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CONTENTS

SPECIFICATION FOR SEMI-DENSE BITUMINOUS CONCRETE

1. INTRODUCTION

1.1. The formulation of the draft of the Specification for Semi-Dense Bituminous Concrete had been under the consideration of the Bituminous Pavements Committee. This Committee in their meeting held at Madras on the 12th December, 1985 discussed the above mentioned Specification and authorised S/Shri K.P. Nair and R.S. Shukla to modify and redraft the Specification in light of the comments received. Accordingly, the draft Specification was revised by this Group and considered by the Specifications & Standards Committee. The draft Specification was modified by Shri P. Bhaskaran, Member-Secretary, Bituminous Pavements Committee on the basis of the comments of the Specifications & Standards Committee and it was again placed before the Bituminous Pavements Committee (personnel given below) in their meeting held at Madras on the 13th March, 1987.

Prof. C.G. Swaminathan — *...Convenor*
P. Bhaskaran — *...Member-Secretary*

Members

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Dr. Arun Kumar
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The President, Indian Roads Congress and Director General (Road Development) & Addl. Secretary to the Govt. of India — (K.K. Sarin) *-Ex-officio*

The Secretary, Indian Roads Congress — (Nainan Koshi) *-Ex-officio*

1.2. The Committee authorised Shri P. Bhaskaran to finalise the draft Specification and forward for further consideration of the Specifications & Standards Committee. The revised draft Specification was considered by the Specifications & Standards Committee in their meeting held at New Delhi on the 23rd April, 1987. Later on the Specification was approved by the Executive Committee on 28th April, 1987 and by the Council in their meeting held at Udaipur on 22nd May, 1987 for being published by the Indian Roads Congress.

2. SCOPE

2.1. This draft Specification deals with the basic outline for the design, construction and controls needed while laying semi-dense bituminous concrete wearing course mixes for highways. It only highlights the essentials so as to be of use while preparing the contractual documents for specific jobs of this type, and is not intended to be a detailed code of practice.

2.2. Semi-dense bituminous concrete shall be used as a wearing course and shall not be laid directly over WBM or any granular base. The item shall consist of mineral aggregates and appropriate binder mixed in a hot-mix plant and laid with a paver on a previously prepared base in accordance with the Specifications and conforming to the lines, grades and cross-sections.

3. DESIGN CRITERIA

3.1. Being high cost specification, semi-dense bituminous concrete mixes should be properly designed so as to satisfy certain criteria needed to assure satisfactory performance and durability. The mix as designed and laid should satisfy the requirements given in Table 1 based on Marshall method which is suggested for the present for the sake of simplicity and uniformity.

TABLE 1. REQUIREMENT OF THE MIX

(i) Number of compaction blows on each end of Marshall specimen	50
(ii) Marshall stability in kg (Minimum)	340
(iii) Marshall flow (mm)	2-4
(iv) Per cent voids in mix	5-10
(v) Per cent voids in mineral aggregate filled with bitumen	55-75
(vi) Binder content as per cent by weight of total mix (to be decided based on Marshall design method)	4.5-6.0

Notes : 1. It is suggested that higher stability values consistent with other requirements should be achieved as far as possible.
2. At bus stops, parking areas and roundabouts, near minimum flow value should be adopted.
3. The attempt should be to have well graded aggregate and the per cent voids in the mix closer to the lower limit.

4. MATERIALS

4.1. In order to satisfy the requirements spelt out in para 3, the semi-dense bituminous concrete mix shall consist of coarse aggregate, fine aggregate and filler in suitable proportions and mixed with sufficient binder content. True and representative samples of the aggregates proposed to be used on the specific job shall be tested in the design laboratory and proper blend of the aggregates shall be worked out so that the gradation of the final composition will satisfy either of the three limits set forth in Table 2.

TABLE 2. GRADATION OF AGGREGATE IN THE FINAL MIX

Grading Number :	1	2	3
Sieve size		(per cent passing by weight)	
22.4 mm	—	100	100
13.2 mm	100	85–100	79–100
11.2 mm	88–100	70–92	68–90
5.6 mm	42–64	42–64	33–55
2.8 mm	22–38	22–38	22–38
710 μm	11–24	11–24	6–22
355 μm	7–18	7–18	4–14
180 μm	5–13	5–13	2–9
90 μm	3–9	3–9	0–5

Grading No. 1 is suggested for compacted thickness of 25mm and Grading Nos. 2 and 3 for compacted thickness of 25-40 mm.

The exact bitumen content required shall be arrived at as per Marshall procedure for the aggregate gradation worked out in the laboratory and by using the same paving bitumen proposed to be used in the field.

4.2. The material shall further satisfy the following physical requirements.

4.2.1 **Bitumen :** The bitumen 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 IS : 73 'Paving Bitumen'. The actual grade of bitumen to be used shall be decided by the Engineer-in-charge, appropriate to the region, traffic, rainfall and other environmental conditions.

4.2.2. **Coarse aggregate :** The coarse aggregate shall be crushed material retained on 2.8 mm sieve and shall be crushed stone, crushed slag, crushed gravel (shingle) and shall consist of angular, clean, tough and durable fragments, free from disintegrated pieces and organic or deleterious matter and adherent coatings. The aggregate shall preferably be hydrophobic and of low porosity. When the hydrophillic aggregates are used, the bitumen shall be treated with anti-stripping agents of approved quality in suitable doses. The aggregate shall satisfy the physical requirements as given in Table 3.

TABLE 3. PHYSICAL REQUIREMENTS OF COARSE AGGREGATE

Test	Requirement (per cent maximum)	Test Method
Aggregate Impact Value	30	IS : 2386 (Part IV)
or Los Angeles Abrasion Value	40	—do—
Flakiness Index	30	IS : 2386 (Part I)
Stripping Value	25	IS : 6241
Water Absorption	1	IS : 2386 (Part III)
Soundness		
Loss with Sodium sulphate, 5 cycles	12	IS : 2386 (Part V)
Loss with Magnesium sulphate, 5 cycles	18	—do—

Notes : 1. For slag, the unit weight shall not be less than 1120 kg/m³

2 Water absorption upto 2 per cent may be permitted in exceptional cases.

4.2.3. **Fine aggregate :** The fine aggregate shall be the fraction passing 2.8 mm sieve and retained on 90 μm sieve, and shall consist of crushed screenings, natural sand or a mixture of both. It shall be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic or deleterious matter.

4.2.4. **Filler :** The requirement of filler in semi-dense bituminious mixes shall normally be met by the material passing 90 μm sieve in fine aggregate. In case the fine aggregate is deficient in material passing 90 μm sieve, extra filler shall be added. The filler shall be an inert material, the whole of which passes 710 μm sieve, atleast 90 per cent passes 180 μm sieve and not less than 70 per cent passes 90 μm sieve. The filler shall be stone dust, cement

hydrated lime, flyash or other approved non-plastic mineral matter.

5. JOB MIX FORMULA

5.1. While the laboratory mix design gives the different proportions of the mineral aggregate combination in terms of individual sieve sizes, for actual operational purposes in the field, blending of two or more sizes of aggregates (each size having within it a range of individual sieve sizes) would be necessary. This blending ratio is obtained on a weight basis, giving the per cent weight of the coarse aggregate, fine aggregate and filler needed to give the ultimate aggregate gradation. It can also be proportioned on a volumetric basis based on the unit weight or bulk density of the aggregates supplied. This mineral aggregate combination together with the corresponding optimum bitumen content as determined in the laboratory constitutes the job mix formula for implementation during construction.

5.2. It is emphasised that in order that this formula be adhered to in practice, the mix design shall be worked out based on a correct and truly representative sample of the materials that will actually be used in the specific construction project.

6. CONSTRUCTION

6.1. Preparation of the Base

The base over which the semi-dense bituminous concrete is to be laid shall be completely free from dust, caked mud, etc. before laying the surface course. Where the existing base is potholed or rutted, the irregularities shall be filled in with premixed materials and well rammed.

If the existing base is extremely irregular and wavy, it may be considered worthwhile to lay a bituminous levelling course (Profile Corrective Course) of adequate thickness to avoid an excessive use of the costly surface course.

A tack coat at the rate of 6 to 7.5 kg of bitumen per 10 m^2 shall be given over a bituminous base or binder course if the existing surface is dry and hungry, and 5 to 5.5 kg per 10 m^2 on a normal bituminous base.

6 2. Praparation of the Mix

It is imperative that the semi-dense bituminous concrete mix be manufactured by using a hot-mix plant of adequate capacity

to yield a mix of proper and uniform quality. The plant may be either a batch type or a continuous one having a co-ordinated set of essential units such as a dryer for heating the aggregates, arrangements for grading and batching by weight or volume the required quantities of aggregates, a bitumen heating and control unit for metering out the correct quantity of heated bitumen together with a paddle mixer for intimate mixing of bitumen and aggregates. A fines feeder for incorporation of the correct quantity of filler is also a necessary auxilliary.

6.3. Spreading of the Mix

The mix shall be transported from the mixer by tipper trucks to the work site and spreading done preferably by means of a self-propelled mechanical paver with suitable screed capable of spreading, tamping and finishing the mix true to grade, line and cross-section. The mix should be spread in such a manner that after compaction, the required thickness of carpet is uniformly laid.

Longitudinal joints and edges shall be constructed true to line marking parallel to the centre line of the road. Longitudinal joints should be offset atleast by 150 mm from those in binder course, if any, and transverse joints or construction joint shall be placed in the vertical plane after cutting back to the original thickness of the previously laid mix. The vertical cut face shall be painted with hot bitumen prior to the laying of fresh mix against it.

6.4. Compaction

The mix after spreading shall be thoroughly and uniformly compacted by rolling by a set of rollers at a speed not more than 5 km per hour, immediately following the paver. The initial or break down rolling shall be with 8-12 tonne three wheel steel roller and the surface finished by final rolling with the 8-10 tonne tandem roller. Before finishing with the tandem roller, breakdown rolling shall preferably be followed by an intermediate smooth wheel pneumatic roller of 15 to 30 tonne having a tyre pressure of 7 kg/sq.cm. The joints and edges shall be rolled with a 8-12 tonne three wheel roller. All the compaction operations i.e. breakdown rolling, intermediate rolling and finish rolling can be accomplished by using a vibratory roller of 8-10 tonne static weight. During finish rolling the vibratory system shall be switched off.

The wheels of roller shall be kept moist to prevent the mix from adhering to them. In no case shall fuel/lubricating oil be

used for this purpose nor excessive water poured on the wheels. Rolling shall commence longitudinally from edge and progress towards the centre except on super-elevated portions where it shall progress from the lower to upper edge, parallel to the centre line of the pavement. The roller should proceed on the fresh material with rear fixed wheel leading so as to minimise the pushing of the mix and each pass of the roller shall overlap the preceding one by half the width of the rear wheel. Rolling shall be continued till the desired density of not less than 98 per cent of the lab design density is achieved and all roller marks are eliminated.

6.5. Opening to Traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature.

7. CONTROLS

7.1. Adequate quality control at every stage of the work is essential and as such a field laboratory must be set up to ensure the following controls.

7.1.1. Periodic sieve analysis of each type of the aggregate at the cold feeder end should be made to see that the gradation of aggregates reasonably follows the original gradation of the job mix designed. The number of samples per day would depend upon the number of bulk supply of the aggregates made in a day at the plant site. The physical properties as required in Table 3 shall be determined at the rate of one test each for every 50-100 m^3 of aggregates or as directed by Engineer-in-charge.

7.1.2. Periodic check on penetration and softening point of the binder should also be done in the manner specified in IS:1203 and 1205.

7.1.3. It shall be ensured that the aggregates are not totally wet as otherwise it would affect the output of the plant adversely. The aggregate temperature measuring device installed at the end of dryer should be checked periodically to see that the aggregate temperature never exceeds 163°C. A tolerance upto 10°C on the lower side may be permitted.

7.1.4. The bitumen temperature should be well within the limits specified. The viscosity of heated bitumen shall be between 150 and 300 centi stokes for which the normal temperature range for paving bitumen is 1500-177°C.

7.1.5. At no time, the difference in temperature between aggregate and bitumen should exceed 14°C.

7.1.6. Periodic check of the aggregate at the gradation control unit (if the plant is fitted with one) or at the hot bin gates should be made to see that the proportion of the aggregates as specified in the job mix formula is complied with.

7.1.7. At least one sample for every 100 tonnes of bituminous mix discharged at the pugmill chute or a minimum of one sample per plant per day shall be collected and the following tests done :

(i) Three Marshall specimens shall be compacted and tested for the average stability, flow, voids content and density. The value should closely follow the laboratory design values.

(ii) Bitumen shall be extracted from about 1000 grams of the mix and bitumen content determined.

(iii) A sieve analysis of the aggregates after the bitumen is extracted, shall be done and the gradation determined.

7.1.8. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula shall be within the limits indicated in Table 4.

TABLE 4. PERMISSIBLE VARIATIONS FROM JOB MIX FORMULA

Sl. No.	Description of Ingredient	Permissible variation by weight of total mix (per cent)
1.	Aggregate passing 13.2 or larger sieve	± 8
2.	Aggregate passing 11.2 mm sieve and 5.6 mm sieve	± 7
3.	Aggregate passing 2.8 mm sieve and 1.4 mm sieve	± 6
4.	Aggregate passing 710 μm sieve and 355 μm sieve	± 5
5.	Aggregate passing 180 μm sieve	± 4
6.	Aggregate passing 90 μm sieve	± 3
7.	Bitumen content	± 0.3

7.1.9. The temperature of the mix at the time of laying shall not exceed 160°C and shall not be less than 120°C.

7.1.10. Rolling operations shall be conducted when the

mix is neither too hot nor too cold so that shoving or hair cracks may be eliminated. Rolling operation shall be completed in every respect before the temperature of the mix falls below 80°C.

7.1.11. After the mix is compacted the thickness laid may be checked by noting the depth of penetration of hot steel scale. This shall also be correlated with the measured area of the surface laid and the total plant output of the mix in tonnes (as given in the plant scale).

7.1.12. For every 500 m^2 or less of compacted surface, one field density test should be conducted to determine the density of the mix as laid, compacted and finished. The density shall not be less than 98 per cent of the laboratory density.

7.1.13. The longitudinal profile of the finished surface shall be tested with a straight edge 4.5 m long parallel to the centre line and the transverse profile with a camber template. Any irregularity greater than 6 mm shall be corrected. The longitudinal profile of the finished surface shall also be tested with a roughometer/profilometer and it should be ensured that the roughness shall not exceed 2500 mm per kilometre.

8. WEATHER AND SEASONAL LIMITATIONS

Semi-dense bituminous concrete carpet shall not be laid during rainy weather or when the base/binder course is damp or wet, and normally when the atmospheric temperature in the shade is 15°C or less.

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