

501 GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS**501.1 General**

Bituminous pavement courses shall be made using the materials described in the 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. The equipment mandatory for any particular project shall be in accordance with the Contract Specifications 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, 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 viscosity grades of bitumen are specified, they are referred to by a designation in accordance with IS:73. Where modified bitumen is specified, it shall conform to the requirements of IRC:SP:53 and IS:15462; and the following provision of this Specification shall apply.

- i) Modified bitumen from refinery sources or blended at approved central plant or at site using appropriate industrial process and plant with high shear mill, and testing facilities to achieve stable and homogenous mix shall be used. The use of high shear mixer or any other device capable of producing a homogeneous blend is essential when the modifier is in powder form.
- ii) Transportation tanks and storage tanks shall be insulated and equipped with effective heating system and circulation/ agitating device to maintain the specified temperature, homogeneity and viscosity of the bitumen during transit and storage.
- iii) Separation, difference in softening point (R&B), shall not be more than 3°C for any type of specified modified bitumen when tested as per Annex B of IS:15462.

Selection criteria for viscosity grade bitumen, based on highest and lowest daily mean temperatures at a particular site, are given in Table 500-1.

Selection criteria for modified bitumen shall be in accordance with IRC:SP:53.

Table 500-1 : Selection Criteria for Viscosity-Graded (VG) Paving Bitumens
Based on Climatic Conditions

| Lowest Daily Mean Air Temperature, °C | Highest Daily Mean Air Temperature, °C | | |
|---------------------------------------|--|------------|----------------|
| | Less than 20°C | 20 to 30°C | More than 30°C |
| More than -10°C | VG-10 | VG-20 | VG-30 |
| -10°C or lower | VG-10 | VG-10 | VG-20 |

Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned in Tables 500-5 and 500-6 can be obtained for the weather station nearest to the project site from the Indian Meteorological Organization (IMO). This daily mean high temperature on a specific day is the same as daily "normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily mean high air temperatures (which usually occurs on some day in May or June) is used in Tables 500-5 and 500-6. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the IMO. Since these are mean temperatures based on the average of 30-40 years data, these temperatures are significantly lower than the absolute maximum temperatures, which may have occurred in a specific year.

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 has poor affinity for bitumen, the Contractor shall demonstrate through test results that with the use of anti-stripping agents, the stripping value is improved to satisfy the specification requirements. The Engineer may approve such a source and, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, at the cost of the Contractor.

Where crushed gravel is proposed for use as aggregate not less than 90 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces, except that in the case of bituminous concrete the requirement in this regard shall be 95 percent. .

The aggregates shall satisfy the physical requirements set forth in the individual relevant clause for the material.

501.2.3 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 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. Natural sand shall not be allowed in binder and wearing courses. However, natural sand upto 50 percent of the fine aggregates may be allowed in base courses. Fine aggregates 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 0.425 mm shall not exceed 4 when tested in accordance with IS:2720 (Part 5). The fine aggregates shall satisfy the physical requirements set forth in the individual relevant-clause for the material in question.

501.2.4 Sources of Material

The sources of materials proposed to be used by the Contractor shall be tested to the satisfaction of the Engineer who shall give the necessary approval. 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 shall 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 material sufficient for at least 5 days' work.

501.3 Mixing

Pre-mixed bituminous materials 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 are given in Table 500-2 of these Specifications. the difference in temperature between the binder and aggregate shall 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. The essential features of the hot mix plants are given in Annex A of IRC:27.

Table 500-2 : Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree Celcius)

| Bitumen Viscosity Grade | Bitumen Temperature | Aggregate Temperature | Mixed Material Temperature | Laying Temperature | *Rolling Temperature |
|-------------------------|---------------------|-----------------------|----------------------------|--------------------|----------------------|
| VG-40 | 160-170 | 160-175 | 160-170 | 150 Min | 100 Min |
| VG-30 | 150-165 | 150-170 | 150-165 | 140 Min | 90 Min |
| VG-20 | 145-165 | 145-170 | 145-165 | 135 Min | 85 Min |
| VG-10 | 140-160 | 140-165 | 140-160 | 130 Min | 80 Min |

* Rolling must be completed before the mat cools to these minimum temperatures.

If a continuous type mixing plant is used, 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.

501.4 Transporting

Bituminous materials shall be transported in clean insulated and covered vehicles. An asphalt release agent, such as soap or lime water, 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:

- i) In presence of standing water on the surface;
- ii) When rain is imminent, and during rains, fog or dust storm;
- iii) When the base/binder course is damp;
- iv) When the air temperature on the surface on which it is to be laid is less than 10°C for mixes with conventional bitumen and is less than 15°C for mixes with modified bitumen;
- v) When the wind speed at any temperature exceeds the 40 km per hour at 2 m height.

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 and air jet. The equipment for applying a high pressure air jet from a compressor to remove dust or loose matter shall be available full time at the site.

501.5.3 Spreading

Prior to spreading the mix, the base shall be prepared by carrying out the required operations as per Clause 501.8 depending upon the site conditions. Except in areas where paver cannot get access, bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine equipped with an electronic sensing device. The essential features of the paver finisher shall conform to Annex A of IRC:27. 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 (such as confined space, foot ways, of irregular shape and varying thickness, approaches to expansion joints, etc.) where paver cannot be used, the material shall be spread, raked and levelled with suitable hand tools by trained staff.

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 300 mm 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 water-proofing systems, unless precautions against heat damage have been approved 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 be covered by either the wearing course or surface treatment, whichever is specified in the Contract.

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 center longitudinally except that on super-elevated and unidirectionally cambered portions, it shall progress from the lower to the upper edge parallel to the center 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 tonne static weight smooth-wheel rollers. The intermediate rolling shall be done with 8–10 tonne static weight or vibratory roller or with a pneumatic tyre roller of 12 to 15 tonne weight, with a tyre pressure of at least 0.56 MPa. The Contractor shall demonstrate the efficiency of the equipment proposed to be used by carrying compaction trials. The procedure for site trials shall be submitted to the Engineer for approval. The finish rolling shall be done with 6 to 8 tonne smooth wheel tandem rollers. Rolling shall continue until the specified compaction is achieved.

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 specify 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 300 mm.

In portions with super-elevated and unidirectional 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/ diesel or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of roller machine shall be in good working order, to prevent the mix from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mix should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

501.7 Joints

501.7.1 Where joints are made, the material shall be fully compacted and the joint made flush in one of the following ways:

- a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face coated with a suitable viscosity grade hot bitumen, or cold applied emulsified bitumen. While spreading the material along the joint the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose

overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix shall be dragged back to the hot lane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.

- b) 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.

501.7.2 All longitudinal 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, whichever is appropriate. Longitudinal joints shall not be situated in wheel track zones.

501.7.3 For transverse joints method a) above shall apply. Transverse joints in the successive and adjoining layers shall have a minimum offset of 2 m.

501.8 Preparation of Surface

501.8.1 Scope

This work shall consist of preparing an existing granular or black-topped surface for laying 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 where specified 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 aggregates salvaged from the scarification of the existing granular base course supplemented by fresh coarse aggregates and screenings so that aggregates and screenings thus supplemented correspond to Clauses 404 or 406.

501.8.2.2 For Patching Potholes and Sealing Cracks

Where the existing surface to be overlaid is bituminous, material required for patching and sealing cracks shall be in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.2.3 For Profile Corrective Course

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.

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 and a tack coat applied in accordance with Clause 503.

The surface of all granular layers on which bituminous works are to be placed, shall 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

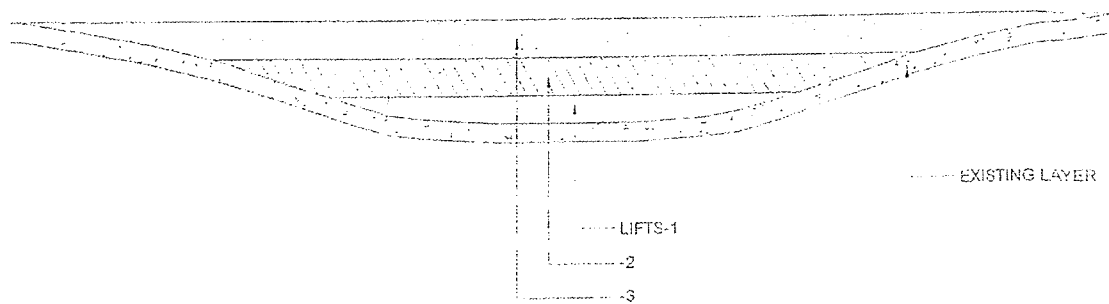
Where specified or shown on the drawings, the existing bituminous layer in the specified width shall be removed with care and without causing undue disturbance to the underlying layer, by a suitable method approved by the Engineer. After removal of all loose and disintegrated material, the underlying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

501.8.3.3 Patching of Potholes and Sealing of Cracks

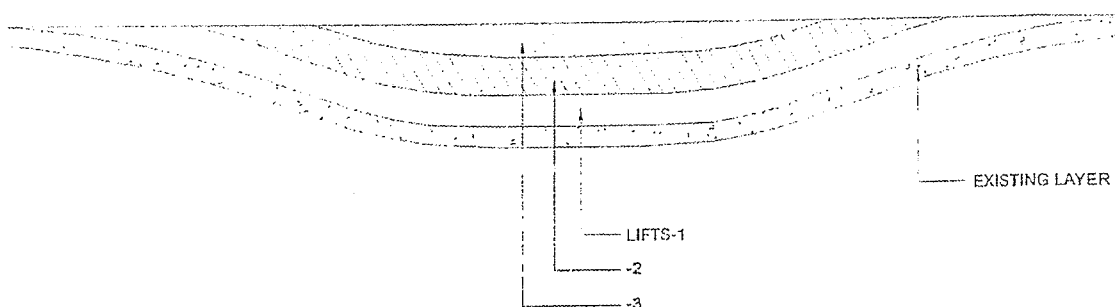
Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.3.4 Profile Corrective Course

- a) **Application of Profile Corrective Course**
- i) A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the Drawings.
 - ii) Any high spots in the existing black-topped 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.
 - iii) 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.
 - iv) The profile corrective course shall be laid to tolerances and densities as specified for wearing course if it is laid integral with the wearing course. The profile corrective course shall be laid to tolerances and densities as specified for base course, if it is to be covered with a wearing course layer.
- b) **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 501.8.3.4 (a), or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.
- c) **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 using material as described in Clauses 501.8.2.3 and 501.8.3.4(a) and compacted to the requirements of the Specification.
- d) **Correction of Local Depressions, Camber and Super-Elevation :** 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 Fig. 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.



(A) CORRECT METHOD



(B) INCORRECT METHOD

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

Fig. 500-1 : Methods for Providing Corrective Course for Short Sags and Depressions

For correction of camber or super-elevation of the existing carriageway, the method shown in Fig. 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 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.

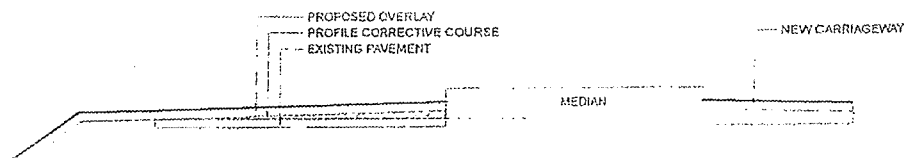
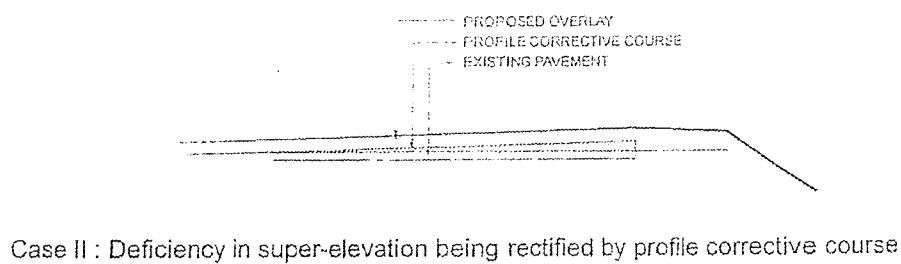
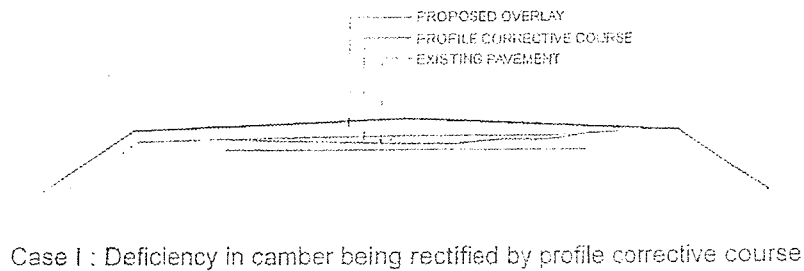


Fig. 500-2 : Correction of Camber or Super-Elevation

501.8.6 Environmental Protection

The provisions of Clause 111 and the provision of Annex A to Clause 501 shall apply.

501.8.7 Measurement for Payment

501.8.7.1 Cleaning of the Surface

The work of cleaning of the surface using mechanical broom and air-jet shall be incidental to the work of preparation of surface.

501.8.7.2 Scarifying

Scarifying the existing bituminous surface shall be measured and paid for on a square metre basis.

Section 500

Bases and Surface Courses (Bituminous)

501.8.7.3 Prime Coat

Prime coat shall be measured and paid for on a square metre basis.

501.8.7.4 Tack Coat

Tack coat shall be measured and paid for on a square metre basis.

501.8.7.5 Potholes and Crack Sealing

The work of filling potholes shall be measured separately and be paid for in square metres or on weight basis in tonnes as specified in the Contract.

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

The work of sealing cracks of size 3 mm to 6 mm in width shall be measured in square metres or in linear meters as specified in the Contract.

The work of sealing cracks of size greater than 6 mm width shall be measured in linear metres.

501.8.7.6 Profile Corrective Course

Profile corrective course shall be measured as the volume laid in position in cubic metres, or in tonnage, as stipulated in the Contract. The volume shall be calculated by plotting the exact profile of 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 of 10 m centre to centre on straight sections and at 5 m center to centre on curves longitudinally and at seven locations transversely, for two lane carriageway, and at three locations transversely for single lane and the volume shall be calculated using the method of end areas.

501.8.7.7 Filling of Local Depressions

The work of filling depressions where instructed to be carried out separately shall be measured by the weight of the bituminous material placed in position.

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 and unusable materials, shall include 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 with all leads and lifts.

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) Cleaning of the surface;
- 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 including all wastage in cutting joints;
- 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;
- viii) The rate shall cover the provision of bitumen at the application rate specified in the contract, with the provision that the variation in actual percentage of bitumen used shall be assessed and the payment adjusted accordingly as per Contract;
- ix) The rates include for all testing, mix design, transporting and testing of samples, and cores and tests as directed by the Engineer; and
- x) The cost of all plant and laying trials as specified to prove the mixing and laying methods shall be deemed to be included in the Contractor's rates.

501.8.8.3 Rate for Potholes and Crack Sealing

The rate for patching potholes shall be as per Clause 3004.2.6.

The rate for sealing cracks by applying fog spray shall be as per Clause 513.9.

The rate for sealing of cracks of width 3 mm or more shall be as per Clause 3004.3.3.5.

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

501.8.8.4 Rate for Prime Coat

The Contract unit rate for prime coat shall be as per Clause 502.8.

501.8.8.5 Rate for Tack Coat

The Contract unit rate for tack coat shall be as per Clause 503.8.

501.8.8.6 Rate for Filling of Local Depressions

The Contract unit rate for filling of local depressions shall be payment in full for (i) furnishing all materials, (ii) all works involved including trimming, cleaning, backfilling, priming, application of tack coat, filling with bituminous material in layers and compacting each layer (iii) all labour, tools, equipment and incidentals to complete the works in accordance with the Specifications.

501.8.8.7 Rate for Profile Corrective Course

The Contract unit rate for profile corrective course when laid separately shall be payment in full for carrying out the required operations as specified, and shall include all components listed in Clause 501.8.8.2.

Annex 'A'
PROTECTION OF THE ENVIRONMENT

1 GENERAL

- 1.1 This Appendix 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 or off site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in these specifications.
- 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 reused 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 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 minimize dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimize adverse impacts on air quality.
- 3.2 The Contractor shall utilize 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 Specifications.
- 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 extended 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 sprinkling water on the road surface at regular intervals.

4**NOISE**

- 4.1 The Contractor shall consider noise abatement measures 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 environmental requirements. The Contractor shall use all necessary measures and shall maintain all plant and silencing equipment in good condition so as to minimize 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 mixes 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 these provisions. 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 Bill of Quantities and full compensation for such compliance will be deemed to be covered by them.

901 GENERAL

901.1 All materials to be used, all methods to be adopted and all works to be performed shall be strictly in accordance with the requirements of these Specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order to carry out Quality Control for works and all the required tests as per Specifications and/or as directed by the Engineer. The provision and maintenance of the laboratory shall be as per Clause 120 and/or as directed by the Engineer. The list of equipment and the facilities to be provided shall be got approved from the Engineer in advance.

901.2 The Contractor's laboratory shall be manned by a qualified Materials Engineer/Civil Engineer assisted by experienced technicians, and the set-up should be got approved by the Engineer.

901.3 The Contractor shall carry out quality control tests on the materials and work to the frequency stipulated in subsequent paragraphs. In the absence of clear indications about method and or frequency of tests for any item, the instructions of the Engineer shall be followed.

901.4 For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the Engineer (by himself, by his Quality Control Units or by any other agencies deemed fit by him), generally to the frequency set forth hereunder. Additional tests may also be conducted where, in the opinion of the Engineer, need for such tests exists.

901.5 The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time. This shall include provision of laboratory equipment, transport, consumables, personnel including labour attendants, assistants in packing and dispatching and any other assistance considered necessary in connection with the tests.

901.6 For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall be done after obtaining permission from the Engineer. Similar permission from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.

901.7 The Contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer. Works falling short of quality shall be rectified/redone by the Contractor at his own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.

901.8 The cost of laboratory building including essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials,

labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no payment shall be made for the same. If, however, there is a separate item in the Bill of Quantities for setting up of a laboratory and installing testing equipment, such work shall be paid for separately.

901.9 For testing of soils/soil mixes, granular materials and mixes, bituminous materials and mixes, cement concrete materials and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied by the Contractor at his own cost.

901.10 For cement, bitumen, steel, emulsion, road marking paint, sign boards, geo-synthetics and similar other materials where essential tests are to be carried out in the presence of Engineer at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor.

Manufacturer's test certificate together with invoice or delivery challan shall be furnished for every lot of supply apart from tests to be conducted at site laboratory for prime properties of the material like cement, bitumen, etc. Where facilities for testing of materials are not available at site laboratory the same shall be tested at an outside laboratory in the presence of the Engineer. For specialized items such as sign boards, road marking paint, etc. the Engineer may order for third party test from an approved laboratory.

901.11 The method of sampling and testing of materials shall be in accordance with the requirements of the relevant Indian Standards and these Specifications. Where they are contradicting, the provisions in these Specifications shall be followed. Where they are silent, sound engineering practices shall be adopted. The sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the Contractor. The cost of all tests shall be borne by the Contractor.

901.12 The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the Contractor who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period.

Similarly, the supply of aggregates and other materials for construction shall be from sources approved by the Engineer. Responsibility for arranging uninterrupted supply of materials from the source shall be that of the Contractor.

901.13 Defective Materials

All materials which the Engineer has determined as not conforming to the requirements of the Contract shall be rejected whether in place or not; they shall be removed immediately

from the site as directed. Materials, which have been subsequently corrected, shall not be used in the work unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with any instruction of the Engineer, the Engineer shall have authority to cause the removal of rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

901.14 Imported Materials

The Contractor shall furnish a list of materials/finished products manufactured, produced or fabricated outside India which he proposes to use in the work. The Contractor shall not be entitled to extension of time for acts or events occurring outside India and it shall be the Contractor's responsibility to make timely delivery to the job site of all such materials obtained from outside India.

The materials imported from outside India shall conform to the relevant Specifications of the Contract. In case where materials/finished products are not covered by the Specifications in the Contract, the details of laboratories/establishments where tests are to be carried out shall be specifically brought out and agreed to in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified mill test reports clearly identified in the lot of materials shall be furnished at the Contractor's cost.

902 CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

902.1 General

All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described herein-after.

902.2 Horizontal Alignment

Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 10 mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 25 mm.

902.3 Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road

shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table 900-1.

Table 900-1 : Tolerances in Surface Levels

| | | |
|----|--------------------------------------|-------------|
| 1) | Subgrade | ± 20 mm |
| 2) | Sub-base | |
| | a) Flexible pavement | ± 10 mm |
| | b) Concrete pavement | ± 6 mm |
| 3) | Base-course for flexible pavement | |
| | a) Bituminous Base/Binder course | ± 6 mm |
| | b) Granular | |
| | i) Machine laid | ± 10 mm |
| | ii) Manually laid | ± 15 mm |
| 4) | Wearing course for flexible pavement | |
| | a) Machine laid | ± 6 mm |
| | b) Manually laid | ± 10 mm |
| 5) | Cement concrete pavement | ± 5 mm |

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than the following limits:

- 4 mm for bituminous wearing course of thickness 40 mm or more
- 3 mm for bituminous wearing course of thickness less than 40 mm
- 5 mm for concrete pavement slab

For checking compliance with the above requirement for subgrade, sub-base and base course, measurements of the surface levels shall be taken on a grid of points placed at 6.25 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses and concrete pavements, measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

902.4 Surface Regularity of Pavement Courses

The longitudinal profile shall be checked with a 3 metre long straight edge/moving straight-edge as directed by the Engineer at the middle of each traffic lane along a line parallel to the centre line of the road.

The maximum permitted number of surface irregularities shall be as per Table 900-2.

Table 900-2 : Maximum Permitted Number of Surface Irregularities

| Irregularity | Surfaces of Carriageways and Paved Shoulders | | | | Surfaces of Laybys, Service Areas and all Bituminous Base Courses | | | |
|---|--|----|------|----|---|----|------|----|
| | 4 mm | | 7 mm | | 4 mm | | 7 mm | |
| Length (m) | 300 | 75 | 300 | 75 | 300 | 75 | 300 | 75 |
| Number of Surface Irregularities on National Highways/ Expressways* | 15 | 9 | 2 | 1 | 40 | 18 | 4 | 2 |
| Number of Surface Irregularities on Roads of lower Category* | 40 | 18 | 4 | 2 | 60 | 27 | 6 | 3 |

* Category of each section of road as described in the Contract.

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

| | |
|---|-------|
| for pavement surface (bituminous and cement concrete) | 3 mm |
| for bituminous base courses | 6 mm |
| for granular sub-base/base courses | 6 mm |
| for sub-bases under concrete pavements | 10 mm |
| for subgrade | 15 mm |

902.5 Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances in Clause 902.4, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

- i) **Subgrade:** Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Clause 305.

- ii) **Granular Sub-base:** Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Clause 401.
- iii) **Lime/Cement Stabilized Soil Sub-base:** For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below.

For cement treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed materials as necessary and recompact as per the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.

- iv) **Water Bound Macadam/Wet Mix Macadam Sub-base/Base:** Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompact as per Clause 404 in the case of Water Bound Macadam and to Clause 406 in the case of Wet Mix Macadam.
- v) **Bituminous Constructions:** For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat, if needed, and recompact as per specifications. Where the surface is high, the extra thickness in the affected layer shall be removed and replaced with fresh material and compacted to Specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 m in length and not less than 3.5 m in width.

- vi) **Dry Lean Concrete Sub-Base:** The defective length of the course shall be removed to full depth and replaced with material conforming to Clause 601. The area treated shall be at least 3 m long, not less than 1 lane width and extend to the full depth. Before relaying the course, the disturbed subgrade or layer below shall be corrected by levelling, watering and compacting.

- vii) **Cement Concrete Pavement:** The defective areas having irregularity exceeding 3 mm but not greater than 6 mm when tested with a 3 metre long straight edge may be rectified by scrubbling or grinding using approved equipment. When required by the Engineer, areas which have been reduced in level by the above operation(s) shall be retextured in an approved manner either by cutting grooves (5 mm deep) or roughening the surface by hacking the surface. If high areas in excess 6 mm or low areas in excess of 3 mm occur, exceeding the permitted numbers and if the Contractor cannot rectify, the slab shall be demolished and reconstructed at the Contractor's expense and in no case the area removed shall be less than the full width of the lane in which the irregularity occurs and full length of the slab.

If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerances shall be demolished and reconstructed at the Contractor's cost.

902.6 Riding Quality

The riding quality of bituminous concrete wearing surface, as measured by a standard towed fifth wheel bump integrator, shall not be more than 2000 mm per Km.

903 QUALITY CONTROL TESTS DURING CONSTRUCTION

903.1 General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the Clauses for the relevant items of work.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 900-3 and 900-4 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

**Table 900-3 : Control Tests and their Minimum Frequency for Sub-Bases and Bases
(Excluding Bitumen Bound Bases)**

| S. No. | Type of Construction | Test | Frequency (min.) |
|--------|--------------------------------------|--|---|
| 1) | Granular | i) Gradation ii) Atterberg limits iii) Moisture content prior to compaction iv) Density of compacted layer v) Deleterious constituents vi) CBR | One test per 400 cu.m One test per 400 cu.m One test per 400 cu.m One test per 1000 sq.m As required As required |
| 2) | Lime/Cement Stabilised Soil Sub-base | i) Quality of lime/ cement ii) Lime/Cement content iii) Degree of pulverization iv) CBR or Unconfined Compressive Strength test on a set of 3 specimens v) Moisture content prior to compaction vi) Density of compacted layer vii) Deleterious constituents | One test for each consignment subject to a minimum of one test per 5 tonnes Regularly, through procedural checks Periodically as considered necessary As required One set of two tests per 500 sq.m One set of two tests per 500 sq.m As required |
| 3) | Water Bound Macadam | i) Aggregate Impact Value ii) Grading of aggregate iii) Combined Flakiness and Elongation Indices iv) Atterberg limits of binding material v) Atterberg limits of screenings | One test per 1000 cu.m of aggregate One test per 250 cu.m One test per 500 cu.m of aggregate One test per 50 cu.m of binding material One test per 100 cu.m of aggregate |
| 4) | Wet Mix Macadam | i) Aggregate Impact Value ii) Grading of aggregate iii) Combined Flakiness and Elongation Indices iv) Atterberg limits of portion of aggregate passing 425 micron sieve v) Density of compacted layer | One test per 1000 cu.m of aggregate One test per 200 cu.m of aggregate One test per 500 cu.m of aggregate One test per 200 cu.m of aggregate One set of three tests per 1000 sq.m |

Table 900-4 : Control Tests for Bituminous Works and their Minimum Frequency

| S. No. | Type of Construction | Test | Frequency (min.) |
|--------|--|--|--|
| 1) | Prime Coat/Tack Coat/Fog Spray | i) Quality of binder ii) Binder temperature for application iii) Rate of spread of Binder | Number of samples per lot and tests as per IS:73, IS:217 and IS:8887 as applicable At regular close intervals Three tests per day |
| 2) | Seal Coat/Surface Dressing | i) Quality of Binder ii) Aggregate Impact Value or Los Angeles Abrasion Value iii) Combined Flakiness and Elongation Indices iv) Stripping value of aggregates (Immersion Tray Test) v) Water absorption of aggregate vi) Water sensitivity of mix vii) Grading of aggregate viii) Soundness (Magnesium Sulphate/ Sodium Sulphate) ix) Polished stone value (not applicable for SAM/SAMI) x) Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction xi) Rate of spread of materials (xii) Percentage of fractured faces (When gravel is used) | Same as mentioned under Serial No. 1 One test per 200 cu.m of each source and whenever there is change in the quality of aggregate One test per 100 cu.m of aggregate for each source and whenever there is change in the quality of aggregate One test of each source and whenever there is change in the quality of aggregate -do- -do- Two tests per day One test for each source and whenever there is change in the quality of aggregate -do- At regular intervals Same as mentioned under Serial No. 1 One test per 100 cu.m of aggregate |
| 3) | Open-graded Premix Surfacing/Close-graded Premix Surfacing | i) Quality of binder ii) Aggregate Impact Value or Los Angeles Abrasion Value iii) Combined Flakiness and Elongation Indices iv) Stripping value v) Water absorption of aggregates vi) Water Sensitivity of mix vii) Grading of aggregates | Same as mentioned under Serial No. 1 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 Same as mentioned under Serial No. 2 |

| S. No. | Type of Construction | Test | Frequency (min.) |
|--------|--|---|---|
| | | viii) Soundness(Magnesium Sulphate and Sodium Sulphate) | Same as mentioned under Serial No. 2 |
| | | ix) Polished stone value | Same as mentioned under Serial No. 2 |
| | | x) Temperature of binder at application | At regular interval |
| | | xi) Binder content | Two tests per day per plant |
| | | xii) Percentage of fractured faces | Same as mentioned under Serial No. 2 |
| 4) | Bituminous Macadam | i) Quality of binder | Same as mentioned under Serial No. 1 |
| | | ii) Aggregate Impact Value or Los Angeles Abrasion Value | Same as mentioned under Serial No. 2 |
| | | iii) Combined Flakiness and Elongation Indices | One test per 350 cu.m for each source |
| | | iv) Stripping value | Same as mentioned under Serial No. 2 |
| | | v) Water absorption of aggregates | Same as mentioned under Serial No. 2 |
| | | vi) Water Sensitivity of mix | Same as mentioned under Serial No. 2 |
| | | vii) Grading of aggregates | Same as mentioned under Serial No. 2 |
| | | viii) Soundness (Magnesium Sulphate/ Sodium Sulphate) | Same as mentioned under Serial No. 2 |
| | | ix) Percentage of fractured faces | Same as mentioned under Serial No. 2 |
| | | x) Binder content | Same as mentioned under Serial No. 3 |
| | | xi) Control of temperature of binder and aggregate for mix and of the mix at the time of laying and rolling | Same as mentioned under Serial No. 2 |
| | | xii) Density of Comp layer | One test per 700 sq.m area |
| | | xiii) Rate of spread of Mixed Material | At regular intervals |
| 5) | Dense Bituminous Macadam/Bituminous Concrete | i) Quality of binder | Number of samples per lot and tests as per IS:73 or IRC:SP:53, IS:15462 |
| | | ii) Aggregate Impact Value/ Los Angeles Abrasion Value | One test per 350 cu.m of aggregate for each source and whenever there is change in the quality of aggregate |
| | | iii) Flakiness and Elongation Indices | One test per 350 cu.m of aggregate for each source and whenever there is change in the quality of aggregate |
| | | iv) Soundness test (Sodium or Magnesium Sulphate test) | One test for each source and whenever there is change in the quality of aggregate |
| | | v) Water absorption of aggregates | One test for each source and whenever there is change in the quality of aggregate |

Quality Control for Road Works

Section 900

| S. No. | Type of Construction | Test | Frequency (min.) |
|--------|--------------------------|---|--|
| | | vi) Sand equivalent test | One test for each source and whenever there is change in the quality of aggregate |
| | | vii) Plasticity Index | One test for each source and whenever there is change in the quality of aggregate |
| | | viii) Polished stone value | One test for each source and whenever there is change in the quality of aggregate |
| | | ix) Percentage of fractured face | One test per 350 cum of aggregate when crushed gravel is used |
| | | x) Mix grading | One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant |
| | | xi) Stability and voids analysis of mix including theoretical maximum specific of loose mix | Three tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to minimum of two tests per day per plant |
| | | xii) Moisture Susceptibility of mix (AASHTO T283) | One test for each mix type whenever there is change in the quality or source of coarse or fine aggregate |
| | | xiii) Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction | At regular intervals |
| | | xiv) Binder content | One set for each 400 tonnes of mix subject to minimum of two tests per day per plant |
| | | xv) Rate of spread of mix material | After every 5 th truck load |
| | | xvi) Density of Compacted layer | One test per 700 sq.m area |
| (i) | Sand Asphalt Base course | i) Quality of binder | Same as mentioned under Serial No. 2 |
| | | ii) Aggregate Impact Value or Los Angeles Abrasion Value | Same as mentioned under Serial No. 2 |
| | | iii) Sand equivalent test | Same as mentioned under Serial No. 2 |
| | | iv) Plasticity Index | Same as mentioned under Serial No. 5 |
| | | v) Mix grading & binder content | Same as mentioned under Serial Nos. 2 and 3 |
| | | vi) Stability of Mix | Same as mentioned under Serial No. 5 |
| | | vii) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling | Same as mentioned under Serial No. 2 |
| | | viii) Thickness of layer | Same as mentioned under Serial No. 5 |
| | | ix) Density of Compacted layer | Same as mentioned under Serial No. 5 |

| S. No. | Type of Construction | Test | Frequency (min.) |
|--------|---------------------------------|--|---|
| 7) | Slurry seal and Micro surfacing | i) Quality of Aggregate Sand Equivalent Value Water Absorption Soundness Test (Sodium/ Magnesium Sulphate Test) ii) Quality of Emulsion iii) Aggregate Moisture iv) Aggregate Gradation v) Binder Content vi) Calibration of Machine vii) Quantity of Slurry (By weight of aggregate) | One per source/ site One per lot of 20 t as per IS:8887 Two per day Two per day at site Two per lane per Km Once per Project Daily (Travel time of Machine) |
| 8) | Stone Matrix Asphalt | i) Quality of binder ii) Aggregate Impact Value/ Los Angeles Abrasion Value iii) Flakiness and Elongation Indices iv) Soundness Test (Sodium and Magnesium Sulphate Test) v) Water absorption of aggregate vi) Sand equivalent test vii) Plasticity Index viii) Polished stone value ix) Percent of fractured faces x) Mix grading xi) Air voids and VMA analysis of mix including theoretical maximum specific gravity of loose mix xii) Moisture Susceptibility of mix (AASHTO T 283) xiii) Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction | Number of samples per lot and tests as per IS:73 or IRC:SP:53, IS:15462 One test per 100 cu.m of aggregate One test per 100 cu.m of aggregate One test for each method for each source and whenever there is change in the quality of aggregate One test for each source and whenever there is change in the quality of aggregate One test for each source One test for each source One test for each source One test per 50 cu.m of aggregate when crushed gravel is used One set for individual constituent and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of two tests per day per plant Three tests per day One test for each mix type whenever there is change in the quality or source of coarse or fine aggregate At regular intervals |

| S. No. | Type of Construction | Test | Frequency (min.) |
|--------|--|--|---|
| | | (xiv) Binder content | One set for each 400 tonnes of mix subject to minimum of two tests per day per plant |
| | | (xv) Rate of spread of mix material | After every 5 th truck load |
| | | (xvi) Density of compacted layer | One test per 250 sq.m area |
| 9) | Mastic asphalt | i) Quality of binder | Same as mentioned under Serial No. 5 |
| | | ii) Aggregate Impact Value and Los Angeles Abrasion Value | Same as mentioned under Serial No. 5 |
| | | iii) Combined Flakiness and Elongation Indices | Same as mentioned under Serial No. 5 |
| | | iv) Stripping value | Same as mentioned under Serial No. 2 |
| | | v) Water Sensitivity of mix | Same as mentioned under Serial No. 5 |
| | | vi) Grading of aggregates | Two tests per day per plant on the individual constituent and mixed aggregates from the dryer |
| | | vii) Water absorption of aggregates | Same as mentioned under Serial No. 5 |
| | | viii) Soundness (Magnesium Sulphate/ Sodium Sulphate) | Same as mentioned under Serial No. 5 |
| | | ix) Percentage of fractured faces | Same as mentioned under Serial No. 5 |
| | | x) Binder content and aggregate grading | Same as mentioned under Serial No. 3 |
| | | xi) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling | At regular close intervals |
| | | xii) Rate of Spread of Mixed Material | Regular control through check of layer thickness |
| | | xiii) Hardness number | Minimum two tests per day |
| 10) | Recycled Material Grading of aggregate | | Two tests per day |
| 11) | Cold Mixes | | All tests as per S. No.5 |
| 12) | Quality of Modified Binder | | Number of samples per lot and tests as per IS:15462. |
| 13) | Geotextiles | | The requirements of Section 700 shall apply |

Note : Daily, weekly, monthly reports on test results shall be prepared indicating the location of sampling and testing, deviation from the specified values for materials and works and remedial action taken in respect of removal of defective work shall certified be prepared by the Contractor. The test record shall be certified by the Engineer that these tests were done in his presence and testing carried as per prescribed methodology.

903.2 Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation

903.2.1 Borrow Material

Grid the borrow area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for proper identification of suitable sources of material. The following tests on representative samples shall be carried out for every 3000 cum for each source:

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

903.2.2 Compaction Control

Control shall be exercised on each layer by taking at least one set of ten measurements of density for each 3000 sq.m of compacted area, or closer as required to yield the minimum number tests results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part-28). Test locations shall be chosen only through random sampling techniques. If non-destructive tests are carried out, the number of tests shall be doubled. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

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

However, for earthwork in shoulders (earthen) and in the subgrade, at least one set of ten density measurements shall be taken for every 2000 sq.m for the compacted area. In other respects, the control shall be similar to that described earlier.

903.2.3 Cut Formation

Tests for the density requirements of cut formation shall be carried out in accordance with Clause 903.2.2.

903.3 Tests on Sub-bases and Bases (Excluding Bitumen Bound Bases)

The tests and their frequencies for the different types of bases and sub-bases shall be given in Table 900-3. The evaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 903.2.2.

903.3.1 Acceptance Criteria

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

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

903.4 Tests on Bituminous Construction**903.4.1 Tests and Frequency**

The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 900-4. The Engineer may direct additional testing as required.

903.4.2 Acceptance Criteria

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

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

903.4.3 Where the Contract specifies the surface roughness requirements, in terms of Bump Integrator value, the surface roughness shall be measured by a calibrated Bump Integrator as per the procedure described in IRC:SP:16. The measurements shall be taken at centre line of each lane for a minimum completed length of one Km.

903.5 Quality Control Tests for Concrete Road Construction**903.5.1 Dry Lean Concrete Sub-base****903.5.1.1 Sampling and Testing of Cubes**

Samples of dry lean concrete for making cubes shall be taken from the uncompacted material from different locations immediately before compaction at the rate of 3 samples for each 1000 sq.m or part thereof laid each day. The sampling of mix shall be done from the paving site.

Test cubes of 150 mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that the cubes shall be compacted by means of a vibratory hammer with the moulds placed on a level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with a square or rectangular foot having an area of between 7500 to 14000 sq.mm. The compaction shall be uniformly applied for 60 ± 5 seconds with a downward force of between 300 N and 400 N on to each of the three layers of the lean concrete material placed into the mould. The surface of each compacted layer shall be scarified before the next layer is added to give key for the next layer. The final layer shall be finished flush with the top of the cube mould.

The dry lean concrete shall be cured in accordance with IS:516.

903.5.1.2 In-situ Density

The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 sq.m or part thereof laid each day and shall comply with the requirements as per Clause 601.6.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non-compliance. Density holes at random may be made to check the density at edges.

903.5.1.3 Thickness

The average thickness of the subbase layer as computed by the level data of sub-base and subgrade or lower sub-base shall be as per the thickness specified in the contract drawings. The thickness at any single location shall not be 8 mm less than the specified thickness. Such areas shall be corrected as stated in Clause 601.6.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

903.5.1.4 Frequency of Quality Control Tests

The frequency of quality control tests for levels, alignment and materials shall be as given in Table 900-6.

903.5.2 Pavement Concrete

903.5.2.1 Sampling and Testing of Beam and Cube Specimens

At least three beams and three cube specimens, one set of three each for 7 day and 28 day strength tests shall be cast for every 150 cu.m (or part thereof) of concrete placed during construction. On each day's work, not less than three pairs of beams and cubes

shall be made for each type of mix from the concrete delivered to the paving plant. Each pair shall be from a different delivery of concrete and tested at a place to be designated by the Engineer in accordance with the testing procedure as outlined in Clause 602.3.3. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the strength requirements. The specimens shall be transported in an approved manner to prevent sudden impact causing fractures or damage to the specimen. The flexural strength test results shall prevail over compressive strength tests for compliance.

903.5.2.2 A quality control chart indicating the strength values of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut at the rate of 2 cores for every 150 cu.m of concrete. The average of the results of crushing strength tests on these cores shall not be less than 0.8 x 0.85 times the corresponding characteristic compressive strength of cubes, where the height to diameter ratio of the cores is two. Where height to diameter ratio is not two, necessary corrections shall be made in calculating the crushing strength of cubes in the following manner.

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$$f = 0.11 n + 0.78$$

where f = correction factor and
 n = height to diameter ratio

The corrected test results shall be analysed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory, they shall have precedence for assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 150 mm.

If, however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to the area from which the cores were cut should be replaced, i.e., at least over an area extending between two transverse joints where the defects could be isolated or over larger area, if necessary, as assessed by additional cores and their test results. The equivalent flexural strength at 28 days shall be estimated in accordance with Clause 602.3.3.2.

In order to ensure that the specified minimum strength at 28 days is attained in 1 in 20 of all test beams, the mix shall be proportioned to give an average strength at 28 days exceeding the specified strength by 1.65 times the standard deviation calculated first from the flexural strengths of test beams made from the trial mix and subsequently from the accumulating result of flexural strengths of job control test beams.

The standard deviation shall be re-calculated from the test results obtained after any change in the source or quality of materials and the mix shall be adjusted as necessary to comply with the requirements.

An individual 28 day test strength below the specified strength shall not be evidence for condemnation of the concrete concerned if the average 28 day strength of this beam plus the preceding 5 and succeeding 4 beams exceeds the specified strength by 1.65 times the standard deviation and provided that there is no other evidence that the concrete mix concerned is substandard.

Beams shall be made each day in pairs at intervals, each pair being from a different batch of concrete. At the start of the work, and until such time as the Engineer may order a reduction in the number of beams required, at least six pairs of beams and cubes shall be made each day, one of each pair for testing at 28 days for determination of minimum permissible flexural strength and the other for testing at an early age for the Engineer to assess the quality of the mix. When the first thirty number of 28-day results are available, and for so long as the Engineer is satisfied with the quality of the mix, he may reduce the number of beams and cubes required.

During the course of construction, when the source of any material is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strength.

The flexural strengths obtained on beams tested before 28 days shall be used in conjunction with a correlation between them and the 28 day flexural strengths to detect any deterioration in the quality of the concrete being produced. Any such deterioration shall be remedied without awaiting the 28 day strengths but the earlier strengths shall not constitute sole evidence of non-compliance of the concrete from which they were taken.

Concrete shall be deemed not to comply with the Specification when more than one test beam in a batch has a 28 day strength less than the specified strength and the average 28 day flexural strength of the batch of beams is less than the specified strength plus 1.65 times the standard deviation of the batch.

Should the concrete fail to comply with the Specification for strength as described above, the Contractor may, all at his own expense, elect to cut cores from the suspect concrete as the Engineer shall direct. From the relation between cube strength and flexural strength, the core strength shall be converted to flexural strength.

The equivalent flexural strength at 28 days shall be the estimated in-situ strength multiplied by 100 and divided by the age-strength relation obtained from Table 900-5.

Any concrete that fails to meet the strength specification shall be removed and replaced at Contractor's expense.

Table 900-5 : Age-Strength Relation of Concrete (Related to 100 percent at 28 Days)

| Days | 0 | 2 | 4 | 6 | 8 |
|------|-------|-------|-------|-------|-------|
| 0 | — | 41.0 | 60.0 | 71.0 | 77.5 |
| 10 | 81.5 | 85.0 | 87.5 | 90.0 | 92.0 |
| 20 | 94.0 | 96.0 | 97.5 | 98.5 | 100.0 |
| 30 | 101.0 | 102.0 | 103.5 | 104.5 | 105.5 |
| 40 | 106.5 | 107.0 | 108.0 | 109.5 | 110.0 |
| 50 | 110.5 | 111.0 | 112.0 | 112.5 | 113.0 |
| 60 | 114.0 | 114.5 | 115.0 | 115.5 | 116.0 |
| 70 | 116.5 | 117.0 | 117.5 | 118.0 | 118.5 |
| 80 | 119.0 | 119.5 | 119.5 | 120.0 | 120.5 |
| 90 | 121.0 | 121.5 | 122.0 | 122.0 | 122.5 |
| 100 | 123.5 | 123.5 | 123.5 | 124.0 | 124.5 |
| 110 | 125.0 | 125.0 | 125.5 | 125.5 | 126.0 |
| 120 | 126.0 | 126.0 | 127.0 | 127.0 | 127.5 |
| 130 | 127.5 | 128.0 | 128.5 | 128.5 | 129.0 |
| 140 | 129.0 | 129.5 | 129.5 | 130.0 | 130.0 |
| 150 | 130.5 | 130.5 | 131.0 | 131.0 | 131.5 |
| 160 | 131.5 | 131.5 | 132.0 | 132.0 | 132.5 |
| 170 | 132.5 | 132.5 | 133.0 | 133.0 | 133.5 |
| 180 | 133.5 | 134.0 | 134.0 | 134.5 | 134.5 |
| 190 | 135.0 | 135.0 | 135.0 | 135.5 | 135.5 |
| 200 | 135.5 | 135.5 | 136.0 | 136.0 | 136.5 |
| 210 | 136.5 | 136.5 | 137.0 | 137.0 | 137.0 |
| 220 | 137.0 | 137.5 | 137.5 | 137.5 | 138.0 |
| 230 | 138.0 | 138.5 | 138.5 | 138.5 | 138.5 |
| 240 | 139.0 | 139.0 | 139.0 | 139.5 | 139.5 |
| 250 | 139.5 | 140.0 | 140.0 | 140.0 | 140.0 |
| 260 | 140.5 | 140.5 | 140.5 | 140.5 | 141.0 |
| 270 | 141.0 | 141.0 | 141.5 | 141.5 | 141.5 |
| 280 | 142.0 | 142.0 | 142.0 | 142.0 | 142.0 |
| 290 | 142.5 | 142.5 | 142.5 | 142.5 | 142.5 |
| 300 | 143.0 | 143.0 | 143.0 | 143.0 | 143.5 |

| Days | 0 | 2 | 4 | 6 | 8 |
|------|-------|-------|-------|-------|-------|
| 3 10 | 143.5 | 143.5 | 144.0 | 144.0 | 144.0 |
| 3 20 | 144.0 | 144.5 | 144.5 | 144.5 | 144.5 |
| 3 30 | 144.5 | 145.0 | 145.0 | 145.0 | 145.0 |
| 3 40 | 145.0 | 145.5 | 145.5 | 145.5 | 145.5 |
| 3 50 | 146.0 | 146.0 | 146.0 | 146.0 | 146.0 |
| 3 60 | 146.0 | 146.0 | 146.5 | 146.5 | 146.5 |

903.5.2.3 In-situ Density

The density of the compacted concrete shall be such that the total air voids are not more than 3 percent. The air voids shall be derived from the difference between the theoretical maximum dry density of the concrete calculated from the specific gravity of the constituents of the concrete mix and the average value of three direct density measurements made on cores at least 150 mm diameter. Three cores shall be taken from trial lengths and in first two km length of the pavement, while the slab is being constructed during normal working. The proportions of the mix and the vibratory effort imparted i.e. the frequency and magnitude of vibration shall be adjusted to achieve the maximum density.

All cores taken for density measurement in the trial section shall also be checked for thickness. The same cores shall be made use of for determining in-situ strength. In case of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the density of concrete slab or the position of dowel/tie bars without any compensation being paid for the same.

In calculation of the density, allowance shall be made for any steel in cores.

Cores removed from the main carriageway shall be reinstated with compacted concrete with mix proportions of 1 part of Portland cement : 2 parts of fine aggregate:2 parts of 10 mm nominal size single sized coarse aggregate by weight. Before filling the fine mix, the sides shall be hacked and cleaned with water. Thereafter cement-sand slurry shall be applied to the sides just prior to filling the concrete mix.

903.5.2.4 Thickness

Thickness shall be controlled by taking levels as indicated in Clause 902.3. Thickness of the slab at any point checked as mentioned above shall be within a tolerance of -5 mm to + 10 mm of the specified thickness as per Drawing. Thickness deficiency more than 5 mm may be accepted and paid for at a reduced rate given in Clause 602.16.3. In no case, however, thickness deficiency shall be more than 10 mm.

903.5.2.5 Summary of Control Tests

Table 900-6 gives a summary of frequency of testing of pavement concrete.

Table 900-6 : Frequency of Quality Control Tests for Pavement Concrete

| | | | |
|--|--|--|--|
| 1) Levels, alignment and texture | | | |
| i) Level tolerance | | | Clause 902.3 |
| ii) Width of pavement and position of paving edges | | | Clause 902.2 |
| iii) Pavement thickness | | | Clause 902.3 and 903.5.2.4 |
| iv) Alignment of joints, widths, depth of dowel grooves | | | To be checked @ one joint per 400 m length or a day's work |
| v) Surface regularity both transversely and longitudinally | | | Once a day or one day's work without disturbing the curing |
| vi) Alignment of dowel bars and their accuracy/tie bars | | | To be checked in trial length as per Clause 602.6.5.2 and once on every 2 km. |
| vii) Texture depth | | | Clause 602.12 |
| 2) Quality of materials and concrete shall be as under : | | | |
| 1) Cement Physical and chemical Tests | | IS:269 IS:455 IS:1489 IS:8112 IS:12269 | Once for each source of supply and occasionally when called for in case of long/improper storage. Besides, the Contractor also will submit daily test data on cement released by the manufacturer |
| 2) Coarse and Fine Aggregates | i) Gradation | IS:2386 | One test for every day's work of each fraction of coarse aggregate and fine aggregate, initially; (may be relaxed later at the discretion of the Engineer) |
| | ii) Deleterious constituents | IS:2386 (Pt. 2) | -do- |
| | iii) Water absorption | IS:2386 (Pt. 3) | Regularly as required subject to a minimum of one test a day for coarse aggregate and two tests a day for fine aggregate. This data shall be used for correcting the water demand of the mix on a daily basis. |
| 3) Coarse Aggregate | i) Los Angeles Abrasion value or Aggregate Impact test | IS:2386 (Pt. 4) | Once for each source of supply and subsequently on monthly basis. |
| | ii) Soundness | IS:2386 (Pt. 5) | Before approving the aggregates and every month subsequently. |
| | iii) Alkali aggregate reactivity | IS:2386 (Pt. 7) IS:456 | -do- |

| | | | |
|-------------|---|---------|---|
| 4) Water | Chemical Tests | IS:2386 | Once for approval of source of supply, subsequently only in case of doubt. |
| 5) Concrete | i) Strength of concrete | IS:516 | 2 cubes and 2 beams per 150 cu.m or part thereof (one for 7 day and other for 28 day strength) or minimum 6 cubes and 6 beams per day's work whichever is more. |
| | ii) Core strength on hardened concrete | IS:516 | As per the requirement of the Engineer, only in case of doubt. |
| | iii) Workability of fresh concrete- Slump Test | IS:1199 | One test per each dumper load at both Batching plant site and paving site initially when work starts. Subsequently sampling may be done from alternate dumper. |
| | iv) Thickness determination | | From the level data of concrete pavement surface and sub-base at grid points of 5/6.25 m x 3.5 m |
| | v) Thickness measurement for trial length | | 3 cores per trial length |
| | vi) Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving | | String line or steel forms shall be checked for level at an interval of 5.0 m or 6.25 m. The level tolerance allowed shall be ± 2 mm. These shall be got approved 1-2 hours before the commencement of the concreting activity. |