

Chapter 7

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CHAPTER 7: ROAD WORKS

7.1 EMBANKMENT CONSTRUCTION

7.1.1 General

7.1.1.1 Description: These Specifications shall apply to the construction of embankment including subgrade, earthen shoulders and miscellaneous backfills with approved material obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrades, 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.

7.1.2 Materials and General Requirements

7.1.2.1 Physical requirements: The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredients likely to deteriorate or affect the stability of the embankment/subgrade.

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

- a) Materials from swamps, marshes 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 70 and plasticity index exceeding 45' and
- f) Materials with salts resulting in leaching in the embankment.

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

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

Materials with a total sulphate content (expressed as SO_3) exceeding 0.5 per cent by mass, when tested in accordance with BS: 1377 Test 9 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

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

Specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

- 7.1.2.1.4** Ordinarily, only the materials satisfying the density requirements given in Table 7.1 shall be employed for the construction of the embankment and the subgrade.

TABLE 7.1: Density Requirements of Embankment and Subgrade Materials

S.No.	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2720 (Part 8)
1.	Embankments up to 3 metres height, not subjected to extensive flooding;	Not less than 15.2 kN/cu.m.
2.	Embankments exceeding 3 metres height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cu.m.
3.	Subgrade and earthen shoulders/verges/backfill	Not less than 17.5 kN/cu.m.

Notes: (1) This Table is not applicable for lightweight fill material e.g. cinder, fly ash etc.

- (2) The Engineer may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.
- (3) The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per Table 7.2.

7.1.2.2 General requirements:

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

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

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

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.

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

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 siting of temporary buildings or structures.

The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the Engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in Table 7.2 shall yield the design CBR value of the subgrade.

TABLE 7.2: Compaction Requirements for Embankment and Subgrade

S.No.	Type of Work / material	Relative compaction as percentage of max. laboratory dry density as per IS: 2720 (Part 8)
1.	Subgrade and earthen shoulders	Not less than 97
2.	Embankment	Not less than 95
3.	Expansive Clays subject to the explanation in clause 7.1.2.1.1 a) Subgrade and 500 mm portion just below the subgrade b) Remaining portion of embankment	Not allowed Not less than 90

The Contractor shall submit, at least 7 working days before commencement of compaction, 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 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
- (ii) A graph of density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.
- (iii) The Dry density-moisture content – CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

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

7.1.3 Construction Operations

7.1.3.1 Setting Out: After the site has been cleared the work shall be set out. The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork the embankment/subgrade shall be suitably prepared to 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.

7.1.3.2 Compacting ground supporting embankment/subgrade: Where necessary, the original ground shall be levelled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in Table 7.2.

In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 per cent relative compaction with respect to the dry density as given in Table 7.2, the ground shall be loosened up to a level 0.5 m below the subgrade level, watered and compacted in layers in accordance with the subsequent clauses to not less than 97 per cent of dry density as given in Table 7.2.

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

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

Any foundation treatment specified for embankments especially high embankments, resting on suspect 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 the material types (a) to (f) in Clause 7.1.2, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

7.1.3.3 Spreading material in layers and bringing to appropriate moisture content

7.1.3.3.1 The embankment and subgrade material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader and compacted as per Clause 7.1.3.4. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in Table 7.2 and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

7.1.3.3.2 Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such constructions, 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 blading, discing or harrowing until uniform moisture content is obtained throughout the depth of 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 sufficient time should be spaced for the material to dry up.

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 7) or IS: 2720 (Part 8) as the case may be. Expansive clays shall, however be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

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 75mm when being placed in the embankment and a maximum size of 50mm when being placed in the subgrade.

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

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

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

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

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

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

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

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 Table 7.2. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 7.15.2.2 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 the gauge is calibrated to provide 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/subgrade/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 to the density requirements and satisfaction of the Engineer.

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

7.1.3.6 Repairing of damages caused by rain/spillage of water: This work is carried out directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 7.1.3.4. If the cut is not sufficiently wide for use of rollers, it shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery/equipment for the purpose.

7.1.3.7 Finishing operations: Finishing operations shall include the work of shaping and dressing the shoulders/verge/roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the surface tolerance described in Table 7.24. Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

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

Where directed, the slopes shall be turfed with sods or if seeding and mulching of slopes is prescribed, this shall be done as per direction of the Engineer.

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

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

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

The material used for backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS: 2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in Appendix 6 of IRC: 78 (Standard Specifications and Code of Practice for Road Bridges-Section VII) in respect of the type of material, the extent of backfill, its laying and compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of Table 7.2.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in Table 7.3. Unless otherwise specified in the Contract.

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

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

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

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

7.1.4 Plying of Traffic

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

7.1.5 Surface Finish and Quality Control of Work

The surface finish of construction of subgrade shall conform to the requirements of Table 7.26. Control on the quality of materials and works shall be exercised in accordance with Clause 7.15.

7.1.6 Subgrade Strength

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

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

7.1.7 Measurements for Payment

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

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

Construction of embankment under water shall be measured in cu.m.

Construction of high embankment with specified material and in specified manner shall be measured in cu.m.

Stripping including storing and reapplication of topsoil shall be measured in cu.m.

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

Removal of unsuitable material at embankment/subgrade foundation and replacement with suitable material shall be measure in cu.m.

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

7.1.8 Rates

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

- (i) Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;
- (ii) Setting out;
- (iii) Compacting ground supporting embankment/subgrade except where removal and replacement of unsuitable material or loosening and recompacting is involved.
- (iv) Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and subgrade as applicable.
- (v) Cost of watering or drying of material in borrow areas and/or embankment and subgrade during construction as required.
- (vi) Spreading in layers, bringing to appropriate moisture content and compacting to Specification requirements;
- (vii) Shaping and dressing top and slopes of the embankment and subgrade including rounding of corners;
- (viii) Restricted working at sites of structures;
- (ix) Working on narrow width of embankment and subgrade;
- (x) Excavation in all soils from borrow pits/designated borrow areas including clearing and grubbing and transporting the material to embankment and subgrade site with all lifts and leads unless otherwise provided for in the Contract;

- (xi) All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;
- (xii) Dewatering; and
- (xiii) Keeping the embankment/completed formation free of water.

7.2 SURFACE/SUB SURFACE DRAINS

7.2.1 Scope

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

7.2.2 Surface Drains

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

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

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

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

The Special Specification for Storm Water Drainage also shall be referred to.

7.2.3 Sub-surface Drains

7.2.3.1 Scope: Sub-surface drains shall be of close-jointed perforated pipes, open-jointed unperforated pipes, surrounded by granular material laid in a trench or aggregate drains to drain the pavement courses or sub-surface drains designed using Geosynthetic material and approved by the Engineer.

7.2.3.2 Materials

- A. Pipe:** Perforated pipes for the drains may be of metal / asbestos cement/ cement concrete / PVC, and unperforated pipes of vitrified clay / cement concrete / asbestos cement. The type, size and grade of the pipe to be used shall be as specified in the contract. In no case, however, shall the internal diameter of the pipe be less than 100mm. Holes for perforated pipes shall be on one half of the circumference only and conform to the spacing indicated on the drawings. Size of the holes shall not ordinarily be greater than half of D85 size of the material surrounding the pipe, subject to minimum 3mm and maximum 6mm. D85 stands for the size of the sieve that allows 85% of the material to pass through it.

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

- i. Where the soil met with in the trench is of fine grained type (e.g., silt, clay or a mixture thereof), the backfill material shall conform to Class I grading set out in Table 7.3.
- ii. Where the soil met with in the trench is of coarse silt to medium sand or sandy type, the backfill material shall correspond to Class II grading of Table 7.3
- iii. Where the soil met with in the trench is of gravelly sand, the backfill material shall correspond to Class III grading of Table 7.3.

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

TABLE 7.3: Grading Requirements for Filter Material

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

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

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

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

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

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

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

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

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

7.2.3.5 Use of Geosynthetic in laying of pipe and backfilling: After excavating the trench for subsurface drain, the filter fabric shall be placed, the pipe installed and the trench backfilled with permeable material according to dimensions and details shown on the plans. Surfaces to receive filter fabric prior to placing shall be free of loose or extraneous material and sharp objects that may damage the filter fabric during installation. Adjacent rolls of the fabric shall be overlapped a minimum of 450mm. The preceding roll shall overlap the following roll in the direction the material is being spread.

Damage to the fabric resulting from Contractor's vehicles, equipment or operations shall be replaced or repaired by the contractor at his expense.

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

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

Aggregate for the drains shall be durable gravel, stone or slag and shall be free from vegetable matter and other deleterious substances.

7.2.4 Measurement of Payment

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

7.2.5 Rates

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

7.3 GRANULAR SUB-BASE

7.3.1 Scope

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as 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.

7.3.2 Materials

7.3.2.1 The material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table 7.4.

While the gradings in Table 7.4 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm.

7.3.2.2 Physical requirements: The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part 111). The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.

TABLE 7.4: Grading for Close-Graded Granular Sub-Base Materials

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading I	Grading II	Grading III
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR value (Minimum)	30	25	20

7.3.3 Strength of sub-base

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

When directed by the Engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content any other tests for the “quality” of materials, as may be necessary.

7.3.4 Construction Operations

7.3.4.1 Preparation of subgrade: Immediately prior to the laying of sub-base, the subgrade already finished to Clause 7.1 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.

7.3.4.2 Spreading and Compacting: The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade 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.

When the sub-base material consists of combination of materials mentioned in Clause 7.3.2, mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS: 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 MN/m² or equivalent capacity roller capable

of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for stretches of unidirectional crossfall and super-elevation, and shall commence at the edges and progress towards the centre for stretches having crossfall on both sides.

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

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

7.3.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 7.15.

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 7.15.

7.3.6 Arrangements for Traffic

During the period of construction, arrangement of traffic diversions shall be maintained as per the direction of Engineer.

7.3.7 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.

7.3.8 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 diversions. Except for initial treatment to verges, shoulders and construction of diversions;
- (ii) furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and 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;
- (v) carrying out the required tests for quality control and
- (vi) multiple handling of materials

7.4 WET MIX MACADAM BASE

7.4.1 Scope

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 subgrade/sub-base/base or existing pavement as the case may be in accordance with the requirements of the 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. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be increased to 200 mm upon approval of the Engineer.

7.4.2 Materials

7.4.2.1 Aggregates

7.4.2.1.1 Physical requirements: Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 7.5 below.

TABLE 7.5: Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Base Courses

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

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

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

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

7.4.2.1.2 Grading requirements: The aggregates shall conform to the grading given in Table 7.6.

TABLE 7.6: Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Per cent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30

IS Sieve Designation	Per cent by weight passing the IS sieve
600.00 micron	8-22
75.00 micron	0-8

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

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

7.4.3 Construction Operations

7.4.3.1 Preparation of base: Prior to laying of the wet mix macadam base the granular sub-base already laid should be prepared by removing of extraneous material, lightly sprinkled with water and rolled with two passes of 80 – 100 kN smooth wheeled roller.

7.4.3.2 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 constructing the adjoining shoulder with approved material alongwith that of the wet Mix Macadam layer.

7.4.3.3 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 pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

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.

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

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

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

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

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

7.4.3.5 **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 100 kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km/h.

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

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

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 subgrade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

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

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

7.4.3.6 **Setting and drying:** After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

7.4.4 **Opening to Traffic**

Preferably no vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

7.4.5 Surface Finish and Quality Control of Work

7.4.5.1 Surface evenness: The surface finish of construction shall conform to the requirements of Clause 7.15.

7.4.5.2 Quality control: Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 7.15.

7.4.6 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 subgrade 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 recompact in accordance with Clause 7.4.3. 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.

7.4.7 Arrangement for Traffic

During the period of construction, arrangement of traffic diversion shall be done as per the direction of Engineer.

7.4.8 Measurements for Payment

Wet Mix Macadam shall be measured as finished work in position in cubic metres.

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

7.4.9 Rate

The Contract unit rate for Wet Mix Macadam shall be payment in full for carrying out the required operations including full compensation for:

- (i) making arrangements for traffic diversions. Except for initial treatment to verges, shoulders and construction of diversions;
- (ii) furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and 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
- (v) carrying out the required tests for quality control.

7.5 CEMENT CONCRETE KERB AND KERB WITH CHANNEL

7.5.1 Scope

This work shall consist of constructing cement concrete kerbs and kerbs with channel in the central median and/or along the footpaths or separators in conformity with the lines, levels and dimensions as specified in the drawings.

7.5.2 Materials

Kerbs and kerb with channel shall be provided in cement concrete of Grade M20 in accordance with the Specifications.

7.5.3 Type of Construction

These shall be cast-in-situ construction with suitable kerb casting machine in all situations except at locations where continuous casting with equipment is not practicable. In those situations, precast concrete blocks shall be used.

7.5.4 Equipment

A continuous kerb casting equipment of adequate capacity and controls, capable of laying the kerbs in required cross-sections and producing a well-compacted mass of concrete free of voids and honeycombs, shall be used.

7.5.5 Construction Operations

7.5.5.1 Kerb shall be laid on firm foundation of minimum 150 mm thickness of cement concrete of M10 grade cast in-situ or one extended width and pavement. The foundation shall have a projection of 50 mm beyond the kerb stone. Before laying the foundation of lean concrete, the base shall be levelled and slightly watered to make it damp.

7.5.5.2 In the median lengths. In the portions where footpath is provided and/or the slope of the carriageway is towards median (as in case of super elevated portions), there shall be sufficient gap/recess left in the kerb to facilitate portions in the straight reaches, the kerb shall be cast in continuous drainage openings.

7.5.5.3 After laying the kerbs and just prior to hardening of the concrete, saw cut grooves shall be provided at 5 m intervals or as specified by the Engineer.

7.5.5.4 Kerbs on the drainage ends such as along the footpath or the median in super elevated portions shall be cast with monolithic concrete channels as indicated in drawings. The slope of the channel towards drainage pipes shall be ensured for efficient drainage of the road surface.

7.5.5.5 Vertical and horizontal tolerances with respect to true line and level shall be ± 6 mm.

7.5.6 Measurements for Payment

Cement concrete kerb/kerb with channel shall be measured in linear metre for the complete item of work.

Foundation of kerb, where separately provided shall be measured in linear metre for complete item of work.

7.5.7 Rates

The Contract unit rates for cement concrete kerb/kerb with channel and foundation for kerb shall be payment in full compensation for furnishing all materials, labour, tools, equipment for construction and other incidental cost necessary to complete the work.

7.6 FOOTPATHS AND SEPARATORS

7.6.1 Scope

The work shall consist of constructing footpaths and/or separators at locations as specified in the drawings or as directed by the Engineer. The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed.

7.6.2 Materials

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

- a) Cast-in-situ cement concrete of Grade M20 as per the Specifications.

- b) Precast cement concrete blocks/tiles of Grade M20 as per the Specifications. The minimum thickness of the cement concrete block/tile shall be 25 mm and minimum size shall be 300 mm × 300 mm.
- 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 minimum thickness of the natural stone slab shall be 25 mm and minimum size shall be 300 mm × 300 mm.

7.6.3 Construction Operations

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

7.6.3.2 Portion on back side of kerbs shall be filled and compacted with granular sub-base material as per Clause 7.3 of the Specifications in specified thickness.

7.6.3.3 The base shall be prepared and finished to the required lines, levels and dimensions as indicated in the drawings with the following:

- a) Minimum 150 mm thick, compacted granular sub-base material as per Clause 7.3 of the Specifications.
- b) Minimum 25 mm thick cement concrete of Grade M 15.

Over the prepared base, precast concrete blocks/tiles/natural stone slabs and/or cast-in-situ slab shall be set/laid as described in Clauses 7.6.3.4 and 7.6.3.5.

7.6.3.4 Precast cement concrete blocks/tiles/natural stone slab: 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).

7.6.3.5 Cast-in-situ cement concrete: The minimum thickness of the cement concrete shall be 25 mm and it shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as directed.

7.6.4 Measurements for Payment

Footpaths and separators shall be measured in sq.metre between inside of kerbs.

7.6.5 Rates

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

7.7 PRIME COAT OVER GRANULAR BASE

7.7.1 Scope

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.

7.7.2 Materials

7.7.2.1 Primer: The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC:16. These are:

- i) Surfaces of low porosity; such as wet mix macadam and water bound macadam,

- ii) Surfaces of medium porosity; such as cement stabilized soil base,
- iii) Surface of high porosity; such as a gravel base.

7.7.2.2

Primer viscosity: The type and viscosity of the primer shall comply with the requirements of IS 8887, as sampled and tested for bituminous primer in accordance with these standards. Guidance on viscosity and rate of spray is given in Table 7.7.

TABLE 7.7: Viscosity Requirement and Quantity of Liquid Bituminous Primer

Type of surface	Kinematic Viscosity of Primer at 60°C (Centistokes)	Quantity of Liquid Bituminous Material per 10 Sq.m. (kg)
Low porosity	30 - 60	6 to 9
Medium porosity	70 – 140	9 to 12
High porosity	250 – 500	12 to 15

7.7.2.3

Choice of primer: The primer shall be bitumen emulsion, complying with IS 8887 of a type and grade as specified in the Contract or as directed by the Engineer. The use of medium curing cutback as per IS 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer.

7.7.3

Weather and Seasonal Limitations

Bituminous primer shall not be applied to a wet surface (see 7.7.4.2) or during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present.

7.7.4

Construction

7.7.4.1

Equipment: The primer distributor shall be a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying of small area, inaccessible to the distributor, or in narrow strips shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

7.7.4.2

Preparation of road surface: The surface to be primed shall be prepared in accordance with Table 7.26 as appropriate. Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

7.7.4.3

Application of bituminous primer: The viscosity and rate of application of the primer shall be as specified in the Contract, or as determined by site trials carried out as directed by the Engineer. The bituminous primer shall be sprayed uniformly. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bard 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.

7.7.4.4

Curing of primer and opening to traffic: A primed surface shall be allowed to cure for at least 24 hours or such other period as is found to be necessary to allow all the volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with an application of sand, using the

minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course. A very thin layer of clean sand may be applied to the surface of the primer, to prevent the primer picking up under the wheels of the paver and the trucks delivering bituminous material to the paver.

7.7.4.5 Tack coat: Over the primed surface, a tack coat should be applied in accordance with Clause 7.8 if required and directed by the Engineer.

7.7.5 Quality Control of Work

For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 7.15 shall apply.

7.7.6 Arrangements for Traffic

During construction operations, arrangements for traffic diversion shall be made in accordance with the direction of the Engineer.

7.7.7 Measurement for Payment

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

7.7.8 Rate

The contract unit rate for prime coat as described in Clause 7.7.7 shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 7.7.4 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 0.6 kg per square metre, with adjustment, plus or minus, for the variation between this amount and the actual amount approved by the Engineer after the preliminary trials referred to in Clause 7.7.4.3.

7.8 TACK COAT

7.8.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to an existing bituminous road surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or instructed by the Engineer.

7.8.2 Materials

7.8.2.1 Binder: The binder used for tack coat shall be bitumen emulsion complying with IS 8887 of a type and grade as specified in the Contract or as directed by the Engineer. The use of cutback bitumen as per IS 217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer.

7.8.3 Weather and Seasonal Limitations

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

7.8.4 Construction

7.8.4.1 Equipment: The tack coat distributor shall be a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

7.8.4.2 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 Clause 7.15 as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a

mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

- 7.8.4.3 Application of tack coat:** The application of tack coat shall be at the rate specified in the Contract, and shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract then it shall be at the rate specified in Table 7.8. 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 if RC-70 is used. The method of application of the tack coat 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.

TABLE 7.8: Rate of Application of Tack Coat

Type of Surface	Quantity of liquid bituminous material in Kg per sq.m. area
i) Normal bituminous surfaces	0.20 to 0.25
ii) Dry and hungry bituminous surfaces	0.25 to 0.30
iii) Granular surfaces treated with primer	0.25 to 0.30
iv) Non bituminous surfaces	
a) Granular base (not primed)	0.35 to 0.40
b) Cement concrete pavement	0.30 to 0.35

Where the material to receive an overlay is a freshly laid bituminous layer, that has not been subjected to traffic, or contaminated by dust, a tack coat is not mandatory where the overlay is completed within two days.

- 7.8.4.4 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.

7.8.5 Quality Control of Work

For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 7.15 shall apply.

7.8.6 Arrangements for Traffic

During the period of construction, arrangements for traffic diversion shall be made as directed.

7.8.7 Measurement for Payment

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

7.8.8 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 Clause 7.8.4 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, with the provision that the variance in actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

7.9 BITUMINOUS MACADAM

7.9.1 Scope

This work shall consist of construction in a single course having 50 mm to 100 mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of these Specifications. Bituminous macadam is more open graded than the dense graded bituminous materials described in Clauses 7.10, 7.11, 7.12.

7.9.2 Materials

7.9.2.1 Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for “Paving Bitumen” IS: 73, and of the penetration indicated in Table 7.10.

7.9.2.2 Coarse aggregates: The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where the Contractor’s selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer’s recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping.

The aggregates shall satisfy the physical requirements set forth in Table 7.9.

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

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

TABLE 7.9: Physical Requirements for Coarse Aggregates for Bituminous Macadam

Property	Test	Specification
Cleanliness	Grain size analysis ¹	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index (Combined) ²	Max 30%
Strength*	Los Angeles Abrasion Value ³	Max 40%
	Aggregate Impact Value ³	Max 30%
Durability	Soundness: ⁴	
	Sodium Sulphate	Max 12%
	Magnesium Sulphate	Max 18%
Water Absorption	Water absorption ⁵	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures ⁶	Minimum retained coating 95%
Water Sensitivity ⁷	Retained Tensile Strength	Min 80%

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

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

7.9.2.4 Aggregate grading and binder content: When tested in accordance with IS: 2386 Part I (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 7.10 for the grading specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

7.9.2.5 Proportioning of material: The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 7.10. The binder content shall be within a tolerance of ± 0.3 per cent by weight of total mixture when individual specimens are taken for quality control tests in accordance with the provisions of Table 7.28.

7.9.3 Construction Operations

7.9.3.1 Weather and seasonal limitations: Laying shall be suspended while free-standing water is present on the surface to be covered, or during fog, rain and dust storms or when the surrounding temperature is below 10°C or when wind speed exceed 40 km/hr at 2m height.

TABLE 7.10: Composition of Bituminous Macadam

Mix designation Nominal aggregate size Layer thickness IS Sieve (mm)	Grading 1 40 mm 80 - 100 mm Cumulative % by weight of total aggregate passing	Grading 2 19 mm 50 - 75 mm
45	100	
37.5	90 – 100	
26.5	75 – 100	100
19	-	90 – 100
13.2	35 – 61	56 – 88
4.75	13 – 22	16 – 36
2.36	4 – 19	4 – 19
0.3	2 – 10	2- 10
0.075	0 – 8	0 – 8
Bitumen content, % by weight of total mixture ¹	3.1 – 3.4	3.3 – 3.5
Bitumen grade	35 to 90	35 to 90

Notes: 1. Appropriate bitumen contents for conditions in cooler areas of India may be up to 0.5% higher subject to the approval of the Engineer.

7.9.3.2 Preparation of the base: The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clause 7.15 as appropriate, and a prime coat, shall be applied in accordance with Clause 7.7 where specified, or as directed by the Engineer.

7.9.3.3 Tack coat: A tack coat in accordance with Clause 7.8 shall be applied as required by the Contract documents, or as directed by the Engineer.

7.9.3.4 Preparation and transportation of the mixture: The bituminous mix materials shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality and shall be transported to site in clean insulated vehicles and shall be covered while in transit or awaiting tipping.

7.9.3.5 Spreading: Except in areas where paver cannot access bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machines. The materials shall be supplied continuously to the paver and laid without delay.

TABLE 7.11: Manufacturing and Rolling Temperatures

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

7.9.3.6 Rolling: Compaction shall be carried out 8 to 10 kN static or vibratory roller or pneumatic roller at temperature specified in Table 7.11.

Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in Clause 7.15.

7.9.4 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Table 7.26. For control of the quality of materials supplied and the works carried out, the relevant provisions of Clause 7.15 shall apply.

7.9.5 Protection of the Layer

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

7.9.6 Arrangements for Traffic

During the period of construction, arrangements for traffic diversions shall be made as directed.

7.9.7 Measurement for Payment

Bituminous macadam shall be measured as finished work in cubic metres, or by weight in metric tones, where used as regulating course, or square metres at the specified thickness as indicated in the Contract or shown on the drawings, or as otherwise directed by the Engineer.

7.9.8 Rate

The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified.

7.10 DENSE GRADED BITUMINOUS MACADAM

7.10.1 Scope

This clause specifies the construction of Dense Graded Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

7.10.2 Materials

7.10.2.1 Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for “Paving Bitumen” IS: 73, and of the penetration indicated in Table 7.14 for dense bitumen macadam, or as otherwise specified in the Contract.

7.10.2.2 Coarse aggregates: The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor’s selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer’s recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in Table 7.12, for dense bituminous macadam.

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

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

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

TABLE 7.12: Physical Requirements for Coarse Aggregate for Dense Graded Bituminous Macadam

Property	Test	Specification
Cleanliness (dust)	Grain size analysis ¹	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index (Combined) ²	Max 30%
Strength*	Los Angeles Abrasion Value ³	Max 35%
	Aggregate Impact Value ⁴	Max 27%

Property	Test	Specification
Durability	Soundness: ⁵ Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
Water Absorption	Water absorption ⁶	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures ⁷	Minimum retained coating 95%
Water Sensitivity**	Retained Tensile Strength ⁸	Min 80%

Notes: 1. IS: 2386 Part 1

5. IS: 2386 Part 5

2. IS: 2386 Part I

6. IS: 2386 Part 3

(the elongation test to be done only on non-flaky aggregate in the sample)

3. IS: 2386 Part 4*

7. IS: 6241

4. IS: 2386 Part 4%

8. AASHTO T283**

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

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

7.10.2.4

Filler: Filler 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 Table 7.13.

TABLE 7.13: Graded Requirements for Mineral Filler

IS Sieve (mm)	Cumulative per cent passing by weight of total aggregate
0.6	100
0.3	95 – 100
0.075	85 – 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 7.12, then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

7.10.2.5

Aggregate grading and binder content: When tested in accordance with IS: 2386 Part I (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in Table 7.14, for dense bituminous macadam grading 1 or 2 as specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

TABLE 7.14: Composition of Dense Graded Bituminous Macadam Pavement Layers

Grading	1	2
Nominal aggregate size	40 mm	25 mm
Layer Thickness	80 – 100 mm	50 – 75 mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	95 – 100	100
26.5	63 – 93	90 – 100
19	-	71 – 95
13.2	55 – 75	56 – 80
9.5	-	-
4.75	38 – 54	38 – 54
2.36	28 – 42	28 – 42
1.18	-	-
0.6	-	-
0.3	7 – 21	7 – 21
0.15	-	-
0.075	2 – 8	2 – 8
Bitumen content % by mass of total mix ²	Min 4.0	Min 4.5
Bitumen grade (pen)	65 or 90	65 or 90

Notes: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

7.10.3 Mixture Design

7.10.3.1 Requirement for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 7.15.

TABLE 7.15: Requirements for Dense Graded Bituminous Macadam

Minimum stability (kN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3 – 6
Per cent voids in mineral aggregate (VMA)	See Table 7.16 below
Per cent voids filled with bitumen (VFB)	65 -75

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 7.16.

TABLE 7.16: Minimum Per cent Voids in Mineral Aggregate (VMA)

Nominal Maximum Particle Size ¹ (mm)	Minimum VMA, Per cent Related to Design Air Voids, Per cent ²		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

- Notes:**
1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent.
 2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

7.10.3.2 Binder Content: The binder content shall be optimized to achieve the requirements of the mixture set out in Table 7.15 and the traffic volume specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer.

Where 40 mm dense bituminous macadam mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures; particularly the minimum stability values in Table 7.15 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

7.10.3.3 Job mix formula: The Contractor shall inform the Engineer in writing at least 20 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details:

- Source and location of all materials;
- Proportions of all materials expressed as follows where each is applicable:
 - Binder type, and percentage by weight of total mixture;
 - Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
- A single definite percentage passing each sieve for the mixed aggregate;
- The individual gradings of the individual aggregate fractions, and the proportion of each in the combined grading.
- The results of tests enumerated in Table 7.15 as obtained by the Contractor;
- Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch.
- Test results of physical characteristics of aggregates to be used;
- Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in

the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer 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 to the Engineer for approval before the placing of the material.

7.10.3.4 Plant trials – permissible variation in job mix formula: Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentage of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 7.17. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

TABLE 7.17: Permissible Variations form the Job Mix Formula

Description	Permissible variation	
	Base/binder course	Wearing course
Aggregate passing 19mm sieve or larger	±8%	±7%
Aggregate passing 13.2mm, 9.5 mm	±7%	±6%
Aggregate passing 4.75 mm	±6%	±5%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	±5%	±4%
Aggregate passing 0.3mm, 0.15mm	±4%	±3%
Aggregate passing 0.075mm	±2%	±1.5%
Binder content	±0.3%	±0.3%
Mixing temperature	±10°C	±10°C

Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

7.10.3.5 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 the specifications. The laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing, by the Engineer. The area of the laying trials shall be a minimum of 100 sq.m. of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material 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.

7.10.4 Construction Operations

7.10.4.1 Weather and seasonal limitations: The provisions of Clause 7.9.3.1 shall apply.

7.10.4.2 Preparation of base: The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Clause 7.15 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

7.10.4.3 Geosynthetics: Where Geosynthetics are specified in the Contract this shall be as directed by the Engineer.

7.10.4.4 Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied as directed by the Engineer.

7.10.4.5 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 Clause 7.7, or as directed by the Engineer.

7.10.4.6 Tack coat: Where the material on which the dense bituminous macadam is to be placed is a bitumen bound surface, a tack coat shall be applied as specified, in accordance with the provisions of Clause 7.8 or as directed by the Engineer.

7.10.4.7 Mixing and transportation of the mixture: The provisions as specified in Clause 7.9.3.4 shall apply.

7.10.4.8 Spreading: The provisions of Clause 7.9.3.5 Shall apply

7.10.4.9 Rolling: The general provisions of Clause 7.9.3.6 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.

7.10.5 Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hrs after laying and completion of compaction, without the express approval of the Engineer in writing.

7.10.6 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 7.15. All materials and workmanship shall comply with the provisions set out in Clause 7.15 of this Specification.

7.10.7 Arrangements for Traffic

During the period of construction, arrangements for traffic diversion shall be made in accordance with the direction of the Engineer.

7.10.8 Measurement for Payment

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

7.10.9 Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out the all required operations as specified, and shall include, the provision of bitumen, at 4.25 per cent by weight of the total mixture.

The variance in actual percentage of bitumen used will be assessed and the payment adjusted, up or down, accordingly.

7.11 SEMI-DENSE BITUMINOUS CONCRETE

7.11.1 Scope

This clause specifies the construction of Semi Dense Bituminous Concrete, for use in wearing/binder and profile corrective courses. This work shall consist of construction in a single or multiple layers of semi dense bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100 mm in thickness.

7.11.2 Materials

7.11.2.1 Bitumen: The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 7.19, for semi dense bituminous concrete, or as otherwise specified in the Contract.

7.11.2.2 Coarse aggregates: The coarse aggregates shall be generally as specified in Clause 7.10.2.2 except that the aggregates shall satisfy the physical requirements of Table 7.18.

7.11.2.3 Fine aggregates: The fine aggregates shall be all as specified in Clause 7.10.2.3.

7.11.2.4 Filler: Filler shall be generally as specified in Clause 7.10.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 7.18 then 2 per cent by total weight of aggregate of hydrated lime shall be added without additional cost.

7.11.2.5 Aggregate grading and binder content: When tested in accordance with IS: 2386 Part I (Wet sieving method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 7.19 for gradings 1 or 2 as specified in the Contract.

7.11.3 Mixture Design

7.11.3.1 Requirements for the mixture: Apart from conformity with the grading and quality requirements of individual ingredients the mixture shall meet the requirements set out in Table 7.20.

TABLE 7.18: Physical Requirements for Coarse Aggregate for Semi Dense Bituminous Concrete Pavement Layers

Property	Test	Specification
Cleanliness (dust)	Grain size analysis ¹	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index (Combined) ²	Max 30%
Strength*	Los Angeles Abrasion Value ³	Max 35%
	Aggregate Impact Value ⁴	Max 27%
Polishing Durability	Polished Stone Value ⁵	Min 55
	Soundness: ⁶ Sodium Sulphate	Max 12%

Property	Test	Specification
	Magnesium Sulphate	Max 18%
Water Absorption	Water absorption ⁷	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures ⁹	Minimum retained coating 95%
Water Sensitivity ^{**}	Retained Tensile Strength ⁸	Min 80%

- Notes: 1. IS: 2386 Part 1 6. IS: 2386 Part 5
2. IS: 2386 Part I 7. IS: 2386 Part 3
(the elongation test to be done only on non-flaky aggregate in the sample)
3. IS: 2386 Part 4* 8. AASHTO T283**
4. IS: 2386 Part 4% 9. IS: 6241
5. BS: 812 Part 114

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

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

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 7.16.

7.11.3.2 Binder content: The binder content shall be optimized to achieve the requirements of the mixture set out in Table 7.20 and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer.

TABLE 7.19: Composition of Semi Dense Bituminous Concrete Pavement Layers

Grading	1	2
Nominal aggregate size	13 mm	10 mm
Layer Thickness	35 – 40 mm	25 – 30 mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5		
19	100	
13.2	90 – 100	100
9.5	70 - 90	90 - 100
4.75	35 – 51	35 – 51
2.36	24 – 39	24 – 39
1.18	15 - 30	15 - 30

Grading	1	2
Nominal aggregate size	13 mm	10 mm
Layer Thickness	35 – 40 mm	25 – 30 mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate passing	
0.6	-	-
0.3	9 – 19	9 – 19
0.15	-	-
0.075	3 – 8	3 – 8
Bitumen content % by mass of total mix ²	Min 4.5	Min 5.0
Bitumen grade (pen)	65*	65*

- Notes:** 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.
- * Only in exceptional circumstances, 80/100 penetration grade may be used, as approved by the Engineer.

TABLE 7.20: Requirements for Semi Dense Bituminous Pavement Layers

Minimum stability (kN at 60°C)	8.2
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3 – 5
Per cent voids in mineral aggregate (VMA)	See Table 7.16
Per cent voids filled with bitumen (VFB)	65 -78

- 7.11.3.3 Job mix formula:** The procedure for formulating the job mix formula shall be generally as specified in Clause 7.10.3.3 and the results of tests enumerated in Table 7.20 as obtained by the Contractors.
- 7.11.3.4 Plant trials – permissible variation in job mix formula:** The requirements for plant trials shall be all as specified in Clause 7.10.3.4 and permissible limits for variation as shown in Table 7.17.
- 7.11.3.5 Laying trials:** The requirements for laying trials shall be all as specified in Clause 7.10.3.5.
- 7.11.4 Construction Operations**
- 7.11.4.1 Weather and seasonal limitations:** The provisions of Clause 7.9.3.1 shall apply.
- 7.11.4.2 Preparation of base:** The surface on which the Semi Dense Bituminous material is to be laid shall be prepared in accordance with Clause 7.15 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 access, other approved methods shall be used as directed by the Engineer.

7.11.4.3 Tack coat: Where specified in the Contract, or otherwise required by the Engineer, a tack coat shall be applied in accordance with the requirements of Clause 7.8.

7.11.4.4 Mixing and transportation of the mixture: The provisions as specified in Clause 7.9.3.4 shall apply.

7.11.4.5 Spreading: The general provisions of Clause 7.9.3.5 shall apply.

7.11.4.6 Rolling: The general provisions of Clause 7.9.3.6 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.

7.11.5 Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the Engineer in writing.

7.11.6 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 7.15. All materials and workmanship shall comply with the provisions set out in Clause 7.15 of this Specification.

7.11.7 Arrangements for Traffic

During the period of construction, arrangements for traffic diversion shall be made as directed by the Engineer.

7.11.8 Measurement for Payment

The measurement shall be all as specified in Clause 7.10.8.

7.11.9 Rate

The contract unit rate shall be all as specified in Clause 7.10.9, except that the rate shall include the provision of bitumen at 4.75 per cent, by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

7.12 BITUMINOUS CONCRETE

7.12.1 Scope

This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layers of bituminous concrete on a previously prepared bituminous bound surface. A single layers shall be 25 mm to 100 mm in thickness.

7.12.2 Materials

7.12.2.1 Bitumen: The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 7.22, for bituminous concrete, or as otherwise specified in the Contract.

7.12.2.2 Coarse aggregates: The coarse aggregates shall be generally as specified in Clause 7.10.2.2 except that the aggregates shall satisfy the physical requirements of Table 7.21.

7.12.2.3 Fine aggregates: The fine aggregates shall be all as specified in Clause 7.10.2.3.

7.12.2.4 Filler: Filler shall be generally as specified in Clause 7.10.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 7.21 then 2 per cent by total weight of aggregate of hydrated lime shall be added without additional cost.

7.12.2.5 Aggregate grading and binder content: When tested in accordance with IS: 2386 Part I (Wet grading method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 7.22 for gradings 1 or 2 as specified in the Contract.

7.12.3 Mixture Design

7.12.3.1 Requirements for the mixture: Apart from conformity with the grading and quality requirements of individual ingredients the mixture shall meet the requirements set out in Table 7.23.

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 7.16.

7.12.3.2 Binder content: The binder content shall be optimized to achieve the requirements of the mixture set out in Table 7.23 and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer.

TABLE 7.21: Physical Requirements for Coarse Aggregate for Bituminous Concrete Pavement Layers

Property	Test	Specification
Cleanliness (dust)	Grain size analysis ¹	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index (Combined) ²	Max 30% (Combined) ²
Strength*	Los Angeles Abrasion Value ³ Aggregate Impact Value ⁴	Max 30% Max 24%
Polishing Durability	Polished Stone Value ⁵ Soundness: ⁶ Sodium Sulphate Magnesium Sulphate	Min 55 Max 12% Max 18%
Water Absorption	Water absorption ⁷	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures ⁹	Minimum retained coating 95%
Water Sensitivity**	Retained Tensile Strength ⁸	Min 80%

7.12.3.3 Job mix formula: The procedure for formulating the job mix formula shall be generally as specified in Clause 7.10.3.3 and the results of tests enumerated in Table 7.23 as obtained by the Contractors.

7.12.3.4 Plant trials – permissible variation in job mix formula: The requirements for plant trials shall be all as specified in Clause 7.10.3.4 and permissible limits for variation as shown in Table 7.17.

7.12.3.5 Laying trials: The requirements for laying trials shall be all as specified in Clause 7.10.3.5.

7.12.4 Construction Operations

7.12.4.1 Weather and seasonal limitations: The provisions of Clause 7.9.3.1 shall apply.

TABLE 7.22: Composition of Bituminous Concrete Pavement Layers

Grading	1	2
Nominal aggregate size	19 mm	13 mm
Layer Thickness	50 – 65 mm	30 – 45 mm
IS Sieve¹ (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5	100	
19	79 – 100	100
13.2	59 – 79	79 – 100
9.5	52 – 72	70 - 88
4.75	35 – 55	53 – 71
2.36	28 – 44	42 – 58
1.18	20 - 34	34 - 48
0.6	15 - 27	26 - 38
0.3	10 - 20	18 - 28
0.15	5 - 13	12-20
0.075	2 – 8	4 – 10
Bitumen content % by mass of total mix ²	5.0 – 6.0	5.0 – 7.0
Bitumen grade (pen)	65	65

Notes: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

TABLE 7.23: Requirements for Bituminous Pavement Layers

Minimum stability (kN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows	75 blows on each of the two faces of the specimen
Per cent air voids	3 – 6

Per cent voids in mineral aggregate (VMA)	See Table 7.16
Per cent voids filled with bitumen (VFB)	65 -75
Loss of stability on immersion in water at 60°C (ASTM D 1075)	Min. 75 per cent retained strength

7.12.4.2 Preparation of base: The surface on which the Bituminous concrete is to be laid shall be prepared in accordance with Clause 7.15 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 access, other approved methods shall be used as directed by the Engineer.

7.12.4.3 Tack coat: Where specified in the Contract, or otherwise required by the Engineer, a tack coat shall be applied in accordance with the requirements of Clause 7.8.

7.12.4.4 Mixing and transportation of the mixture: The provisions as specified in Clause 7.9.3.4 shall apply.

7.12.4.5 Spreading: The general provisions of Clause 7.9.3.5 shall apply.

7.12.4.6 Rolling: The general provisions of Clause 7.9.3.6 shall apply, as modified by the approved laying trials.

7.12.5 Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the Engineer in writing.

7.12.6 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 7.15. All materials and workmanship shall comply with the provisions set out in Clause 7.15 of this Specification.

7.12.7 Arrangements for Traffic

During the period of construction, arrangements for traffic diversion shall be made as directed by the Engineer.

7.12.8 Measurement for Payment

The measurement shall be all as specified in Clause 7.10.8.

7.12.9 Rate

The contract unit rate shall be all as specified in Clause 7.10.9 except that the rate shall include the provision of bitumen at 5.0 per cent, by weight of total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

7.13 TRAFFIC SIGNS

7.13.1 General

7.13.1.1 The colour, configuration, size and location of all traffic signs shall be in accordance with the Code of Practice for Road Signs, IRC: 67 or as shown on the drawings.. In the absence of any details or for any missing details, the signs shall be provided as directed by the Engineer.

7.13.1.2 The signs shall be either reflectorised or non-reflectorised as shown on the drawing or as directed by the Engineer. When they are of reflectorised type, they shall be of

retro-reflectorised type and made of encapsulated lens type reflective sheeting vide Clause 7.13.3, fixed over aluminium sheeting as per these Specifications.

- 7.13.1.3** In general, cautionary and mandatory signs shall be fabricated through process of screen printing. In regard to informatory signs with inscriptions, either the message could be printed over the reflective sheeting, or cut letters of non-reflective black sheeting used for the purpose which must be bonded well on the base sheeting as directed by the Engineer.

7.13.2 Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:

- 7.13.2.1 Concrete:** Concrete shall be of the grade shown on the Contract drawings or otherwise as directed by the Engineer.
- 7.13.2.2 Reinforcing steel:** Reinforcing steel shall conform to the requirement of IS: 1786 unless otherwise shown on the drawing.
- 7.13.2.3 Bolts, nuts, washers:** High strength bolts shall conform to IS: 1367 whereas precision bolts, nuts, etc., shall conform to IS: 1364.
- 7.13.2.4 Plates and supports:** Plates and support sections for the sign posts shall conform to IS: 226 and IS: 2062 or any other relevant IS Specifications.
- 7.13.2.5 Aluminium:** Aluminium sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS: 736-Material designation 24345 or 1900.
- 7.13.2.6** Signs with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick. All others shall be at least 2 mm thick. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under the prevailing wind and other loads.
- 7.13.2.7** In respect of sign sizes not covered by IRC: 67, the structural details (thickness, etc.) shall be as per the approved drawings.

7.13.3 Traffic Signs Having Retro-reflective Sheeting

- 7.13.3.1 General requirements:** The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface which has the property of retro-reflection over its entire surface. It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for these properties in an unprotected outdoor exposure facing the sun for two years and its having passed these tests shall be obtained from a reputed laboratory, by the manufacturer of the sheeting. The reflective sheeting shall be either of Engineering Grade material with enclosed lens or of High Intensity Grade with encapsulated lens. The type of the sheeting to be used would depend upon the type, functional hierarchy and importance of the road.
- 7.13.3.2 High intensity grade sheeting:** This sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent water-proof plastic having a smooth surface.
- 7.13.3.3 Engineering grade sheeting:** This sheeting shall be of enclosed lens type consisting of microscopic lens elements embedded beneath the surface of a smooth, flexible, transparent, water-proof plastic, resulting in a non-exposed lens optical reflecting system.
- 7.13.3.4 Messages/borders:** The messages (legends, letters, numerals etc.) and borders shall either be screen-printed or of cut-outs. Screen printing shall be processed and finished

with materials and in a manner specified by the sheeting manufacturer. Cut-outs shall be of materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer.

7.13.3.5 Cut-out messages and borders, wherever used, shall be made out of retro-reflective sheeting (as per Clause 7.13.3.2 or 7.13.3.3 as applicable), except those in black which shall be of non-reflective sheeting.

7.13.3.6 **Colour:** Unless otherwise specified, the general colour scheme shall be as stipulated in IS: 5 “Colour for Ready Mixed Paints”, viz.

Blue - IS Colour No. 166: French Blue

Red - IS Colour No. 537: Signal Red

Green - IS Colour No. 284: India Green

Orange - IS Colour No. 591: Deep Orange

The Colours shall be durable and uniform in acceptable hue when viewed in day light or under normal headlights at night.

7.13.3.7 **Adhesives:** The sheeting shall either have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent or other preparation for adhesion to a smooth clean surface, or a tack free adhesive activated by heat, applied in a heat-vacuum applicator, in a manner recommended by the sheeting manufacturer. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheeting from the sign base in the piece by use of sharp instrument. In case of pressure-sensitive adhesive sheeting, the sheeting shall be applied in accordance with the manufacturer’s Specifications. Sheetting with adhesives requiring use of solvents or other preparation for adhesive shall be applied strictly in accordance with the manufacturer’s instructions.

7.13.3.8 **Refurbishment:** Where existing signs are specified for refurbishment, the sheeting shall have a semi-rigid aluminium backing pre-coated with aggressive-tack type pressure sensitive adhesive. The adhesive shall be suitable for the type of material used for the sign and should thoroughly bond with that material.

7.13.3.9 **Fabrication:**

7.13.3.9.1 Surface to be reflectorised shall be effectively prepared to receive the retro-reflective sheeting. The aluminium sheeting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheeting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handled, except by suitable device or clean canvas gloves, between all cleaning and preparation operation and application of reflective sheeting/primer. There shall be no opportunity for metal to come in contact with grease, oil or other contaminants prior to the application of retro-reflective sheeting.

7.13.3.9.2 Complete sheets of the material shall be used on the signs except where it is unavoidable; at splices, sheeting with pressure sensitive adhesives shall be overlapped not less than 5 mm. Sheetting with heat-activated adhesives may be spliced with an overlap not less than 5 mm or butted with a gap not exceeding 0.75 mm. Where screen printing with transparent colours is proposed, only butt jointing shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

- 7.13.3.10 Warranty and durability:** The contractor shall obtain from the manufacturer a seven-year warranty for satisfactory field performance including stipulated retro-reflectance of the retro-reflective sheeting of high intensity grade and a five year warranty for the adhesive sheeting of engineering grade and submit the same to the Engineer. In addition, a seven year and a five year warranty for satisfactory in-field performance of the finished sign with retro-reflective sheeting of high intensity grade and engineering grade respectively, inclusive of the screen printed or cut out letters/legends and their bonding to the retro-reflective sheeting shall be obtained from the Contractor/supplier and passed on to the Engineer. The Contractor/supplier shall also furnish a certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty.

Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and, following cleaning, shall show no appreciable discolouration, cracking, blistering or dimensional change and shall not have less than 50 per cent of the specified minimum reflective intensity values when subjected to accelerated weathering for 1000 hours, using type E or EH Weatherometer (AASHTO Designation M 268).

7.13.4 Installation

- 7.13.4.1** Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind loads or displacement by vandalism. Normally, signs with an area upto 0.9 sq.m shall be mounted on a single post, and for greater area two or more supports shall be provided. Sign supports may be of mild steel, reinforced concrete or galvanized iron (G.I). Post-end(s) shall be firmly fixed to the ground by means of properly designed foundation. The work of foundation shall conform to relevant Specifications as specified.

- 7.13.4.2** All Components of signs and supports, other than the reflective portion and G.I. posts shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. Any part of mild steel (M.S.) post below ground shall be painted with three coats of red lead paint.

- 7.13.4.3** The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size in the case of reinforced concrete or G.I. posts. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

7.13.5 Measurements for Payment

The measurement of standard cautionary, mandatory and information signs shall be in numbers of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured by area in square metres.

7.13.6 Rate

The Contract unit rate shall be payment in full for the cost of making the road sign, including all materials, installing it at the site and incidentals to complete the work in accordance with the Specifications.

7.14 ROAD MARKINGS

7.14.1 General

The colour, width and layout of road markings shall be in accordance with the Code of Practice for Road Markings with paints, IRC: 35, and as specified in the drawings or as directed by the Engineer.

7.14.2 Materials

Road markings shall be of hot applied thermoplastic compound, or reflectorised paint as specified in the item and the material shall meet the requirements as specified below.

7.14.3 Hot Applied Thermoplastic Road Marking

7.14.3.1 General:

- i) The work under this section consists of marking traffic stripes using a thermoplastic compound meeting the requirements specified herein.
- ii) The thermoplastic compound shall be screeded/extruded on to the pavement surface in a molten state by suitable machine capable of controlled preparation and laying with surface application of glass beads at a specific rate. Upon cooling to ambient pavement temperature, it shall produce an adherent pavement marking of specified thickness and width and capable of resisting deformation by traffic.
- iii) The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.
- iv) Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.

7.14.3.2 Thermoplastic Material

7.14.3.2.1 General: The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads.

7.14.3.2.2 Requirements:

- i) Composition: The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 7.24.

TABLE 7.24: Proportions of Constituents of Marking Material (Percentage by weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-40	30-40
Titanium Dioxide	10.0 min.	-
Calcium Carbonate and Inert Fillers	42.0 max.	See Note
Yellow Pigments	-	

Note: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met.

- ii) Properties: The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262 (Part I), shall be as below:
 - a) Luminance:

White: Daylight luminance at 45 degrees-65 per cent min. as per AASHTO M 249.

Yellow: Daylight luminance at 45 degrees 45 per cent min. as per AASHTO M 249.

- b) Drying time: When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.
 - c) Skid resistance: not less than 45 as per BS 6044.
 - d) Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
 - e) Softening point: $102.5 \pm 9.5\%$ C as per ASTM D 36.
 - f) Flow resistance: Not more than 25 per cent as per AASHTO M 249.
 - g) Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249
- iii) **Storage life:** The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/Contractor.
- iv) **Reflectorisation:** Shall be achieved by incorporation of beads, the grading and other properties of the beads shall be as specified in Clause 7.14.4.3.
- v) **Marking:** Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
- 1. The name, trade mark or other means of identification of manufacturer
 - 2. Batch number
 - 3. Date of manufacture
 - 4. Colour (white or yellow)
 - 5. Maximum application temperature and maximum safe heating temperature.
- vi) **Sampling and testing:** The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

7.14.3.3 Reflectorising glass beads

7.14.3.3.1 General: This Specification covers two types of glass beads to be used for the production of reflectorised pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 7.24 and Type 2 beads are those which are to be sprayed on the surface vide Clause 7.14.6.3.

7.14.3.3.2 The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions.

These shall conform to the requirements spelt out in Clause 7.14.4.3.3

7.14.3.3.3 Specific requirements

- A. **Gradation:** The glass beads shall meet the gradation requirements for the two types as given in Table 7.25.

TABLE 7.25: Gradation Requirements for Glass Beads

Sieve Size	Per cent retained	
	Type 1	Type 2
1.18 mm	0 to 3	-
850 micron	5 to 20	0 to 5
600 micron	-	5 to 20
425 micron	65 to 95	-
300 micron	-	30 to 75
180 micron	0 to 10	10 to 30
Below 180 micron	0	0 to 15

- B. **Roundness:** The glass beads shall have a minimum of 70 per cent true spheres.
- C. **Refractive index:** The glass beads shall have a minimum refractive index of 1.50.
- D. **Free flowing properties:** The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

7.14.3.3.4 Test methods: The specific requirements shall be tested with the following methods:

- i) Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter desiccator which is filled within 25 mm of the top of a desiccator plate with sulphuric acid water solution (specific gravity 1.10). Cover the desiccator and let it stand for 4 hours at 20 to 29 degree C. Remove sample from desiccator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be essentially free of lumps and clusters and shall flow freely through the funnel.
- ii) The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS 6088 and BS 3262 (Part I).
- iii) The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification. However, if so required, these tests may be carried out as directed by the Engineer.

7.14.3.4 Application properties of thermoplastic material

7.14.3.4.1 The thermoplastic material shall readily get screeded/extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

7.14.3.4.2 The material upon heating to application temperatures, shall not exclude fumes, which are toxic, obnoxious or injurious to persons or property.

7.14.3.5 Preparation:

- i) The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.
- ii) After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

7.14.3.6 Properties of finished road marking:

- a) The stripe shall not be slippery when wet.
- b) The marking shall not shift from the pavement in freezing weather.
- c) After application and proper drying, the stripe shall show no appreciable deformation or discolouration under traffic and under road temperatures upto 60°C.
- d) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil drippings from traffic.
- e) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
- f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS: 164.

7.14.4 Reflectorised Paint

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirement of Clause 7.14.4.3.

7.14.5 Application

7.14.5.1 Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

7.14.5.2 The thermoplastic material shall be applied hot either by screeding or extrusion process. After transfer to the laying apparatus, the material shall be laid at a

temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine.

- 7.14.5.3** The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line of compatible material. Such new material shall so bond itself to the old line that no splitting or separation takes place.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

- 7.14.5.4** The minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS – 3262 (Part 3).

- 7.14.5.5** The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

7.14.6 Measurements for Payment

- 7.14.6.1** The painted markings shall be measured in sq.metres of actual area marked (excluding the gaps, if any).

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

7.14.7 Rate

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

7.15 QUALITY CONTROL TESTS DURING CONSTRUCTION

7.15.1 General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the following Clauses.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 7.27 and 7.28 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of material can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. 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.

There shall not be any separate item in the Boq for the measures for quality control; the rates for measurable items are deemed to include the cost of all the measures advised in the sub clauses of 7.15

7.15.2 Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the rod shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table 7.26.

TABLE 7.26: Tolerances in Surface Levels

1.	Subgrade	+ 20 mm - 25 mm
2.	Sub-base + 10 mm a) Flexible pavement b) Concrete pavement [Dry lean concrete or Rolled concrete]	- 20 mm + 6 mm - 10 mm
3.	Base-course for flexible pavement a) Bituminous course b) Other-than bituminous i) Machine laid ii) Manually laid	+ 6 mm - 6 mm + 10 mm - 10 mm + 15 mm - 15 mm
4.	Wearing course for flexible pavement a) Machine laid b) Manually laid	+ 6 mm - 6 mm + 10 mm - 10 mm
5.	Cement concrete pavement	+ 5 mm - 6 mm*

* This may not exceed – 8 mm at 0 – 30 cm from the edges.

7.15.3 Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation/Fill Formation

7.15.3.1 Borrow material: Grid the borrow area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for

proper identification of suitable sources of material. The following tests on representative samples shall be carried out:

- a) Sand Content [IS: 2720 (Part-4)]: 2 tests per 3000 cubic metres of soil.
- b) Plasticity Test [IS: 2720 (Part-5)]: Each type to be tested, 2 tests per 3000 cub.metres of soil.
- c) Density Test [IS: 2720 (Part 8)]: Each soil type to be tested, 2 tests per 3000 cubic metres of soil.
- d) Deleterious Content Test [IS: 2720 (Part 27)]: As and when required by the Engineer.
- e) Moisture Content Test [IS: 2720 (Part-2)]: One test for every 250 cubic metres of soil.
- f) CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [IS: 2720 (part 16)]: one CBR test for every 3000 cu.m. atleast or closer as and when required by the Engineer.

7.15.3.2 Compaction Control: Control shall be exercised on each layer by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part-28). Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of anyone test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 6 (if non-destructive tests are carried out, the number of tests shall be doubled) as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

$$\left[1.65 - \frac{1.65}{(\text{No. of Samples})^{0.5}} \right] \text{times the standard deviation}$$

However, for earthwork in shoulders and median (earthen) and in the subgrade, at least one density measurement shall be taken for every 500 square metres for the compacted area provided further that the number of tests in each set of measurements shall be atleast 10. In other respects, the control shall be similar to the described earlier.

7.15.3.3 Cut formation: Tests for the density requirements of cut formation shall be carried out in accordance with Clause 7.15.3.2.

7.15.4 Tests on Sub-bases and Bases (excluding bitumen bound bases)

The tests and their frequencies for the different types of bases and sub-bases shall be as given in Table 7.27. The evaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 7.15.3.2

7.15.4.1 Acceptance criteria: The acceptance criteria for tests on the strength of cement/lime stabilized soil and distribution of stabilizer content shall be subject to the condition that the mean value is not less than the specified value plus:

$$\left[1.65 - \frac{1.65}{(\text{No. of Samples})^{0.5}} \right] \text{times the standard deviation}$$

TABLE 7.27: Control Tests and Their Minimum Frequency for Sub-bases and Bases (Excluding Bitumen Bound Bases)

Sl. No.	Type of Construction	Test	Frequency (min.)
1.	Granular	i) Gradation ii) Atterberg limits iii) Moisture content prior to compaction iv) Density of compacted layer v) Deleterious constituents vi) C.B.R.	One test per 200 m ³ One test per 200 m ³ One test per 250 m ³ One test per 500 m ³ As required As required
2.	Wet Mix Macadam	i) Aggregate impact Value ii) Grading iii) Flakiness and Elongation Index iv) Atterberg limits of portion of aggregate passing 425 micron sieve v) Density of compacted layer.	One test per 200 m ³ of aggregate One test per 100 m ³ of aggregate One test per 200 m ³ of aggregate One test per 100 m ³ of aggregate One test per 500 m ³

7.15.5 Tests on Bituminous Construction

7.15.5.1 Tests and frequency: The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 7.28. The Engineer may direct additional testing as required.

7.15.5.2 Acceptance criteria: The acceptance criteria for tests on density and Marshall stability shall be subject to the condition that the mean value is not less than the specified value plus:

$$\left[1.65 - \frac{1.65}{(\text{No. of Samples})^{0.5}} \right] \text{ times the standard deviation}$$

TABLE 7.28: Control Tests for Bituminous works, and their Minimum Frequency

Sl. No.	Type of Construction	Test	Frequency (min.)
1.	Prime Coat/Tack Coat/Fog Spray	i) Quality of binder ii) Binder temperature for application	Number of samples per lot and tests as per IS: 73, IS: 217 and IS: 8887 as applicable. At regular close intervals. One test per 500m ² and not less

		iii) Rate of spread of Binder	than two tests per day.
2.	Bituminous Macadam	<p>i) Quality of binder</p> <p>ii) Aggregate Impact Value/Los Angeles Abrasion Value</p> <p>iii) Flakiness Index and Elongation Index</p> <p>iv) Stripping Value</p> <p>v) Water sensitivity of mix</p> <p>vi) Grading of aggregates</p> <p>vii) Water absorption of aggregates</p> <p>viii) Soundness (Magnesium and Sodium Sulphate)</p> <p>ix) Percentage of fractured faces</p> <p>x) Binder content and aggregate grading</p> <p>xi) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling</p> <p>xii) Rate of spread of mixed material</p>	<p>Number of samples per lot and tests as per IS: 73, IS: 217 and IS: 8887 as applicable.</p> <p>One test per 50 m³ of aggregate</p> <p>One test per 50 m³ of aggregate</p> <p>Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates</p> <p>Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates</p> <p>Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer</p> <p>Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates</p> <p>Initially, one determination by each method for each source of supply, then as warranted by change in the quality of the aggregates.</p> <p>When gravel is used, one test per 50m³ of aggregate</p> <p>Periodic, subject to minimum to two tests per day per plant</p> <p>At regular close intervals</p> <p>Regular control through checks of layer thickness</p> <p>One test per 250m² of area</p>

		xiii) Density of Compacted layer	
3.	Dense Bituminous Macadam/Semi Dense Bituminous Concrete/Bituminous Concrete	<p>i) Quality of binder</p> <p>ii) Aggregate Impact Value/Los Angeles Abrasion Value</p> <p>iii) Flakiness Index and Elongation Index</p> <p>iv) Stripping Value</p> <p>v) Soundness (Magnesium and Sodium Sulphate)</p> <p>vi) Water absorption of aggregates</p> <p>vii) Sand equivalent test</p> <p>viii) Plasticity Index</p> <p>ix) Polished stone value</p> <p>x) Percentage of fractured faces</p> <p>xi) Mix grading</p>	<p>Number of samples per lot and tests as per IS: 73, IS: 217 and IS: 8887 as applicable.</p> <p>One test per 50 m³ of aggregate</p> <p>One test per 50 m³ of aggregate</p> <p>Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates</p> <p>Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates</p> <p>Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates</p> <p>As required</p> <p>As required</p> <p>As required, for Semi Dense Bituminous Concrete/Bituminous Concrete</p> <p>When gravel is used, one test per 50m³ of aggregate</p> <p>One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day</p>

7.15.6 Measurement for payment

There shall not be a separate item in the Bill of Quantities, for the measures for quality control; the rates for measurable items in the Contract are deemed to include the cost of all the tests advised at specified frequencies, in the sub clauses of Clause 7.15