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SPECIFICATION FOR DENSE BITUMINOUS MACADAM

1. INTRODUCTION

The initial draft of the Specification for Dense Bituminous Macadam was prepared by the Ministry of Transport, Deptt. of Surface Transport (Roads Wing). On the request of the Ministry, it was placed before the Bituminous Pavements Committee (personnel given below) in their meeting held at Madras on the 12th December, 1985.

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The Director General (Road Development) & Addl. Secy. to the Govt. of India (K.K. Sarin) -*Ex-officio*
The Secretary, Indian Roads Congress (Ninan Koshi) -*Ex-officio*

The Bituminous Pavements Committee after long deliberations on the subject decided to entrust the job of redrafting the Specification to K.P. Nair of I.O.C., R.S. Shukla of C.R.R.I., and P. Bhaskaran (Member-Secretary, Bituminous Pavements Committee).

The Specification as redrafted and finalised by the above mentioned Working Group was considered by the Specifications & Standards Committee in their meeting held on the 28th August, 1986. This Committee set up another Working Group comprising

R.S. Shukla, K.P. Nair, P. Bhaskaran and R.K. Saxena (Chief Engineer Roads, M.O.T.) for making minor changes/modifications keeping in view the comments of the members. This Group held its meeting on the 4th September, 1986 and finalised the Specification for placing before the Executive Committee and the Council.

The Specification for Dense Bituminous Macadam was approved by the Executive Committee and later by the Council in their 117th meeting held at Srinagar on the 19th September, 1986 for being published by the Indian Roads Congress.

2. SCOPE

This specification deals with the basic outlines for the design, construction and control needed for dense bituminous macadam to be used as binder/base course for pavements. It only highlights the essentials so as to be of use while preparing the contractual documents for specific jobs of this type and as such it is not intended to be a detailed code of practice.

3. DESIGN CRITERIA

Being a high cost specification, dense bituminous macadam mixes shall be properly designed based on a standard design method so as to satisfy certain criteria, needed to assure adequate stability and durability. The mix as designed and laid shall satisfy the requirements given in Table 1, which are based on Marshall method and suggested for the sake of uniformity.

TABLE 1. REQUIREMENTS OF THE MIX

(i) Number of compaction blows on each end of Marshall specimen	50
(ii) Marshall stability in k.g. (Minimum)	340
(iii) Marshall flow in 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 per cent by weight of total mix	4.5—6.0

It is suggested that higher stability values consistent with other requirements should be achieved as far as possible. Also, at traffic stops, parking areas and roundabouts, it is recommended that near minimum flow value be specified.

4. MATERIALS

4.1. In order to satisfy the above mentioned requirements, the dense bituminous macadam mix shall consist of coarse aggregate, fine aggregate and filler in suitable proportions with required binder content. Truly representative sample 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 two limits set forth in Table 2.

TABLE 2. GRADATION OF THE MINERAL AGGREGATE IN THE MIX

Sieve size	Grading number	
	1	2
	(Percentage Passing)	
37.5 mm	—	100
26.5 mm	100	85—100
19.0 mm	85—100	71— 95
13.2 mm	63— 82	58— 82
9.5 mm	52— 74	52— 72
4.75 mm	39— 54	35— 50
2.36 mm	28— 43	28— 43
600 μm	15— 27	15— 27
300 μm	7— 21	7— 21
150 μm	5— 15	5— 15
75 μm	2— 8	2— 8

For compacted thickness upto 50 mm, grading 1 will only be used while as for thickness greater than 50 mm, grading 2 could be used. The exact bitumen content required for grading 1 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 or likely to be used in the field. The bitumen content for the grading 2 shall be computed from the volume of aggregates and thickness of the film. It shall also be determined by Marshall Method, replacing the aggregates retained on 26.5 mm sieve by the aggregates passing 26.5 mm and retained on 19.0 mm sieve. The maximum thickness of any single layer shall not be more than 75 mm.

4.2. The materials 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 Indian Standard Specification for "Paving Bitumen" IS : 73-1961. The actual grade of bitumen to be used shall be decided by the Engineer-in-Charge, appropriate to the region, traffic and environmental conditions.

4.2.2. **Coarse aggregate :** The coarse aggregate shall be crushed material retained on 2.36 mm sieve and shall be crushed stone, crushed, slag, crushed gravel (shingles) and shall consist of angular fragments, clean, tough and durable rock free from disintegrated pieces and organic or deleterious matter and adherent coatings. Preferably, the aggregate shall be hydrophobic and of low porosity. But if hydrophillic aggregates are to be used, the bitumen shall preferably be treated with antistripping agents of approved quality in suitable doses. In case of porous aggregates having more than 2 per cent water, absorption extra bitumen for absorption by aggregates shall be provided to satisfy the design criteria. The aggregates shall also satisfy the physical requirements as given in Table 3.

TABLE 3

Test	Maximum per cent
Aggregate Impact Value	35
Or Los Angeles Abrasion Value	40
Flakiness Index	35
Stripping Value	25
Soundness	
(i) Loss with Sodium Sulphate—5 cycles	12
(ii) Loss with Magnesium Sulphate—5 cycles	18
Water absorption	2

Note : For slag the unit weight shall not be less than 1120 kg per m^3.

4.2.3. **Fine aggregate :** Fine aggregate shall be the fraction passing 2.36 mm sieve and retained on 75 mm sieve consisting of crushed screenings, natural sand or a mixture of both. It shall be clean, hard, durable, uncoated and dry, free from soft and flaky pieces and organic or other deleterious substances.

4.2.4. **Filler :** The requirement of filler in dense bituminous macadam shall normally be met by the material passing 75 μm sieve in fine aggregate, if any. In case the fine aggregate is deficient in material passing 75 μm sieve, extra filler shall be added. The filler shall be an inert material, the whole of which passes 600 μm sieve, at least 90 per cent passing 150 μm sieve and not less than 70 per cent passing 75 μm sieve. The filler shall be stone dust, cement, hydrated lime, flyash or any other approved non-plastic mineral matter.

5. JOB MIX FORMULA

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 aggregate (each size having within it a range of individual sieve sizes) would be necessary. This blending ratio can be 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 aggregate supplied. This mineral aggregate combination with optimum bitumen content as determined in the laboratory constitutes the job-mix formula.

It is emphasized 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 on which dense bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified line, grade and cross-section. The surface shall be thoroughly swept and scraped clean and free from dust, caked mud and other deleterious materials etc. Where the existing base is pot holed or rutted, the same shall be rectified by filling with premixed bituminous material well rammed and compacted.

If the existing base is irregular and wavy, it may be considered necessary to provide a suitable profile corrective course of adequate thickness to rectify the profile both longitudinally and transversely before laying the dense bituminous macadam course.

A tack coat at the rate of 6 to 7.5 kg of bitumen per 10 m^2 over the bituminous base course if the existing surface is dry, and hungry, 5 to 5.5 kg per 10 m^2 on a normal bituminous surface and 7.5 to 10 kg per 10 m^2 in case of non-bituminous surface, shall be applied as directed by the Engineer-in-charge. It should be ensured that in the case of granular surface, the same has been primed as per IRC : 16-1965 "Tentative Specification for Priming of Base Course with Bituminous Primers" prior to laying tack coat as envisaged.

6.2. Preparation of the Mix

It is imperative that the dense bituminous macadam mix be manufactured by using a hot-mix plant of adequate capacity to yield a mix of proper and uniform quality and thoroughly coated aggregates. The plant may be either a batch type or a continuous one having a co-ordinated set of essential units such as dryer for heating the aggregates arrangements for grading and batching by weight or volume, the required quantities of aggregates, a bitumen heating unit for metering out the correct quantity of heated bitumen together with a paddle mixer for intimate mixing of bitumen and aggregates. A fine's feeder for incorporation of the correct quantity of filler is also a necessary auxiliary.

6.3. Spreading of the Mix

The mix shall be carried from the mixer by tipper trucks to the work site and spreading done preferably by means of self propelled mechanical paver with suitable screeds capable of spreading the mixture to grade, line and cross section.

The mix shall be spread in such a manner that after compaction, the required thickness of binder/base course is uniformly laid.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the pavement. Longitudinal joints shall be offset at least by 150 mm from those on base course, if any. Longitudinal and transverse joints 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 laying of fresh mix against it.

6.4. Compaction

The mix after spreading shall be thoroughly compacted by rolling by a set of rollers at a speed not more than 5 km per hour, immediately following close to the paver. The initial or breakdown rolling shall be with 8 to 12 tonnes, three wheel steel

roller and the finished rolling with 8 to 10 tonnes tandem roller. Before finishing with the tandem roller, breakdown rolling shall preferably be followed by an intermediate rolling with a smooth wheel pneumatic roller of 15 to 30 tonnes having a tyre pressure of 7 kg per cm^2. All the compaction operations i.e. breakdown rolling, intermediate rolling and finished rolling can be accomplished by using a vibratory roller of 8 to 10 tonnes static weight. During finished rolling, the vibratory system shall be switched off. The joints and edges shall be rolled with a 8 to 10 tonnes static roller.

The wheels of roller shall be kept moist to prevent the mix from adhering to them. But in no case shall fuel/lubricating oil be used for this purpose nor excessive water poured on the wheels and rolling shall commence longitudinally from edge and proceed towards the centre, except that on superelevated portion, it shall progress from the lower to upper edge parallel to the centre line of the pavement. The roller shall proceed on the fresh material with rear or 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 is achieved.

6.5. Opening to Traffic

Traffic can be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. However, the dense bituminous macadam course shall be covered by a suitable wearing course prior to regular opening to normal traffic and/or impending rain.

7. CONTROLS

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. Periodic sieve analysis of each type of the aggregate at the cold feeder end shall be made to see that the gradation of aggregates follows the original gradation as 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. Physical properties such as aggregate impact value/Los Angeles Abrasion, flakiness index and stripping value shall be determined at the rate of one test each for every 50-100 m^3 of aggregate or as directed by the Engineer-in-charge.

7.2. Periodic check on penetration and softening point of the bitumen shall also be done in the manner specified in Indian Standards IS : 1203 and 1205-1978.

7.3. It shall be ensured that the aggregate are not totally wet otherwise it would affect the output of the plant adversely. The aggregate temperature measuring device installed at the end of the dryer shall 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.

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

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

7.6. 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.

7.7. 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.

7.7.1. Three Marshall specimens shall be prepared and tested for the average stability flow, voids content and density. The values should closely follow the laboratory design values.

7.7.2. Bitumen shall be extracted from about 1000 gms of the mix and bitumen content determined.

7.7.3. A sieve analysis of the aggregates after the bitumen is extracted shall be done and the gradation determined.

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 as specified in Table 4.

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

TABLE 4. PERMISSIBLE VARIATIONS FROM JOB-MIX FORMULA

Sieve sizes	Permissible variation by weight of total mix
13.2 mm and larger	± 8 Per cent
9.5 mm and 4.75 mm	± 7 ,,
2.36 mm and 1.18 mm	± 6 ,,
600 μm and 300 μm	± 5 ,,
150 μm	± 4 ,,
75 μm	± 3 ,,
Bitumen content	± 0.5 ,,

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

7.10. 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 in a day).

7.11. For every 500 m^2 or less of compacted surface, one field density test is to be conducted to determine the density of the mix as laid, compacted and finished. The density shall not be less than 95 per cent of the laboratory density.

7.12. The longitudinal profile of the finished surface shall be tested with a straight edge, 4.5 m long, and the transverse profile with a camber template. Any irregularities greater than 8 mm in the longitudinal profile and 6 mm in the transverse profile shall be corrected.

8. Dense bituminous macadam shall not be laid on a damp or wet base course and normally when the atmospheric temperature in the shade is 15°C or less.

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