8887 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC: 70 as per IS: 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be as specified in the Contract or as directed by the Engineer.

10.3. Weather and seasonal limitations

Bituminous material shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

10.4. Equipment

The tack coat shall be applied by a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying shall not be permitted except in small areas, inaccessible to the distributor, or narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

10.5. Preparation of base

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of MORTH-5TH REVISION clauses 501.8. The granular or stabilized surfaces shall be primed as per MORTH-5TH REVISION clause 502. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high-pressure air jet, or by other means as directed by the Engineer.

10.6. Application of tack coat

The application of tack coat shall be at the rate specified in MORTH-5TH REVISION table 500-5, and it shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract, then it shall be the rate specified in MORTH-5TH REVISION table 500-5. No dilution or heating at site of RS1 bitumen emulsion shall be permitted. Paving bitumen if used for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2poise. The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for cutback, 50°C to 80°C. The method of application of tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed or forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

As per MORTH-5TH REVISION table 500 – 5: Rate of application of tack coat

Type of surface	Rate of spray of binder in Kg per Sqm
Bituminous surfaces	0.20 – 0.30
Granular surfaces treated with primer	0.25 – 0.30
Cement concrete pavement	0.30 – 0.35

10.7. Curing of tack coat

The tack coat shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

10.8. Quality control of work

For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

10.9. Arrangements for traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of MORTH-5TH REVISION clause 112.

10.10. Measurement for payment

Tack coat shall be measured in terms of surface area of application in square metres.

10.11. Rate

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in MORTH-5TH REVISION Clause 401.8 (i) to (v) and as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat, at 0.2 kg per square metre or at the rate specified in the Contract, with the provision that the variation between this quantity and actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

11 Dense Bituminous Macadam

11.1. General

The specification describes the design and construction procedure for Dense Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

11.2. Bitumen/ Crumb rubber modified bitumen (CRMB)

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS: 73, modified bitumen complying with MORTH-5TH REVISION clause 501.2.1 and IRC: SP: 53/ IS: 15462 or as otherwise specified in the contract.

11.3. Coarse aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. They shall be clean, hard and durable of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates has poor affinity for bitumen, the Contractor shall produce test results that with the use of anti-stripping agents, the stripping value is improved to satisfy the specification requirements. The

Engineer may approve such a source and 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, at the cost of the Contractor. The aggregates shall satisfy the requirements specified in MORTH-5TH REVISION table 500-8.

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

11.4. Fine aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand up to 50 percent of the fine aggregate may be allowed in base courses. 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 37). The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4, when tested in accordance with IS: 2720 (Part 5).

11.5. Filler

Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer. The filler shall be graded within the limits indicated in MORTH-5TH REVISION table 500-9.

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. Where the aggregates fail to meet the requirements of the water sensitivity test in MORTH-5TH REVISION table 500-8, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly.

11.6. 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 filler for the particular mixture shall fall within the limits given in MORTH-5TH REVISION table 500 -10 for grading 1 or 2 as specified in the Contract. To avoid gap grading, the combined aggregate gradation shall not vary from the lower limit on one sieve to higher limit on the adjacent sieve.

As per MORTH-5TH REVISION table 500 – 8: Physical requirements for coarse aggregate for Dense Bituminous Macadam

Property	Test	Specification	Method of test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS: 2386 Part I
Particle shape	Combined flakiness and elongation indices*	Max 35%	IS: 2386 Part I
Strength	Los Angeles abrasion value or aggregate impact value	Max 35% Max 27%	IS: 2386 Part IV
Durability	Soundness either : Sodium sulphate or magnesium sulphate	Max 12% Max 18%	IS:2386 Part V
Water absorption	Water Absorption	Max 2%	IS: 2386 Part III
Stripping	Coating and stripping of bitumen aggregate Mix	Minimum retained coating 95%	IS: 6241
Water sensitivity	Retained tensile strength**	Min. 80%	AASHTO 283

**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 values of flakiness index and elongation index so found are added up.*

***If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.*

As per MORTH-5TH REVISION table 500 – 9: Grading requirements for mineral filler

15 Sieve (mm)	Cumulative percent passing by weight of total aggregate
0.6	100
0.3	95 – 100
0.075	85 – 100

As per MORTH-5TH REVISION table 500 – 10: Composition of Dense Graded Bituminous Macadam

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5 mm
Layer thickness	75 - 100 mm	50 – 75 mm
IS Sieve1 (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

Grading	1	2
2.36	28- 42	28- 42
1.18	-	-
0.6	-	-
0.3	7- 21	7- 21
0.15	-	-
0.075	2- 8	2- 8
Crumb rubber modified bitumen (CRMB) content % by mass of total mix	Min 4.3**	Min 4.7**

* The nominal maximum particle size is the largest specified sieve size upon which any of the aggregate is retained.

** Corresponds to specific gravity of aggregates being 2.7. In case aggregate have specific gravity more than 2.7, the minimum CRMB content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is - 10°C or lower, the CRMB content may be increased by 0.5 percent.

CRMB content indicated in MORTH-5TH REVISION table 500 - 10 is the minimum quantity. The quantity shall be determined in accordance with MORTH-5TH REVISION clause 505.3.

11.7. Modified bitumen

- Studies have revealed that properties of bitumen and bituminous mixes can be improved /modified with the incorporation of certain additives or blend of additives. These additives are called "Modifiers" and the bitumen premixed with these modifiers is known as "Modified Bitumen".
- Use of modified bitumen in the top layers of the pavement is expected to significantly enhance the life of the surfacing and extend the time of the next renewal.
- The use of Modified Bitumen in construction/maintenance of bituminous roads significantly improves the pavement performance and is cost effective, when life-cycle cost is taken into consideration.
- Since a bituminous mix prepared with modified bitumen has a higher stiffness modulus, enhanced fatigue life, better resistance to creep and higher indirect tensile strength, it is suitable as a wearing course, a binder course and overlay material on surfaces which are cracked and subjected to heavy traffic.
- Modified bitumen performs better than conventional bitumen in situations, where the aggregates are prone to stripping. Due to their better creep resistance properties, they can also be used at busy intersections, bridge decks and roundabouts for increased life of the surfacing.
- There are four types of modified bitumen and CRMB (Crumb rubber modified bitumen) is one of the four types of modified bitumen.
- These four types are further divided into three grades based on the penetration value/softening point value.

- The specification requirements of modified bitumen for various climatic conditions are given in table 2 of IRC: SP:53-2010.

11.8. Crumb rubber modified bitumen (CRMB)

- Crumb Rubber Modified Bitumen (CRMB) is hydrocarbon binder obtained through physical and chemical interaction of crumb rubber (produced by recycling of used tyres) with bitumen and some specific additives. Readily available in the market from reputed suppliers.
- The three grades of CRMB are CRMB-50, CRMB-55 and CRMB-60.
- As per IRC: SP: 53-2010, CRMB-60 grade shall be used as binder for the flexible pavement works based on the climatic condition of the project area

11.9. Mix design

The CRMB content required shall be determined following the Marshall mix design procedure contained in Asphalt Institute Manual MS - 2.

The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2.

11.10. Requirements for the mix

Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in MORTH-5TH REVISION table 500 -11.

As per MORTH-5TH REVISION table 500 – 11: Requirements for Dense Graded Bituminous Macadam

Properties	Viscosity grade paving bitumen	Modified bitumen		Test method
		Hot climate	Cold climate	
Compaction level	75 blows on each face of the specimen			
Minimum stability (kN at 600C)	9.0	12.0	10.0	AASHTO T245
Marshall flow (mm)	2 - 4	2.5 - 4	3.5 - 5	AASHTO T245
Marshall Quotient <div style="border: 1px solid black; padding: 2px; display: inline-block;"> $\frac{\text{Stability}}{\text{Flow}}$ </div>	2 - 5	2.5 - 5		MS - 2 and ASTM D2041
% air voids	3 - 5			
% Voids Filled with Bitumen (VFB)	65 - 75			
Coating of aggregate particle	95% minimum			IS: 6241
Tensile Strength ratio	80% Minimum			AASHTO T 283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 500-13			

11.11. Binder content

The binder content shall be optimized to achieve the requirements of the mix set out in MORTH-5TH REVISION table 500 -11. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS - 2.

Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS - 2 and ASTM D 5581 shall be used. This method requires modified equipment and procedures. When the modified Marshall test is used, the specified minimum stability values in MORTH-5TH REVISION table 500-12 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

As per MORTH-5TH REVISION table 500 – 12: Minimum percent voids in mineral aggregate (VMA)

Nominal maximum particle Size ¹ (mm)	Minimum VMA percent related to design percentage air voids		
	3.0	4.0	5.0
26.5	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Note: Interpolate minimum voids in the mineral aggregate (VMA) for designed percentage air voids values between those listed.

11.12. Job mix formula

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the following details:

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows:
 - a. Binder type, and 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 individual grading of the individual aggregate fraction, and the proportion of each in the combined grading;
- v) The results of mix design such as maximum specific gravity of loose mix (G_{mm}), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test;

- vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, 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 mix 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 for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

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 by the Contractor to the Engineer for approval before the placing of the material.

11.13. Plant trials - Permissible variation in job mix formula

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in MORTH-5TH REVISION table 500-13 and shall remain within the gradation band. These variations are intended to apply to individual specimens taken for quality control tests in accordance with MORTH-5TH REVISION Section 900.

As per MORTH-5TH REVISION table 500 – 13: Permissible variations in the actual mix from the job mix formula

Description	Base / binder course
Aggregate passing 19 mm sieve or larger	± 8%
Aggregate passing 13.2 mm, 9.5 mm	± 7%
Aggregate passing 4.75 mm	± 6%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 5%
Aggregate passing 0.3 mm, 0.15 mm	± 4%
Aggregate passing 0.075 mm	± 2%
Binder content	± 0.3%
Mixing temperature	± 10°c

11.14. 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 MORTH-5TH REVISION clause 501. The laying trial shall be carried out on a suitable area which is not to form part of the works. The area of the laying trials shall be a minimum of 100 Sqm 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 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. The compacted layers of Dense Graded Bituminous Macadam (DBM) shall have a minimum field density equal to or more than 92% of the density based on theoretical maximum specific gravity (Gmm) obtained on the day of compaction in accordance with ASTM D 2041.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

11.15. Weather and seasonal limitations

The provisions of MORTH-5TH REVISION clause 501.5.1 shall apply.

11.16. Preparation of base

The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with MORTH-5TH REVISION clauses 501 and 902 as appropriate, or as directed by the Engineer.

11.17. Geo synthetics

Where Geo synthetics are specified in the Contract, this shall be in accordance with the requirements stated in MORTH-5TH REVISION clause 703.

11.18. Stress absorbing layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of MORTH-5TH REVISION clause 517.

11.19. Prime coat

Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of MORTH-5TH REVISION clause 502, or as directed by the Engineer.

11.20. Tack coat

Where the material on which the dense bituminous macadam is to be laid is either bitumen bound layer or primed granular layer, tack coat shall be applied, as specified, in accordance with the provisions of MORTH-5TH REVISION clause 503, or as directed by the Engineer.

11.21. Mixing and transportation of the mix

The provisions as specified in MORTH-5TH REVISION clauses 501.3 and 501.4 shall apply. MORTH-5TH REVISION table 500-2 gives the mixing, laying and rolling temperature for dense mixes using viscosity grade bitumen. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

11.22. Spreading

The provisions of MORTH-5TH REVISION clauses 501.5.3 and 501.5.4 shall apply.

11.23. Rolling

The general provisions of MORTH-5TH REVISION clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

11.24. Opening to traffic

It shall be ensured that the traffic is not allowed without the approval of the Engineer in writing, on the surface until the dense bituminous layer has cooled to the ambient temperature.

11.25. Surface finish and quality control of work

The surface finish of the completed construction shall conform to the requirements of MORTH-5TH REVISION clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of these Specifications.

11.26. Arrangements for traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of MORTH-5TH REVISION clause 112.

11.27. Measurement for payment

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tonnes or by the square metre at a specified thickness as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

11.28. Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out all the required operations as specified and shall include, to all components listed in MORTH-5TH REVISION clause 501.8.8.2. The rate shall include the provision of bitumen, at 4 percent and 4.5 percent by weight of the total mixture for grading 1 and grading 2 respectively.

The variation in actual percentage of bitumen used shall be assessed and the payment adjusted plus or minus accordingly.

12 Bituminous concrete

12.1. General

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

12.2. Bitumen/ CRMB

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS: 73, modified bitumen complying with MORTH clause 501.2.1 and IRC: SP: 53/ IS: 15462 or as otherwise specified in the Contract.

The type and grade of bitumen to be used shall be as specified in clause 9.2.5 and 9.2.6 of this specification.

12.3. Coarse aggregates

The coarse aggregates shall be generally as specified in MORTH clause 504.2.2, except that the aggregates shall satisfy the physical requirements of MORTH table 500-16 and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

As per MORTH-5TH REVISION table 500 – 16: Physical requirements for coarse aggregate for bituminous concrete

Property	Test	Specification	Method of test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I

Property	Test	Specification	Method of test
Particle shape	Combined flakiness and elongation indices	Max 35%	IS:2386 Part I
Strength	Los angeles abrasion value or aggregate impact value	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Polishing	Polished stone value	Min 55	BS:812-114
Water absorption	Water absorption	Max 2%	IS:2386 Part III
Stripping	Coating and stripping of bitumen aggregate mix	Minimum retained coating 95%	IS:6241
Water sensitivity	Retained tensile strength*	Min 80%	AASHTO 283

*If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.

12.4. Fine aggregates

The fine aggregates shall be all as specified in MORTH-5TH REVISION clause 505.2.3.

12.5. Filler

Filler shall be as specified in MORTH-5TH REVISION clause 505.2.4.

12.6. Aggregate grading and binder content

When tested in accordance with IS: 2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in MORTH -5TH REVISION table 500-17. The grading shall be as specified in the Contract.

As per MORTH-5TH REVISION table 500 – 17: Composition of bituminous concrete pavement layers

Grading	1	2
Nominal aggregate size*	19 mm	13.2 mm
Layer thickness	50 mm	30 – 40 mm
15 Sieve1 (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5	100	
19	90 – 100	100
13.2	59 – 79	90 – 100
9.5	52 – 72	70 – 88
4.75	35 – 55	53 – 71

Grading	1	2
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
CRMB content % by mass of total mix	Min 5.4*	Min 5.6**

Notes:

* The nominal maximum particle size is the largest specified sieve size up on which any of the aggregate is retained.

** Corresponds to specific gravity of aggregate being 2.7. In case aggregate have specific gravity more than 2.7, the minimum CRMB content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is - 10°C or lower, the CRMB content may be increased by 0.5 percent

12.7. Mix design

12.7.1. Requirements for the mix

MORTH -5TH REVISION Clause 505.3.1 shall apply.

12.7.2. Binder content

MORTH -5TH REVISION Clause 505 .3.2 shall apply.

12.7.3. Job mix formula

MORTH-5TH REVISION Clause 505.3.3 shall apply.

12.7.4. Plant trials – Permissible variation in job mix formula

The requirements for plant trials shall be as specified in MORTH clause 505.3.4 and permissible limits for variation as given in MORTH table 500-18.

As per MORTH-5TH REVISION table 500 – 18: Permissible variations in plant mix from the job mix formula

Description	Permissible variation
Aggregate passing 19 mm sieve or larger	± 7%
Aggregate passing 13.2 mm, 9.5 mm	± 6%
Aggregate passing 4.75 mm	± 5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 4%
Aggregate passing 0.3 mm, 0.15 mm	± 3%

Description	Permissible variation
Aggregate passing 0.075 mm	± 1.5%
Binder content	± 0.3%
Mixing temperature	± 10°C

12.8. Laying trials

The requirements for laying trials shall be as specified in MORTH clause 505.3.5. The compacted layers of bituminous concrete (BC) shall have a minimum field density equal to or more than 92 percent of the average theoretical maximum specific gravity (Gmm) obtained on the day of compaction in accordance with ASTM 02041

12.9. Weather and seasonal limitations

The provisions of MORTH-5TH REVISION clause 501.5.1 shall apply.

12.10. Preparation of base

The surface on which the bituminous concrete is to be laid shall be prepared in accordance with MORTH-5TH REVISION clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer.

12.11. Geo synthetics

Where Geo synthetics are specified in the Contract, this shall be in accordance with the requirements stated in MORTH-5TH REVISION Clause 703.

12.12. Stress absorbing layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of MORTH-5TH REVISION Clause 517.

12.13. Tack coat

The provisions as specified in MORTH-5TH REVISION Clause 504.4.6 shall apply.

12.14. Mixing and transportation of the mix

The provisions as specified in MORTH-5TH REVISION Clauses 501.3, 501.4 and 504.4.7 shall apply.

12.15. Spreading

The general provisions of MORTH-5TH REVISION clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

12.16. Rolling

The general provisions of MORTH-5TH REVISION clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

12.17. Opening to traffic

Provisions in MORTH-5TH REVISION Clause 504.5 shall apply.

12.18. Surface finish and quality control

The surface finish of the completed construction shall conform to the requirements of MORTH -5TH REVISION Clause 902. All materials and workmanship shall comply with the provisions set out in MORTH -5TH REVISION Section 900 of these specifications.

12.19. Arrangements for traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of MORTH-5TH REVISION Clause 112.

12.20. Measurement for payment

The measurement shall be as specified in MORTH-5TH REVISION Clause 505.8

12.21. Rate

The contract unit rate shall be all as specified in MORTH-5TH REVISION clause 504.9, except that the rate shall include the provision of bitumen at 5.2 percent & 5.4 percent for grading 1 and grading 2 by weight of total mix respectively. The variation in actual percentage of bitumen used will be assessed and the payment adjusted plus and minus accordingly.

13 Pipe culverts

13.1. General

This work shall consist of furnishing and installing reinforced cement concrete pipes, of the type, diameter and length as per design and details and at locations shown on the drawings or as ordered by the Engineer and in accordance with the requirements of these specifications.

13.2. Materials

All materials used in the construction of pipe culverts shall conform to the requirements of MORTH-5TH REVISION Section 1000.

Each consignment of cement concrete pipes shall be inspected, tested, if necessary, and approved by the Engineer either at the place of manufacture or at the site before their incorporation in the works.

13.3. Excavation for pipe

The foundation bed for pipe culverts shall be excavated true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to levels as shown on the drawings. In case of high embankments where the height of fill is more than three times the external diameter of the pipe, the embankment shall first be built to an elevation above the top of the pipe equal to the external diameter of the pipe, and to width on each side of the pipe of not less than five times the diameter of pipe, after which a trench shall be excavated and the pipe shall be laid.

Where trenching is involved, its width on either side of the pipe shall be a minimum of 150 mm or one-fourth of the diameter of the pipe whichever is more and shall not be more than one-third the diameter of the pipe. The sides of the trench shall be as nearly vertical as possible.

The pipe shall be placed where the ground for the foundation is reasonably firm. Installation of pipes under existing bridges or culverts shall be avoided as far as possible. When during excavation the material encountered is soft, spongy or other unstable soil, and unless other special construction methods are called for on the drawings or in special provisions, such unsuitable material shall be removed to such depth, width and length as directed by the Engineer. The excavation shall then be backfilled with approved granular material which shall be properly shaped and thoroughly compacted up to the specified level.

Where bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock/ boulders in this area be removed and the space filled with approved earth, free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Trenches shall be kept free from water until the pipes are installed and the joints have hardened.

13.4. Bedding for pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the culvert, shall conform to the specified levels and grade, and shall be of one of the following two types as specified on the drawings:

- i) **First Class Bedding:** Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material, shaped concentrically to fit the lower part of the pipe exterior for at least ten percent of its overall height or as otherwise shown on the drawings. The bedding material shall be well graded sand or another granular material passing 5.6 mm sieve suitably compacted/rammed. The compacted thickness of the bedding layer shall be as shown on the drawings and in no case shall it be less than 75 mm.
- ii) **Concrete Cradle Bedding:** When indicated on the drawings or directed by the Engineer, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M 15 conforming to Section 1700. The shape and dimensions of the cradle shall be as indicated on the drawings. The pipes shall be laid on the concrete bedding before the concrete has set.

13.5. Laying of pipe

No pipe shall be laid in position until the foundation has been approved by the Engineer. Where two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

The arrangement for lifting, loading and unloading concrete pipes from factory/yard and at site shall be such that the pipes do not suffer any undue structural strain, any damage due to fall or impact. The arrangement may be got approved by the Engineer.

Similarly, the arrangement for lowering the pipe in the bed shall be got approved by the Engineer. It may be with tripod-pulley arrangement or simply by manual labour in a manner that the pipe is placed in the proper position without damage.

The laying of pipes on the prepared foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. In case of use of pipes with bell-mouth, the belled end shall face upstream. The pipes shall be fitted and matched so that when laid in work, they form a culvert with a smooth uniform invert.

Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

13.6. Jointing

The pipes shall be jointed either by collar joint or by flush joint. In the former case, the collars shall be of RCC 150 to 200 mm wide and having the same strength as the pipes to be jointed. Caulking space shall be between 13 and 20 mm according to the diameter of the pipe. Caulking material shall be slightly wet mix of cement and sand in the ratio of 1:2 rammed with caulking irons. Before caulking, the collar shall be so

placed that its center coincides with the joint and an even annular space is left between the collar and the pipe.

Flush joint may be internal flush joint or external flush joint. In either case, the ends of the pipes shall be specially shaped to form a self centering joint with a jointing space 13 mm wide. The jointing space shall be filled with cement mortar, 1cement to 2sand, mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed.

For jointing pipe lines under light hydraulic pressure, the recess at the end of the pipe shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damp for at least four days.

13.7. Backfilling

Trenches shall be backfilled immediately after the pipes have been laid and the jointing material has hardened. The backfill soil shall be clean, free from boulders, large roots, excessive amounts of sods or other vegetable matter, and lumps and shall be approved by the Engineer. Backfilling upto 300 mm above the top of the pipe shall be carefully done and the soil thoroughly rammed, tamped or vibrated in layers not exceeding 150 mm, particular care being taken to thoroughly consolidate the materials under the haunches of the pipe. Approved pneumatic or light mechanical tamping equipment can be used.

Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of high embankment, after filling the trench upto the top of the pipe in the above said manner, a loose fill of a depth equal to external diameter of the pipe shall be placed over the pipe before further layers are added and compacted.

13.8. Head walls and other ancillary works

Headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the drawings or as directed by the Engineer. Masonry for the walls shall conform to MORTH-5TH REVISION sections 1300, 1400 or 1700 as applicable. Aprons shall conform to MORTH-5TH REVISION section 2500.

13.9. Opening to traffic

No traffic shall be permitted to cross the pipes unless height of filling above the top of the pipes is atleast 600 mm.

13.10. Measurements for payment

RCC pipe culvert shall be measured as complete work in linear metres along its length between the inlet and outlet ends. Culverts with multiple rows of pipes shall be measured as one unit, irrespective of the number of rows.

13.11. Rate

The Contract unit rate for the pipe culvert shall include the cost of pipes including loading, unloading, hauling, handling, storing, laying in position and jointing and all ancillary works such as excavation, bedding for pipes, backfilling, concrete, masonry and aprons and incidental costs to complete the work as per these Specifications.

14 Footpaths, cycle track and separators

14.1. General

The work shall consist of constructing footpaths, cycle track and/or separators at locations as specified in the drawings or as directed by the Engineer.

The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed by the Engineer.

14.2. Materials

The footpaths, cycle track and separators shall be constructed with any of the following types:

- a) Cast-in-situ cement concrete of Grade M 20 as per Section 1700 of the Specifications. The minimum size of the panels shall be as specified in the drawings.
- b) Precast cement concrete blocks and interlocking blocks/tiles of grade not less than M 30 as per Section 1700 of the Specifications. The thickness and size of the cement concrete blocks or interlocking blocks/ tiles shall be as specified in the drawings.
- c) Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the Contractor and approved by the Engineer. The thickness and size of the natural stone slab shall be as specified in the drawings.

14.3. Construction operations

Drainage pipes below the footpath originating from the kerbs shall be first laid in the required slope and connected to the drains/sumps/storm water drain/drainage chutes as per provisions of the drawings, or as specified.

Portion on back side of kerbs shall be filled and compacted with granular sub-base material as per MORTH-5TH REVISION clause 401 of the Specifications in specified thickness.

The base for cast-in-situ cement concrete panels/ tiles/ nature stone slab shall be prepared and finished to the required lines, levels and dimensions as indicated in the drawings.

Over the prepared base, precast concrete interlocking blocks/tiles/natural stone slabs and/or cast-in- situ slab shall be set/ laid as described in MORTH-5TH REVISION clauses 410 .3.4 and 410.3.5.

14.4. Tiles/Natural stone slabs

The blocks/tiles/slabs shall be set on a layer of average 12 mm thick cement-sand mortar (1:3) laid on prepared base in such a way that there is no rocking. The gaps between the blocks/tiles/slabs shall not be more than 12 mm and shall be filled with cement-sand mortar (1:3).

14.5. Cast-in-situ cement concrete

The panels of specified size shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as per Section 1700 of the Specifications.

14.6. Precast concrete blocks and interlocking concrete block pavements

The precast concrete blocks and interlocking concrete block pavement shall be laid on a bedding of sand of thickness specified in the drawing. The grading of the sand layer shall be as in MORTH-5TH REVISION table 400-19.

As per MORTH-5TH REVISION table 400 – 19

IS sieve size	Percent passing
9.52 mm	100
4.75 mm	95 – 100
2.36 mm	80 – 100
1.18 mm	50 – 95
600 micron	25 – 60
300 micron	10 – 30
150 micron	0 – 15
75 micron	0 – 10

The joints shall be filled with sand passing a 2.35 mm size with the grading as in MORTH-5TH REVISION table 400-20.

As per MORTH-5TH REVISION table 400 – 20

IS sieve size	Percent passing
2.36 mm	100
1.18 mm	90 – 100
600 micron	60 – 90
300 micron	30 – 60
150 micron	15 – 30
75 micron	0 – 10

The bedding sand slightly moist, the moisture content being about 4% the bedding sand shall be compacted by vibratory plate compactor.

The blocks shall be laid to the levels indicated on the drawings and to the pattern directed by the Engineer. The surface tolerance shall be ± 10 mm with respect to the design level. The blocks shall be embedded using a hammer.

14.7. Measurements for payment

Footpaths, cycle track and separators shall be measured in Sq.m between inside of kerbs. The edge restraint block and kerb shall be measured separately in linear meter. The items pertaining to drainage shall be measured separately.

14.8. Rate

Contract unit rates shall be inclusive of full compensation for all labour, materials, tools, equipment for footpaths including the base. Cost of providing pipes and arrangement for their discharge into appropriate drainage channels shall be incidental to the construction of footpaths.

15 Road markings

15.1. General

The work shall consist of providing road markings at site including supply of materials and carrying out the work in accordance with IRC: 35 and these Specifications.

The colour, width and layout of road markings shall be in accordance with the Code of Practice for Road Markings IRC: 35 and as specified in the drawings or as directed by the Engineer. No centre line marking shall be done on single-lane roads.

15.2. Materials

Ordinary paints shall be used for road markings, conforming to IS:164. These shall have a wear resistance of at least 4 hours under accelerated laboratory test Yellow colour (conforming to IS colour No. 356) as given in IS:164, white and black colours are the standard colours used for markings.

15.3. Application

Painting may be done by machine or by hand (preferably by machine). The Contractor shall maintain traffic control while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

The finished lines shall be free from ruggedness on sides and ends and be in true plane with the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

15.4. Measurements for payment

The painted markings shall be measured in square meter with no deductions for intermediate gaps as shown on the drawings.

In respect of markings, like directional arrows and lettering, etc., the measurement shall be by numbers.

15.5. Rate

The Contract unit rate for road markings shall be payment in full compensation for furnishing all labour, materials, tools, equipment, and carrying out the markings at site as per the approved drawing(s) or as directed by the Engineer and all other incidental costs necessary to complete the work in accordance with these Specifications.