500

Base and Surface Courses (Bituminous)

501. GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS

501.1. General

Bituminous pavement courses shall be made using the materials described in the following Specifications.

The use of machinery and equipment mentioned in various Clauses of these Specifications is mandatory. Details of the machinery and equipment are available in the Manual for Construction and Supervision of Bituminous Works. Equipment mandatory for any particular project shall be in accordance with the Contract Specification for that project.

501.2. Materials

501.2.1. Binder: The binder shall be an appropriate type of bituminous material complying with the relevant Indian Standard (IS), as defined in the appropriate Clauses of these Specifications, or as otherwise specified herein. The choice of binder shall be stipulated in the Contract or by the Engineer. Where penetration grades of bitumen are specified, they are referred to by a single-figure designation in accordance with IS:73. Thus bitumen grade 35 refers to a bitumen in the penetration range 30 to 40. Where Modified Binder is specified, the Clause 521 of these Specifications shall apply.

501.2.2. 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 the individual relevant clause for the material in question.

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.

501.2.3. Fine Aggregates: Fine aggregates shall consist of crushed or naturally occurring 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.

501.2.4. Source of material: The source of all materials to be used on the project must be tested to the satisfaction of and be expressly approved by the Engineer. The Engineer may from time to time withdraw approval of a specific source, or attach conditions to the existing approval. Any change in aggregate source for bituminous mixes, will require a new mix design, and laying trials, where the mix is based on a job mix design. Stockpiles from different sources, approved or otherwise, shall be kept separate, such that there is no contamination between one material and another. Each source submitted for approval shall contain sufficient material for at least 5 days work.

501.3. Mixing

Pre-mixed bituminous materials, including bituminous macadam, dense bituminous macadam, semi-dense bituminous concrete and bituminous concrete, shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures can be found in Table 500-5 of these Specifications; the difference in temperature between the binder and aggregate should at no time exceed 14°C. In order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time.

If a continuous mixing plant is to be used for mixing the bituminous bound macadam, the Contractor must demonstrate by laboratory analysis that the cold feed combined grading is within the grading limits specified for that bituminous bound material. In the case of a designed job mix, the bitumen and filler content shall be derived using this combined grading. Further details are available in the Manual for Construction and Supervision of Bituminous Works.

501.4. Transporting

Bituminous materials shall be transported in clean insulated vehicles, and unless otherwise agreed by the Engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the Engineer, a thin

coating of diesel or lubricating oil may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

501.5. Laying

501.5.1. Weather and seasonal limitations: Laying shall be suspended while free-standing water is present on the surface to be covered, or during rain, fog and dust storms. After rain, the bituminous surface, prime or tack coat, shall be blown off with a high pressure air jet to remove excess moisture, or the surface left to dry before laying shall start. Laying of bituminous mixtures shall not be carried out when the air temperature at the surface on which it is to be laid is below 10°C or when the wind speed at any temperature exceeds 40 km/h at 2m height unless specifically approved by the Engineer.

501.5.2. Cleaning of surface: The surface on which the bituminous work is to be laid shall be cleaned of all loose and extraneous matter by means of a mechanical broom or any other approved equipment / method as specified in the contract. The use of a high pressure air jet from a compressor to remove dust or loose matter shall be available full time on the site, unless otherwise specified in the Contract.

501.5.3. Spreading: Except in areas where a mechanical paver cannot access, bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay.

The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and levelled with suitable hand tools by experienced staff, and compacted to the satisfaction of the Engineer.

The minimum thickness of material laid in each paver pass shall be in accordance with the minimum values given in the relevant parts of these Specifications. When laying binder course or wearing course approaching an expansion joint of a structure, machine laying shall stop 300mm short of the joint. The remainder of the pavement up to the joint,

and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material.

Bituminous material, with a temperature greater than 145°C, shall not be laid or deposited on bridge deck waterproofing systems, unless precautions against heat damage have been approved by the Engineer.

Hand placing of pre-mixed bituminous materials shall only be permitted in the following circumstances:

(i) For laying regulating courses of irregular shape and varying thickness.

(ii) In confined spaces where it is impracticable for a paver to operate.

(iii) For footways.

(iv) At the approaches to expansion joints at bridges, viaducts or other structures.

(v) For laying mastic asphalt in accordance with Clause 515.

(vi) For filling of potholes.

(vii) Where directed by the Engineer.

Manual spreading of pre-mixed wearing course material or the addition of such material by hand-spreading to the paved area, for adjustment of level, shall only be permitted in the following circumstances:

(i) At the edges of the layers of material and at gullies and manholes.

(ii) At the approaches to expansion joints at bridges, viaducts or other structures.

(iii) As directed by the Engineer.

501.5.4. Cleanliness and overlaying: Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a binder course is to be sealed or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated the Contractor shall make it good to the satisfaction of the Engineer, in compliance with Clause 501.8.

Binder course material shall not remain uncovered by either the wearing course or surface treatment, whichever is specified in the Contract, for more than three consecutive days after being laid. The Engineer may extend this period, by the minimum amount of time necessary, because of weather conditions or for any other reason. If the surface of the base course is subjected to traffic, or not covered within three days, a tack coat shall be applied, as directed by the Engineer.

501.6. Compaction

Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirements and compaction to be achieved.

Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these Specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the centre longitudinally except that on super elevated and unidirectional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8-10 tonnes dead weight smooth-wheeled rollers. The intermediate rolling shall be done with 8-10 tonnes dead weight or vibratory roller or with a pneumatic tyred roller of 12 to 15 tonnes weight having nine wheels, with a tyre pressure of at least 5.6 kg/sqcm. The finish rolling shall be done with 6 to 8 tonnes smooth wheeled tandem rollers.

Where compaction is to be determined by density of cores the requirements to prove the performance of rollers shall apply in order to demonstrate that the specified density can be achieved. In such cases the Contractor shall nominate the plant, and the method by which he intends to achieve the specified level of compaction and finish at temperatures above the minimum specified rolling temperature. Laying trials shall then demonstrate the acceptability of the plant and method used.

Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third of the width of the rear roll or, in the case of a pneumatic-tyred roller, at least the nominal width of 300mm

In portions with super-elevated and uni-directional camber, after the edge has been rolled, the roller shall progress from the lower to the upper edge.

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of rollers shall be kept moist with water, and the spray system provided with the machine shall be in good working order, to prevent the mixture from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mixture should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

501.7. Joints

Where longitudinal joints are made in pre-mixed bituminous materials, the materials shall be fully compacted and the joint made flush in one of the following ways; only method (iii) shall be used for transverse joints:

(i) by heating the joints with an approved joint heater when the adjacent width is being laid, but without cutting back or coating with binder. The heater shall raise the temperature of the full depth of material, to within the specified range of minimum rolling temperature and maximum temperature at any stage for the material, for a width not less than 75 mm. The Contractor shall have equipment available, for use in the event of a heater breakdown, to form joints by method (iii);

(ii) by using two or more pavers operating in echelon, where this is practicable, and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling;

(iii) by cutting back the exposed joint, for a distance equal to the specified layer thickness, to a vertical face, discarding all loosened material and coating the vertical face completely with 80/100 penetration grade hot bitumen, or cold-applied bitumen, or polymer modified adhesive bitumen tape with a minimum thickness of 2 mm, before the adjacent width is laid.

All joints shall be offset at least 300 mm from parallel joints in the layer beneath or as directed, and in a layout approved by the Engineer. Joints in the wearing course shall coincide with either the lane edge or the lane marking, which ever is appropriate. Longitudinal joints shall not be situated in wheel track zones.

501.8. Preparation of Surface

501.8.1. Scope : This work shall consist of preparing an existing granular or black-topped surface bituminous course. The work shall be performed on such widths and lengths as shown on the drawings or as instructed by the Engineer. The existing surface shall be firm and clean,

and treated with Prime or Tack coat as shown on the drawings as otherwise stated in the Contract.

501.8.2. Materials

501.8.2.1. For scarifying and re-laying the granular surface: The material used shall be coarse aggregate salvaged from the scarification of the existing granular base course supplemented by fresh coarse aggregate and screenings so that aggregates and screenings thus supplemented correspond to Clause 404: Water Bound Macadam or Clause 406: Wet Mix Macadam.

501.8.2.2. For patching potholes and sealing cracks: Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.2.3. For profile corrective course: A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the Drawings, or as indicated in the Contract Documents. The profile corrective course shall be laid to tolerances and densities as specified for wearing course if a single layer, or base course, if it is to be covered with a wearing course layer.

501.8.2.4. Profile corrective course and its application: The type of material for use as profile corrective course shall be as shown on the drawings or as directed by the Engineer. Where it is to be laid as part of the overlay/strengthening course, the profile corrective course material shall be of the same specification as that of the overlay/ strengthening course. However, if provided as a separate layer, it shall be of the specification and details given in the contract drawings.

(i) Any high spots in the existing surface shall be removed by a milling machine or other approved method, and all loose material shall be removed to the satisfaction of the Engineer.

(ii) Where the maximum thickness of profile corrective course will be not more than 40 mm, the profile corrective course shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer, adopting such construction procedures and using such equipment as approved by the Engineer, to lay the specified type of material, to thickness and tolerance as specified, for the course, to be provided.

501.8.3. Construction Operations

501.8.3.1. Preparing existing granular surface: Where the existing surface is granular, all loose materials shall be removed, and the surface lightly watered where the profile corrective course to be provided as a separate layer is also granular. Where the profile corrective course of bituminous material is to be laid over the existing granular surface, the latter shall, after removal of all loose material, be primed in accordance with Clause 502.

The surface finish of all granular layers on which bituminous works are to be placed, shall, unless otherwise specifically instructed by the Engineer, be free from dust. All such layers must be capable of being swept, after the removal of any non-integral loose material, by means of a mechanical broom, without shedding significant quantities of material and dust removed by air jet, washing, or other means approved by the Engineer.

After cleaning the surface shall be correct to line and level, within the tolerances specified for base course.

501.8.3.2. Scarifying existing bituminous surface: Where specified or shown on the drawings, the existing bituminous layer in the specified width shall be removed with care and without causing undue disturbance to the underlying layer, by a suitable method approved by the Engineer. After removal, all loose and disintegrated material, the underlying layers which might have been disturbed should be suitably reworked and compacted to line and level. After supplementing the base material as necessary with suitable fresh stone, the compacted finished surface shall be primed in accordance with Clause 502. Reusable materials shall be stacked as directed by the Engineer within 1000 m of their origin.

501.8.3.3. Patching of potholes and sealing of cracks: Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.3.4. Laying the profile corrective course

501.8.3.4.1. Laying on granular base: After preparing the granular surface in accordance with Clauses 501.8.3.1 and 501.8.3.2, the profile corrective course shall be laid using material as described in Clauses

501.8.2.3 and 501.8.2.4, or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.

501.8.3.4.2. Laying on existing bituminous surface: The existing bituminous surface shall be prepared in accordance with Clause 501.8.3.3, and after applying a tack coat conforming to Clause 503, the bituminous profile corrective course shall be laid and compacted to the requirements of the particular Specification.

501.8.3.4.3. Correction of local depressions: Where local sags or depressions occur in the existing pavement, a specific filling operation shall be instructed by the Engineer, which should be laid in accordance with Figure 500-1. Normally, the maximum layer thickness at any point should not exceed 100 mm. In placing multiple lifts, they should be arranged according to the correct method as illustrated.

For correction of camber or super-elevation of the existing carriageway, the method shown in Figure. 500-2 shall be adopted, depending on the profile of the existing carriageway.

501.8.3.5. Covering the profile corrective courses: Profile corrective course particularly shall be so planned that the layer shall be covered by the designed base/wearing course at the earliest opportunity, before opening to regular traffic.

501.8.4. Surface finish and quality control of work: The relevant provisions of Section 900 shall apply.

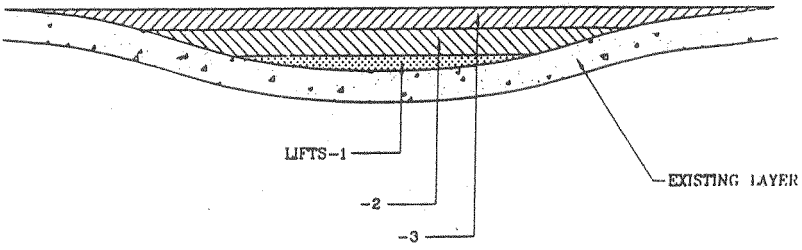
501.8.5. Arrangements for traffic: During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

501.8.6. Environmental protection: The provisions of Clause 111 and the provision of ***Annexure A to Clause 501*** shall apply.

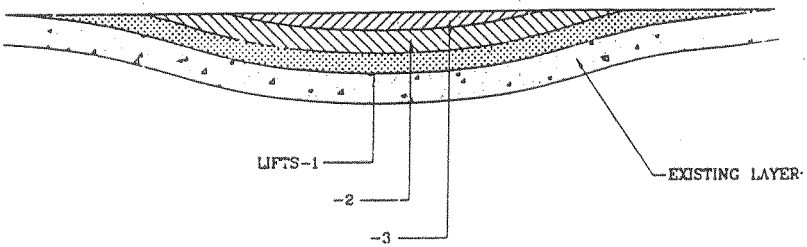
501.8.7. Measurement for payment

501.8.7.1. Potholes and cracks: The work of filling potholes shall be measured separately and be paid for in square metres.

The work of filling cracks by applying fog spray or emulsion slurry seal shall be measured in square metres, for the area covered by the spray.



(A) CORRECT METHOD



(B) INCORRECT METHOD

Note: Profile corrective course material to be in accordance with the lift thickness

Figure. 500-1. Methods for providing corrective course for short sags and depressions

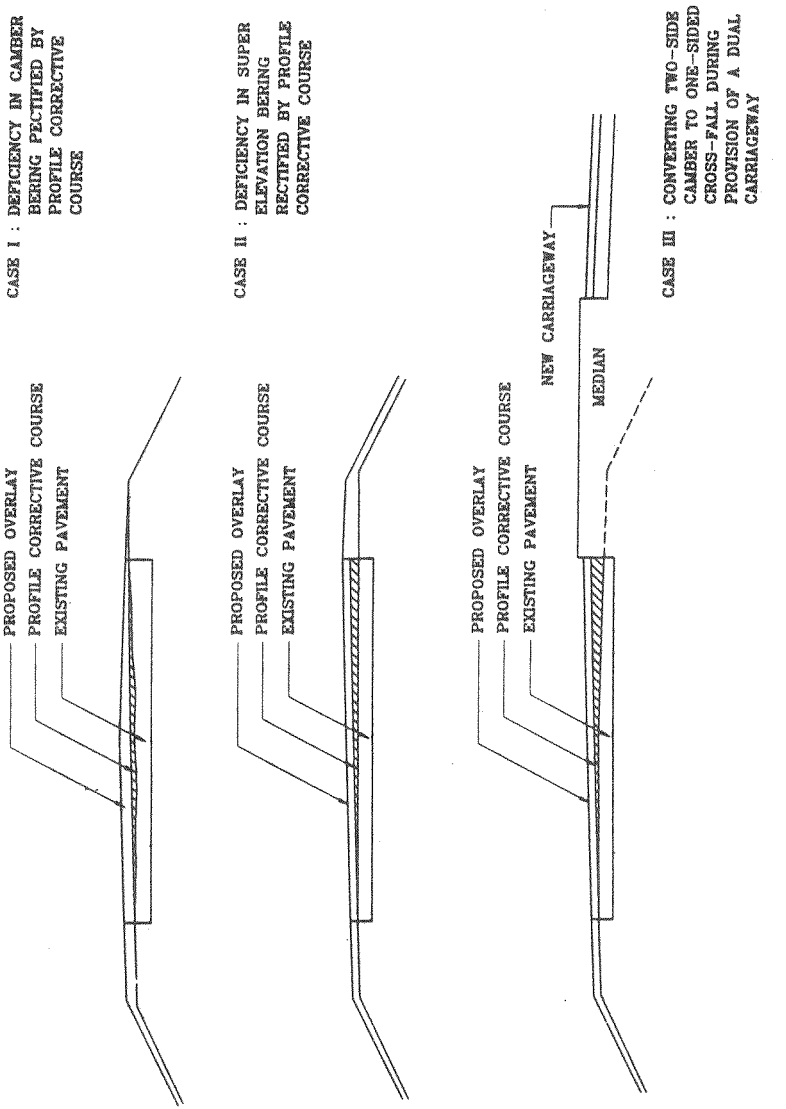


Figure. 500-2. Correction of Camber or Superelevation

The work in filling cracks larger than 3mm in width shall be measured and paid for on a linear metre basis.

501.8.7.2. Scarifying: Scarifying the existing bituminous surface shall be measured on a square metre basis.

501.8.7.3. Profile corrective course: Profile corrective course shall be measured as the volume instructed and compacted in position and measured in cubic metres, or in tonnage, as stipulated in the Contract. The volume shall be calculated by plotting the exact profile of profile corrective course as required, and laid, superimposed on the existing pavement profile. Cross-sectional areas of the profile corrective course shall be measured at intervals as used in the design, or as determined by the Engineer, and the volume shall be calculated using the method of end areas.

501.8.7.4 Prime coat: Prime coat is to be measured and paid for on a per square metre basis.

501.8.7.5 Tack coat: This is to be a PROVISIONAL item, which may be used in-part or not at all, at the Engineers direction, and is to be measured and paid for, if used, on a square metre basis.

501.8.8. Rates

501.8.8.1. Rate for scarifying: The contract unit rate for scarifying existing bituminous surfaces, including repairing / reworking disturbed underlying layers and removing and stacking reusable / unusable materials, shall include for but not necessarily be limited to, the cost of all labour, supply of materials needed for repair / reworking, hire charges of tools and plant, and transportation of scarified materials within 1000 m of their origin.

501.8.8.2. Rate for premixed bituminous material: The contract unit rate for premixed bituminous material shall be payment in full for carrying out the required operations including full compensation for, but not necessarily limited to:

(i) Making arrangements for traffic to Clause 112 except for initial treatment to verge, shoulders and construction of diversions;

(ii) Preparation of the surface to receive the material.

(iii) Providing all materials to be incorporated in the work including arrangement for stock yards, all royalties, fees, rents where necessary and all leads and lifts;

(iv) Mixing, transporting, laying and compacting the mix, as specified.

(v) All labour, tools, equipment, plant including installation of hot mix plant, power supply units and all machinery, incidental to complete the work to these Specifications;

(vi) Carrying out the work in part widths of the road where directed;

(vii) Carrying out all tests for control of quality; and

(viii) The rate shall cover the provision of bitumen at the rate specified in the contract, with the provision that the variation in actual percentage of bitumen used will be assessed and the payment adjusted accordingly.

(ix) The rates for premixed material are to include for all wastage in cutting of joints etc.

(x) The rates are to include for all necessary testing, mix design, transporting and testing of samples, and cores. If there is not a project specific laboratory, the Contractor must arrange to carry out all necessary testing at an outside Laboratory, approved by the Engineer, and all costs incurred are deemed to be included in the rate quoted for the material.

(xi) The cost of all plant and laying trials as specified to prove the mixing and laying methods is deemed to be included in the Contractor's rates for the material.

501.8.8.3. Rate for potholes and crack sealing: The rate for patching potholes shall include for breaking out, trimming edges, cleaning out, painting edges and bottom with bitumen, and filling and compacting the excavation with the specified material. The rate should be inclusive of all plant, tools, labour and materials, transport, and disposal of surplus material,

The contract unit rate for sealing cracks by applying fog spray shall be inclusive of providing all materials, tools, labour and plant and carrying out the work. The contract unit rate for sealing cracks by providing emulsion slurry seal shall be as set forth in Clause 516.9.

The contract unit rate for crack sealing 3mm to 6mm cracks with straight run or other specified bitumen, shall be based on either a square metre basis, or linear metre of cracks as measured, as stipulated by the Contract.

The contract unit rate for cracks between 6mm and 15mm is to be measured on a linear metre basis, and the rate is to include for all materials, tools, plant, labour, and transport.

Annexure 'A'

PROTECTION OF THE ENVIRONMENT

1. General

1.1. This section of the Specification sets out limitations on the Contractor's activities specifically intended to protect the environment.

1.2. The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on site or off-site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in this document.

1.3. The Contractor shall take all measures and precautions to avoid any nuisance or disturbance arising from the execution of the Works. This shall wherever possible be achieved by suppression of the nuisance at source rather than abatement of the nuisance once generated.

1.4. In the event of any spoil, debris, waste or any deleterious substance from the Site being deposited on any adjacent land, the Contractor shall immediately remove all such material and restore the affected area to its original state to the satisfaction of the Engineer.

2. Water Quality

2.1. The Contractor shall prevent any interference with the supply to or abstraction from, and prevent any pollution of, water resources (including underground percolating water) as a result of the execution of the Works.

2.2. Areas where water is regularly or repetitively used for dust suppression purposes shall be laid to fall to specially-constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be re-used for dust suppression and rinsing.

2.3. All water and other liquid waste products arising on the Site shall be collected and disposed of at a location on or off the Site and in a manner that shall not cause either nuisance or pollution.

2.4. The Contractor shall not discharge or deposit any matter arising from the execution of the Works into any waters except with the permission of the Engineer and the regulatory authorities concerned.

2.5. The Contractor shall at all times ensure that all existing stream courses and drains within, and adjacent to, the Site are kept safe and free from any debris and any materials arising from the Works.

2.6. The Contractor shall protect all watercourses, waterways, ditches, canals, drains, lakes and the like from pollution as a result of the execution of the Works.

3. **Air Quality**

3.1. The Contractor shall devise and arrange methods of working to minimise dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimise adverse impacts on air quality.

3.2. The Contractor shall utilise effective water sprays during delivery manufacture, processing and handling of materials when dust is likely to be created, and to dampen stored materials during dry and windy weather. Stockpiles of friable materials shall be covered with clean tarpaulins, with application of sprayed water during dry and windy weather. Stockpiles of material or debris shall be dampened prior to their movement, except where this is contrary to the Specification.

3.3. Any vehicle with an open load-carrying area used for transporting potentially dust producing material shall have properly fitting side and tail boards. Materials having the potential to produce dust shall not be loaded to a level higher than the side and tail boards, and shall be covered with a clean tarpaulin in good condition. The tarpaulin shall be properly secured and extend at least 300 mm over the edges of the side and tail boards.

3.4 In the event that the Contractor is permitted to use gravel or earth roads for haulage, he shall provide suitable measures for dust palliation, if these are, in the opinion of the Engineer, necessary. Such measures may include spraying the road surface with water at regular intervals.

4. **Noise**

4.1. The Contractor shall consider noise as an environmental constraint in his planning and execution of the Works.

4.2. The Contractor shall take all necessary measures so that the operation of all mechanical equipment and construction processes on and off the Site shall not cause any unnecessary or excessive noise, taking into account applicable environment requirements. The Contractor shall use all necessary measures and shall maintain all plant and silencing equipment in good condition so as to minimise the noise emission during construction works.

5. **Control of Wastes**

5.1. The Contractor shall control the disposal of all forms of waste generated by the construction operations and in all associated activities. No uncontrolled deposition or dumping shall be permitted. Wastes to be so controlled shall include, but shall not be limited to, all forms of fuel and engine oils, all types of bitumen, cement, surplus aggregates, gravels, bituminous mixtures etc. The Contractor shall make specific provision for the proper disposal of these and any other waste products, conforming to local regulations and acceptable to the Engineer.

6. **Emergency Response**

6.1. The Contractor shall plan and provide for remedial measures to be implemented in the event of occurrence of emergencies such as spillages of oil or bitumen or chemicals.

6.2. The Contractor shall provide the Engineer with a statement of the measures he intends to implement in the event of such an emergency which shall include a statement of how he intends to provide personnel adequately trained to implement such measures.

7. **Measurement**

7.1. No separate measurement shall be made in respect of compliance by the Contractor with the provisions of this Section of the Specification. The Contractor shall be deemed to have made allowance for such compliance with these provisions in the preparation of his prices for items of work included in the Bills of Quantities and full compensation for such compliance will be deemed to be covered by them.

502. PRIME COAT OVER GRANULAR BASE

502.1. 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.

502.2. Materials

502.2.1. 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 stabilised soil base,

(iii) Surfaces of high porosity; such as a gravel base.

502.2.2. 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 500-1.

TABLE 500-1. 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

502.2.3. 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.

502.3. Weather and Seasonal Limitations

Bituminous primer shall not be applied to a wet surface (see 502.4.2) 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.

502.4. Construction

502.4.1. 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 areas, inaccessible to the distributor, or in narrow strips shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

502.4.2. Preparation of road surface: The surface to be primed shall be prepared in accordance with Clauses 501.8. and 902 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.

502.4.3. 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. Where a geosynthetic is proposed for use, the requirements of Clauses 703.3.2 and 703.4 shall apply. The bituminous primer shall be sprayed uniformly in accordance with Clause 501.The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

502.4.4. 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.

502.4.5. Tack coat: Over the primed surface, a tack coat should be applied in accordance with Clause 503.

502.5. Quality Control of Work

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

502.6. Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

502.7. Measurement for Payment

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

502.8. Rate

The contract unit rate for prime coat with adjustments as described in Clause 502.7 shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.8 (i) to (v) and as applicable to the work specified in these Specifications. Payment shall be made on the basis of the provision of prime coat at an application rate of 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 502.4.3.

503. TACK COAT

503.1. 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.

503.2. Materials

503.2.1. 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.

503.3. 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 consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

503.4. Construction

503.4.1. 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.

503.4.2. 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 Clauses 501.8 and 902 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.

503.4.3. 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 500-2. The normal range of spraying

TABLE 500-2. 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

temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C if RC-70/MC-70 is used. Where a geosynthetic is proposed for use, the provisions of Clauses 703.3.2 and 703.4.4 shall apply. 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.

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.

503.4.4. 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.

503.5. Quality Control of Work

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

503.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

503.7. Measurement for Payment

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

503.8. 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 401.8 (i) to (v) and as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat at 0.2 kg

per square metre, with the provision that the variance in actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

504. BITUMINOUS MACADAM

504.1. Scope

This work shall consist of construction in a single course having 50mm to 100mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on 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 507, 508 and 509.

504.2. Materials

504.2.1. 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 500-4.

504.2.2. 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 500-3.

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

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

TABLE 500-3. PHYSICAL REQIREMENTS FOR COARSE AGGREGATES FOR BITUMINOUS MACADAM

Property	Test	Specification
Cleanliness	Grain size analysis[1]	Max 5 % passing 0.075 mm 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
2. IS: 2386 Part 1 (the elongation test to be done only on non-flaky aggregates in the sample)
3. IS: 2386 Part 4*
4. IS: 2386 Part 5
5. IS: 2386 Part 3
6. IS: 6241
7. The water sensitivity test is only to be carried out if the minimum retained coating in the stripping test is less than 95%.

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

504.2.4. Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 500-4 for the grading specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

504.2.5. Proportioning of material: The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 500-4. 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 Section 900.

504.3. Construction Operations

504.3.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

TABLE 500-4. COMPOSITION OF BITUMINOUS MACADAM

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

504.3.2. 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 Clauses 501.8 and 902.3 as appropriate, and a prime coat, shall be applied in accordance with Clause 502 where specified, or as directed by the Engineer.

504.3.3. Tack coat : A tack coat in accordance with Clause 503 shall be applied as required by the Contract documents, or as directed by the Engineer.

504.3.4. Preparation and transportation of the mixture: The provisions of Clauses 501.3 and 501.4 shall apply.

504.3.5. Spreading: The provisions of Clauses 501.5.3 shall apply.

TABLE 500-5. 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

504.3.6. Rolling: Compaction shall be carried out in accordance with the provisions of Clauses 501.6 and 501.7.

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 903.

504.4. Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902. For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

504.5. 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 to the requirement of Clause 513 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.

504.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112

504.7. Measurement for Payment

Bituminous macadam shall be measured as finished work in cubic metres, or by weight in metric tonnes, 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.

504.8. Rate

The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include for, all components listed in Clause 501.8.8.2. (i) to (xi).

505. BITUMINOUS PENETRATION MACADAM

505.1. Scope

The work shall consist of construction of one or more layers of compacted crushed coarse aggregates with alternate applications of bituminous binder and key aggregates in accordance with the requirements of these Specifications to be used as a base course on roads, subject to the requirements of the overall pavement design, in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. Thickness of an individual course shall be 50 mm or 75 mm, or other as specified.

505.2. Materials

505.2.1. Bitumen: The binder shall be paving bitumen of suitable penetration grade within the range of S-35 to S-90 or A-35 to A-90 (30/40 to 80/100) as per Indian Standards Specifications for "Paving Bitumen" IS :73, or approved cutback satisfying the requirements of IS : 217 or 454. The actual grade of bitumen or cutback to be used shall be as specified or as directed by the Engineer.

505.2.2. Aggregates: The aggregates shall satisfy the physical requirements set out in Clause 504.2.2. and Table 500-3. The coarse and key aggregates shall conform to the grading given in Table 500-6.

505.2.3. Quantities of materials: The quantities of materials used for this work shall be as specified in Table 500-6.

505.3. Construction Operations

505.3.1. Weather and Seasonal Limitations: The provisions of Clause 501.5.1. shall apply.

505.3.2. Equipment : A mechanical broom, compressor, self propelled or trailed bitumen heater/distributor, mechanical aggregate spreader and 8 to 10 tonne smooth steel wheel roller or vibrating roller are required for the preparation of Penetration Macadam.

505.3.3. Preparation of the base: The base on which the Penetration Macadam Course is to be laid shall be prepared, shaped and compacted to the specified lines, grades and sections to Clauses 501 and 902 as appropriate, or as directed by the Engineer. A prime coat, where specified, shall be applied over the base in accordance with Clause 502 or as directed by the Engineer. A tack coat as per Clause 503 shall be applied.

505.3.4. Spreading coarse aggregates: The coarse aggregate shall be dry and clean and free from dust, and shall be spread uniformly and evenly at the rate specified in Table 500-6. It shall be spread by a self-propelled or tipper tail mounted aggregate spreader capable of spreading aggregate uniformly at the specified rates over the required widths. The surface of the layer shall be carefully checked with camber templates to ensure correct line and level and cross fall. The spreading shall be carried out such that the rolling and penetrating operations can be completed on the same day. Segregated aggregates or aggregates contaminated with foreign material shall be removed and replaced.

TABLE 500-6. COMPOSITION OF PENETRATION MACADAM

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing			
	For 50 mm compacted Thickness		For 75 mm compacted Thickness	
	Coarse Aggregate	Key Aggregate	Coarse Aggregate	Key Aggregate
63	—	—	100	—
45	100	—	58 – 82	—
26.5	37 – 72	—	—	100
22.4	—	100	5 – 27	50 – 75
13.2	2 – 20	50 - 75	—	—
11.2	—	—	—	5 – 25
5.6	—	5 - 25	—	—
2.8	0 – 5	0 - 5	0 – 5	0 – 5
Approx. Loose aggregate quantities cu.m/m^2	0.06	0.015	0.09	0.018
Binder quantity (penetration grade)(1) (kg/m^2)	5		6.8	

Note:(1) If cutback bitumen is used, adjust binder quantity such that the residual bitumen is equal to the values in this table

505.3.5. Compaction: After the spreading of coarse aggregates, dry rolling shall be carried out with an 8 – 10 tonne smooth steel wheel roller.

The requirements given in Clause 501.6 and 501.7 shall apply.

After initial dry rolling, the surface shall be checked with a crown

template and a 3 metre straight-edge. The surface shall not vary more than 10 mm from the template or straight-edge. All surface irregularities exceeding the above limit shall be corrected by removing or adding aggregates as required.

The rolling shall continue until the compacted coarse aggregate has a firm surface true to the cross section shown on the plans and has a texture that will allow free and uniform penetration of the bituminous material.

505.3.6. Application of bituminous material: After the coarse aggregate has been rolled and checked, the bituminous binder shall be applied, at the rate given in Table 500-6, in accordance with Clause 501, and at a temperature directed by the Engineer.

At the time of applying the binder, the aggregates shall be surface dry for the full depth of the layer.

In certain circumstances, depending on the type and size of aggregate used, the Engineer may direct the placing of a bed of clean sand or quarry fines, not exceeding 10mm in thickness, on the prepared foundation before placing the coarse aggregate. The sand or fine material shall be slightly wetted, just sufficient for it to slurry up during the compaction process. Where cut back is used, if flooding of the binder occurs it should be applied in two operations, or as directed by the Engineer.

505.3.7. Application of key aggregates: Immediately after the first application of bitumen, the key aggregates, which shall be clean, dry, and free from dust shall be spread uniformly over the surface by means of an approved mechanical spreader or by approved manual methods at the rate specified in Table 500-6.

Where directed by the Engineer, the surface shall be swept and the quantity of key aggregate adjusted to ensure uniform application, with all the surface voids in the coarse aggregate being filled without excess. The entire surface shall then be rolled with a 8 – 10 tonnes smooth steel wheel roller (or vibrating roller operating in non-vibratory mode) in accordance with the procedure specified in Clause 505.3.5.

505.4. Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. For control of the quality of materials

supplied and the works carried out the relevant provisions of Section 900 shall apply.

505.5. Surfacing

The Penetration Macadam shall be provided with a surfacing (binder/ wearing course) within a maximum of forty-eight hours. If there is to be any delay, the penetration macadam shall be covered by a seal coat to the requirements of Clause 513 before opening to traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

505.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

505.7. Measurement for Payment

Penetration Macadam base course shall be measured as finished work in square metres.

505.8. Rate

The contract unit rate for Penetration Macadam course shall be payment in full for carrying out the required operations including, but not necessarily limited to, all components listed in Clause 501.8 8.2.(i) to (xi).

506. BUILT-UP SPRAY GROUT

506.1. Scope

This work shall consist of a two-layer composite construction of compacted crushed coarse aggregates with application of bituminous binder after each layer, and with key aggregates placed on top of the second layer, in accordance with the requirements of these Specifications, to serve as a base course and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. The thickness of the course shall be 75 mm.

Built-up spray grout shall be used in a single course in a pavement structure.

506.2. Materials

506.2.1. Bitumen: Clause 504.2.1. shall apply. Where permitted by the Engineer, an appropriate grade of emulsion complying with IS 8887 may be used.

506.2.2. Aggregates: The coarse aggregate shall conform to Clause 504.2.2.

The aggregate shall satisfy the physical requirements set out in Table 500-3. The coarse and key aggregates for built-up spray grout shall conform to the grading given in Table 500-7.

TABLE 500-7. GRADING REQUIREMENTS FOR COARSE AND KEY AGGREGATES FOR BUILT-UP SPRAY GROUT

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing	
	Coarse Aggregate	Key Aggregate
53.0	100	—
26.5	40 – 75	—
22.4	—	100
13.2	0 – 20	40 – 75
5.6	—	0 – 20
2.8	0 – 5	0 – 5

506.3. Construction Operations

506.3.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

506.3.2. Equipment: The provisions of Clause 505.3.2 shall apply.

506.3.3. Preparation of base: The base on which the built-up spray grout course is to be laid shall be prepared, shaped and compacted to the specified lines, grades and cross-sections in accordance with Clauses 501 and 902 as appropriate. A prime coat shall be applied in accordance with Clause 502 with approved primer as directed by the Engineer.

506.3.4. Tack coat: A tack coat shall be applied in accordance with the procedure described in Clause 503, as directed by the Engineer.

506.3.5. Spreading and rolling coarse aggregates for the first layer: Immediately after the application of prime or tack coat, the clean, dry and dust free coarse aggregates shall be spread uniformly and evenly,

by mechanical means, at the rate of 0.5 cu.m. per 10 sq.m. area.

Immediately after spreading of the aggregates, the entire surface shall be rolled with an 8 – 10 tonnes smooth wheel steel roller. Rolling shall commence at the edges and progress towards the centre except in super-elevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass.

The surface of the layer shall be carefully checked, after rolling, with a template and straight edge and shall be within the tolerances specified, and any deficiencies corrected by reworking and recompacting the layer.

Care shall be taken not to over-compact the layer.

506.3.6. Application of binder - first spray: The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer and sprayed on the aggregate at the rate of 15 kg/10 sq.m. (measured in terms of residual bitumen content) at a uniform rate of spray by mechanical sprayers capable of spraying bitumen uniformly at the specified rates and temperatures. Excessive deposits of binder caused by stopping or starting of the sprayers or through leakage or for any other reason shall be removed and made good.

506.3.7. Spreading and rolling of coarse aggregate for the second layer: Immediately after the first application of the binder, the second layer of coarse aggregates shall be spread and rolled in accordance with the procedure detailed in Clause 506.3.5.

506.3.8. Application of binder - second spray: The second aggregate layer shall then be sprayed with binder at the rate of 15 kg/10 sq. m. (measured in terms of residual bitumen content) in accordance with Clause 506.3.6.

506.3.9. Application of key aggregate: Immediately after the second application of binder, key aggregates shall be spread uniformly and evenly, preferably by mechanical means, at the rate of 0.13 cu.m./10 sq.m. so as to cover the surface completely. The key aggregate shall be clean, dry and free from dust and deleterious matter. If necessary, the surface shall be swept to ensure uniform application of the key aggregates. The entire

surface shall then be rolled with an 8-10 tonnes smooth wheel steel roller in accordance with Clause 506.3.5. While rolling is in progress, additional key aggregates, where required, shall be spread by hand. Rolling shall continue until the entire course is thoroughly compacted and the key aggregates are firmly in position.

506.4. Surface Finish and Quality Control

The surface finish of construction shall conform to the requirements of Clause 902. All materials shall comply with the requirements of the relevant provisions in Section 900 of the Specifications.

506.5. Final Surfacing

The built-up-spray-grout shall be provided with final surfacing within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before it is open to traffic. Where the seal coat is required as a result of the selected method of performing this operation, then it shall be considered incidental to the work and shall not be paid for separately.

506.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

506.7. Measurement for Payment

Built-up spray grout shall be measured as finished work in square metres.

506.8. Rate

The contract unit rate for built-up spray grout shall be payment in full for carrying out the required operations as specified. The rate shall include for, but not necessarily be limited to the components listed in Clause 501.8.8.2. (i) to (xi).

507. DENSE GRADED BITUMINOUS MACADAM

507.1. 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 50mm to 100mm.

507.2. Materials

507.2.1. 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 500-10 for dense bitumen macadam, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works..

507.2.2. 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 500-8, 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.

507.2.3. 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 500-8. 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%
Durability	Soundness:[5]	
	Sodium Sulphate	Max 12%
	Magnesium Sulphate	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
2. IS: 2386 Part 1
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS: 2386 Part 4*
4. IS: 2386 Part 4*
5. IS: 2386 Part 5
6. IS: 2386 Part 3
7. IS: 6241
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%.

507.2.4. 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 500-9.

TABLE 500-9. GRADING REQUIREMENTS FOR MINERAL FILLER

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

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 500-8, then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

507.2.5. Aggregate grading and binder content: When tested in accordance with IS:2386 Part 1 (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 500-10, 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 500-10. 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]	Min4.0	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.

507.3. Mixture Design

507.3.1. 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 500-11.

TABLE 500-11. 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 500-12 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 500-12.

TABLE 500-12. 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.

507.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-11 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 500-11 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

507.3.3. 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:

(i) Source and location of all materials;

(ii) Proportions of all materials expressed as follows where each is applicable:

  (a) Binder type, and percentage by weight of total mixture;

  (b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;

(iii) A single definite percentage passing each sieve for the mixed aggregate;

(iv) The individual gradings of the individual aggregate fractions, and the proportion of each in the combined grading.

(v) The results of tests enumerated in Table 500-11 as obtained by the Contractor;

(vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch,

(vii) Test results of physical characteristics of aggregates to be used;

(viii) Mixing temperature and compacting temperature.

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

507.3.4. 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 percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 500- 13. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

TABLE 500-13. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation	
	Base/binder course	Wearing course
Aggregate passing 19mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2mm, 9.5mm	± 7%	± 6%
Aggregate passing 4.75mm	± 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.

507.3.5. 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 Clause 501. 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.

507.4. Construction Operations

507.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

507.4.2. Preparation of base: The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Clauses 501 and 902 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.

507.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 70 3.

507.4.4. Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

507.4.5. 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 502, or as directed by the Engineer.

507.4.6. 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 503, or as directed by the Engineer.

507.4.7. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

507.4.8. Spreading: The provisions of Clauses 501.5.3 and 501.5.4. shall apply.

507.4.9. Rolling: The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

507.5. 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.

507.6. Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of this Specification.

507.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112

507.8. 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.

507.9. 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, but not necessarily limited to all components listed in Clause 501.8.8.2 (i) to (xi). The rate shall include the provision of bitumen, at 4.25 per cent by weight of the total mixture.

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

508. SEMI-DENSE BITUMINOUS CONCRETE

508.1. 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 25mm to 100mm in thickness.

508.2. Materials

508.2.1. 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 500-15, for semi dense bituminous concrete, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

508.2.2. Coarse aggregates: The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-14.

508.2.3. Fine aggregates: The fine aggregates shall be all as specified in Clause 507.2.3.

508.2.4. Filler: Filler shall be generally as specified in Clause 507.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-14 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

508.2.5. Aggregate grading and binder content: When tested in accordance with IS:2386 Part 1 (Wet sieving method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 500-15 for gradings 1 or 2 as specified in the Contract.

508.3. Mixture Design

508.3.1. Requirements 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 500-16.

TABLE 500-14. 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	Polished Stone Value[5]	Min 55
Durability	Soundness:[6]	
	Sodium Sulphate	Max 12%
	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

2. IS: 2386 Part 1

(the elongation test may be done only on non-flaky aggregates in the sample)

3. IS: 2386 Part 4*

4. IS: 2386 Part 4*

5. BS: 812 Part 114

6. IS: 2386 Part 5

7. IS: 2386 Part 3

8. AASHTO T283**

9. IS: 6241

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

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

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

508.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-16 and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5mm sieve and retained on the 22.4mm sieve, where approved by the Engineer.

TABLE 500-15. 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
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 500-16. 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 500-12
Per cent voids filled with bitumen (VFB)	65-78

508.3.3. Job mix formula: The procedure for formulating the job mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-16 as obtained by the Contractors.

508.3.4. Plant trials – permissible variation in job mix formula: The requirements for plant trials shall be all as specified in Clause 507.3.4, and permissible limits for variation as shown in Table 500-13.

508.3.5. Laying trials: The requirements for laying trials shall be all as specified in Clause 507.3.5.

508.4. Construction Operations

508.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

508.4.2. Preparation of base: The surface on which the Semi Dense Bituminous material is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

508.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 703.

508 4.4. Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

508.4.5. 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 503.

508.4.6. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3.and 501.4 shall apply.

508.4.7. Spreading: The general provisions of Clauses 501.5.3 and 501.5.4 shall apply.

508.4.8. Rolling: The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials. The compaction

process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

508.5. 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.

508.6. Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of this Specification.

508.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

508.8. Measurement for Payment

The measurement shall be all as specified in Clause 507.8.

508.9. Rate

The contract unit rate shall be all as specified in Clause 507.9, 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.

509. BITUMINOUS CONCRETE

509.1. 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 ɔound surface. A single layers shall be 25mm to 100mm in thickness.

509.2. Materials

509.2.1. 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 500-18, for bituminous concrete, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

509.2.2. Coarse aggregates: The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-17.

509.2.3. Fine aggregates: The fine aggregates shall be all as specified in Clause 507.2.3.

509.2.4. Filler: Filler shall be generally as specified in Clause 507.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-17 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

509.2.5. Aggregate grading and binder content: When tested in accordance with IS:2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 500-18 for gradings 1 or 2 as specified in the Contract.

509.3. Mixture Design

509.3.1. Requirements 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 500-19.

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

509.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-19 and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5mm sieve and retained on the 22.4mm sieve, where approved by the Engineer.

509.3.3. Job mix formula: The procedure for formulating the job

TABLE 500-17. 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	Max 30% (Combined)[2]
Strength*	Los Angeles Abrasion Value[3]	Max 30%
	Aggregate Impact Value[4]	Max 24%
Polishing	Polished Stone Value[5]	Min 55
Durability	Soundness:[6]	
	Sodium Sulphate	Max 12%
	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
2. IS: 2386 Part 1
(the elongation test to be done only on non-flaky aggregates in the sample)
3. IS: 2386 Part 4*
4. IS: 2386 Part 4*
5. BS: 812 Part 114
6. IS: 2386 Part 5
7. IS: 2386 Part 3
8. AASHTO T283**
9. IS: 6241

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

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

mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-19 as obtained by the Contractors.

509.3.4. Plant trials – permissible variation in job mix formula: The requirements for plant trials shall be all as specified in Clause 507.3.4, and permissible limits for variation as shown in Table 500-13.

509.3.5. Laying trials: The requirements for laying trials shall be all as specified in Clause 507.3.5.

509.4. Construction Operations

509.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

TABLE 500-18. COMPOSITION OF BITUMINOUS CONCRETE PAVEMENT LAYERS

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

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 500-19. 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 500-12
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

509.4.2. Preparation of base: The surface on which the bituminous concrete is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

509.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 703.

509.4.4. Stress absorbing layer. Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

509.4.5. 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 503.

509.4.6. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

509.4.7. Spreading: The general provisions of clauses 501.5.3 and 501.5.4 shall apply.

509.4.8. Rolling: The general provisions of clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

509.5. 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.

509.6. Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of this Specification.

509.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be

made in accordance with the provisions of Clause 112

509.8. Measurement for Payment

The measurement shall be all as specified in Clause 507.8.

509.9. Rate

The contract unit rate shall be all as specified in Clause 507.9, 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.

510. SURFACE DRESSING

510.1. Scope

This work shall consist of the application of one coat or two coats of surface dressing, each coat consisting of a layer of bituminous binder sprayed on a previously prepared base, followed by a cover of stone chips rolled in to form a wearing course to the requirements of these Specifications. For information on the Design of Surface Dressing refer to the Manual for Construction and Supervision of Bituminous Works.

510.2. Materials

510.2.1. Binder: The binder shall have a kinematic viscosity lying in the range $1x10^4$ to $7x10^5$ centistokes at the expected range of road surface temperatures at the construction site during the period of laying. The type of binder to be used will be stated in the Contract documents and shall comply with one of the following:

Paving Bitumen	IS:73
Bitumen Emulsion	IS:8887

510.2.2. Aggregates: The chips shall conform to the requirements of Clause 504.2.2., except that their water absorption shall be restricted to a maximum of 1 per cent and they shall have a Polished Stone value, as measured by the method given in BS812 (Part 114), of not less than 60. The chips shall be single sized, clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter and conforming to one of the gradings given in Table 500-21.

510.2.3. Rates of spread of binder and chips: For the purpose of pricing the Bill of Quantities the rates of spread given in Table 500-20 shall be priced.

TABLE 500-20. NOMINAL RATES OF SPREAD FOR BINDER AND CHIPPINGS (1)

Nominal Chipping Size mm	Binder (penetration grade bitumen) kg/m²	Chips Cum/m²
19	1.2	0.015
13	1.0	0.010
10	0.9	0.008
6	0.75	0.004

Note: (1) These rates of spread are for pricing purposes - see Clause 510.2.3 and Clause 510.8

(2) For emulsion, these rates of spread are for the residual bitumen and appropriate adjustment must be made to determine the total quantity.

(3) Refer to Manual for Construction and Supervision of Bituminous Works for the procedure of determining the rates of spread of binder and chips.

510.2.4. Anti-stripping agent: Where the proposed aggregate fails to pass the stripping test then an approved adhesion agent (Appendix 5 for details) may be added to the binder in accordance with the manufacturer's instructions. The effectiveness of the proposed anti-stripping agent must be demonstrated by the Contractor, before approval by the Engineer.

510.2.5. Pre-coated chips: As an alternative to the use of an adhesion agent the chips may be pre-coated before they are spread except when the sprayed binder film is a bitumen emulsion. Pre-coating the chips may be carried out in any one of the two methods:

(a) Mixing them with 0.75 to 1.0 per cent of paving bitumen by weight of chips in a suitable mixer, the chips being heated to 160°C and the bitumen to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non sticky and can be spread easily.

(b) Spraying the chips with a light application of creosote, diesel oil or kerosene at ambient temperature. This spraying can be done in a concrete mixer or on a belt conveying the chips from stockpile to gritting lorries.

510.3. Construction operations

510.3.1. Weather and seasonal limitations : Clause 501.5.1 shall apply.

TABLE 500-21. GRADING REQUIREMENTS FOR CHIPS FOR SURFACE DRESSING

IS Sieve Designation mm	Cumulative per cent by weight of total aggregate passing for the following nominal sizes (mm)			
	19	13	10	6
26.5	100	-	-	-
19.0	85-100	100	-	-
13.2	0-40	85-100	100	-
9.5	0-7	0-40	85-100	100
6.3	-	0-7	0-35	85-100
4.75	-	-	0-10	-
3.35	-	-	-	0-35
2.36	0-2	0-2	0-2	0-10
0.60	-	-	-	0-2
0.075	0-1.5	0-1.5	0-1.5	0-1.5
Minimum 65% by weight of aggregate	Passing 19 mm, retained 13.2 mm	Passing 13.2 mm, retained 9.5 mm	Passing 9.5 mm, retained 6.3 mm	Passing 6.3 mm, retained 3.35 mm

510.3.2. Preparation of base : The base on which the surface dressing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Clause 501 or as directed by the Engineer. Prime coat, where needed, shall be provided as per Clause 502 or as directed by the Engineer. Where the existing surface shows signs of fatting up, the excess bitumen shall be removed by burning off, or manually, as specified in the Contract or directed by the Engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and / or compressed air, or any other approved equipment / method as specified in the Contract or by the Engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be damp).

510.3.3. Application of binder : The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for the grade of binder used shall be as given in Table 500-22 and the rate of spray as given in 510.2.3.

510.3.4. Application of stone chips : The equipment and general

TABLE 500-22. SPRAYING TEMPERATURES FOR BINDERS

Binder grades	Whirling spray jets		Slot jets	
	Min°C	Max°C	Min°C	Max°C
Penetration Grades				
400/500	160	170	140	150
280/320	165	175	150	160
180/200	170	190	155	165
80/100	180	200	165	175

procedure shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. For relatively small areas of surface dressing, careful application of chips by hand may be acceptable if approved by the Engineer. The rate of application of chips shall be as determined by the procedure given in the Manual for Construction and Supervision of Bituminous Works. Immediately after application of the binder, clean, dry chips (in the case of emulsion binder the chippings may be damp) shall be spread uniformly on the surface so as to cover the surface completely with a single layer of chips.

510.3.5. Rolling : Rolling of the chips should preferably be carried out by a pneumatic tyred roller in accordance with Clause 501.6 and Clause 501.7. Traditional steel wheeled rollers tend to crush the aggregates and if their use cannot be avoided their weight should be limited to 8 tonnes. Rolling shall commence at the edges and progress towards the centre except in superelevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

510.3.6. Application of second coat of surface dressing : Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for 2 or 3 weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in Clauses 510.3.3 to 510.3.5.

510.4. Opening to Traffic

Traffic shall not be permitted to run on any newly surface dressed area until the following day. In special circumstances, however, the Engineer may allow the road to be opened to traffic immediately after rolling, but in such cases traffic speed shall be limited to 20 km per hour until the following day.

510.5. Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902.

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

510.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

510.7. Measurement for Payment

Each coat of surface dressing shall be measured as finished work, for the area instructed to be covered, in square metres.

510.8. Rate

The Contract unit rate for surface dressing, based on the notional rates of spread for binder and each size of chippings given in Clause 510.2.3, which shall be adjusted, plus or minus, for the difference between the notional rates of spread and the rates of spread determined as described in the Manual for Construction and Supervision of Bituminous Works, and approved by the Engineer, multiplied by the rates entered in the Bill of Quantities for binder and each size of chipping. The adjusted rate shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

511. OPEN-GRADED PREMIX SURFACING

511.1. Open-graded Premix Surfacing using Penetration Bitumen or Cutback.

511.1.1. Scope : This work shall consist of the preparation, laying and compaction of an open-graded premix surfacing material of 20 mm

thickness composed of small-sized aggregate premixed with a bituminous binder on a previously prepared base, in accordance with the requirements of these Specifications, to serve as a wearing course.

511.1.2. Materials

511.1.2.1. Binder : The binder shall be a penetration bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS: 73.

511.1.2.2. Aggregate : The aggregate shall conform to Clause 504.2.2 except that the water absorption shall be limited to a maximum of 1 per cent. The Polished Stone Value, as measured by the test in BS 812- (Part 114), shall not be less than 55.

511.1.2.3. Proportioning of materials: The materials shall be proportioned in accordance with Table 500-23.

511.1.3. Construction operations

511.1.3.1. Weather and seasonal limitations : Clause 501.5.1 shall apply.

511.1.3.2. Preparation of surface : The underlying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-section in accordance with Clause 501. A prime coat where needed shall be applied in

TABLE 500-23. QUANTITIES OF MATERIALS REQUIRED FOR 10 m² OF ROAD SURFACE FOR 20mm THICK OPEN-GRADED PREMIX SURFACING USING PENETRATION BITUMEN OR CUTBACK

Aggregates		
(a)	Nominal Stone size 13.2mm (passing 22.4 mm sieve and retained on 11.2 mm sieve)	0.18m³
(b)	Nominal Stone size 11.2mm (passing 13.2 mm sieve and retained on 5.6 mm sieve).	0.09m³
	Total	0.27m³
Binder (quantities in terms of straight run bitumen)		
(a)	For 0.18 m³ of 13.2 mm nominal size stone at 52 kg bitumen per m³	9.5 kg
(b)	For 0.09 m³ of 11.2 mm nominal size stone at 56 kg bitumen per m³	5.1 kg
	Total	14.6kg

accordance with Clause 502 as directed by the Engineer.

511.1.3.3. Tack coat : A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

511.1.3.4. Preparation of premix : Hot mix plant of appropriate capacity and type shall be used for the preparation of the mix material. The hot mix plant shall have separate dryer arrangement for heating aggregate.

The temperature of the binder at the time of mixing shall be in the range of 150°C to 163° C and that of the aggregate in the range of 155°C to 163°C provided that the difference in temperature between the binder and aggregate at no time exceeds 14°C. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly and the discharge temperature of mix shall be between 130°C and 160°C.

The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or hand barrows. The vehicles employed for transport shall be clean and the mix being transported covered in transit if so directed by the Engineer.

511.1.3.5. Spreading and rolling : The pre mixed material shall be spread by suitable means to the desired thickness, grades and cross-full (camber) making due allowance for any extra quantity required to fill up depressions, if any. The cross-fall should be checked by means of camber boards and irregularities levelled out. Excessive use of blades or rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 8 – 10tonne rollers, - smooth wheel tandem type, or other approved equipment. Rolling shall begin at the edge and progress toward the centre longitudinally, except that on superelevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions, which become apparent, shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled and all the roller marks eliminated. In each pass of the roller the preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels. In no case shall fuel / lubricating oil be used

for this purpose. Excess use of water for this purpose shall also be avoided.

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below 100° C. Joints along and transverse to the surfacing laid and compacted earlier shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with a thin coat of appropriate binder before the new mix is placed against it.

511.1.3.6. Seal coat : A seal coat conforming to Clause 513 of the type specified in the Contract shall be applied to the surface immediately after laying the surfacing.

511.1.4. Opening to traffic : No traffic shall be allowed on the road until the seal coat has been laid. After the seal coat is laid, the road may be opened to traffic according to Clause 513.4.

511.1.5. Surface finish and quality control of work : The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

511.1.6. Arrangements for traffic : During the period of construction, arrangement of traffic shall be made in accordance with the provisions of Clause 112.

511.1.7. Measurement for payment : Open graded premix surfacing shall be measured as finished work, for the area instructed to be covered, in square metres. The area will be the net area covered, and all allowance for wastage and cutting of joints shall be deemed to be included in the rate.

511.1.8. Rate : The contract unit rate for open-graded premix surfacing shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

511.2. Open graded premix surfacing using cationic bitumen emulsion

511.2.1. Scope : This work shall consist of the preparation, laying and compaction of an open graded premix surfacing of 20 mm thickness composed of small-sized aggregate premixed with a cationic bitumen

emulsion on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

511.2.2. Materials

511.2.2.1. Binder : The binder for Premix wearing course shall be cationic bitumen emulsion of Medium Setting (MS) grade complying with I.S.8887 and having a bitumen content 65 per cent minimum by weight. For liquid seal coat RS grade of Cationic bitumen emulsion shall be used. Where expressly specified in the Contract MS grade emulsion shall be used or otherwise directed by the Engineer. Slow Setting (SS) grade Cationic bitumen Emulsion shall be used for premix seal coat.

511.2.2.2. Aggregate : The requirements of Clause 511.1.2.2. shall apply.

511.2.3. Proportioning of materials: The materials shall be proportioned as quantities given in Tables 500-24 and 500-25.

TABLE 500-24. QUANTITIES OF AGGREGATE FOR 10 M^2 AREA

(A)	**Premix Carpet**	
(a)	Coarse aggregate nominal 13.2 mm size; passing IS 22.4 mm sieve and retained on IS 11.2 mm sieve	0.18 m^3
(b)	Coarse aggregate nominal 11.2 mm size; passing IS 13.2 mm sieve and retained on IS 5.6 mm sieve	0.09 m^3
(B)	For Seal Coat: Refer to Clause 513.	

TABLE 500-25. QUANTITIES OF EMULSION BINDER

		For 10m^2 area
(A)	**For Premix Carpet:**	20 to 23 kg
(B)	**For Seal Coat:**	
	(a) for liquid seal coat	12 to 14 kg
	(b) for premix seal coat	10 to 12 kg

511.2.4. Construction operations

511.2.4.1. Weather and seasonal limitations : Clause 501.5.1 shall apply except that the minimum air temperature for laying shall be 10°C. Cationic bitumen emulsions shall not normally be stored below 0°C.

511.2.4.2. Preparation of surface : The underlying surface on which

the premix surfacing is to be laid shall be prepared, in accordance with the requirements of Clause 504.3.2 for a newly primed surface, and in accordance with Clause 507.4.2 where an existing bituminous surface is to be overlaid.

511.2.4.3. Preparation of binder : Before opening, the cationic bitumen emulsion drums shall be rolled at slow speed, to and fro, at least 5 times, for a distance of about 10 metres, to distribute any storage sedimentation.

511.2.4.4. Tack coat : A tack coat complying with Clause 503, shall be applied over the surface preparatory to laying of the surfacing where specified in the Contract, or directed by the Engineer.

511.2.4.5. Preparation of premix : Premixing of cationic bitumen emulsion and aggregates can be carried out in a suitable mixer such as cold mixing plant as per IS: 5435 (Revised) or concrete mixer or by pay loaders in exceptional cases where approved by the Engineer. Where specified in the Contract continuous mixing operation shall be done either in batch or continuous hot mix plant suitable for emulsion mixes.

When using concrete mixer for preparing the premix, 0.135 cu.m. (0.09 cu.m. of 13.2 mm size and 0.045 cu.m. of 11.2 mm size) of aggregates per batch shall be used which quantity will cover 5 sq.m. of road surface with 20 mm average thickness.

The aggregates required for one batch shall be prepared adjacent to the mixer.

First the coarse aggregate of 13.2 mm size shall be placed into the mixer followed by 5 to 6.5 kg of Cationic bitumen emulsion and then the 11.2 mm size aggregate shall be added, followed by 5 to 6.5 kg of Cationic bitumen emulsion. After the materials have been mixed thoroughly, the mix shall be immediately transported to the laying site in suitable vehicles. Too much mixing shall be avoided.

When mixed manually by shovels, with the approval of the Engineer, 0.06 cu.m. of aggregates can be conveniently mixed in one heap, with appropriate quantity of emulsion. It is preferable to make the aggregates damp before mixing as it reduces the effort required for mixing and also helps to get better coating of aggregates. The 13.2 mm size aggregates and emulsion are mixed first and then the 11.2 mm size aggregates and

remaining quantity of emulsion are added and mixed. Too much mixing shall be avoided.

511.2.4.6. Spreading and rolling: The premixed cationic bitumen emulsion and aggregates shall be spread within 10 minutes of applying the tack coat. All levelling, raking, etc. should be completed within 20 minutes of the time of mixing.

The mix should be spread uniformly to the desired thickness, grades and crossfall (camber) making due allowance for any extra quantity required to fill up depressions, if any. The crossfall should be checked by means of camber boards and irregularities leveled out. Too much raking is to be avoided.

The rolling shall start immediately after laying the premix. A smooth wheeled tandem roller of 8-10 tonnes shall be used, unless other compaction methods are approved by the Engineer, based on the results of laying trials, if necessary. While rolling, wheels of roller should be clean and kept moist to prevent the premix from adhering to the wheels. In no case shall fuel / lubricating oil be used for this purpose. Use of water for this purpose shall be strictly limited to an absolute minimum.

Rolling shall commence at the edges and progress towards the centre longitudinally except in the case of superelevated and uni-directional cambered sections where rolling shall be carried out from the lower edge towards the higher edge parallel to the centre line of the road.

After one pass of roller over the whole area, depressions or uncovered spots should be corrected by adding premix material. Rolling shall be continued until the entire surface has been rolled to maximum compaction and all the roller marks eliminated. In each pass of the roller the preceding track shall be overlapped uniformly by at least 1/3 width. Roller(s) shall not stand on newly laid material. Joints both longitudinal and transverse to the road sections laid and compacted earlier, shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of binder before the new mix is placed against it.

511.2.4.7. Seal coat : A seal coat, conforming to Clause 510 or Clause 513, as specified in the Contract, shall be applied 4 to 6 hours after laying the premix carpet.

511.2.5. Opening to traffic : Traffic should not be allowed over the

premix surface with or without seal coat, for 6 to 8 hours after rolling. In case of single lane roads, traffic shall be allowed onto the surface once it has reached ambient temperature, but speed must be rigorously restricted to not more than16 km per hour. If any premix material is picked up by vehicle tyres, the spot shall be filled up by new mix. If traffic conditions permit, the road shall not be opened until a full 24 hours after laying.

511.2.6. Surface finish and quality control : The surface finish of construction shall conform to the requirements of Clause 902.

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

511.2.7. Arrangements for traffic : During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

511.2.8. Measurement for payment : Open graded premix carpet shall be measured as finished work, for the area specified to be covered, in square metres at the specified thickness, in cubic metres, or in tonnes weight as specified in the Contract. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

511.2.9. Rate : The contract unit rate for premix carpet and seal coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

Bitumen quantities are to be as stated in Table 500-23 for premix, 3.0 Kg per 10 sq.m., for tack coat, 13Kg per 10 sq.m. for liquid seal coat and 11 Kg per 10 sq.m. for premix seal coat. The rate will be adjusted according to actual material used.

512. CLOSE-GRADED PREMIX SURFACING/ MIXED SEAL SURFACING

512.1. Scope

512.1.1. This work shall consist of the preparation, laying and compaction of a close-graded premix surfacing material of 20 mm thickness composed of graded aggregates premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

512.1.2. Close graded premix surfacing shall be of Type A or Type B as specified in the Contract documents.

512.2. Materials

512.2.1. Binder : The provisions of Clause 511.1.2.1 shall apply.

512.2.2. Coarse aggregates : The provisions of Clause 511.1.2.2 shall apply.

512.2.3. Fine aggregates : The fine aggregates shall consist of crushed rock quarry sands, natural gravel / sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particles, dry and free from injurious, soft or flaky particles and organic or deleterious substances.

512.2.4. Aggregate gradation: The coarse and fine aggregates shall be so graded or combined as to conform to one or the other gradings shown in Table 500-26, as specified in the contract.

TABLE 500-26. AGGREGATE GRADATION

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing	
	Type A	Type B
13.2 mm	-	100
11.2 mm	100	88 – 100
5.6 mm	52 - 88	31 – 52
2.8 mm	14 - 38	5 – 25
0.090 mm	0 – 5	0 – 5

512.2.5. Proportioning of materials: The total quantity of aggregates used for Type A or B close-graded premix surfacing shall be 0.27 cubic metre per 10 square metre area. The quantity of binder used for premixing in terms of straight-run bitumen shall be 22.0 kg and 19.0 kg per 10 square metre area for Type A and Type B surfacing respectively.

512.3. Construction Operations

The provisions of Clause 511.1.3.1 through 511.1.3.5 shall apply.

512.4. Opening to Traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Excessive traffic speeds should not be permitted.

512.5. Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. For control on the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

512.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be in accordance with the provisions of Clause 112.

512.7. Measurements for Payment

Close-graded premix surfacing, Type A or B shall be measured as finished work, for the area specified to be covered, in square metres at a specified thickness. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

512.8. Rate

The contract unit rate for close-graded premix surfacing, Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

513. SEAL COAT

513.1. Scope

513.1.1. This work shall consist of the application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber).

513.1.2. Seal coat shall be of either of the two types specified below:

(A) Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chips.

(B) Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

513.2. Materials

513.2.1. Binder : The requirements of Clauses 511.1.2.1 and 511.2.2.1 shall apply.

The quantity of bitumen per 10 square metres, shall be 9.8 kg for

Type A, and 6.8 kg for Type B seal coat. Where bituminous emulsion is used as a binder the quantities for Type A and Type B seal coats shall be 15 Kg and 10.5 Kg respectively.

513.2.2. Stone chips for Type A seal coat : The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They should be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7mm size defined as 100 per cent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chips shall satisfy the quality requirements in Table 500-3 except that the upper limit for water absorption value shall be 1 per cent.

513.2.3. Aggregate for Type B seal coat : The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky / elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metres per 10 square metres area.

513.3. Construction Operations

513.3.1. Weather and seasonal limitations: The requirements of Clause 501.5.1 shall apply.

513.3.2. Preparation of surface : The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other extraneous matter.

513.3.3. Construction of Type A seal coat : Bitumen shall be heated to 150°C-163°C and sprayed at the rate specified on the dry surface in a uniform manner with a self-propelled mechanical sprayer as described in the Manual for Construction and Supervision of Bituminous Works.

Immediately after the application of binder, stone chips, which shall be clean and dry, shall be spread uniformly at the rate specified on the surface preferably by means of a self-propelled or towed mechanical grit spreader so as to cover the surface completely. If necessary, the surface shall be brushed to ensure uniform spread of chips.

Immediately after the application of the cover material, the entire

surface shall be rolled with a 8 – 10 tonne smooth wheeled steel roller, 8 – 10 tonne static weight vibratory roller, or other equipment approved by the Engineer after laying trials if required. Rolling shall commence at the edges and progress towards the centre except in superelevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

513.3.4. Construction of Type B seal coat : A mixer of appropriate capacity and type approved by the Engineer shall be used for preparation of the mixed material. The plant shall have separate dryer arrangements for heating aggregate.

The binder shall be heated in boilers of suitable design, approved by the Engineer to the temperature appropriate to the grade of bitumen or as directed by the Engineer. The aggregates shall be dry and suitably heated to a temperature between 150°C and 165°C or as directed by the Engineer before these components are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued untill the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

As soon as a sufficient length has been covered with the premixed material, the surface shall be rolled with an 8-10 tonne smooth-wheeled roller. Rolling shall be continued until the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

513.4. Opening to Traffic

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of Type A seal coat, traffic shall not be permitted to run on any newly sealed area until the following day. In special circumstances, however, the Engineer may open the road to traffic

immediately after rolling, but in such cases traffic speed shall be rigorously limited to 16 km per hour until the following day.

513.5. Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902.

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

513.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

513.7. Measurement for Payment

Seal coat, Type A or B shall be measured as finished work, over the area specified to be covered, in square metres at the thickness specified in the Contract.

513.8. Rate

The contract unit rate for seal coat Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

514. SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES

514.1. Scope

This Specification Clause shall apply to the supply of stone aggregates only. The work shall consist only of collection, transportation and stacking the stone aggregates and stone filler for subsequent use in pavement courses. The actual work of laying the pavement courses shall, however, be governed by the individual Specification Clause for the actual work, given elsewhere in this Specification. The size and quantities of the aggregates to be supplied shall be so selected by the Engineer that the grading requirements set forth in the individual Specification Clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective

Specification Clauses for the individual items given elsewhere in this Specification.

514.2. Sizes of Stone Aggregates

The stone aggregates shall be designated by their standard sizes in the Contract and shall conform to the requirements shown in Table 500-27.

TABLE 500-27. SIZE REQUIREMENTS FOR COARSE STONE AGGREGATES

S.No.	Nominal size of aggregate	Designation of sieve through which the aggregates shall wholly pass	Designation of sieve on which the aggregates shall be wholly retained
(i)	75 mm	106 mm	63 mm
(ii)	63 mm	90 mm	53 mm
(iii)	45 mm	53 mm	26.5 mm
(iv)	26.5 mm	45 mm	22.4 mm
(v)	22.4 mm	26.5 mm	13.2 mm
(vi)	13.2 mm	22.4 mm	11.2 mm
(vii)	11.2 mm	13.2 mm	6.7 mm
(viii)	6.7 mm	11.2 mm	2.8 mm

514.3. Stacking

1. Coarse Aggregates:

Only the aggregates satisfying the Specification requirements shall be conveyed to the roadside and stacked. Each size of aggregate shall be stacked separately. Likewise, materials obtained from different quarry sources shall be stacked separately and in such a manner that there is no contamination of one source with another..

2. Fine Aggregate: As stated in the individual relevant Specification Clauses.

The aggregates shall be stacked entirely clear of the roadway on even clear hard ground, or on a platform prepared in advance for the purpose by the Contractor at his own cost and in a manner that allows correct and ready measurement. If the stockpile is placed on ground where the scraping action of the loader can contaminate the material with underlying soil, then the stockpile shall be rejected by the

Engineer. Materials shall not be stacked in locations liable to inundation or flooding.

The dimensions of the stockpiles and their location shall be approved by the Engineer. Where the material is improperly stacked, the Engineer shall direct complete re-stacking of the materials in an approved manner at the Contractor's cost.

Stone filler shall be supplied in a dry state in bags or other suitable containers approved by the Engineer and shall be protected from the environment, so as to prevent deterioration in quality.

514.4. Quality Control of Materials

The Engineer shall exercise control over the quality of the materials so as to ascertain their conformity with the Specification requirements, by carrying out tests for the specified properties.

Testing shall be to the following frequencies and the Engineer may, at his discretion, direct these to be modified according to requirements:

Coarse and fine: One test for each specified property per 50 m^3 of stone aggregates.

Stone filler: One test for each specified property for every five tonnes, subject to a minimum of one test for each consignment.

Materials shall only be brought to site from a previously tested and approved source, and any materials not conforming to the requirements of the Specification shall be rejected by the Engineer and removed from the work site.

514.5. Measurement for Payment

Coarse and fine aggregates supplied to the site shall be paid for in cubic metres. The actual volume of the aggregates to be paid for shall be computed after deducting the specified percentages in Table 500-28, from the volume computed by stack measurements, to allow for bulking.

Unless otherwise directed by the Engineer, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by white wash or other means as directed by the Engineer.

Stone filler as delivered to the site shall be measured in tonnes.

TABLE 500-28. PER CENT REDUCTION IN VOLUME OF AGGREGATES

S.No.	Standard size of aggregates	Percentage reduction in volume computed by stack measurements to arrive at the volume to be paid for
1.	75 mm and 63 mm	12.5
2.	45 mm and 26.5 mm	10.0
3.	22.4 mm, 13.2 mm, 11.2 mm and 6.7 mm	5.0
4.	Fine aggregate	5.0

514.6. Rates

The contract unit rates for different sizes of coarse aggregate, fine aggregate and stone filler shall be payment in full for collecting, conveying and stacking or storing at the site including full compensation for :

(i) all royalties, fees, rents where necessary;

(ii) all leads and lifts; and

(iii) all labour, tools, equipment and incidentals to complete the work to the Specifications.

(iv) all necessary testing of material, both initial, to approve the source, and regular control testing thereafter.

515. MASTIC ASPHALT

515.1. Scope

This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks.

Mastic asphalt is an intimate homogeneous mixture of selected well-graded aggregates, filler and bitumen in such proportions as to yield a plastic and voidless mass, which when applied hot can be trowelled and floated to form a very dense impermeable surfacing.

515.2. Materials

515.2.1. Binder: Subject to the approval of the Engineer, the binder shall be a paving grade bitumen meeting the requirements given in Table 500-29.

515.2.2. Coarse aggregate : The coarse aggregate shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, hard, durable, of fairly cubical shape, uncoated and free from soft, organic or other deleterious substances. They shall satisfy the physical

TABLE 500-29. REQUIREMENTS FOR PHYSICAL PROPERTIES OF BINDER

Property		Test method	Requirement
Penetration at 25°C		IS 1203	15 ± 5*
Softening point, °C		IS 1205	65 ± 10
Loss on heating for 5h at 163°C, % by mass	Max.	IS 1212	2.0
Solubility in trichloroethylene, % by mass	Min.	IS 1216	95
Ash (mineral matter), % by mass	Max.	IS 1217	1.0

* In cold climatic regions (temperature ≤10°C), a softer penetration grade of 30/40 may be used.

requirements given in Table 500-3.

The percentage and grading of the coarse aggregate to be incorporated in the mastic asphalt depending upon the thickness of the finished course shall be as specified in Table 500-30.

TABLE 500-30. GRADE AND THICKNESS OF MASTIC ASPHALT PAVING, AND GRADING OF COARSE AGGREGATE

Application	Thickness range (mm)	Nominal size of coarse aggregate (mm)	Coarse aggregate content, % by mass of total mix
Roads and carriageways	25 - 50	13	40 ± 10
Heavily stressed areas i.e. junctions and toll plazas	40 – 50	13	45 ± 10

Nominal size of coarse aggregate	13mm
IS Sieve (mm)	Cumulative % passing by weight
19	100
13.2	88 – 96
2.36	0 – 5

Fine aggregate : The fine aggregate shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from soft or flaky pieces and organic or other deleterious substances.

Filler : The filler shall be limestone powder passing the 0.075 mm sieve and shall have a calcium carbonate content of not less than 80 percent by weight when determined in accordance with IS: 1514.

The grading of the fine aggregate inclusive of filler shall be as given in Table 500-31.

TABLE 500-31. GRADING OF FINE AGGREGATE (INCLUSIVE OF FILLER)

I.S. Sieve	Percentage by weight of aggregate
Passing 2.36 mm but retained on 0.600 mm	0 – 25
Passing 0.600 mm but retained on 0.212 mm	10 – 30
Passing 0.212 mm but retained on 0.075 mm	10 – 30
Passing 0.075	30 – 55

515.3. Mix Design

515.3.1. Hardness number : The mastic asphalt shall have a hardness number at the time of manufacture of 60 to 80 at 25°C prior to the addition of coarse aggregate and 10 to 20 at 25°C at the time of laying after the addition of coarse aggregate.

The hardness number shall be determined in accordance with the method specified in IS:1195-1978.

515.3.2. Binder content : The binder content shall be so fixed as to achieve the requirements of the mixture specified in Clause 515.3.1. and shall be in the range of 14 to 17 per cent by weight of total mixture as indicated in Table 500-32.

TABLE 500-32. COMPOSITION OF MASTIC ASPHALT BLOCKS WITHOUT COARSE AGGREGATE

IS Sieve	Percentage by weight of mastic asphalt	
	Minimum	Maximum
Passing 2.36 mm but retained on Q.600 mm	0	22
Passing 0.600 mm but retained on 0.212 mm	4	30
Passing 0.212 mm but retained on 0.075 mm	8	18
Passing 0.075 mm	25	45
Bitumen Content	14	17

515.3.3. Job mix formula : The Contractor shall inform the Engineer in writing at least 1 month before the start of the work of the job mix formula proposed to be used by him for the work, indicating the source and location of all materials, proportions of all materials such as binder and aggregates, single definite percentage passing each sieve for the mixed aggregate and results of the tests recommended in the various Tables and Clauses of this Specification.

515.4. Construction Operations

515.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply, except that laying shall not be carried out when the air temperature at the surface on which the Mastic Asphalt is to be laid is below 10°C.

515.4.2. Preparation of the base: The base on which mastic asphalt is to be laid shall be prepared, shaped and conditioned to the profile required, in accordance with Clause 501 or 902 as appropriate or as directed by the Engineer. In the case of a cement concrete base, the surface shall be thoroughly power brushed clean and free of dust and other deleterious matter. Under no circumstances shall mastic asphalt be spread on a base containing a binder which might soften under high application temperatures. If such material exists, the same shall be cut out and repaired before the mastic asphalt is laid.

515.4.3. Tack coat: A tack coat in accordance with Clause 503 shall be applied on the base or as directed by the Engineer.

515.4.4. Preparation of mastic asphalt: Penetration of mastic asphalt consists of two stages. The first stage shall be mixing of filler and fine aggregates and then heating the mixture to a temperature of 170°C to 210°C. Required quantity of bitumen shall be heated to 170°C to 180°C and added to the heated aggregated. They shall be mixed and cooked in an approved type of mechanically agitated mastic cooker for some time till the materials are thoroughly mixed. Initially the filler alone is to be heated in the cooker for an hour and then half the quantity of binder is added. After heating and mixing for some time, the fine aggregates and the balance of binder are to be added and further cooked for about one hour. The second stage is incorporation of coarse aggregates and cooking the mixture for a total period of 3 hours. During cooking and mixing, care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210°C.

Where the material is not required for immediate use it shall be cast into blocks consisting of filler, fine aggregates and binder, but without the addition of coarse aggregate, weighing about 25 Kgs each. Before use, these blocks shall be reheated to a temperature of not less than 175°C and not more than 210°C, thoroughly incorporated with the requisite quantity of coarse aggregates and mixed continuously. Mixing shall be

continued until laying operations are completed so as to maintain the coarse aggregates in suspension. At no stage during the process of mixing shall the temperature exceed 210°C.

The mastic asphalt blocks (without coarse aggregate) shall show on analysis a composition within the limits as given in Table 500-32.

The mixture shall be transported to the laying site in a towed mixer transporter having arrangement for stirring and keeping the mixture hot during transportation.

515.4.5. Spreading : The mastic asphalt shall be laid, normally in one coat, at a temperature between 175°C and 210°C and spread uniformly by hand using wooden floats or by machine on the prepared and regulated surface. The thickness of the mastic asphalt and the percentage of added coarse aggregate shall be in accordance with Table 500-30 or as specified by the Engineer. Where necessary, battens of the requisite dimensions should be employed. Any blow holes that appear in the surface shall be punctured while the material is hot, and the surface made good by further floating.

515.4.6. Joints : All construction joints shall be properly and truly made. These joints shall be made by warming existing mastic asphalt by the application of an excess quantity of the hot mastic asphalt mixture which afterwards shall be trimmed to leave it flush with the surfaces on either side.

515.4.7. Surface finish : The mastic asphalt surface can have poor skid resistance after floating; in order to provide resistance to skidding, the mastic asphalt after spreading, while still hot and in a plastic condition, shall be covered with a layer of stone aggregate. This aggregate shall be 13.2 mm size (passing the 19.0 mm sieve and retained on the 9.5 mm sieve) or 9.5mm size (passing the 13.2 mm sieve and retained on the 6.7 mm sieve) subject to the approval of the Engineer. Hard stone chips, complying with the quality requirements of Table 500-17, shall be precoated with bitumen at the rate of $2 \pm 0.4\%$ of S-65 penetration grade. The addition of 2% of filler complying with Table 500-9 may be required to enable this quantity of binder to be held without draining. The chips shall then be applied at the rate of 0.005 cu. m. per 10 sq. m. and rolled or otherwise pressed into the surface of the mastic layer when the temperature of the mastic asphalt is not less than 100°C.

515.5. Opening to Traffic

Traffic may be allowed after completion of the work when the mastic asphalt temperature at the mid-depth of the completed layer has cooled to the daytime maximum ambient temperature.

515.6. Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902.

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

The surface of the mastic asphalt, tested with a straight edge 3.0m long, placed parallel to the centre line of the carriageway, shall have no depression greater than 7mm. The same limit shall also apply to the transverse profile when tested with a camber template.

515.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

515.8. Measurement for Payment

Mastic asphalt shall be measured as finished work in square metres at a specified thickness, or by weight in tonnes as stated in the Contract.

515.9. Rate

The contract unit rate for mastic asphalt shall be payment in full for carrying out the required operations including full compensation for all components listed under Clause 501.8.8.2. (i) to (ix).

516. SLURRY SEAL

516.1. Scope

Slurry seals are mixtures of fine aggregate, portland cement filler, bitumen emulsion and additional water. When freshly mixed, they have a thick consistency and can be spread to a thickness of 1.5 - 5 mm. They may be used to seal cracks, arrest fretting and fill voids and minor depressions, to provide a more even riding surface or a base for further treatment; they may also be used on top of a single coat surface dressing.

516.2. Materials

The materials for slurry seal immediately prior to mixing shall conform to the following requirements:

516.2.1. Emulsified bitumen: The emulsified bitumen shall be a cationic rapid setting type as approved by the Engineer, conforming to the requirements of IS: 8887. Where special mobile mixing machines are available, Class A4* rapid setting or Class K3* road emulsions to BS 434: Part 1 should be used to obtain very early resistance to traffic and rain. Generally, emulsion for slurry seal should be capable of producing a slurry that will develop early resistance to traffic and rain and is sufficiently stable to permit mixing with the specified aggregate, without breaking during the mixing and laying processes. If approved by the Engineer, a slow setting emulsion may be used. Guidance on selection of an appropriate grade of emulsion is given in the Manual for Construction and Supervision of Bituminous Works.

516.2.2. Water : Water shall be of such quality that the bitumen will not separate from the emulsion before the slurry seal is in place.

The pH of the water must lie in the range 4 to 7, and if the total dissolved solids in the water amount to more than 500ppm, the Engineer may reject it, or order the Contractor to conduct a trial emulsion mix to demonstrate that it does not cause early separation.

516.2.3. Aggregate : The aggregate shall be crushed rock, or slag and may be blended, if required, with clean, sharp, naturally occurring sand free from soft pieces and organic and other deleterious substances to produce a grading as given in Table 500-33. The aggregates shall meet the requirements of the film stripping test (IS: 6241), and a suitable amount and type of anti-stripping agent added, as may be needed (details given in Appendix 5).

516.2.4. Additives: It is usual to use ordinary Portland cement, hydrated lime or other additives to control consistency, mix segregation and setting rate. The proportion of the additive should not normally exceed 2 per cent by weight of dry aggregates.

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* The corresponding grades in IS:8887 are only broadly classified as RS, MS and SS and further sub-classification is not available at present.

516.3. Mixture Design

A range of residual binder contents for each aggregate grading is given in Table 500-33. The optimum mixture design for the aggregate, additive, water and bitumen emulsion mixture should be determined in accordance with ASTM D 3910.

516.4. Construction Operations

516.4.1. Weather and seasonal limitations: Clause 501.5.1 shall apply.

TABLE 500-33. AGGREGATE GRADING, BINDER CONTENT AND APPROXIMATE COVERAGE RATE

Sieve Size (mm)	Percentage by mass passing finished thickness of sealing		
	5 mm	3mm	1.5mm
9.5	100	-	-
4.75	90 – 100	100	—
3.35	-	80 – 100	100
2.36	65 – 90	75 – 100	95 – 100
1.18	45 – 70	55 – 90	70 – 95
0.600	30 – 50	35 – 70	55 – 75
0.300	18 – 30	20 – 45	30 – 50
0.150	10 – 21	10 – 25	10 – 30
0.075	5 – 15	5 – 15	5 – 15
Quantity of residual binder, percentage by mass of aggregate	7.5 – 13.5	10 – 16	12 – 20
Approximate coverage rate (kg/m²)	8 – 15	4 – 6	2 – 4

516.4.2. Surface preparation: Any necessary remedial work to the road surface and structure shall be completed either prior to or as part of the Contract and agreed as acceptable by the Engineer, according to the provisions of Clause 501.

Before slurry seal is applied, street furniture and, where directed by the Engineer, road markings, shall be masked using self-adhesive masking material or other material firmly secured against the passage of the spreader box or the tools used for hand laying. Any packed mud or other deposits on the surface shall be removed, all organic growth shall be

removed by suitable means, and the surface shall be swept free of all loose material.

516.4.3. Tack coat: If required by the Engineer, a tack coat may be applied prior to the slurry seal, with or without grit or chips, in order to seal the existing substrata and enhance the bond to the existing road surface. Unless otherwise agreed by the Engineer, the rate of spread of tack coat shall be 0.15 to 0.30 litres/m^2 for bituminous surfaces and 0.4 to 0.6 litres/m^2 for concrete surfaces

516.4.4. Mixing and transportation of mixture: Mixing (and laying) techniques vary according to the type of emulsion used. For class A4 rapid setting and K3 emulsions, only special mobile mixing machines should be used. These carry supplies of aggregate, emulsion, water and filler (e.g. ordinary Portland cement or hydrated lime) and are fitted with metering devices to feed the ingredients in their correct proportions to a mixer fitted to the rear of the machine. From the mixer the slurry is fed into the screed box towed by the machine.

For all other emulsions, mixing may be by hand, concrete mixer or other mixer which effectively coats the aggregate uniformly and produces a slurry seal of suitable consistency for satisfactory laying. For large areas, a bulk transit concrete mixer may be used into which the ingredients (including water) are measured and mixed as the mixer travels to the area to be treated. A screed box fitted with an adjustable rubber screed should be towed by the mixer which feeds it during laying.

The special mobile mixing machine, when used, shall be capable of uniform application to provide a continuous surface without ridges or segregation. Before laying begins, the Contractor shall provide the Engineer with a test certificate showing test results for rate of application carried out under the supervision of a competent authority, demonstrating that the machine has been tested, using the system to be used in the Contract, not more than six weeks before the commencement of the work.

Where the material is to be hand laid, the slurry may be supplied to site pre-mixed in suitable containers and steps shall be taken to ensure that the material in each container is of an even consistency throughout the container immediately prior to use.

516.4.5. Application: Transverse joints for machine laid areas shall be formed with spreading, starting and finishing on a protective strip not

less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips.

Unless otherwise approved by the Engineer, longitudinal joints shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.

Hand work around street furniture and other obstructions should meet the same performance requirements and form a homogeneous surface with the rest of the treated carriageway.

Footways and other confined areas may be spread by hand using squeegees and brooms. Transverse joints shall be formed with spreading, starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips. Kerb edges and other areas not being treated shall be suitably masked with self adhesive masking material. Footways shall be finished by dragging a dampened broom transversely over the footway under its own weight.

All voids, cracks and surface irregularities shall be completely filled. In warm dry weather the surface, immediately ahead of the spreading, shall be slightly damped by mist water spray applied mechanically, or for hand laying by a hand operated pressure sprayer, unless otherwise approved by the Engineer.

516.4.6. Rolling: The need for rolling shall be as instructed by the Engineer. Where rolling is required, a pneumatic-tyred roller having an individual wheel load between 0.75 and 1.5 tonnes shall be used, or as may be directed by the Engineer. Rolling shall commence as soon as the slurry has set sufficiently to ensure that rutting or excessive movement will not occur.

516.5. Opening to Traffic

Masking shall be removed after the slurry seal has been applied, without damage to the edge of the surfacing, and before opening the road or footway to traffic.

The Contractor shall remove surplus aggregate from the treated areas using a method agreed by the Engineer. The Contractor shall monitor the slurry seal closely for a minimum period of 2 hours and if necessary the

lane shall be swept again. The monitoring shall continue until the slurry seal has reached sufficient stability to carry unrestricted traffic. If there are signs of distress, the Engineer shall require the Contractor to reinstate traffic safety and management procedures or other such remedial action where necessary in order to prevent further damage.

Further operations to remove subsequently loosened aggregate shall be carried out over the next 48 hours. The areas treated and adjacent side roads, footways and paved areas shall be kept substantially free of loose aggregate for a period of 30 days after completion of the work.

516.6. Surface Finish and Quality Control of Work

Generally, the surface finish of the completed construction shall conform to the requirements of Clause 902. For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

In addition, the finished slurry shall have a uniform surface texture throughout the work, without variations of texture within the lane width, or from lane to lane, due to segregation of aggregates, or due to variations in the emulsion/water content of the mixture.

The finished surface shall be free from blow holes and surface irregularities in excess of 3 mm beneath a 1 metre straight edge due to scraping, scabbing, dragging, droppings, excess overlapping or badly aligned longitudinal or transverse joints, damage by rain or frost, or other defects which remain 24 hours after laying.

516.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

516.8. Measurement for Payment

Slurry seal shall be measured as finished work as specified, in square metres.

516.9. Rate

The contract unit rate for slurry seal shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi).

517. RECYCLING OF BITUMINOUS PAVEMENT

517.1. Scope

This Clause of the Specifications covers the recycling of existing bituminous pavement materials to upgrade an existing bituminous pavement which has served its first-intended purpose. The work shall be performed on such widths and lengths as may be directed by the Engineer and may consist of pavement removal, stockpiling of materials from the old pavement, addition of new bitumen and untreated aggregate in the requisite proportions, mixing, spreading and compaction of the blended materials.

Recycling processes can be categorised into in-situ recycling (where processing takes place on site), and central plant recycling (where reclaimed material is processed off site). The processes can be further sub-divided into hot and cold processes. This Specification covers the hot process only. However, reclaimed aggregate from cold insitu recycling can be used in the Bituminous Cold Mix process specified in Clause 519, subject to the resultant mixes achieving the specified standards.

517.2. Reclaimed Bituminous Materials for Central Plant Recycling

517.2.1. Proportion of reclaimed materials less than 10 per cent: If not more than 10% of reclaimed bituminous material is to be used in the production of bituminous macadam or dense graded bituminous base or binder course material, then Clauses 517.2.2 to 517.2.9 do not apply. However:

a) all reclaimed bituminous material shall be pre-treated before use such that the material is homogeneously mixed and the maximum particle size of reclaimed material does not exceed 40 mm.

b) the mixed material shall comply with the requirements of Clauses 504 or 507 as appropriate.

517.2.2. Proportions of reclaimed materials greater than 10 per cent: Reclaimed bituminous material of an amount greater than 10 per cent, may be used in the production of bituminous macadam and dense graded bituminous base and binder course material, subject to the requirements of Clauses 517.2.3 to 517.2.9 and subject to the satisfactory completion of full trial investigations in respect of all related materials, layer thickness, machine operations and finished works on a case-by-

case basis entirely at the contractors cost and subject to the approval of the Engineer. For estimating purposes, a maximum amount not greater than 30 per cent reclaimed bituminous material should be assumed.

517.2.3. Materials for recycled pavement : The recycled materials shall be a blend of reclaimed and new materials proportioned to achieve a paving mixture with the specified engineering properties. The reclaimed materials shall be tested and evaluated to find the optimum blend meeting the mixture requirements. Such testing and evaluation shall be carried out on representative samples, either cores sampled from the carriageway or samples taken from stockpiles in accordance with current practice. The sampling frequency should be sufficient to determine how consistent the reclaimed material is and to provide representative samples for composition analysis and measurement of properties of recovered binder. As an absolute minimum, one sample to represent 500m of lane carriageway shall be taken.

517.2.4. Bitumen extraction : The procedure described in ASTM D-2172 shall be used to quantitatively separate aggregate and bitumen from any representative sample of reclaimed bituminous pavement.

517.2.5. Aggregate evaluation : Mechanical sieve analysis (IS: 2386, Part I, wet sieving method) shall be performed on the aggregate portion of the reclaimed bituminous pavement sample to determine the grading. It is essential that the reclaimed materials to be recycled are consistent, as variable materials will cause problems with the control of quality and impede the efficiency of the recycling operation. Suitable sources of consistent material of sufficient quantity for the scheme being considered need to be identified either in existing pavements, from stockpiled planings of known origin or from another suitable source, before a decision can be made on the optimum percentage of reclaimed material.

After selecting the proportion of reclaimed materials to be recycled, the grading of the mixture may need adjustment, to meet Specification requirements, by the addition of selected aggregate sizes.

517.2.6. Evaluation of bitumen : When the amount of reclaimed bituminous materials to be used in the mixture exceeds 10%, the penetration value of the recovered binder from the reclaimed bituminous material, before mixing, shall exceed 15 pen, after recovery of binder in accordance with the requirements of BS 2000 : Part 397, when tested in

accordance with IS : 1203. Provided the above requirement is met, hardening of the old binder, during the original mixing process or through ageing, can be compensated for by adding a softer bitumen, to obtain the appropriate final grade of binder.

The determination of the type and amount of binder required to be added in the final mix is essentially a trial and error procedure.

After mixing with recycled materials, the binder recovered from the mixture shall have a recovered penetration value not less than the value specified in Table 500-34.

TABLE 500-34. MINIMUM RECOVERED BINDER PENETRATION OF RECYCLED MIXTURE

Specified Grade of Binder (Penetration)	Minimum Recovered Penetration Value of Binder after Mixing
45	27
65	39
90	54

517.2.7. Rejuvenators: The use of rejuvenators, and a test to measure their effectiveness, is described in Clause 517.6.3.

517.2.8. Untreated aggregate : If necessary, fresh untreated aggregate shall be added to the reclaimed bituminous pavement to produce a mix with the desired grading. The aggregate shall be checked for quality requirements in accordance with Table 500-3 or Table 500-8 as appropriate. Reclaimed aggregate, if any, or any aggregate normally used for the desired bituminous mixture, or both, may be used for this purpose.

517.2.9. Combined aggregate grading : The blend of reclaimed and new aggregate shall meet the grading criteria specified in the relevant parts of Clause 504 or 507, as appropriate and as approved by the Engineer. The blend of aggregates shall be checked for resistance to stripping as specified in Tables 500-3 or 500-8 as appropriate.

517.3. Mixture Design

The combined aggregate grading and binder content shall comply with the relevant tables in Clauses 504 or 507. For dense graded bituminous mixtures the mixture design shall also comply with the requirements of Table 500-11.

517.4. Reclaiming Old Pavement Materials

The removal of pavement materials to the required depth shall be accomplished either at ambient temperature (cold process) or at an elevated temperature (hot process), as approved by the Engineer.

517.4.1. Cold removal process: In the cold process, the ripping and crushing operations shall be carried out using scarifiers, grid rollers, or rippers or by any other means as directed by the Engineer. The removed materials shall be loaded and hauled for crushing to the required size as directed by the Engineer. Alternatively, cold milling or planing machines can be used to reclaim bituminous pavement to controlled depths. After the bituminous layers are removed, any remaining aggregate materials that are to be incorporated in the recycled hot mixture shall be scarified and removed. When the pavement material removal is completed, any drainage deficiencies shall be corrected. After that, the base/sub-base as the case may be shall be cut, graded and compacted to the required profile and density.

517.4.2. Hot removal process: In this process, the road surface shall be heated, by any suitable means approved by the Engineer, before scarification. A self propelled plant shall be used, and a milling drum that follows the planer removes the heated soft bituminous layer. The depth, width and speed of travel shall be adjusted to suit specific requirements as directed by the Engineer. During the heating process, the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

517.4.3. Stockpiling : In the cold process, the reclaimed bituminous pavement material shall be stockpiled with the height of stockpiles not exceeding 3 m. The reclaimed untreated aggregate base/sub-base material shall be stockpiled in the same manner as new aggregate. The number and location of stockpiles shall be carefully planned for efficient operation of the hot-mix plant.

517.5. Mixing and Laying

Generally, the requirements of Clauses 504.3 or 507.4, as appropriate, shall apply.

517.6. In Situ Recycling - The Remix and Repave Processes

These processes are suitable for the production of bituminous concrete wearing course in accordance with the provisions of Clause 509.

517.6.1. Scope: In the process of repaving, the existing surface is preheated and scarified but the scarified material is not removed. A layer of fresh bituminous mix material prepared in the integrated mixing unit of the plant is then spread evenly on the scarified surface to give a uniform profile. The spread material should be compacted as soon as possible after laying. In the process the total thickness of the pavement is increased by up to 50mm.

In the remix process, the scarified material should be taken from the mixing unit of the plant where it is recycled with fresh binder, aggregate and recycling agent. Then the recycled mixture is spread on the preheated surface and tamped and compacted to the required profile.

517.6.2. Heating and scarifying: Surfaces to be treated shall be heated by plant with surfaces insulated and fully enclosed. The heated width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilled onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.

The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of wearing course material specified. A tolerance of ± 6 mm is permissible.

Where street furniture and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressing and large areas of road markings shall be removed by milling, planing, scarifying or by similar approved processes.

The heated surface shall be evenly scarified to comply with the requirements of this Clause. When street furniture is left in place or raised, the adjacent areas shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If furniture needs to be repositioned on completion of work, the new wearing course material shall be used to make good the road surface for a maximum width of 200 mm around the obstruction.

During the reheating process the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

517.6.3. Rejuvenator: For Remix, when required, rejuvenator shall be uniformly sprayed across the full-width of the processed material. The machine shall incorporate a meter for continuous verification of quantities which shall be within ±5% of the specified rate. The volume of rejuvenator shall vary in relation to the operating speed of the machine, which shall be related to the volume of material mixed or scarified.

The rejuvenator shall be a non-emulsified aromatic extract. Its properties shall be verified using the Rolling Thin Film Oven Test.

Rejuvenation of the existing pavement may also be performed by adding new hot-mix bituminous material containing a soft binder of suitable penetration for restoring the binder in the existing pavement to the required penetration.

517.6.4. Mixing: When required, new hot-mix material shall be mixed with the heated and scarified road pavement material in a pugmill within the Remix machine, observing the mixing temperatures specified in Table 500-5.

After mixing, the recycled bituminous materials shall be automatically fed to a finishing unit, which spreads and levels the mixture to the specified thickness and cross-section. The new bituminous concrete wearing course shall be material complying with Clause 509.

517.6.5. Additional material (general): The proportion of new hot-mix bituminous material, and the proportion of existing bituminous pavement material shall be as directed by the Engineer, together with the amount the road surface level is to be raised (if any).

The type and quantity of the new hot-mix material shall be determined by using the Marshall Mix Design procedure specified in The Asphalt Institute Manual MS-2, before work commences. Remix designs shall incorporate the stated proportion of material sampled from the existing road surface.

When additional coarse or fine aggregate or filler are required to be added, they shall comply with the requirements of Clause 509.2. The amount of additional coarse or fine aggregate or filler to be added to the existing bituminous pavement material shall be notified to the Engineer.

517.6.6. Additional aggregate (remix process): The coarse

aggregate, fine aggregate and filler added to the Remixed material shall comply with the requirements of Clause 509.2.

517.6.7. New surfacing (repave and remix/repave processes): New surfacing material shall be bituminous concrete wearing course complying with Clause 509, or other wearing course material approved by the Engineer.

The new surfacing material shall be laid on, and compacted with, the reprofiled surfacing, which shall be at a temperature within the range of 100°C to 150°C.

517.6.8. Binder: The binder shall be recovered from samples taken from each layer of material laid. The method of recovery shall be in accordance with BS 2000 : Part 397 or an equivalent test. The penetration of the binder shall be in the range 35-70 pen.

517.6.9. Mixture design: The surfacing material shall be sampled from the paver hopper or augers. Care shall be taken that only the material forming the new surface layer is sampled. The sample shall be reduced on site by rifling or quartering to approximately 5 kg and placed loose in an air-tight container.

The sample shall only be reheated once whilst within the container. As soon as the sample reaches the required temperature, the reheated material shall be remixed and three Marshall test specimens prepared in accordance with the procedures specified in MS-2.

The bulk density of each specimen shall be measured before Marshall Stability testing. The mean stability and flow of the three specimens, measured in accordance with the procedures specified in MS-2, shall comply with the requirements of Table 500-19.

Finally the 3 Marshall specimens shall be combined and the maximum theoretical specific gravity (G_{mm}) of the mixture is determined in accordance with ASTM D 2041. This maximum theoretical specific gravity (G_{mm}) corresponds to 0% air voids in the mixture. The actual bulk specific gravity of a Marshall specimen determined in the Laboratory (G_{mb}) will naturally be less than G_{mm}. The percent air voids (P_a) in the specimen of the compacted mixture given by $P_a = \frac{G_{mm} - G_{mb}}{G_{mm}} x100$ should meet the requirements of air voids laid down in Table 500-19.

517.7. Opening to Traffic

For recycled material forming the base or binder course layer, Clause 504.5 or 507.5 shall apply as appropriate. For recycled material forming the wearing course layer, Clause 509.5 shall apply.

517.8. Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902.

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

517.9. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

517.10. Measurement for Payment

The recycled pavement work shall be measured in cubic metres or tonnes of finished work as stated in the Contract..

517.11. Rate

The contract unit rate for recycled pavement shall be payment in full for carrying out the required operations including full compensation for all items as Clause 501.8.8.2. (i) to (xi)

518. FOG SPRAY

518.1. Scope

Fog spray is a very light application of low viscosity bitumen emulsion for purposes of sealing cracks less than 3mm wide or incipient fretting or disintegration in an existing bituminous surfacing, and to help reduce loosening of chips by traffic on newly finished surface dressing.

518.2. Material

The bitumen emulsion shall be as specified in the Contract or as instructed by the Engineer. The emulsion shall be

SS-1h* (SS-1 can be used if the former is not available) complying with the requirements of ASTM D-977, or;

CSS-1h* (CSS-1 can be used if the former is not available) complying with the requirements of ASTM D-2397.

Before use these emulsions shall be diluted, 1 part emulsion to 1 part water. Alternatively, Class A1-40* or K1-40* emulsions complying with the requirements of BS434:Part 1:1984 may be used. These emulsions have a lower viscosity than the above ASTM grades, they are rapid setting and they do not require to be diluted. Because of their low viscosity they should be used as soon as possible after delivery. If this is not possible, the drums should be very thoroughly rolled before use.

518.3. Weather and Seasonal Limitations

Spraying shall not take place when the temperature is below 10°C, nor in windy or dusty conditions, nor when it is raining or the surface to be sprayed is wet (a damp surface is acceptable but refer to Clause 518.4.2.).

518.4. Construction Operations

518.4.1. Equipment: The fog spray shall be applied by means of a self-propelled or towed bitumen pressure sprayer complying with the requirements of the Manual for Construction and Supervision of Bituminous Works. The spray bar should be protected from gusts of wind by means of a hood.

518.4.2. Preparation of surface: The surface on which the fog spray is to be applied shall be thoroughly cleaned with compressed air, scrubbers etc. The cracks shall be cleaned with a pressure air jet to remove all dirt, dust etc.

518.4.3. Application: The fog seal shall be applied at a rate of 0.5 – 1.0 litres/m^2, using equipment such as pressure tank, flexible hose and spray bar or lance.

518.5. Blinding

If specified in the Contract or ordered by the Engineer, the fog spray shall be blinded with graded grit of 3mm size and under, coated with about 2 per cent of the emulsion by weight. The pre coated grit shall be

* The grades in IS:8887 are only broadly classified as RS, MS and SS and further sub-classification is not available at present.

allowed to be cured for at least one week or until they become non-sticky and can be spread easily.

518.6. Quality Control of Work

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

518.7. Arrangements for Traffic

During the spraying operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112. The surface should not be opened to traffic for 24 hours after spraying. If pick-up does occur a light blinding of crusher dust or sand should be applied.

518.8. Measurement for Payment

Fog spray and blinding (if used) shall be measured in terms of surface area of application, for the area covered, in square metres.

518.9. Rate

The contract unit rate for fog spray and blinding (if used) shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi) as applicable to the work specified in these Specifications.

519. BITUMINOUS COLD MIX (INCLUDING GRAVEL EMULSION)[1]

519.1. The Design Mix

Bituminous Cold Mix consists of a mixture of unheated mineral aggregate and emulsified or cutback bitumen. This Specification deals only with plant mix (as opposed to mixed-in-place). Two types of mix are considered, namely Designed Cold Mix and Recipe Cold Mix. The Design Mix procedure shall be used unless the Recipe Mix procedure is specifically approved by the Engineer.

[1]This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD), Ministry of Road Transport & Highways, Transport Bhavan, Parliament Street, New Delhi-110 001. Fax # 3710236

519.2. Designed Cold Mix

This Specification is based on The Asphalt Institute Manual MS-14, which contains additional information for guidance. These mixes are considered suitable for use as base course, appropriate to their stability, in new work or major repair work.

519.2.1. Materials

519.2.1.1. Binder: The binder shall be a bituminous emulsion as specified in AASHTO M 140 (ASTM D977)* or AASHTO M 208 (ASTM D2397)*, namely MS-2, MS-2h, HFMS-2, HFMS-2h, HFMS-2s, SS-1, SS-1h, CMS-2, CMS-2h, CSS-1 and CSS-1h. Alternatively, a cutback bitumen as specified in AASHTO M 82 (ASTM D2027) or ASTM D 2026, namely MC 70, 250, 800 & 3000 and SC 250, 800 and 3000 may be used, or, if approved by the Engineer, an equivalent material which conforms with IS:8887 and IS:217.

A general guide for the use of these binders is given in Table 500-35 and in the Manual for Construction and Supervision of Bituminous Works. However the final selection shall be made only after laboratory evaluation

TABLE 500-35. USES OF BITUMEN IN COLD MIX

Type of Construction	Emulsified Bitumen									Cutback Bitumen						
	Anionic					Cationic				Medium Curing (MC)				Slow Curing (SC)		
	MS-2, HFMS-2	MS-2h, HFMS-2h	HFMS-2s	SS-1	SS-1h	CMS-2	CMS-2h	CSS-1	CSS-1h	70	250	800	3000	250	800	3000
***Cold-Laid Plant Mix* Pavement Base and Surfaces**																
Open-Graded Aggregate	*	*				*	*									
Well-Graded Aggregate			*	*	*			*	*		*	*	*	*	*	*
Patching, Immediate Use				*	*			*	*		*	*			*	
Patching, Stockpile											*	*		*	*	

* The corresponding grades in IS:8887 are only broadly classified as RS, MS and SS and further sub-classification is not available at present.

with the aggregates to be used. The binder with the highest residual viscosity at ambient temperatures that can reasonably be handled by the mixing and laying equipment proposed shall be used.

519.2.1.2. Aggregates: The aggregates shall comply with the requirements of Clause 504.2.2. and 504.2.3. If the aggregates are not properly coated with anionic emulsion or cutback bitumen, a small amount of hydrated lime, an approved antistripping agent (see Appendix 5) or a change to cationic emulsion shall be proposed by the Contractor, for the approval of the Engineer.

519.2.1.3. Aggregate grading and binder content: The combined aggregate grading for the particular mixture, when tested in accordance with IS:2386 Part 1, (wet sieving method), shall fall within the limits shown in Table 500-36.

519.2.2. Mixture Design

519.2.2.1. Requirements 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 500-37.

519.2.2.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-41. The method adopted shall be that described in Appendix F and H of Asphalt Institute's Manual, MS-14.

519.2.2.3. Job Mix Formula: The Contractor shall inform the Engineer in writing, at least one month before the start of the work, the job mix formula proposed for use in the works and shall give the following details:

(i) Source and location of all materials;

(ii) Proportions of all materials expressed as follows where each is applicable:
  (a) Binder, as percentage by weight of total mixture;
  (b) Coarse aggregate/fine aggregate as percentage by weight of total aggregate;

(iii) A single definite percentage passing each sieve for the mixed aggregate;

(iv) The results of tests enumerated in Table 500-39 as obtained by the Contractor;

(v) Test results of the physical characteristics of the aggregates to be used;

(vi) Spraying temperature of binder if appropriate.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different

TABLE 500-36. AGGREGATE GRADING AND BITUMEN CONTENT

Nominal maximum size (mm)	9.5	13.2	19.0	26.5
Allowable thickness (mm)	25-35	36-50	51-75.	76-100
IS Sieve (mm)	Cumulative % by weight of total aggregate passing			
37.5	-	-	-	100
26.5	-	-	100	90-100
19.0	-	100	90-100	-
13.2	100	90-100	-	56-80
9.5	90-100	-	60-80	-
4.75	60-80	45-70	35-65	29-59
2.36	35-65	25-55	20-50	19-45
0.30	6-25	5-20	3-20	5-17
0.075	2-10	2-9	2-8	1-7
	[1]Guide to binder content, % by weight of total mixture			
Cutback	Min 4 to Max 6			
Emulsion	Min 7 to Max 10			

[1]To be determined by the modified Marshall Test.

TABLE 500-37. MIXTURE REQUIREMENTS FOR DESIGNED COLD MIX

Parameter	Emulsion[1]	Cutback[2]
Minimum Stability (kN at 22.2°C) Emulsion (kN at 25°C) Cutback	2.2 for paving	2.2 for maintenance 3.3 for paving
Percent maximum stability loss on soaking	50[3]	25[4]
Minimum flow (mm)	2	2
Compaction level (number of blows)	50	75
Per cent air voids	3-5[5]	3-5
Per cent voids in mineral aggregate (VMA)	See Table 500-38	
Per cent minimum coating[6]	50	

Notes [1]Using "Marshall method for emulsified asphalt-aggregate cold mixture design". Appendix F, MS -14.
[2]Using "Marshall method for cut-back asphalt-aggregate cold mixture design", Appendix H, MS-14.
[3]With vacuum saturation and immersion.
[4]Four days soak at 25°C.
[5]Refers to total voids in the mix occupied by air and water.
[6]Coating Test, Appendix F, MS-14.

TABLE 500-38. MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Particle Size IS Sieve (mm)	Minimum VMA (per cent)
9.5	16.0
12.5	15.0
19.0	14.0
25.0	13.0
37.5	12.0

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 selected jointly with the Engineer of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established and approved by the Engineer before actually using the materials.

519.2.2.4. Permissible variation from the job mix formula : It shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-39. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

519.2.3. Construction operations

519.2.3.1. Weather and seasonal limitations: Construction with cold mix must not be undertaken when ambient temperatures below 10°C are expected, during rain, in standing water, or generally when poor weather is predicted. Bitumen emulsions and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesion characteristics. Cold weather, rain and high humidity slow down the rate of curing. Extra manipulation may be required to remove

TABLE 500-39. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation	
	Base/binder course	Wearing course'
Aggregate passing 19mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2mm, 9.5mm	± 7%	± 6%
Aggregate passing 4.75mm	± 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%

volatiles in cool and humid conditions. Wind increases the rate of evaporation.

519.2.3.2. Preparation of the base: The base on which cold mix is to be laid shall be prepared, shaped and levelled to the required profile in accordance with Clauses 501 and 902 as appropriate, and a prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

519.2.3.3. Tack coat: A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid where specified in the Contract.

519.2.3.4. Preparation and transportation of the mixture: Mixing can be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

(a) rotary drum type concrete mixer;

(b) single or twin shaft concrete or macadam mixer;

(c) batch or continuous type mixer without dryer or screens other than a scalping screen.

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site must be suited to the Contractor's nominated laying procedure methodology.

519.2.3.5. Spreading: Designed cold mix shall be placed only when the specified density can be obtained. The mixture shall not be placed on

any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader must have a blade that is straight and sharp and long enough to ensure finishing to close, straight, transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mixture.

If climatic conditions and aggregate grading permit evaporation of moisture or volatiles without aeration by manipulation, a conventional self-propelled asphalt paver shall be used to place designed cold mix.

Other methods of spreading may be used as approved by the Engineer.

519.2.3.6. Compaction: Initial compaction of the laid material shall be carried out using a pneumatic-tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thicknesses being 25-100mm and all compaction being in accordance with Clause 501.6 and Clause 501.7. Smooth tyres shall be used. Final rolling and smoothing of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

519.2.4. Opening to traffic: Traffic shall not be allowed to run on new work until all the water or volatiles in the mixture have evaporated, as determined by the Engineer. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

519.2.5. Surface finish and quality control of work: The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of supplied materials and the works carried out, the relevant provisions of Section 900 shall apply.

519.2.6. Arrangements for traffic: During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

519.2.7. Measurement for payment: Designed Cold Mix shall be measured as finished work, for the area covered, in cubic metres, by weight in metric tonnes, or by square metres at a specified thickness as specified in the Contract.

519.2.8. Rate : The contract unit rate for Designed Cold Mix shall

be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi). The rate shall cover the provision of the specified grade of cutback in the mix at 5 per cent of the weight of the total mix or emulsion at 8 per cent of the weight of the total mix, with the provision that the variation of quantity of binder will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted as per the rate for cutback or emulsion quoted in the Bill of Quantities.

Recipe Cold Mix

519.3. Recipe Cold Mix

This Specification is based on BS434:Part 2:1984 which contains additional information. These are premixes made with emulsion binder which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. These mixes are considered suitable for use only for emergency and minor repair work and temporary road surface improvement.

519.3.1. Materials

519.3.1.1. Binder: Emulsions of sufficient stability for mixing with the particular graded aggregate should be used. Grades of emulsion quoted are in accordance with BS434: Part 1:1984 but comparable grades to IS or AASHTO specifications may be used. Guidance on selection of an appropriate grade of emulsion is given in the Manual for Construction and Supervision of Bituminous Works. The corresponding grades in IS:8887 are only broadly classified as RS, MS and SS and further sub-classification is not available at present.

519.3.1.2. Aggregates: Any normal, clean, but not necessarily dry, aggregate can be used, provided that it has a sufficiently high crushing strength with regard to the traffic to be carried. Typical gradings are given in Table 500-40.

519.3.1.3 Aggregate grading and binder content: When tested in accordance with IS:2386 Part 1 (wet sieving method)the combined aggregate grading for the particular mixture shall fall within the limits shown in Table 500-40. The grade and range of quantity of emulsion are also indicated in this table. The actual quantity of emulsion to be used shall be approved by the Engineer after seeing the results of trial mixes made in the laboratory.

TABLE 500-40. COMPOSITION OF RECIPE MIXES

Nominal Size (mm) and Type of Macadam	40 Single course	40 Open textured base course	14 Open textured wearing course	6 Medium textured wearing course	- Fine coated
Allowable Thickness (mm)	**75-100**	**75-100**	**31-50**	**21-30**	**15-20**
IS Sieve Size mm	**Cumulative % by weight of total aggregate passing**				
45	100	100	-	-	-
37.5	90-100	90-100	-	-	-
26.5	55-90	55-85	-	-	-
19	-	-	100	-	-
13.2	35-55	15-35	90-100	-	-
9.5	-	-	55-75	100	-
6.3	20-30	-	25-45	90-100	100
3.35	10-20	0-10	15-25	45-65	-
2.36	-	-	-	-	75-100
1.18	-	-	-	10-30	-
0.60	-	-	-	-	30-55
0.30	2-10	-	-	-	-
0.15	-	-	-	-	10-25
0.075	-	-	2-6	2-8	5-15
	Emulsion grade and quantity				
Generally	A2 – 57[4]	or	A2 - 50[4]		
Under some circumstances	-	-	-	A3	A3
Quantity[1] litres/tonne	55 to 70	45 to 65	70 to 90	85 to 100	100 to [2][3] 120

Note:(1) For pricing purposes the lower quantity in these ranges should be assumed.

(2) With coarser grading quantity may sometimes be reduced to 80 litres/tonne and with finer grading it may sometimes be increased up to 135 litres/tonne.

(3) Use 0 - 70 litres/tonne of water as necessary.

(4) A2-50 and A2-57 are British grades of emulsion and their grading system is explained in the Manual.

519.3.2. Construction operations

519.3.2.1. Weather and seasonal limitations: Construction with cold mix must not undertaken when ambient temperatures below 10°C are expected of generally when poor weather is predicted. Bitumen emulsion and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesive characteristics. Cold weather, rain, and high humidity slow down the rate of curing. Extra manipulation may be required to remove volitiles in cool or humid conditions. Wind increases the rate of evaporation.

519.3.2.2. Preparation of base: The base on which the cold mix is to be laid shall be prepared shaped and graded to the required profile in accordance with Clauses 501 and 902 as appropriate, and a prime coat if specified in the contract, or required by the Engineer, shall be applied in accordance with Clause 502, or as directed by the Engineer.

519.3.2.3. Tack coat: A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid if specified in the Contract or required by the Engineer.

519.3.2.4. Preparation and transportation of the mixture: Mixing shall be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate, and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

(a) rotary drum type concrete mixer;

(b) single or twin shaft concrete or macadam mixer;

(c) batch or continuous type mixer without dryer or screens other than a scalping screen.

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site must be suited to the chosen laying procedure.

519.3.2.5. Spreading: The mixed material should be spread immediately after preparation. The mixture shall be placed only when the specified density can be obtained. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader must have a blade that is

straight and sharp and long enough to ensure finishing to close straight transverse tolerances and all joints and linkages must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mixture. On surface courses, the tyres must be smooth.

The methodology for spreading shall be approved by the Engineer prior to laying, and if required a laying trial conducted to prove the laying method satisfactory before approval.

519.3.2.6. Compaction: Initial compaction of the laid material shall be carried out using a pneumatic-tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thicknesses being 25-100mm and all compaction being in accordance with Clause 501.6 and 501.7. Smooth tyres shall be used. Final rolling and smoothing of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

519.3.3. Opening to traffic: Traffic shall not be allowed to run on new work until all the water or volatiles in the mixture have evaporated. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

519.3.4. Surface finish and quality control of work: The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

519.3.5. Arrangements for traffic: During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

519.3.6. Measurement for payment: Recipe Cold Mix shall be measured as finished work, for the area instructed to be covered, in cubic metres, by weight in metric tonnes, or in square metres at a specified thickness, as specified in the Contract.

519.3.7. Rate

The contract unit rate for Recipe Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi). The rate shall cover the provision of the specified grade of emulsion at the lower quantity in

the range for each type of mix indicated in Table 500-44 with the provision that the variation of quantity of emulsion will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted as per the rate for emulsion quoted in the Bill of Quantities.

520. SAND ASPHALT BASE COURSE[1]

520.1. Scope

This work shall consist of a base course composed of a mixture of sand, mineral filler where required and bituminous binder, placed and compacted upon a prepared and accepted subgrade in accordance with these Specifications and the lines, levels, grades dimensions and cross sections shown on the Drawings or as directed by the Engineer,

Note: Sand Asphalt Base course is used in special situations like quality coarse aggregates not being available within economical leads and/or water needed for conventional base course not being readily available, as in desert areas.

520.2. Materials

520.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration Grade S65 (60/70) or S90 (80/100), as specified in the Contract, both as per Indian Standard Specifications for "Paving Bitumen" IS:73.

520.2.2. Sand: The sand shall be clean, naturally occurring or blended material free from any deleterious substances, dry and well graded within the limits given in Table 500-41 and with other physical properties conforming to the requirements of this table.

520.2.3. Filler: When required, filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer. The filler shall conform to Clause 507.2.4.

520.3. Mix Design

520.3.1. Requirements 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 500-42.

[1] This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD), Ministry of Road Transport & Highways, Transport Bhavan, Parliament Street, New Delhi – 110 001. Fax No. # 3710236.

TABLE 500-41. SAND GRADING AND PHYSICAL REQUIREMENTS

Sieve Size (mm)	Cumulative percentage by weight of total aggregate passing
9.5	100
4.75	85 – 100
2.36	80 - 100
1.18	70 – 98
0.60	55 – 95
0.30	30 – 75
0.15	10 – 40
0.075	4 – 10
Plasticity Index (%)	6 max.
Sand equivalent (IS:2720, Part 37)	30 min.
Los Angeles Abrasion Value (IS:2386, part 4)	40 max.

Note : Maximum thickness for sand asphalt is 80 mm.

TABLE 500-42. REQUIREMENTS FOR SAND ASPHALT BASE COURSE

Parameter	Requirement
Minimum stability (kN at 60°C)	2.0
Minimum flow (mm)	2
Compaction level (Number of blows)	2 x 75
Per cent air voids	3 – 5
Per cent voids in mineral aggregate (VMA)	> 16
Per cent voids filled with bitumen (VFB)'	65 – 75

520.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-46. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2.

520.3.3. Job mix formula : The Contractor shall develop the job mix formula proposed for use in the works and shall give the following details:

(i) Source and location of all materials;

(ii) Proportions of all materials expressed as follows where each is applicable:

(a) Binder, as percentage by weight of total mixture;

(b) Sand/Mineral filler as percentage by weight of total aggregate including mineral filler;

(iii) A single definite percentage passing each sieve for the mixed aggregate;

(iv) The results of tests enumerated in Table 500-46 as obtained by the Contractor;

(v) Test results of physical characteristics of aggregates to be used;

(vi) Mixing temperature and compacting temperature.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the 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 joint samples of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established and approved by the Engineer before actually using the materials.

520.3.4. Permissible variation from job mix formula : The Contractor shall produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-43. These variations are intended to apply to individual specimens taken for quality control tests as described in Section 900.

520.4. Construction Operations

520.4.1. Weather and seasonal limitations : Clause 501.5.1 shall apply.

520.4.2. Preparation of base : The surface on which Sand Asphalt Basecourse Material is to be laid shall be prepared, shaped and graded to the profile required for the particular layer in accordance with Clauses 501 and 902 as appropriate or as directed by the Engineer. The surface shall be thoroughly swept clean free from dust and foreign matter using a mechanical brush, and the dust blown off by compressed air. In confined locations where mechanical plant cannot access, other methods shall be used as approved by the Engineer. A prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

TABLE 500-43. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation
Aggregate passing 4.75mm	± 6%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	± 5%
Aggregate passing 0.3mm, 0.15mm	± 4%
Aggregate passing 0.075mm	± 2%
Binder content	± 0.3%
Mixing temperature	± 10°C

520.4.3. Tack coat : A tack coat over the base shall be applied in accordance with Clause 503, or otherwise as directed by the Engineer.

520.4.4. Preparation and transportation of the mixture : The provisions of Clauses 501.3 and 501.4 shall apply.

520.4.5. Spreading: The provisions of Clauses 501.5.2 to 501.5.4. shall apply. Mixing must be accomplished at the lowest temperature and in the shortest time that will produce a mixture with complete coating of the aggregate and at a suitable temperature to ensure proper compaction. The ideal mixing and compaction temperatures for the particular bitumen in use shall be obtained from the Bitumen Test Data Chart given in the Manual for Construction and Supervision of Bituminous Works and shall correspond to a viscosity of 2 Poise (0.2 Pa.s) and 3 Poise (0.3 Pa.s) respectively, based on the original (unaged) bitumen properties. For guidance, the ranges of acceptable mixing and rolling temperatures for some typical penetration grade bitumen are shown in Table 500-5.

520.4.6. Rolling : Clause 501.6 shall apply. Generally the initial or breakdown rolling shall be done with 8-10 tonne deadweight smooth-wheeled rollers. The intermediate rolling shall be done with 8 -10 tonne deadweight or vibratory rollers or with a pneumatic tyred roller of 12-15 tonne weight having a tyre pressure of at least 5.6 kg / sq.cm.. The finish rolling shall be done with 8 - 10 tonne deadweight smooth wheeled tandem rollers. The exact pattern of rolling shall be established at the laying trials.

520.5. Opening to Traffic

Traffic may be allowed after completion of the final rolling when the temperature of the mixture at the mid-depth of the completed layer has cooled to the daytime maximum ambient temperature. When daytime

maximum ambient temperatures are in excess of 35°C, great care is needed to ensure that this criterion is met, particularly where slow moving heavy traffic is involved.

520.6. Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902.

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

520.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

520.8. Measurement for Payment

Sand Asphalt Basecourse materials shall be measured as finished work, for the area covered, in cubic metres, metric tonnes, or in square metres at a specified thickness, as stated in the Contract.

520.9. Rate

The contract unit rate for Sand Asphalt Basecourse materials shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2 (i) to (xi). The rate shall cover the provision of 5 per cent of bitumen by weight of the total mixture.

The variation from the actual percentage of bitumen approved by the Engineer and used will be assessed and the rate adjusted, plus or minus, using the rate for bitumen in the Bill of Quantities.

521. MODIFIED BINDER[1]

521.1. Scope

Modified binders comprise a base binder, to which is added either natural rubber, crumb rubber or a polymer such as Styrene-Butadiene-

[1] This Specification Clause has been introduced for the first time. Difficulties in using this Clause and suggestions for improvement may be forwarded to DG(RD), Ministry of Road Transport & Highways, Transport Bhavan, Parliament Street, New Delhi – 110 001. Fax No. # 3710236.

Styrene (SBS), Ethylene-Vinyl-Acetate (EVA) or Low Density Polyethylene (LDPE). The purpose is to achieve a high performance binder with improved properties, particularly at extremes of temperature.

521.2. Materials

521.2.1. Base Binder : The base binder into which the modifier is incorporated shall conform to IS:73. The choice of grade shall be such that it is compatible with the modifier and, when mixed shall have the properties described in Clause 521.3.

521.2.2. Modifier : The modifier shall be a natural rubber, crumb rubber or any other polymer which is compatible with the base binder and which allows the properties given in Clause 521.3 to be achieved. For further details, IRC:SP:53-1999 may be referred to. The modifier, in the required quantity shall be blended at the refinery or at the site plant capable of producing modified binder.

521.3. Modifier Proportions

The quantity of modifier to be added shall be determined by tests on the base binder and the modified binder and the properties desired. A reference may be made to the Manual for Construction and Supervision of Bituminous Works for indicative dosage of different types of modifiers. The properties of the modified binder shall be as given in Table 500-44, 500-45 or 500-46 according to the requirements of the Contract.

521.4. Mixing

The modifier shall be blended with the base binder so that it disperses thoroughly prior to use. The type of mixing equipment used shall be suited to the modifier type. Further guidance is given in the Manual for Construction and Supervision of Bituminous Works.

521.5. Quality Control of Materials

521.5.1. Binder Properties : For control of the quality of the base binder, the relevant provisions of Section 900 shall apply. Additionally, the modified binder shall be tested for all the properties listed in Table 500-44, 500-45 or 500-46 as appropriate and certificates produced prior to use.

During use, the requirements for softening point, penetration and elastic recovery shall be tested regularly. If the modified binder is produced

TABLE 500-44. REQUIREMENTS OF POLYMER MODIFIED BINDERS (ELASTOMERIC THERMOPLASTICS AND RUBBER LATEX)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 25°C, 0.1mm, 100g, 5 sec.	90 to 150	50 to 89	30 to 49	IS:1203-1978
Penetration at 4°C, 0.1mm, 200g, 60 sec., Minimum*	35	22	18	IS:1205-1978
Softening Point, (R&B), °C, Minimum	38	48	59	IS:1205-1978
Fraass Breaking Point, °C, Maximum*	-24	-16	-12	IS:9381-1978
Ductility at 27°C, cm, Minimum	75	50	50	IS:1208-1978
Flash Point, COC, °C, Minimum	220	220	220	IS:1209-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	70 (50)**	60 (40)**	50 (30)**	ASTM D5976-1996
Separation, Difference in Softening Point, R&B, °C, Maximum	4	4	4	ASTM D5976-1996
Viscosity at 150°C, Poise	1-3	2-6	4-8	IS:1206-1978

Test on Thin Film Oven Test Residue, TFOT (IS:9382-1979)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 4°C, 0.1mm, 200g, 60 sec., Minimum*	18	15	12	IS:1203-1978
Loss in Weight, %, Maximum	1.0	1.0	1.0	IS:9382-1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205-1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS:1203-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	60 (35)**	40 (30)**	35 (25)**	ASTM D5976-1996

* Relevant to snow bound cold climate areas

** Natural Rubber Modified Bitumen

on site then tests shall be carried out daily. If pre-blended modified binder is used tests shall be carried out weekly.

521.5.2. Storage Stability : Pre-blended modified binders which are to be stored without circulation or agitation facility shall be tested for storage stability prior to use, in accordance with Appendix 1 of IRC:SP:53-1999. The mean of the differences in softening point, top to bottom, of

TABLE 500-45. REQUIREMENTS OF POLYMER MODIFIED BINDERS (PLASTOMERIC THERMOPLASTICS)

Designation	Grade and Requirements			Method of Test
	PMB 120	PMB 70	PMB40	
Penetration at 25°C, 0.1mm, 100g, 5 sec.	90 to 150	50 to 89	30 to 49	IS:1203-1978
Penetration at 4°C, 0.1mm, 200g, 60 sec., Minimum*	35	22	18	IS:1205-1978
Softening Point, (R&B), °C, Minimum	38	48	59	IS:1205-1978
Fraass Breaking Point, °C, Maximum*	-20	-15	-10	IS:9381-1978
Ductility at 27°C, cm, Minimum	50	40	30	IS:1208-1978
Flash Point, COC, °C, Minimum	220	220	220	IS:1209-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	60	50	40	ASTM D5976-1996
Separation, Difference in Softening Point, R&B, °C, Maximum	3	3	3	ASTM D5976-1996
Viscosity at 150°C, Poise	1-2	2-4	4-8	IS:1206-1978
Test on Thin Film Oven Test Residue, TFOT (IS:9382-1979)				
Designation	**Grade and Requirements**			**Method of Test**
	PMB 120	**PMB 70**	**PMB40**	
Penetration at 4°C, 0.1mm, 200g, 60 sec., Minimum*	18	15	12	IS:1203-1978
Loss in Weight, %, Maximum	1.0	1.0	1.0	IS:9382-1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205-1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS:1203-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	45	35	30	ASTM D5976-1996

* Relevant to snow bound cold climate areas

not less than three pairs of samples shall not exceed 5°C.

Other pre-blended modified binders shall be stored with appropriate circulation or agitation facility, according to the manufacturer's instructions.

521.6. Measurement for Payment

Modified binder supplied for the Contract shall be paid for in Tonnes.

TABLE 500-46. REQUIREMENTS OF POLYMER MODIFIED BINDERS (TREATED WITH MODIFIED CRUMB RUBBER)

Designation	Grade			Method of Test
	CRMB 60	CRMB 55	CRMB 50	
Penetration at 25°C, 0.1 mm, 100 g, 5 sec.	50 – 70	50 – 60	40 – 60	IS:1203-1978
Softening Point, (R&B), °C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, % Minimum	40	35	30	ASTM D5976 – 1996
Test on Thin Film Oven Test Residue (IS:9382 – 1979)				
Reduction in Penetration at 25°C, %, Maximum	60	60	60	IS:1203 – 1978
Increase in Softening Point (R&B), °C, Maximum	5	5	5	IS:1205 – 1978
Elastic Recovery of Residue of Half Thread in Ductilometer at 15°C, %, Minimum	25	20	15	ASTM D 5976 – 1996

CRMB – Crumb Rubber Modified Bitumen

521.7 Rate

The contract rate for modified binder shall be as per contract agreement.

522. CRACK PREVENTION COURSES[1]

522.1. Scope

This clause covers the provision of Stress Absorbing Membrane (SAM) and Stress Absorbing Membrane Interlayer (SAMI) as measures to inhibit the propagation of cracks. A SAM is an elastomeric bitumen rubber membrane, which is laid over a cracked road surface, together with a covering of aggregate chips, in order to extend the life of the pavement before major treatment is carried out. SAM can be laid as a

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single coat or a double coat. A SAMI is a layer which is applied to a cracked pavement surface but which is followed (within 12 months) by the application of an overlay course. A SAMI may be a material similar to that used for a SAM. It may alternatively consist of a bitumen impregnated geotextile.

522.2. Materials

522.2.1. Binder : Binder shall be a modified binder complying with the requirements of Clause 523, according to the requirements of the Contract, except that paving grade bitumen of 80-100 penetration complying with the requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

522.2.2. Aggregate · The requirements of Clause 510.2.2 apply except that the Polished Stone Value requirement does not apply in the case of a SAMI. Where required by the contract, aggregate shall be pre-coated using either of the techniques permitted by Clause 510.2.5.

522.2.3. Rates of spread of binder and aggregate : The rates of spread of binder and aggregate shall be according to one of the size alternatives in Table 500-47, as required by the Contract.

522.2.4. Geotextile: The use of geotextile as prescribed for Sl. No. 7 in Table 500-47 shall conform to the requirements of Clause 703.3.

522.3. Construction Operations

522.3.1. Weather and seasonal limitations: Clause 501.5.1 shall apply.

522.3.2. Preparation of base: The base on which the SAM, SAMI or bitumen impregnated geotextile is to be laid shall be prepared, in accordance with Clause 501 and as directed by the Engineer. The surface shall be thoroughly cleaned either by using a mechanical brush or any other equipment / method approved by the Engineer. Dust removed in the process shall be blown off with compressed air.

522.3.3. Application of binder: The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for modified binder shall be 160-170°C. Binder for bitumen impregnated

TABLE 500-47. QUANTITY OF MATERIALS REQUIRED FOR 10 SQ.M. OF ROAD SURFACE FOR STRESS ABSORBING MEMBRANE

Sl. No	Type and Width of Crack	Specification of SAM to be applied	Quantity of binder Kg/10m^2	Quantity of chipping
1.	Hair cracks and map cracks upto 3mm width	Single coat SAM or 2nd coat of two coat SAM	8 – 10	0.10 m^3 of 5.6mm chips
2.	Map cracks or alligator cracks 3mm to 6mm width	Single coat SAM	10 – 12	0.11m^3 of 5.6mm chips
3.	Map cracks or alligator cracks 6mm to 9mm width	Two coat SAM 1st coat 2nd coat	12 – 14 8 – 10	0.12m^3 of 5.6mm and 11.2mm chips in 1:1 ratio 0.10^3 of 5.6mm chips
4.	Cracks above 9mm width and cracked area above 50%	Two coat SAM 1st coat 2nd coat	 14 – 16 8 – 10	 0.12m^3 of 11.2mm chips 0.10^3 of 5.6mm chips
5.	All types of cracks with crack width below 6mm	Single coat SAM as interlayer	8 – 10	0.10 m^3 of 5.6mm chips.
6.	All types of cracks with crack width above 6mm	Single coat SAM as interlayer	10 – 12	0.10 m^3 of 11.2mm chips.
7.	Bitumen Impregnated Geotextile			

Note: 1. Binder quantities for bitumen impregnated geotextile shall be in the range 0.9 to 1.2 litres/m^2. Binder quantities outside this range are permitted according to the geotextile manufacturer's instructions and subject to the agreement of the Engineer.

geotextile shall be applied according to Clause 502.4. The surface on which the binder is to be applied shall be dry.

522.3.4. Application of aggregates : The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. Immediately after application of the modified binder, clean, dry aggregate shall be spread uniformly on the surface.

522.3.5. Sweeping : The surface of SAMs and SAMIs shall be swept to ensure uniform spread of aggregate and that there are no loose chips on the surface.

522.3.6. Two coat SAM or SAMI : Where a two coat SAM or SAMI is required by the Contract, the second coat shall be applied within 90 days of the first.

522.3.7. Geotextile placement : For bitumen impregnated geotextile,

the requirements of Clause 703.4.5.

522.4. Opening to Traffic

Traffic may be permitted over a SAM or SAMI 2 hours after rolling, but the speed shall be limited to 20 km/h, until the following day. Speed control measures are to be approved by the Engineer, prior to laying.

522.5. Surface Finish and Quality Control of Work

The surface finish shall conform to the requirements of Clause 902.

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

522.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

522.7. Measurement for Payment

Each application of SAM, SAMI or bitumen impregnated geotextile shall be measured as finished work, for the area specified, in square metres.

522.8. Rate

The contract unit rate for SAM, SAMI or bitumen impregnated geotextile shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2, (i) to (xi).