SPECIFICATIONS FOR DENSE BITUMINOUS MACADAM AND BITUMINOUS CONCRETE FOR AIRFIELD PAVEMENTS

(First Revision)

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ABBREVIATIONS

All abbreviations are explained where they occur first. Some of these are:

AASHTO	-	American Association of State Highway and Officials
ASTM	-	American Society of Testing and Materials
BC	-	Bituminous Concrete
BIS	-	Bureau of Indian Standards
DAC	-	Dense Asphaltic Concrete
DBM	-	Dense Bituminous Macadam
HMA	-	Hot Mix Asphalt
IRC	-	Indian Roads Congress
ICAO	-	International Civil Aviation Organisation
IMD	-	India Meteorological Department
MORTH	-	Ministry of Road Transport & Highways
NMAS	-	Nominal Maximum Aggregate Size
PMB	-	Polymer Modified Bitumen
SAMI	-	Stress Absorbing Membranes Interlayer
SMA	-	Stone Matrix Asphalt
VG	-	Viscosity Grade

SPECIFICATIONS FOR DENSE BITUMINOUS MACADAM AND BITUMINOUS CONCRETE FOR AIRFIELD PAVEMENTS

1. INTRODUCTION

Airfield pavements are one of the most important assets of any Nation. Keeping these national assets operational all the time has strategic importance. The IRC prepared IRC: 105 "Tentative Specification for Bituminous Concrete (Asphaltic Concrete) for Airfield Pavements" in the year 1988. However, with the induction of New Large Aircrafts and heavy weight fighter aircrafts with high tyre pressure and single wheel landing gear, a need has emerged to revise the technical specifications of different asphalt pavement layers in the airfield pavement. Besides reducing fatigue cracking, these high-quality pavement layers would increase the service life of the pavement. Sophisticated and high-speed weigh batch hot mix asphalt plants available in the industry can ensure a high degree of quality output conforming to the mix design parameters. This high-quality material can be rapidly paved with the new technology paving and compacting equipment available. Hence need was felt to revise this document. According, the task of revision of this document was entrusted to Flexible Pavement, Airfield & Runways Committee (H-2) of IRC during tenure 2018-20. The initial draft was prepared by the subgroup comprising Col. R.S. Bhanwala and Shri Manoj Kumar Shukla. Later H-2 Committee co-opted officers Col. Kulbir Singh, MES and Shri Manoj Kumar Garg, AAI in the sub group. The draft was further deliberated in various meetings of H-2 Committee. The H-2 Committee in its meeting held on 08.06.2019 approved the document subject to incorporation of comments of members for placing before HSS Committee.

The composition of the H-2 Committee is given below:

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Secretary General, Indian Roads Congress	Nirmal, Sanjay Kumar

The draft document was placed before the Highways Specifications and Standards Committee (HSS) in its meeting held on 20.07.2019. The HSS Committee decided that Co-Convenor, H-2 Committee will modify the document based on written comments and verbal comments offered during the meeting and submit the final document to IRC for placing before the IRC Mid-Term Council meeting. The Mid-Term Council in its meeting held on 9th and 10th August, 2019 at Goa approved the document for publishing.

The HSS Committee in its meeting held on 20.07.2019 authorized the Co-Convenor to finalize the document based on comments offered during the meeting and submit final document to IRC for placing in the Mid-Term Council meeting. The Mid-Term Council in its meeting held on 9th and 10th August, 2019 at Goa approved the document for publishing.

2. SCOPE

2.1 These Specifications deal with the basic outline for the design, construction and controls needed while laying dense graded bituminous mixes in base course, binder course and wearing course for airfield pavements.

2.2 Dense graded bituminous mixes shall consist of mineral aggregate and appropriate bituminous binder, mixed in a hot mix plant and laid with a mechanized paver. Dense graded bituminous mixes such as binder and wearing courses are usually laid on a previously prepared bituminous layer. Binder course is the intermediate layer between bituminous base course and bituminous wearing course. Three different Specifications for dense graded bituminous mixes are available for use for airfield pavements. Purpose, layer thickness and number of layers allowed for these Specifications are given in **Table 2.1**.

Table 2.1 Types of Dense Graded Bituminous Mixes, their uses, Number of Layers and Layer Thickness

Specification	Purpose	Number of layers	Thickness of each layer
Dense Bituminous Macadam (DBM) Grading 2 (NMAS 26.5 mm)	Base Course	Single or multiple	50 mm - 100 mm
Bituminous Concrete (BC) Grading 1 (NMAS 19 mm) DAC-I	Binder Course	Single	50 mm - 75 mm
Bituminous Concrete (BC) Grading 2 (NMAS 13.2 mm) DAC-II	Wearing Course	Single	40 mm - 50 mm

3. DENSE BITUMINOUS MACADAM (DBM) AND DENSE ASPHALTIC CONCRETE (DAC)

3.1 Material

3.1.1 *Bitumen*

The bitumen for dense graded bituminous mixes shall comply with Indian Standard Specification for viscosity-graded paving bitumen, IS:73 or Polymer Modified Bitumen (PMB) complying with the Bureau of Indian Standards Specification IS:15462. Only elastomeric Polymer Modified Binder (PMB) with an elastic recovery value of at least 75% at 15ºC for the unaged binder shall be used. All VG grades shall be produced at refineries only with conventional refining processes. Guidelines for selection of grade of viscosity-graded paving bitumen and modified bitumen are given in **Tables 3.1** and **3.2**.

As per given design Specification, the type and grade of modified bitumen to be used shall be specified in the Contract.The use of Polymer Modified Bitumen is recommended for airfields intended to be used by heavy aircrafts or aircrafts with high tyre pressures.

The Highest Daily Mean Air Temperatures and the Lowest Daily Mean Air Temperatures mentioned in **Tables 3.1** and **3.2** can be obtained from the weather station nearest to the project site from the Indian Meteorological Department (IMD). The IMD has data on daily mean high temperature for all 365 days in a year for all weather stations based on historical records of the last 30-40 or more years. 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 3.1** and **3.2**. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the IMD.

Table 3.1 Selection Criteria for Viscosity Graded (VG) Paving Bitumen Based on Climatic Conditions for DBM and AC (DAC)

7-day Average Maximum Air Temperature, ºC	Less than 30	30 to 38	38 to 45	More than 45
Grade of Bitumen	VG-10	VG-20	VG-30	VG-40

Table 3.2 Selection Criteria for Elastomeric Polymer Modified Bitumen (PMB) for DBM and BC

Highest Daily Mean Air Temperature, ºC			
Lowest Daily Mean Air Temperature, ºC	Less than 20º C	20º to 30º C	> 30º C
	Grade of Modified Bitumen		
More than -10º C	PMB 120	PMB 70	PMB 40
-10º C or lower	PMB 120	PMB 120	PMB 120

Bitumen shall be classified based on its absolute viscosity and suitability recommended for maximum air temperature as given in **Table 3.2**. The paving bitumen binder shall be homogenous and shall not foam when heated to 175°C. The selection of grade of bitumen shall conform to the requirements prescribed in **Table 3.3**. The PMB, shall be prepared by blending a suitable VG bitumen with additives at a refinery with high shear mixing facility. On site blending should not be permitted. The material shall be homogenous and shall not foam, when heated at 170°C. No mineral matter other than naturally present, in the ingredient materials, shall be used. Modifier shall not de-mix of heating at 170°C or later during cooling. Elastomeric thermoplastic polymer modified bitumen shall be used and it should conform to the requirements given in **Table 3.4**.

Table 3.3 Requirements of Paving Bitumen

S. No	Characteristic	Paving Grade				Test Method
		VG-10	VG-20	VG-30	VG-40	
1	Penetration at 25°C, 100 g, 5 s, 0.1 mm, min	80	60	45	35	IS 1203
2	Absolute viscosity at 60°C, Poise	800-1200	1600-2400	2400-3600	3600-4800	IS 1206 (Part 2)
3	Kinematic viscosity at 135°C, cSt, min	250	300	350	400	IS 1206 (Part 3)
4	Flash Point (COC method), °C, min	220	220	220	220	IS 1448 [P:69]
5	Solubility in trichloroethylene, %, min	99.0	99.0	99.0	99.0	IS 1216
6	Softening point (R&B) temperature, °C, min	40	45	47	50	IS 1205
7	Tests on Residue from Rolling Thin Film Oven Test					
	(a) Viscosity ratio at 60°C, max	4.0	4.0	4.0	4.0	IS 1206 (Part 2)
	(b) Ductility at 25°C, cm, min	75	50	40	25	IS 1208

3.1.2 *Coarse Aggregate*

The coarse aggregate shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. It shall be clean, hard, and durable and shall have cubical shape, free from dust and soft organic and other deleterious substances. The aggregate should preferably be of low porosity. The coarse aggregate shall satisfy the physical requirements specified in **Table 3.5**. Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces.

Table 3.4 Requirements of Elastomeric Thermoplastic Polymer Modified Bitumen (PMB)

S. No	Characteristic	Grade and Requirements			Test Method
		PMB-120	PMB-70	PMB-40	
1	Penetration at 25°C, 100 g, 5 s, 0.1 mm, min	90-150	50-90	30-50	IS 1203
2	Softening point (R&B) temperature, °C, min	50	55	60	IS 1205
3	Fraass Breaking Point*, °C, max	-20	-16	-12	IS 9381
4	Flash Point (COC method), °C, min	220	220	220	IS 1209
5	Elastic Recovery of Half Thread in ductilometer at 15°C, percent, min	75	75	75	Annex 2 of IRC:SP:53-2010
6	Separation, difference in softening point (R&B) temperature, °C, max	3	3	3	Annex 3 of IRC:SP:53-2010
7	Viscosity at 150°C, Poise	1-3	2-6	3-9	IS 1206 (part 2)
8	Tests on Residue from Rolling Thin Film Oven Test				
	(a) Loss in mass, percent, max	1.0	1.0	1.0	IS 9382
	(b) Increase in Softening Point, °C, max	7	6	5	IS 1205
	(c) Reduction in Penetration, of residue at 25 °C, percent, max	35	35	35	IS 1203
	(d) Elastic Recovery of Half Thread in ductilometer at 25°C, percent, min	50	50	50	Annex 2 of IRC:SP:53-2010

* Relevant to snow bound cold climate arears

Table 3.5 Physical Properties of Coarse Aggregate

Property	Test	Requirement	Test Method
Cleanliness	Grain Size Analysis	Max.3% passing 0.075 mm sieve	IS 2386 Part 1
Particle shape	Flakiness and Elongation Index (combined)	Max 30%	IS 2386 Part 1
Strength	Los Angeles Abrasion Value	Max 30%	IS 2386 Part 4
	Aggregate Impact Value	Max 24%	IS 2386 Part 4
Polishing *	Polished Stone Value	Min 55	IS 2386 Part 4
Durability	Soundness (Sodium or Magnesium Sulphate) – 5 cycles		
	Sodium Sulphate	Max. 12%	IS 2386 Part 5
	Magnesium Sulphate	Max. 18%	IS 2386 Part 5
Water Absorption	Water Absorption	Max. 1%	IS 2386 Part 3
Stripping **	Coating and Stripping of Bitumen Aggregate Mixtures	Min. retained coating 95%	IS 6241
Water sensitivity***	Retained Tensile Strength Ratio (TSR)	Min. 80%	AASHTO T 283

* Only for wearing courses

** This test shall be conducted as a screening test for coarse aggregate only. It is mandatory to conduct AASHTO T 283 for moisture susceptibility (**Annexure I**), which is conducted on the whole designed bituminous mix as specified in **Table 3.9**

*** for TSR less than 80%, use of anti-stripping agents is recommended.

3.1.3 *Fine Aggregate*

Fine aggregate shall consist of crushed or naturally occurring mineral material, or a combination of two, passing 2.36 mm sieve and retained on 0.075 mm sieve. No natural sand shall be allowed in the binder and wearing courses and no more than 10 percent natural sand shall be allowed in the base courses. The fine aggregate shall be clean, hard, durable, dry and free from dust and soft organic and other deleterious substances. Fine aggregate shall have a sand equivalent value not less than 50 when tested in accordance with the requirement of IS 2720 Part 37. The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4% when tested in accordance with IS 2720 Part 5. Aggregates for pavement mix shall be natural material complying with IS:383 but with a Los Angeles Abrasion Test value not exceeding 30 percent. The limits of deleterious materials shall not exceed the requirements set out in **Table 3.6**.

Table 3.6 Permissible Limits of Deleterious Substances in Fine and Coarse Aggregates (for All Layers)

S. No	Deleterious Matter	Test Method	For Fine Aggregates, Percent by weight, max		For Coarse Aggregates, Percent by weight, max	
			Uncrushed	Crushed*	Uncrushed	Crushed*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Coal and lignite	IS:2386 (Part 2)-1963	1.0	1.0	1.0	1.0
2	Clay lumps	IS:2386 (Part 2)-1963	1.0	1.0	1.0	1.0
3	Material finer than 75 Micron IS sieve	IS:2386 (Part 1)-1963	3.0	8.0	3.0	3.0
4	Soft fragments	IS:2386 (Part 2)-1963	-	-	3.0	-
5	Shale	IS:2386 (Part 2)-1963	1.0	-	-	-
6	Total of percentages of all deleterious materials (except mica) including SNos. 1 to 5 for col 4,6 and 7 and SNos. 1 and 2 for Col 5 only		5.0	2.0	5.0	5.0

* Crushed aggregate with at least one fractured face

3.1.4 *Filler*

Filler shall consist of finely divided mineral matter such as rock dust, or hydrated lime or cement as approved by the Engineer. The use of hydrated lime is encouraged because of its very good anti-stripping and antioxidant properties. Rock dust or cement may be used if hydrated lime is not available. The filler shall be graded within the limits indicated in **Table 3.7**.

Table 3.7 Grading Requirement of Mineral Filler

IS Sieve (mm)	Cumulative % passing by Weight of total Aggregate
0.6	100
0.3	95 - 100
0.075	85 - 100

The filler shall be inert material free from organic impurities and shall have Plasticity Index (PI) not greater than 4%. PI requirement will not apply if the filler is hydrated lime or cement. Where the complete bituminous mixture fails to satisfy requirement of moisture susceptibility test (AASHTO T 283 with freeze & thaw option) 2% (by total weight of aggregate) hydrated lime shall be used and the percentage of fine aggregate reduced accordingly. See **Annexure I** for the outline of modified AASHTO T 283.

3.1.5 *Aggregate Grading and Bitumen Content*

The combined grading of the coarse aggregate, fine aggregate and filler, when tested in accordance with IS 2386 Part 1, wet sieving method, shall confirm to limits given in **Table 3.8**. The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The fines to bitumen (F/B) ratio by weight of total mix shall range from 0.8 to 1.2 for all mixes mentioned in **Table 3.1**.

Table 3.8 Aggregate Gradation and Bitumen Content

Course	**Base Course**	**Binder Course**	**Wearing Course**
Grading	DBM Grading 2	BC Grading 1	BC Grading 2
Nominal Maximum Aggregate Size (NMAS)*	26.5 mm	19 mm	13.2 mm
Layer Thickness	50-100 mm	50-75 mm	40-50 mm
IS Sieve Size (mm)	Cumulative % by weight of total aggregate passing		
37.5	100		
26.5	90-100	100	
19	71-95	90-100	100
13.2	56-80	59-79	90-100
9.5	-	52-72	70-88
4.75	38-54	35-55	53-71
2.36	28-42	28-44	42-58
1.18	-	20-34	34-48
0.6	-	15-27	26-38
0.3	7-21	10-20	18-28
0.15	-	5-13	12-20
0.075	2-8	2-8	4-10
Bitumen Content (Min)**			
VG Grade Bitumen	4.5%	5.2%	5.4%
PMB	-	5.4%	5.6%

* Nominal Maximum Aggregate Size is the largest specified sieve size upon which any of the aggregate is retained.

** Bitumen content indicated in **Table 3.8** is the minimum only. The exact bitumen content required shall be determined following the Marshall Mix Design procedure contained in the Asphalt Institute Manual MS-2 (Seventh Edition). The minimum bitumen contents given in the table correspond to a bulk specific gravity of aggregates of 2.7. If the bulk specific gravity of aggregates is more than 2.7, the minimum bitumen content requirement can be reduced proportionately.

3.2 Mix Requirements

3.2.1 Besides conforming to the requirements of grading and quality for individual ingredients, the mix shall meet the requirement set out in **Table 3.9**.

Table 3.9 Requirements for DBM Grading 2, BC Grading 1 and BC Grading 2 Mixes

Parameter	Requirement		
Compaction Level (number of blows)	75 blows on each face of the specimen		
Stability at 60°C (kN) AASHTO T 245, Min	9.0 for DBM-2 12.0 for BC-1 14.0 for BC-2		
Flow (AASHTO T 245), mm	2.0 – 4.0		
Air Voids (MS-2 and ASTM D 2041), Percent	3-5		
Voids Filled with Bitumen (VFB) (Asphalt Institute, MS-2), Percent	65-75		
Marshall Quotient (stability/flow), kN/mm	2.5 to 5.0		
Tensile Strength Ratio (TSR), (AASHTO T 283 with freeze and thaw option) (see **Annexure I** for the outline of this modified test method), Percent, Min.	80		
Skid resistance (Airport Surface Friction Tester-ASFT), ASTM E 1551, Min.	0.74 (ICAO 2002)		
% Voids in Mineral aggregate VMA*			
Nominal Maximum Aggregate Size (mm)	Min VMA (%) related to design air voids (%)		
	3.0	4.0	5.0
9.5	14	15	16
13.2	13	14	15
19.0	12	13	14
26.5	11	12	13
Coating and stripping of aggregates, Min	95%	95%	95%
Retained Stability (24 hours, 60°C, %, Min	90	90	95

* for intermediate air void contents, the min. VMA can be interpolated

3.2.2 *Binder Content*

The binder content shall be selected to obtain 3 - 5 percent air voids in the mix and to meet all the requirements given in **Table 3.9**. The Marshall Method for designing the mix shall be adopted as described in the Seventh Edition of the Asphalt Institute Manual MS-2. Binder content test to be regularly conducted on plant mix.

3.2.3 *Tensile Strength Ratio (TSR)*

TSR of the design mix shall be determined in accordance with AASHTO T 283 (Refer **Annexure-I** for outline of this test). If the TSR of the mix conditioned with one Freeze and thaw cycle is less than 80%, hydrated lime or liquid anti-stripping agent shall be used to satisfy this criterion.

3.2.4 *Job Mix Formula*

Prior to the start of work, the job mix formula shall be developed based on mix design conducted by an approved laboratory. The laboratory mix design gives the proportion of the mineral aggregate combination in terms of individual sieve sizes, for actual operational purpose in the field, blending of the two or more sizes of aggregates (each size having within its range of individual sieve size) would be necessary. This blending ratio is obtained on a weight basis giving percent weight of the coarse aggregate, fine aggregate and filler needed to give the ultimate gradation. This mineral aggregate combination together with the corresponding optimum bitumen content as determined in the laboratory, constitute the job mix formula for implementation during construction. The job mix formula proposed for the use in the work shall give the following details:

i. Source and location of all materials
ii. Proportions of all materials
iii. Binder type and percentage by weight of total mixture
iv. Coarse aggregate/fine aggregates/mineral filler as percentage by weight of total aggregate
v. A single definite percentage passing each sieve for the mix aggregate
vi. The individual grading of the individual aggregate fraction and the proportion of each in the combined grading
vii. The test results of mix design such as theoretical maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs, and test results of AASHTO T 283 Moisture Susceptibility Test
viii. In case of batch mixer, the individual weight of each type of aggregate and binder per batch
ix. Test results of aggregates and of all constituent materials.

Approval of the job mix formula shall be based on independent testing by the Engineer on the samples furnished by the Contractor. It should be ensured that it is based on the truly representative samples of the material that will be used for the work. New job mix formula shall be approved whenever there is change in source of any constituent material used for the work.

3.2.5 *Plant Trials*

Plant trials shall be carried out to establish that the plant can produce uniform mix conforming to the job mix formula. The permissible variation of the various ingredients in the actual mix from the job mix formula shall be within the limits given in **Table 3.10.** These variations are intended to apply to individual specimen taken for quality control test.

Table 3.10 Permissible Variation from the Job Mix Formula

Description	Permissible Variation	
	DBM	BC
Aggregate cumulative % passing		
19 mm or larger	± 8%	± 7%
13.2 mm/9.5 mm	± 7%	± 6%
4.75 mm	± 6%	± 5%
2.36 mm, 1.18 mm, 0.6 mm	± 5%	± 4%
0.3 mm, 0.15 mm	± 4%	± 3%
0.075 mm	± 2%	± 1.5%
Binder Content	± 0.3%	± 0.3%
Mixing Temperature	± 10°C	± 10°C

3.2.6 *Laying Trials*

Laying trials are carried out to establish that the proposed mix can be successfully laid and compacted. The laying trial shall be carried out in an area, which does not form a part of the work. A test track of 90 m long and 6-9 m wide is to be laid. This shall be similar to the project area on which the bituminous layer is to be laid. Methodology, equipment and mix shall also be similar to those proposed for the project.

The trials should establish that the proposed laying plan, compaction plan, and methodology are capable of producing satisfactory results. The density of finished paving layer should not be less than 93% of the average (Sample size N=3) theoretical maximum specific gravity of the loose mix (Gmm) obtained on the day of trial following ASTM D 2041. See **Annexure II** for the outline of ASTM D 2041.

3.3 Construction Operations

3.3.1 *Preparation of Base*

(a) **Cleaning of the Surface:** The surface shall be cleaned of all loose extraneous matter by means of mechanical broom and high- pressure air jet from compressor or any other approved equipment/method.

(b) **Filling up of potholes and sealing of cracks:** Any potholes and/or cracks shall be repaired and sealed with the same material with which it is overlaid.

(c) **Geosynthetics or Stress Absorbing Layers:** Where specified layer of geosynthetics/stress absorbing material is to be laid it should be as per Specifications confirming to MoRTH.

(d) **Profile Correcting Course:** Depending upon site requirement, profile correcting course for correcting the existing pavement profile shall be laid either as a separate layer or as a composite layer with varying thickness as per layer charts. DBM Grading 2 be used for this or as per given design.

3.3.2 *Mixing*

Dense graded bituminous mixes shall be prepared in a Hot Mix Plant (HMP) of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregate. The HMP employed at site shall be a weigh batch plant having a minimum capacity of 100 TPH. The calibration certificate of the HMP used in the project shall be submitted to the Engineer prior to the commencement of trial works. All plants used by the contractor for the preparation of asphalt paving mixes shall be equipped with the following:

a) Facility for obtaining hot bin aggregate samples
b) Means for accurately weighing each batch of aggregate with separate load cells in each bin before the combined aggregate mix is finally added to the pug mill with heated bitumen
c) Bitumen tanks with arrangement of heating under effective and positive control at all times. There should be satisfactory devices for weight, metering and temperature monitoring of the bitumen
d) A mixer unit capable of producing a uniform mixture
e) If Polymer Modified Bitumen is used, Guidelines on use of Modified Bitumen as stated in IRC:SP:53 should be followed for transportation, storage and heating.

Table 3.11 gives the mixing, laying, and rolling temperatures for dense graded mixtures with reference to clause 501.3 MoRTH Specifications. Exact mixing and compaction temperatures for VG-30 and other viscosity grades will be determined based on paving bitumen viscosities at 60ºC and 135ºC following the procedure given in the Asphalt Institute Manual MS-2. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with conventional bitumen as binder. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to ensure uniform quality of mix, the plant shall be calibrated from time to time.

Table 3.11 Mixing, Laying and Rolling Temperatures for Dense Bituminous Mixtures (Degree Celsius)

Bitumen Viscosity Grade	Bitumen Temperature (°C)	Aggregate Temperature (°C)	Mixed Material Temperature (°C)	Laying Temperature (°C)	*Rolling Temperature (°C)
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
PMB	165-185	165-185	150-170	140-160	110 Min

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

3.3.3 *Transportation*

Bituminous material shall be transported in clean, insulated covered vehicles. Asphalt release agent, which does not adversely affect the bituminous mix, may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material. Use of diesel oil shall not be allowed as asphalt release agent. The hot mix in the truck shall be covered adequately with tarpaulin at all times to minimize loss of heat.

3.3.4 *Laying*

(a) Weather and Seasonal Limitations

Bituminous mixes shall not be laid:

(a) In presence of standing water on the surface

(b) When rain is imminent and during rains, fog, or dust storm

(c) When the base/binder course is damp

(d) When the air temperature on the surface on which it is to be laid is less than 10°C for mix with conventional bitumen as binder and is less than 15°C for mix with modified bitumen as binder

(e) When the wind speed at any temperature exceeds 40 km/h at 2-meter height

(b) Preparation of the Base: Base shall be prepared by carrying out all or some of the operations as per Clause 3.3.1, depending upon the site conditions.

(c) Spreading: Except in areas where paver cannot access, bituminous mix shall be spread, levelled and tamped by self-propelled hydrostatic paver finisher with a sensor. The paver shall be capable of laying asphalt mix to a minimum width of 7.5 m. As soon as possible after arrival at site the material 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 to avoid minor undulations. The travel rate of paver and the method of operation shall be adjusted to ensure even and uniform flow of bituminous mix, free from dragging, tearing and segregation.

3.3.5 *Compaction*

Compaction shall commence as soon as possible after laying and shall be completed before the temperature falls below the minimum rolling temperatures given in **Table 3.11**. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, the rolling shall commence at the edge and progress towards the center longitudinally except at sections with unidirectional camber, where it shall progress from lower edge to upper edge parallel to center line of the pavement. Paving and Rolling operations should be planned such that the pavers and rollers do not stop anywhere on the paving mat during the work (to avoid minor undulations).

The initial or breakdown rolling shall be done with a vibratory steel wheel roller in vibratory mode. However, the vibratory system shall be turned off during the first pass if the mix is too tender or plastic. The intermediate rolling shall be done with smooth wheel pneumatic tyred roller of

15 to 30 tonnes, with a tyre pressure of at least 7 kg/sq cm. The finished rolling shall be done with 8 to 10 tonnes smooth wheel roller. Rolling shall continue till all the roller marks are removed from the surface and the minimum specified field density is achieved. Rolling pattern shall be finalized by engineer while laying the trial bay.

The dense graded bituminous mixes shall be rolled in the longitudinal direction, with the roller as close as possible to the paver. The overlap on successive passes should be at least one-third of the width of the rear roll or in the case of pneumatic wheeled rollers, at least the nominal width of 300 mm. The roller should move at a speed of no more than 5 km/hour. The roller shall not be permitted to stand on the pavement, which has not been fully compacted. All precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign material on the pavement. The wheel of the rollers shall be kept moist with the water or spray system provided with the machine to prevent the mixture from adhering to the wheels. Minimum moisture to prevent adhesion between wheels and mixture shall be used and surplus water shall not be allowed to stand on the partially completed pavement.

The final compaction will be carried out with a pneumatic tyred roller of 15 to 30-ton capacity having tyre pressure of 7 kg/sq cm after the of entire paving operations are completed. This should be done on bright sunny days such that each area on the entire airfield is rolled minimum five times considering overlap of each pass of PTR.

The degree of compaction achieved by rolling shall be determined by cutting 150 mm diameter cores from the finished surface. One field density test shall be conducted for every 500 sq m. If required cores can be cut as per site condition/finished surface to determine the field density and relative compaction in percentage. The field density should be at least 93% of the maximum theoretical specific gravity of the loose mix obtained on that day, that is, no more than 7% air voids in the compacted mat. The maximum theoretical specific gravity shall be determined in accordance with ASTM D 2041 (refer **Annexure-II** for outline of this test). The portion of the work represented by the field density of which is less than 93% of maximum theoretical specific gravity shall be rejected.

Where this is not found possible, the work shall be removed and redone by the contractor at his own risk and cost. Use of nuclear or non-nuclear portable density gauge to control mat density during paving operations is recommended. However, only core density from 150 mm diameter cores shall be used for acceptance. Therefore, contractor shall correlate his density gauge with cores for that specific project during construction.

3.3.6 *Joints*

Echelon paving with two or more pavers should be used to minimize the number of longitudinal joints on the airfield. Longitudinal joints in successive layers shall be offset by at least 300 mm from parallel joints in the layer beneath.

All joints shall be cut vertical to an even line with a cutting wheel or other suitable device to a width not less than the course thickness. All loosened material shall be discarded and the vertical face be coated with tack coat of VG-30 or VG-10 viscosity grade bitumen or cold applied emulsified bitumen prior to laying the adjacent lane. While spreading the material along the joint the material spread shall overlap 25 mm to 40 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 should be bumped back with a lute just across the joint so that the excess material on the hot side can be pressed to obtain a high joint density. Rolling of longitudinal joints shall be done with roller on the hot side with 150 mm overlap on the previously laid cold lane. The joint density when measured by taking 150 mm diameter cores right on the joint shall be at least 90% of the theoretical maximum specific gravity obtained on that day. In multi–layer construction, the joints in one layer shall offset the joints in the underlying layer by 150 mm. However, the joint in the top layer shall be along the centre line of the pavement and to be kept to the minimum.

3.3.7 *Arrangement for Traffic*

It shall be ensured that no traffic is allowed on the surface until the paved mat has cooled below a temperature of 50°C, at its surface.

3.4 Controls

3.4.1 *Thickness Control and Measurement*

Thickness of various layers shall be accurately maintained during the construction as specified in the design and shall be checked/monitored continuously by taking regular levels and maintaining level sheets. Regular calibration of sensor paver to be ensured for thickness to be spread and compacted thickness should be monitored. In case of dispute the following method for determination of thickness be adopted:

Average Thickness Determination Using Cores: In areas where density testing using cores has been undertaken in accordance with the clause on compaction the average thickness of the course will be determined on the basis of thickness measurements of the cores obtained. Measurement of individual cores will be made after cleaning of any adhering material from the bottom of the core and shall be the average of four measurements of thickness made at approximately 90° apart. Measurements shall be made to the nearest 1 mm and the average of the four measurements expressed to the nearest 1 mm. The average thickness of a course in an area will be the average thickness of a minimum of four cores expressed to the nearest 1 mm and the area for each assessment shall be not less than 1,000 m^2 and not more than 1,500 m^2.

3.4.2 *Determination of Finished Surface Levels*

All finished surface levels shall be surveyed by precise levelling instruments and the survey shall be undertaken by Engineer-in-Charge. The finished surface level of the completed pavement shall not vary by more than 7 mm below or 7 mm above the finished surface level as finalized. Not withstanding, the interface of runway or taxiway and shoulders shall be flush.

3.4.3 *Tolerance in Surface Levels of Different Layers*

The levels of the subgrade and different pavement layers as constructed shall not vary from those calculated with surface to the longitudinal and cross profile of pavement as per ICAO standards/Relevant Specifications beyond the tolerances as mentioned below :

(a) Subgrade: +/- 15 mm
(b) Sub-base: +/- 10 mm (flexible pavement)
(c) Base Course:
   i. Bituminous: +/- 6 mm
   ii. Granular: +/- 10 mm
(d) Wearing Course: +/- 3 mm

3.4.4 *Surface Evenness*

The measurement and checking of surface evenness shall be done by a 3 m straight edge in accordance with the procedures in IRC:SP:16. The maximum permissible surface unevenness using this longitudinal profile 3 m straight edge shall be 3 mm.

Where the surface unevenness falls outside the tolerance, in either case i.e. the surface is low or high, the full depth of the layer shall be removed and replaced with fresh material and compacted to the Specification.

3.4.5 *Surface Finish*

The finished surface of the asphalt wearing course shall present a tightly bonded surface of uniform appearance, free of dragged areas, cracks, segregation and open textured patches. The quality of surface finish shall be finalized during trial bay.

3.4.6 *Quality Control during Construction*

The material supplied and the work shall conform to the Specifications prescribed in the preceding Clauses. To ensure the quality of the material and the work, control tests shall be conducted during the execution of the paving project. The tests and minimum frequency for each test are indicated in **Table 3.12**.

Table 3.12 Control Tests for Dense Graded Bituminous Mixes/BC and their Minimum Frequency

S. No	Test	Frequency
1	Quality of binder*	Number of samples per lot and tests as per IS 73/IRC:SP:53/IS 15462
2	Aggregate impact value/Los Angeles Abrasion value	One test per 50 m^3 of aggregate and whenever there is change of source
3	Flakiness and Elongation Index (combined)	One test per 50 m^3 of aggregate
4	Soundness test (Sodium or Magnesium Sulphate test)	1 test for each method for each source and whenever there is change in the quality of aggregate
5	Water absorption of aggregate	1 test for each source and whenever there is change in the source of aggregate
6	Sand equivalent test	1 test for each source

S. No	Test	Frequency
7	Plasticity Index	1 test for each source
8	Polished stone value	2 test for each source and whenever there is change in aggregate
9	Percent of fractured faces	One test per 50 m^3 of aggregate when crushed gravel is used.
10	Mix grading	One set for individual constituent material and mixed aggregate from dryer for each 400 tonnes of mix subject to minimum of three tests per day per plant
11	Stability and voids analysis of mix including theoretical maximum specific gravity of loose mix	3 tests for stability, flow value, density and void contents for each 400 tonnes of mix subject to minimum of three tests per day per plant
12	Moisture Susceptibility of mix (AASHTO T 283)	1 test for each mix type whenever there is change in the quality or source of coarse or fine aggregate
13	Temperature of binder in boiler, aggregate in dryer and mix at the time of laying and compaction	At regular intervals during everyday's work
14	Binder content (centrifuge or NCAT Ignition Oven Method)**	One set for each 400 tonnes of mix subject to minimum of three tests per day per plant
15	Density of compacted layer	One test per 500 m^2 area.

* Each tanker of bitumen binder before being used shall be tested for all Specifications as per IRC/IS and manufacture test certificate.

** Bitumen content shall be determined using the centrifuge method (ASTM D 2172) or NCAT Ignition Oven method (ASTM D 6307). If centrifuge method is used, the fines passing through the filter and are in the extract solvent shall be accounted for by the ash method. If NCAT Ignition Oven is used it shall be calibrated for the mix being tested.

Annexure I

OUTLINE OF AASHTO T 283, "RESISTANCE OF COMPACTED ASPHALT MIXTURES TO MOISTURE-INDUCED DAMAGE"

1. Scope and Summary of Test Method

This method covers preparation of compacted bituminous mixtures and the measurement of the change of diametral tensile strength resulting from the effects of water saturation and laboratory accelerated stripping phenomenon with a freeze-thaw cycle. The result may be used to predict long-term stripping susceptibility of bituminous mixtures and evaluate liquid anti-stripping additives that are added to bitumen or pulverized mineral materials such as hydrated lime, which are added to the mineral aggregate.

Each set of 6 compacted specimens is divided into two equal subsets. One subset is tested in dry condition for indirect tensile strength. The other subset is subjected to vacuum saturation and a freeze-thaw cycle (thawing in a hot water bath) before testing for indirect tensile strength. Numerical indices of retained indirect tensile strength properties are calculated from the test data obtained by testing the two subsets: dry and conditioned.

2. Testing Equipment

(a) Vacuum container, vacuum pump, manometer, and other accessories as specified in ASTM D 2041, "Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures".

(b) Balance or scale accurate to 0.1 percent of the test load

(c) Two water baths capable of maintaining temperatures of 60ºC +/- 1ºC and 25ºC +/- 0.5ºC

(d) Freezer maintained at –18ºC (+/- 3º C)

(e) 10 ml graduate cylinder

(f) Loading jack and ring dynamometer (Marshall stability testing machine can be used) to provide a vertical rate of deformation of 50 mm (2 inches) per minute and capable of reading the maximum failure load

(g) Steel loading strips with a concave surface having a radius equal to the normal radius of the test specimen. The loading strips shall be 12.7 mm (0.5 inch) wide for specimens 100 mm (4 inches) in diameter. The loading strips for 150 mm (6 inches) diameter specimens shall be 19.05 mm (0.75 inch) wide. The length of the loading strips shall exceed the thickness of the specimens. Steel strip are provided at the top and bottom of specimens during indirect tensile testing.

3. Test Procedure

(a) Make at least 6 compacted specimens for each mixture, 3 to be tested dry and 3 to be tested after partial saturation and moisture conditioning with a freeze-thaw cycle. Some extra specimens will need to be made to establish compaction procedures in order to obtain specified air void contents in the test specimens by trial and error.

(b) Compact the 6 specimens with a Marshall Compactor so that the compacted specimens have air voids of 7.0 +/- 0.5 percent. This level of high air voids can be obtained by adjusting the number of Marshall blows applied on each side of the specimen by trial and error (start at about 10 blows as a starting point). Air void content must be calculated from the bulk specific gravity of the compacted specimen (determined by saturated surface dry method as per procedure given in the Asphalt Institute MS-2) and the maximum theoretical specific gravity of the loose bituminous mixture obtained by ASTM D 2041.

(c) Separate the 6 specimens into 2 subsets so that the average air voids of the two subsets are approximately equal.

(d) One set will be tested dry. Keep it at room temperature and then place in a 25ºC (+/- 0.5ºC) water bath for 2 hours prior to determining their indirect tensile strength.

(e) The other subset will be conditioned as follows:

   (i) Place and submerge the 3 specimens in the vacuum container filled with water at room temperature. Apply a vacuum of 13-67 kPa absolute pressure (10-26 inches Hg partial pressure) for 30 minutes. Remove the vacuum and leave the specimens submerged in water for 5 to 10 minutes. (Note: The water saturation procedure noted above deviates from AASHTO T 283, which obtains a specified degree of saturation. The above procedure keeps the time of saturation constant).

   (ii) Wrap a plastic film around eachsaturated specimen and place the wrapped specimen in a plastic bag containing 10 ml of water and seal the plastic bag. Place the plastic bag in a freezer at temperature of –18ºC +/- 3ºC for a minimum of 16 hours. Remove the specimens from the freezer.

   (iii) Place the specimens in a waterbath maintained at 60ºC +/- 1ºC for 24 hours. Remove the plastic bag and the plastic film from each specimen after placing the specimens under water.

   (iv) Remove the specimens from hotwater bath and place in a water bath maintained at 25ºC +/- 0.5ºC for 2 hours.

   (v) Remove the conditioned specimens and test for indirect tensile strength.

(f) Determine the indirect tensile strength of the 3 dry and 3 conditioned specimens at 25º C +/- 0.5ºC after removing from water bath. First, measure their mean thicknesses (t). Then place the two steel loading strips on the bottom and top of the specimens across diameter and place in the Marshall testing machine or a compression-testing machine. Apply load to the specimens diametrally at a vertical rate of 50 mm (2 inches) per minute.

(g) Record the maximum compressive strength noted on the testing machine and continue loading until a vertical crack appears in the specimen. Remove the cracked specimen from the machine and visually estimate the approximate degree of moisture damage (extent of stripped or bare aggregate) on the fractured faces of the specimen on a scale of 0 to 5 (5 being the most stripping).

(h) Calculate the tensile strength (S_t) in SI units of each specimen as follows: $S_t = 2000\ P/\pi\ td$

Where, S_t = tensile strength, kPa

P = maximum loads, N

t = specimen thickness, mm

d = specimen diameter, mm

(i) Express the numerical index of resistance of bituminous mixture to the detrimental effects of water as the ratio of the original strength that is retained after accelerated moisture and freeze-thaw conditioning.

Calculate the tensile strength ratio (TSR) as follows:

Tensile Strength Ratio (TSR) = 100*(S2 / S1)

Where,

S1 = average tensile strength of the dry subset, kPa

S2 = average tensile strength of the conditioned subset, kPa

Annexure II

OUTLINE OF ASTM D 2041, "THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF BITUMINOUS PAVING MIXTURES"

1. Scope and Summary of the Test Method

This test method covers the determination of the theoretical maximum specific gravity and density of uncompacted bituminous paving mixtures at 25ºC. The theoretical maximum specific gravity (Gmm) is used: (a) to calculate air voids in compacted bituminous mixtures, (b) to calculate the amount of bitumen absorbed by the aggregate, and (c) to provide target value for the compaction of paving mixtures in the field.

A sample of loose paving mixture is placed in a tarred vacuum vessel. Water at 25ºC is added to completely submerge the sample. A specified amount of vacuum is gradually applied to remove the air bubbles entrapped between asphalt mix particles. After the vacuum is released, the volume of the sample of the void less paving mixture is obtained by either immersing the vacuum container with the sample in a water bath and weighing or by filling the calibrated vacuum container level full of water and weighing in air.

2. Testing Equipment

(a) Container (either i or ii detailed below)

i. Vacuum bowls – Either a metal or plastic bowl with a diameter arranging from 180 to 260 mm and a bowl height of at least 160 mm. The bowl shall be equipped with a stiff, transparent cover fitted with a rubber gasket and a connection for the vacuum line. The hose connection shall be covered with a small piece of fine wire mesh to minimize loss of any fine material from the mix.

ii. Vacuum flask for weighing in air only – A thick-walled volumetric glass flask with a capacity of approx. 4000 ml, fitted with a rubber stopper with a connection for the vacuum line. The hose connection shall be covered with a small piece of fine wire mesh to minimize loss of any fine material from the mix.

(b) Balance capable of being read to the nearest 0.1 gram. If weighing is to be done under water, a suitable suspension arrangement shall be provided for weighing the sample while suspended from the center of the balance.

(c) Vacuum pump, capable of evacuating air from the vacuum container to a residual pressure of 4.0 kPa (30 mm of Hg) or less. Provide a suitable trap between the pump and container to minimize water vapour entering the vacuum pump.

(d) Residual pressure manometer or calibrated absolute pressure gauge with a bleed valve to adjust the vacuum level.

(e) Water bath capable of maintaining a constant temperature of 25ºC +/-1ºC and suitable for immersion of the suspended container.

3. Calibration of Containers

(a) Bowls – Determine the mass (B) of the container immersed in water at 25ºC +/- 1ºC. If the bowl is used for weighing in air, place the volumetric lid on the bowl while under water. Remove the water-filled bowl with the lid in place and dry prior to determining the combined mass of the bowl, lid and water. Repeat 3 times and average the 3 masses. Designate the average mass as D.

(b) Flasks – Calibrate the volumetric flask by accurately determining the mass of the flask filled with water at 25ºC +/- 1ºC. Use a glass cover plate to ensure the flask is completely full.

4. Test Procedure

(a) Separate the particles of the loose paving mixture (while it is warm) by hand so that the particles are not larger than about 6 mm. Do not fracture the aggregate. Place the mix sample directly into the tared bowl or flask. Weigh the container with the sample and designate the net mass of the sample only as A. (Note: The minimum sample size shall be 1500 g for mixes with nominal maximum aggregate sizes of 12.5 mm or smaller; and shall be 2500 g for mixes with nominal maximum aggregate sizes from 19 to 25 mm.)

(b) Add sufficient water at 25ºC to cover the sample completely. Place the cover (bowels) or stopper (flasks) on the containers.

(c) Place the container with the sample and water on a mechanical agitation device or agitate manually at frequent intervals (2 to 3 minutes). Begin removing entrapped air by gradually applying vacuum and increasing the vacuum pressure until the residual manometer reads 3.7 +/- 0.3 kPa (27.5 +/- 2.5 mm of Hg). After achieving this level within 2 minutes, continue the vacuum and agitation for 15 +/- 2 minutes. Gradually release the vacuum with the bleed valve.

(d) Weighing in water: Suspend the bowl (without lid) and contents in water for 10 +/- 1 minutes and then determine mass. Designate the mass under water of the bowl and sample as C.

(e) Weighing in air:

i. Bowl – Submerge the bowl and sample slowly in the 25ºC +/- water bath. Keep it there for 10 +/- 1 minutes. Immerse the lid in water and slide it onto the bowl without removing water from the bowl so that no air is trapped inside the bowl. Remove the bowl with the lid in place from the water bath. Dry the bowl and lid with a dry cloth. Determine the mass of the bowl, sample, and lid and designate it as E.

ii. Flask – Fill the flask slowly with water ensuring not to introduce any air into the sample. Place the flask in water bath for 10 +/- 1 minutes to stabilize the temperature at 25ºC without submerging the top of the flask. Completely fill the flask with water using a cover plate without entrapping air beneath the cover plate. Wipe the exterior of the flask and cover plate. Determine the mass of the flask, plate and its contents completely filled with water. Designate this mass as E.

(f) Calculations – Calculate the maximum specific gravity of the sample of loose paving mixture as follows:

Bowls Used Under Water

Determination: Gmm = A / [A-(C-B)]

Where,

Gmm = maximum specific gravity of the mixture

A = mass of the dry sample in air, g

B = mass of bowl under water, g

C = mass of bowl and sample under water, g

Bowls in Air Determination

Gmm = A / (A+D-E)

Where,

Gmm = maximum specific gravity of the mixture

A = mass of dry sample in air, g

D = mass of lid and bowl with water at 25ºC, g

E = mass of lid, bowl, sample and water at 25ºC, g

Flask

Gmm = A/(A+D-E)

Gmm = maximum specific gravity of the mixture

A = mass of dry sample in air, g

D = mass of cover plate and flask filled with water at 25ºC, g

E = mass of flask, cover plate, sample, and water at 25ºC, g

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the Code/Guidelines/Manual, etc. from the date specified therein)