ROAD PAVEMENTS – BITUMINOUS BOUND MATERIALS

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Road Pavements – Bituminous Bound Materials

901 Bituminous Base and Surfacing Materials

General

1 Bituminous pavement courses shall be made using the materials described in Appendix 7/1. For the purpose of this specification all references to BS EN 12591 bitumen grade penetration 100/150 in BS 4987 'Coated macadams (asphalt concrete) for roads and other paved areas' shall be replaced by IS EN 12591 bitumen grade penetration 70/100. In addition, when 70/100 bitumen grade penetration is used in coated macadams (asphalt concrete):

(i) The maximum temperature of the mixture at any stage shall be 180°C,

(ii) The minimum temperature of the mixture in the lorry within 30 minutes after arrival on site shall be 125°C,

(iii) The minimum temperature immediately prior to rolling shall be 105°C,

(iv) The minimum rolling temperature shall be 85°C, and

(v) The recommended storage temperature of 70/100 bitumen grade penetration is 160°C.

2 All references in BS 4987 to the Highways Agency Specification for Highway Works Clause 929 shall be replaced by the National Roads Authority Specification for Road Works Clause 929.

The aggregate gradings contained in Tables 9/1 and 9/2 of this series shall take precedence over the aggregate grading requirements of BS 4987 and BS 594.

Aggregates for Bituminous Materials

3 Aggregates shall be natural, clean, hard and durable crushed rock or crushed gravel and shall comply with the selected requirements of IS EN 13043. Crushed gravel shall comply with category $C_{100/0}$ as defined in IS EN 13043.

Additionally, aggregates for use in surface course mixes, surface dressing, and in coated chippings for application to rolled asphalt surface courses, shall have a uniform and similar colour throughout the area of surfacing within the contract.

Resistance to Fragmentation (Hardness)

Unless otherwise stated in Clause 938, 942 or Appendix 7/1, coarse aggregates for bituminous materials shall have the following property:

(i) The resistance to fragmentation of the coarse aggregate in accordance with clause 4.2.2 of IS EN 13043 shall be LA_{30} or less.

Resistance to Freezing and Thawing (Durability)

Unless otherwise stated in Appendix 7/1, aggregates shall be deemed to be freeze/thaw resistant if they conform to the water absorption category $WA_{24}2$ in accordance with IS EN 13043 Clause 4.2.9.1. Aggregates with water absorption greater than 2% should be considered satisfactory if they conform to the magnesium sulfate soundness category MS_{25} in accordance with IS EN 13043 Clause 4.2.9.2.

Cleanness

Unless otherwise stated in Table 9/1, 9/2 or Appendix 7/1, the fraction of material passing the 0.063 mm sieve, for coarse and fine aggregates for bituminous materials, shall not exceed the limits stated in BS 594: Part 1 and BS 4987: Part 1, when tested in accordance with the washing and sieving method of IS EN 933-1.

Transporting

4 Bituminous materials shall be transported in clean insulated vehicles and shall be covered while in transit or awaiting tipping. To facilitate discharge of the mixed materials, dust, coated dust, water or the minimum of liquid soap, vegetable

oil, or other non-solvent solutions may be used on the interior of the vehicles, but the amount shall be kept to a minimum by brushing. Prior to loading, the body shall be tipped to its fullest extent with the tailboard open to ensure drainage of any excess. The floor of the vehicle shall be free from adherent bituminous materials or other contaminants.

Laying

5 On each day, and at each location where bituminous material is laid, at least 300 tonnes from an approved source shall be placed before material from another approved source is used. If the Contractor demonstrates that the materials from different approved sources are of equivalent quality and possess equivalent laying and compaction characteristics this requirement will be waived.

6 Wherever practicable, bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine. As soon as possible after arrival at site the materials shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The horizontal alignments, surface levels and surface regularity of the finished surface shall comply with Clause 702.

7 The travel rate of the paver, and its method of operation, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, so that the material is free from dragging, tearing and segregation.

8 Unless otherwise stated in Appendix 7/1, or elsewhere in this Specification, materials shall be laid in accordance with the requirements and recommendations for laying in BS 4987: Part 2 or BS 594: Part 2, as appropriate. The minimum thickness of material laid in each paver pass shall be in accordance with BS 4987: Part 2 or BS 594: Part 2, as appropriate, or the full course thickness, where this is less than the specified minimum in BS 4987: Part 2 or BS594: Part 2.

9 When laying binder course or surface course the paver shall be taken out of use when approaching an expansion joint of a structure. In laying the remainder of the pavement up to the joint, and the corresponding area beyond it by hand, the joint or joint cavity shall be kept clear of surfacing material.

10 With the exception of sand asphalt carpet, bituminous materials with a temperature greater than 125°C shall not be laid or deposited on bridge deck waterproofing systems unless adequate precautions are taken to avoid heat damage in accordance with a good industry practice. A maximum temperature of 145°C is permitted for sand asphalt carpet.

11 Hand placing of bituminous materials shall only be permitted in the following circumstances:

(i) For laying regulating courses of irregular shape and varying thickness.
(ii) In confined spaces where it is impracticable for a paver to operate.
(iii) For footways.
(iv) At the approaches to expansion joints at bridges viaducts or other structures.
(v) For laying mastic asphalt in accordance with BS 1447.

12 Hand-raking of surface course material or the addition of such material by hand spreading to the paved area, for adjustment of level, shall only be permitted in the following circumstances:

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

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

13 Hand laid work shall conform with the requirements of this Clause except those relating to pavers.

Compaction

14 Bituminous materials shall be laid and compacted in layer thicknesses, which enable surface level and regularity requirements to be met and adequate compaction to be achieved.

15 Compaction of bituminous materials shall commence as soon as the uncompacted material will bear the effects of the rollers without undue displacement or surface

cracking. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in BS 594: Part 2 or BS 4987: Part 2 or Clause 901 when using bitumen grade penetration 70/100. Rolling shall continue until all roller marks have been removed from the surface.

16 Except where otherwise specified compaction shall be carried out using 8-10 tonnes deadweight smooth wheeled rollers having a width of roll not less than 450 mm, or by multi-wheeled pneumatic-tyred rollers of equivalent mass, or by vibratory rollers or a combination of these rollers. Surface course and binder course material shall be surface finished with a smooth-wheeled roller which may be a deadweight roller or a vibratory roller in non-vibrating mode. Vibratory rollers shall not be used in vibrating mode on bridge decks.

17 Vibratory rollers may be used if they are capable of achieving at least the standard of compaction of an 8-tonnes deadweight roller. They shall be equipped or provided with devices, indicating the frequency at which the mechanism is operating and the travel speed, which can be read from the ground. The performance of vibratory rollers proposed for use shall be assessed as follows:

(i) by means of site trials in accordance with BS 598: Part 109; or

(ii) by the Contractor producing evidence of independent trials demonstrating that, under comparable conditions, a state of compaction at least equivalent to that obtained using an 8-tonnes deadweight roller is achieved by the make and model of vibratory roller proposed for use.

Where compaction is to be determined in accordance with sub-Clause 20 of this Clause, the requirements to prove the performance of rollers shall not apply. In such case the Contractor may use any plant to achieve the specified level of compaction and finish at temperatures above the minimum specified rolling temperature.

18 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 half the width of the rear roll or, in the case of a pneumatic-tyred roller, at least the nominal width of one tyre.

19 Rollers shall not be permitted to park or stand on warm compacted materials.

Compaction Assessment

20 Unless stated otherwise in Appendix 7/1, the compaction level of base and binder course macadams shall be determined by the Percentage Refusal Density Test procedure carried out in accordance with BS 598: Part 104 and as follows:

(i) At least 3 days before material from each source of macadam is first laid in the Works, the Contractor shall carry out a trial to demonstrate compaction plant and rolling procedures. The trial area shall be not less than 30 m nor more than 60 m long and of a width and thickness approved by the Employer's Representative. If the trial area complies with the Contract it may form part of the Permanent Works.

(ii) The materials, mixing and laying plant proposed for the Works shall be used for the trial.

(iii) At three locations selected by the Employer's Representative, two nominal 150 mm diameter cores shall be taken by the Contractor using an approved coring machine, in accordance with BS 598: Part 100. At least two of the locations shall be from the wheel track zones of the completed carriageway unless otherwise selected by the Employer's Representative. For the purposes of this Clause the wheel track zone shall be taken to be between 0.5 m and 1.1 m and between 2.55 m and 3.15 m from the centre of the nearside lane markings for each traffic lane.

(iv) The material in the trial area shall be deemed acceptable if the average

Percentage Refusal Density of the three locations is 93% or more when determined in accordance with the Percentage Refusal Density Test procedure carried out in accordance with BS 598: Part 104. Should the material not be deemed acceptable the trial area shall be removed and the trial repeated.

(v) Further material shall not be laid in the Works until the Employer's Representative has approved the material laid in the trial area.

(vi) The compaction level of base and binder course macadam forming the Permanent Works shall be tested to the frequency stated in BS 4987: Part 2, at locations as stated above.

(vii) The material in the Permanent Works shall be deemed acceptable if the average Percentage Refusal Density of the three locations is 93% or more when determined in accordance with the Percentage Refusal Density Test procedure carried out in accordance with BS 598: Part 104. Should the material not be deemed acceptable it shall be removed and replaced with complying material.

(viii) The walls and bases of holes from which core samples have been cut shall be dried, painted with hot bituminous binder, and filled to the underside of the surface course with heavy duty or dense macadam as appropriate, in accordance with BS 4987: Part 1, and be well rammed in layers not exceeding 50 mm. Where cores have been cut through the surface course, the last layer of fill material shall comply with the specification for the surface course.

The assessment of compaction of design mixes for base and binder courses shall be carried out in accordance with Clause 929.

Chippings

21 The application of coated chippings to areas of asphalt surface course shall be by an approved mechanical spreader capable of distributing chippings to an even rate of spread. Addition of chippings by hand operation shall only be permitted in the following circumstances:

(i) In confined spaces, where it is impracticable for a chipping spreader to operate.

(ii) As a temporary expedient, when adjustments have to be made to the spreader distribution mechanism.

(iii) When hand laying of the surface course is permitted.

(iv) To correct uneven distribution of chippings.

22 Chippings shall be applied uniformly and rolled into the surface course so they are effectively held and provide the specified texture depth.

Joints

23 Except where otherwise specified, where longitudinal joints are made in surface courses, the material shall be fully compacted and the joint made flush in one of the following ways;

(i) by using two or more pavers operating in echelon, where this is practicable. The pavers shall be in sufficient proximity for adjacent widths to be fully compacted by continuous rolling and the longitudinal edges effectively rolled together whilst hot.

(ii) by cutting back the exposed joint, for a distance equal to the specified layer thickness, to a vertical face, discarding all loosened material and coating the vertical face completely with a hot applied 40/60 penetration grade bitumen, or polymer modified adhesive bitumen tape with a minimum thickness of 2 mm, before the adjacent width is laid.

24 All joints shall be offset at least 300 mm from parallel joints in the layer beneath. Joints in surface courses shall coincide with either the lane edge or the lane marking, whichever is appropriate. No joints shall be formed between a hardstrip and the edge of the carriageway, nor within a hardstrip. Longitudinal joints in materials subject to Percentage Refusal

Density testing procedures shall not be situated in wheel track zones.

Bituminous Sprays

25 All bituminous surfaces shall be treated with a tack coat prior to overlay. The application of the bituminous tack coat spray shall be carried out immediately prior to laying the following course or surface treatment, which ever is specified in the contract. The bituminous tack coat spray shall comply with Clause 920 of this series. This requirement shall not apply to bond and tack coats for thin surface course systems complying with Clause 942.

Protection and Rectification of Bituminous Layers

26 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 blinded or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated the Contractor shall make it good by cleaning it and, if this proves impracticable, by rectification in compliance with the 700 Series.

Regulating Course

27 Regulating course material shall be made and laid in accordance with the requirements of Clause 907.

Use of Surfaces by Traffic and Construction Plant

28 Where a bituminous layer other than the surface course is to be opened to roadway traffic as a temporary running surface without speed restriction, it shall be surface dressed in accordance with Clause 919 using chippings of category $PSV60_{declared}$, unless otherwise specified in Appendix 7/1.

29 All temporary running surfaces shall be thoroughly cleaned and a tack or bond coat applied immediately prior to laying the succeeding course.

30 Tack coat or bond coat in accordance with Clause 920 shall be spraying grade cationic bitumen emulsion complying with Table 3 or Table 5 of the 'Binder Specification' published by the National Roads Authority and shall be applied at the uniform rate of spread specified in Appendix 7/4. The cationic bitumen emulsion shall not be permitted to collect in any hollows and shall be allowed to break before the next layer is placed.

31 Construction plant and traffic used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or the pavement courses already constructed. The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

902 Reclaimed Bituminous Materials

1 Reclaimed bituminous materials may be used in the production of bituminous base. The maximum amount of reclaimed bituminous material permitted shall be 20% for coated macadam base complying with BS 4987. The mixed material shall comply with the requirements of this Series.

2 When the amount of reclaimed bituminous material comprises 10% by mass or less, compliance with this Clause is not required. However, when it exceeds 10% by mass, the Contractor shall carry out trials to the satisfaction of the Employers Representative to demonstrate that the mixed materials comply with the requirements of this Clause.

3 After mixing with recycled materials, the binder recovered from the mixture shall have a recovered penetration value not less than the value specified below. The binder shall be recovered from the mixture in accordance with the requirements of BS 2000: Part 397 and tested in accordance with IS EN 1426.

Specified Grade of Binder to IS EN 12591 (Paving Grade)	Minimum Recovered Penetration Value of Binder after Mixing
40/60	30
70/100	50
160/220	120

4 When the amount of reclaimed bituminous materials to be used in the mixture exceeds 10%, the recovered penetration value of the binder in the reclaimed bituminous materials before mixing shall exceed 15 pen, after recovery of binder in accordance with the requirements of BS 2000: Part 397 and testing in accordance with IS EN 1426.

5 All reclaimed bituminous materials shall be pretreated before use such that the material is homogeneously mixed and the maximum particle size of reclaimed material does not exceed 28 mm.

903 Dense Macadam Base

1 Dense macadam base designed and recipe mixes shall be 0/32 mm nominal size aggregate dense base complying with BS 4987, and Table 9/1, sub- Clauses 2, 3 and 4 of this Clause and the requirements of Appendix 7/1. The nominal layer thickness shall be within the range of 70mm to 150mm.

In the absence of binder course, when used as upper base, the material shall comply with the requirements of clause 906 Dense Macadam binder course.

Aggregate

2 The coarse aggregate shall comply with Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987. The aggregate shall be in a surface dry condition prior to mixing.

Filler

3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when crushed limestone gravel is used as the coarse aggregate.

Binder

4 The binder shall be petroleum bitumen of paving grade 70/100 complying with IS EN 12591.

904 Not Used

905 Not Used

906 Dense Macadam Binder Course

1 Dense macadam binder course designed and recipe mixes shall be 0/20 mm nominal size aggregate dense binder course complying with BS 4987, and with Table 9/1, sub-Clauses 2, 3 and 4 of this Clause, and the requirements of Appendix 7/1. The nominal layer thickness of material containing aggregate of 20 mm maximum aggregate size shall be within the range of 50 to 100 mm.

Aggregate

2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987. The aggregate shall be in a surface dry condition prior to mixing.

Filler

3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when crushed limestone gravel is used as the coarse aggregate.

Binder

4 The binder shall be petroleum bitumen of paving grade 70/100 Pen complying with IS EN 12591.

907 Regulating Course

1 Regulating courses shall be in accordance with sub-Clauses 2, 3 and 4 of this Clause and the requirements of Appendix 7/1. Bituminous materials for regulating courses shall meet the requirements for the appropriate material, as specified in BS 594 or BS 4987 as relevant.

2 Regulating courses, which may consist of one or more layers of a bituminous material, shall have their finished surfaces laid to achieve the appropriate tolerances for horizontal alignments, surface levels and surface regularity, for pavement layers, in accordance with Clause 702.

3 Where the total depth of a regulating course exceeds 100 mm then the course shall be laid so that each regulating layer has a compacted thickness of between 50 mm and 100 mm.

908 Not Used

909 Dense Macadam Surface Course

1 Dense macadam surface course shall comply with BS 4987 for dense surface course, Table 9/2, sub-Clauses 2, 3 and 4 of this Clause, and with the requirements of Appendix 7/1.

2 The coarse aggregate shall consist of crushed rock complying with Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987. The aggregate shall be in a surface dry condition prior to mixing.

3 The binder shall be petroleum bitumen of paving grade 70/100 or 160/220 Pen complying with IS EN 12591, as described in Appendix 7/1.

910 Rolled Asphalt Surface Course (Recipe Mix)

1 Rolled asphalt surface course shall comply with BS 594 for surface course recipe mixtures and with Table 9/2, sub-Clauses 2, 3, 4 and 5 of this Clause, and the requirements of Appendix 7/1. The mix designation for the material shall be Type F - 30% 0/14 mm or 35% 0/14 mm.

Binder

2 The binder shall be petroleum bitumen of paving grade 40/60 Pen complying with IS EN 12591. The binder content, expressed as percentage by mass of the total mix, shall be in accordance with the requirements of Table 9/2 and BS 594.

Coarse Aggregate

3 The coarse aggregate shall comply with Clause 901.3 and the grading requirements of Table 9/2 and BS 594. The resistance to polishing of the coarse aggregate shall be category PSV_{44} as defined in IS EN 13043 Clause 4.2.3.

Fine Aggregate

4 The fine aggregate may be crushed rock or sand or mixtures thereof. The fine aggregate shall be obtained from a source, which has proven by experience to give continuously satisfactory performance in recipe mixtures. The source shall be subject to the approval of the Employer's Representative.

Coated Chippings

5 Coated chippings shall be Category 14/20 G_c 85/20 nominal size unless otherwise described in Appendix 7/1 and shall comply with Clause 915 and Table 9/2.

Table 9/1: Composition of Base and Binder Course mixes

Clause	903	906	930	932	933	934
Description	**Dense Macadam Base**	**Dense Macadam Binder Course**	**Heavy Duty Macadam Base with grade 40/60 Pen Binder (HDM50)**	**Dense Macadam Base with grade 40/60 Pen Binder (DBM50)**	**Heavy Duty Macadam Binder Course with grade 40/60 Pen Binder (HDM50)**	**Dense Macadam Binder Course with grade 40/60 Pen Binder (DBM50)**
Nominal Size	0/32 mm	0/20 mm	0/32 mm	0/32 mm	0/20 mm	0/20 mm
Nominal Layer Thickness (mm)	70 – 150	50 – 100	70 – 150	70 – 150	50 – 100	50 – 100
Min. Thickness at any one point (mm)	55	40	55	55	40	40
Aggregate Grading (% by mass passing)						
40 mm	100		100	100		
31.5 mm	90 – 100	100	90 – 100	90 – 100	100	100
20 mm	71 – 95	95 – 100	71 – 95	71 – 95	95 – 100	95 – 100
14 mm	58 – 82	65 – 85	58 – 82	58 – 82	65 – 85	65 – 85
10 mm	---------	52 – 72	---------	---------	52 - 72	52 - 72
6.3 mm	44 – 60	39 – 55	44 – 60	44 – 60	39 - 55	39 – 55
2 mm	24 – 36	24 – 36	24 – 36	24 – 36	24 – 36	24 – 36
250 μm	6 – 20	7 - 21	6 – 20	6 – 20	7 – 21	7 – 21
63 μm	2 – 9*	2 – 9*	7 – 11*	2 – 9*	7 - 11*	2 – 9*
Binder Content (% by mass of total mixture)						
Crushed Rock Aggregate	4.0 % ± 0.6	4.7 % ± 0.6	4.0 % ± 0.6	4.0 % ± 0.6	4.7 % ± 0.6	4.7 % ± 0.6
Crushed Gravel Aggregate	4.5 % ± 0.6	5.0 % ± 0.6	4.5 % ± 0.6	4.5 % ± 0.6	5.0 % ± 0.6	5.0 % ± 0.6
Binder Grade	70/100 Pen		40/60 Pen			
Range of Temperatures						
Max. Mixing Temperature (^{o}C)	180		185			
Min. Rolling Temperature (^{o}C)	85		105			

* When gravel other than limestone gravel is the aggregate, the material passing the 63 μm test sieve shall include Portland cement or hydrated lime to the amount of 2 per cent by mass of the total aggregate.

911 Rolled Asphalt Surface Course (Design Mix)

1 Rolled asphalt Surface course shall be designed in accordance with the procedures of BS 598: Part 107 and shall comply with BS 594 for surface course design mixtures, and with Table 9/2, with sub-Clauses 2 to 7 of this Clause, and the requirements of Appendix 7/1. The design mix material shall be designation Type F - 30% 0/14 mm or 35% 0/14 mm. The design mixture selected by the Contractor shall be notified to the Employer's Representative prior to its use in the Works.

Binder

2 The binder shall be petroleum bitumen of paving grade 40/60 Pen complying with IS EN 12591.

Coarse Aggregate

3 Coarse aggregate shall be crushed rock complying with Clause 901.3. The resistance to polishing of the coarse aggregate shall be category PSV_{44} as defined in IS EN 13043 Clause 4.2.3.

Marshall Stability and Flow

4 The Marshall stability and flow for the complete mixture at the target binder content, determined in accordance with the procedures of BS 598: Part 107, shall be as described in Appendix 7/1.

Verification

5 Verification of the design proposal shall be carried out using materials obtained from the plant before manufacture of the surface course commences. Stability and flow values shall be determined at the proposed target binder content.

6 The results of design verification for stability shall fall within 2 kN of the design proposal. Additionally, the stability shall be not more than 0.5 kN below the lower range value described in Appendix 7/1. The flow value obtained shall not exceed that stated in BS 594: Part 1. The target binder content determined on verification shall be not less than the specified minimum value given in BS 594.

Composition

7 When determined in accordance with the procedures of BS 598: Part 102, the composition of the plant mixture shall comply with the requirements for the surface course design mixture.

Coated Chippings

8 Coated chippings shall be 14/20 G_c 85/20 to IS EN 13043 unless otherwise described in Appendix 7/1 and shall comply with Clause 915 and Table 9/2.

912 Close Graded Macadam Surface Course

1 Close graded macadam surface course shall comply with BS 4987, and with Table 9/2, sub- Clauses 2, 3 and 4 of this Clause, and the requirements of Appendix 7/1.

Aggregate

2 The coarse aggregate shall consist of crushed rock complying with Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987. The aggregate shall be in a surface dry condition prior to mixing.

3 Unless otherwise stated in Appendix 7/1, the coarse aggregate shall have a minimum resistance to polishing of $PSV60_{declared}$ in accordance with IS EN 13043 Clause 4.2.3. In addition, the resistance to abrasion of the coarse aggregate shall have a maximum category of AAV_{10} in accordance with IS EN 13043 Clause 4.2.4.

Binder

5 The binder shall be petroleum bitumen of paving grade 70/100 or 160/220 Pen complying with IS EN 12591, as described in Appendix 7/1.

913 Not Used

914 Not Used

Table 9/2: Composition of Surface Course Mixes

Clause	910		911		915	912		909	916
Description	**Rolled Asphalt Surface Course (Recipe Mix)**		**Rolled Asphalt Surface Course (Design Mix)**		**Coated Chippings For Rolled Asphalt Surface Course**	**Close Graded Macadam Surface Course**		**Dense Macadam Surface Course**	**Open Graded Macadam Surface Course**
Designation[a]	30% 0/14	35% 0/14	30% 0/14	35% 0/14	14/20 G_c 85/20	0/14 mm	0/10 mm	0/6 mm	0/10 mm
Nominal Layer Thickness (mm)	40	45 or 50	40	45 or 50	N / A	40 – 55	30 – 40	20 – 30	30 – 35
Min. Thickness at any one point (mm)	---		---		N / A	35	25	15	25
Aggregate Grading (% by mass passing)									
40 mm					100				
31.5 mm					98 – 100				
20 mm	100	100	100	100	85 – 99	100			
14 mm	85 – 100	87 – 100	85 – 100	87 – 100	0 – 20	95 – 100	100		100
10 mm	60 – 90	55 – 88	60 – 90	55 – 88	---	70 – 90	95 – 100	100	85 – 100
6.3 mm	---	---	---	---	0 – 5	45 – 65	55 – 75	90 – 100	30 – 60
2 mm	59 – 71	55 – 67	59 – 71	55 – 67	---	19 – 33[b]	19 – 33[b]	36 – 52[b]	10 – 18
1 mm	---	---	---	---	---	15 – 30	15 – 30	20 – 50	---
500 μm	44 – 71	40 – 67	44 – 71	40 – 67	---	---	---	---	---
250 μm	18 – 62	15 – 55	18 - 62	15 – 55	---	---	---	7 – 23	---
63 μm	7 – 11	6 – 10	7 – 11	6 – 10	0 – 2	3 – 8	3 – 8	2 – 10	2 – 7
Max. % Aggregate passing 2 mm and Retained on the 500 μm test sieves	15	14	15	14	---	---	---	---	---
Binder Content (% by mass of total mixture)									
Crushed Rock Aggregate	7.8 % ± 0.6	7.4% ± 0.6	6.5 % Min.	6.4 % Min.	1.5 % ± 0.3	---	---	---	---
Crushed Gravel Aggregate	7.5 % ± 0.6	7.0%± 0.6	6.5 % Min.	6.4 % Min.	---	---	---	---	---
Crushed Rock Aggregate (excluding limestone)	---	---	---	---	---	5.1% ± 0.5	5.3% ± 0.5	6.3 % ± 0.5	5.3 % ± 0.5
Crushed Rock Aggregate (limestone)	---	---	---	---	---	4.9 % ± 0.5	5.2 % ± 0.5	6.0 % ± 0.5	5.1% ± 0.5
Binder Grade	40/60 Pen		40/60 Pen		40/60 Pen	70/100 Pen	or 160/220 Pen		160/220 Pen
Range of Temperatures									
Max. Mixing Temperature (°C)	190				170	180	155		145
Min. Rolling Temperature (°C)	105				---	85	60		80

[a] The mixture designation numbers (e.g. 30% 0/14) refer to the nominal coarse aggregate content of the mixture and nominal size of the coarse aggregate in the mixture respectively.
[b] May be increased to 38 in Clause 912 mixes and 60 in Clause 909 mix when sand fine aggregate is used.

915 Coated Chippings for Application to Rolled Asphalt Surface Course

1 The chippings and the manner of coating, when used for rolling into the surface of rolled asphalt, shall be in accordance with BS 594-1, except size and grading shall be in accordance with Table 9/2 of this series. The chippings shall also comply with sub-Clauses 2 and 3 of this Clause and with sub-Clause 901.3,

2 Unless otherwise stated in Appendix 7/1, the resistance to polishing of the chippings shall be category $PSV60_{declared}$, in accordance with IS EN 13043 Clause 4.2.3. In addition, the resistance to abrasion of the coarse aggregate shall have a maximum category of AAV_{10} in accordance with IS EN 13043 Clause 4.2.4. The shape of the chippings shall comply with FI_{15} as defined in IS EN 13043 Clause 4.1.6.

3 The polished stone value shall be determined in accordance with IS EN 1097-8. The aggregate shall be deemed to comply if the 2 most recent consecutive results, from tests relating to the material to be supplied, and carried out within the previous 12 months by a testing laboratory approved by the Employer's Representative, are equal to or greater than $PSV60_{declared}$.

916 Open Graded Macadam Surface Course

1 Open graded macadam surface course shall comply with BS 4987, and with Table 9/2, sub-Clause 2, 3 and 4 of this Clause and the requirements of Appendix 7/1.

2 The coarse aggregate shall consist of crushed rock complying with Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987. The aggregate shall be in a surface dry condition prior to mixing.

4 Unless otherwise stated in Appendix 7/1, the coarse aggregate shall have a minimum resistance to polishing of $PSV60_{declared}$ in accordance with IS EN 13043 Clause 4.2.3. In addition, the resistance to abrasion of the coarse aggregate shall have a maximum category of AAV_{10} in accordance with IS EN 13043 Clause 4.2.4.

5 The binder shall be petroleum bitumen of paving grade 160/220 Pen complying with IS EN 12591.

917 Cold-milling (Planing) of Bituminous Bound Flexible Pavement

1 Where cold-milling of bituminous bound flexible pavement is required, the area of carriageway to be milled shall be removed to the specified depth by a suitable milling machine. The process shall be carried out so as not to produce excessive quantities of either fumes, smoke or dust. Dust shall be minimised by damping with water sprays.

2 The cut edges shall be left neat, vertical and in straight lines. The Contractor shall brush and sweep the milled surface by mechanical means to produce a clean and regular running surface with a groove depth not greater than 10 mm, and with a uniform texture.

3 Carriageways shall be milled to the tolerance for surface levels specified in Clause 702 for binder course. If the tolerances in this Clause are exceeded, the full extent of the area, which does not comply, shall be rectified by further milling or by regulating with materials in accordance with Clause 907.

4 Existing ironwork shall not be disturbed by the milling action. Where necessary, surfacing in the vicinity of ironwork and in other small or irregular areas shall be cut out by pneumatic tools or other suitable methods and removed.

5 Where milling is carried out on a carriageway open to traffic, temporary ramping to ensure the safe passage of vehicles shall be provided in accordance with the requirements of Appendix 1/17.

6 If the milled surface profile varies by more than 10 mm, when measured transversely or longitudinally by a 3 metre straight edge, adjustments or replacements shall be made to the cutting teeth on the milling drum before work continues. Any discontinuity between adjacent milling passes exceeding 10 mm,

when measured transversely by a 3 metre straight edge, shall be rectified by further milling or regulating before placing bituminous materials.

7 Where milling is required over extensive areas, the Contractor shall programme the work to allow removal of full lane widths unless this is impracticable. The Contractor shall notify his proposed programme of milling to the Employer's Representative prior to commencement of the work.

8 Immediately after milling, surplus material shall be removed by a machine of suitable and efficient design and the milled surface swept to remove all dust and loose debris.

9 Where possible the material removed from the carriageway shall be reused in accordance with Clause 902 or in other such locations as approved by the Employers Representative. All other surplus material shall be run to licensed tips provided by the contractor. No stockpiling shall be allowed on Site unless the material is to be used in the Works.

10 Carriageways, which are closed to traffic, shall be resurfaced after milling prior to reopening the carriageway to traffic, unless otherwise agreed by the Employer's Representative.

918 Slurry Sealing

1 Slurry sealing shall comply with BS 434: Part 1 and Part 2, and with sub-Clauses 2 to 22 of this Clause.

Aggregate

2 Crushed or natural sand free from silt, clay or other fine material. The aggregate, whether a mixture or not, shall have a smooth grading within the limits of Table 9/3.

Additive

3 The additive shall be CEM1 Portland cement complying with IS EN 197: Part 1 or hydrated lime complying with BS 890. At least 75% shall pass the 63 micron sieve.

Table 9/3: Aggregate Grading

Sieve Size	**Percentage by mass of total aggregate and additive passing**	
	3 mm Finished thickness	*1.5 mm Finished thickness*
6.3 mm	100	100
4 mm	80 – 100	100
2 mm	75 – 100	95 – 100
1 mm	55 – 90	70 – 95
500 micron	35 – 70	55 – 75
250 micron	20 – 45	30 – 50
125 micron	10 – 25	10 – 30
63 micron	5 - 15	5 - 15

Bitumen Emulsion

4 The slurry seal bitumen emulsion shall comply with BS 434: Part 1 and shall be either:

(i) Class A4 Rapid Setting or Class K3 capable of producing a slurry which on laying develops early resistance to traffic and rain and is sufficiently stable to permit mixing with the specified aggregate, without breaking during the mixing and laying processes, or

(ii) Class A4 Slow Setting.

Tack Coat

5 Where required, or described in Appendix 7/3, tack coat shall be cationic bitumen emulsion complying with BS 434: Part 1.

Composition of Mixed Material

6 The mixed material shall comprise aggregate, bitumen emulsion and, where necessary, additive complying with sub-Clause 3 of this Clause. The amount of emulsion used shall be between 180 litres/tonne and 250 litres/tonne of dry aggregate; the precise proportions of each constituent being selected after laboratory tests and trials using the same plant intended to be used in the Works. When additive complying with sub-Clause 3 of this Clause is used, the proportion shall not normally exceed 2% by mass of aggregate.

Mixing

7 The materials shall be measured into a mechanical mixer and mixed such that the

aggregate is completely and uniformly coated with bitumen emulsion and a slurry is produced of consistency that can be satisfactorily laid as described in sub-Clauses 12 to 14 of this Clause. When required, an additive complying with sub-Clause 3 of this Clause, shall be used to control consistency, mix, segregation and setting rate.

Preparation of Site

8 Before applying tack coat or spreading slurry, any necessary patching of the road surface shall be completed. Immediately before application of bituminous materials, loose material, dust and vegetation shall be cleaned from the existing surface by sweeping, supplemented if necessary by air jet, and removed from the site. All ironwork, road studs and road markings, shall be masked. At junctions with surfaces not to be treated, clean lines shall be defined by masking, or other suitable means.

Laying

9 If required, a tack coat shall be applied in accordance with BS 434: Part 2 before spreading the slurry seal.

10 The rate of spread of tack coat shall depend on the surface to be treated. For bituminous surfaces the rate shall be 0.15-0.30 l/m^2 and for concrete surfaces it shall be 0.4-0.6 l/m^2.

11 Slurry shall be evenly spread by mechanical means such that the aggregate cover (dry mass equivalent) is 4-6 kg/m^2 for 3 mm finished thickness and 2-4 kg/m^2 for 1.5 mm finished thickness.

12 All voids, cracks and surface irregularities shall be completely filled. Spreading shall not be undertaken when the ground temperature falls below 4°C or when standing water is present on the surface. In warm dry weather the surfacing, immediately ahead of the spreading, shall be slightly damped by mist water spray applied mechanically.

13 The slurry shall be rolled by a self-propelled or towed multi-wheeled smooth tread rubber-tyred roller, having an individual wheel load between 0.75 and 1.5 tonnes, making at least six passes unless the Contractor demonstrates that rolling is unnecessary or that a smaller number of passes is satisfactory for a particular process. Rolling shall commence as soon as the slurry has set sufficiently to ensure rutting or excessive movement will not occur.

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

15 The finished surface shall be free from blowholes and surface irregularities due to scraping, scabbing, dragging, droppings, excess overlapping or badly aligned longitudinal or transverse joints, damage by rain or frost, or other defects. Slurry sealing which does not comply with this Clause or is non-uniform in surface texture or colour 24 hours after laying shall be rectified by removal and replacement with fresh material rolled in compliance with the Specification or, if this is impractical, by having fresh material superimposed and rolled in compliance with the Specification. Areas so treated shall be not less than 5 m long and not less than one lane wide. All areas being worked on shall be kept free of traffic until permitted by the Employer's Representative.

Preliminary Slurry Mixture Design and Trial Areas

16 Using the same plant proposed for the Works, the Contractor shall make trial mixes of the slurry, varying the bitumen emulsion/aggregate ratio to produce a slurry of creamy consistency which, whilst the screed box is travelling at the laying speed, will flow ahead of the screeding blade across the whole width of the spreader at all times. At least three trial mixes shall be made, each sufficient to spread a trial area of 40 square metres, to the specified finished thickness. The preparation of the existing surface for the trials, the tack coat spreading and the rolling methods shall comply in all respects with this Clause. Trial areas, which achieve the required spreading consistency, will be examined after 24 hours, for surface texture and adhesion, and if satisfactory the test specified in sub-Clause 17 of this Clause shall be carried out on samples of the same composition.

17 For each of the satisfactory trial mixes, at least two circular specimens shall be prepared, as described in BS 434: Part 2, for a wet track abrasion test. The approved mix proportions for the main work shall be selected following laboratory tests using a combination of bitumen emulsion, aggregate blended where necessary with additive and water, having a wet track abrasion test result of less than 500 g/m^2.

18 When a proposed mix has been approved variations shall not be made in mixing time, mix proportions or in the type, size, grading or source of any of the constituents without the agreement of the Employer's Representative who may require further tests to be made.

Site Control Tests

19 The mix proportions shall be controlled and the mass of all materials incorporated shall be checked and recorded at least four times daily. The quantity of emulsion used, and the rate of spread of mixed material, in kilogrammes of aggregate per square metre, shall be recorded for each load of aggregate and, if required, for each separate run within a load of aggregate.

20 The Contractor shall provide all necessary testing equipment and whenever spreading is taking place shall carry out the tests specified in Table 9/4 at the frequency stated therein. A copy of the results of each of the tests and of each recorded mass and check for rate of spread shall be passed to the Employer's Representative

21 75 gm of the blended aggregate shall be weighed in a glass beaker or similar container and the corresponding quantities of water and cationic emulsion in the slurry mix added. The slurry shall be stirred with a slow deliberate action (about 60 rpm) for 15 to 30 seconds, after which a specimen of about half the mixture shall be cast upon an impervious surface.

22 The cast specimen shall exhibit cohesive properties in not more than 10 minutes and when set and drenched in water shall be waterfast as demonstrated by the absence of brown colour in the wash water**.**

Table 9/4: Site Control Test Requirements

Test	Frequency	
	Batch mixing	**Continuous mixing**
Wet Track Abrasion Test (BS 434: Part 2)	4 times daily	Every second run
Grading of each separate stockpile of sand and crusher run fine aggregate	Every 20 tonnes	Every 20 tonnes
Grading of samples of the blended aggregate	4 times daily	4 times daily
Percentage of bitumen in the cured seal	4 times daily	4 times daily

919 Surface Dressing

1 Surface dressing shall be designed and carried out in accordance with the recommendations of the Institute of Asphalt Technology (IAT) – Guidelines for Surface Dressing in Ireland, published in 2003, and the requirements as stated in Appendix 7/3.

Aggregates

2 The chippings shall be crushed rock or gravel complying with the requirements of clause 901.3 of this series.

3 When referencing Table I of the IAT guidelines the grading category "EN 85/20" shall be selected as the grading category for all chipping sizes.

4 The polished stone value requirements from Table III of the IAT guidelines shall be category $PSV60_{declared}$, $PSV57_{declared}$ or $PSV52_{declared}$ as appropriate.

Aftercare

5 On high speed roads convoy vehicles shall be introduced in order to keep traffic speeds low. Masking shall be removed after the Surface Dressing has been applied and before opening the road to unrestricted traffic. The Contractor shall remove surplus chippings from the road by suction sweeping before it is opened to unrestricted traffic.

6 The Contractor shall monitor the Surface Dressing closely for a minimum period of 2 hours, or as specified in Appendix 7/21, after the road is opened to traffic. The Contractor shall reinstate traffic safety and management procedures or institute other remedial action where necessary, such as dusting, if there are signs of distress, such as turning of the chippings, in order to prevent further damage to the Surface Dressing.

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

8 Any defects arising from deficiencies in the materials, workmanship and aftercare manifest during or at the end of the maintenance period shall be rectified by the Contractor at his own expense.

As Built Manual

9 Not more than 30 days after completion of the work the Contractor shall provide a record of the progress of the work in accordance with section 6 of the IAT Guidelines and any such other information that the Employers Representative may reasonably require to be included.

920 Bond or Tack Coats and Other Bituminous Sprays

1 This clause shall not apply to bond coats for proprietary thin surface coarse systems complying with Clause 942. The bond coats required for such systems are specified in Clause 942-11. A bond or tack coat shall be sprayed onto the existing surface prior to overlay in accordance with sub-Clauses 3 and 4. Bond or tack coats for hot rolled asphalt and coated macadam shall be in accordance with BS 594: Part 2 and BS 4987: Part 2, respectively. Application shall be by spray tanker. For small areas application may be by hand held sprayer with the agreement of the Employer's Representative.

2 When it is necessary to prepare a surface for the application of a bituminous spray and to undertake the spraying and any specified blinding, this shall be done in accordance with the requirements as set out in Clause 919 in so far as it applies to the work to be undertaken in accordance with the under mentioned general requirements and any specified requirements as described in Appendix 7/4.

3 The binder shall be spraying grade cationic bitumen emulsion complying with Table 3 or Table 5 of the 'Binder Specification' published by the National Roads Authority. Where a bond coat incorporating a polymer modified emulsion is proposed for use it shall have prior written approval from the Employers Representative. The binder shall be sprayed at a rate specified in Appendix 7/4.

4 The Employer's Representative may require the Contractor to provide a test certificate showing that a particular binder distributor has been tested since the previous surface dressing season and that the test indicates conformity of the distributor with the requirements of IS EN 12272-1 for emulsion distributors.

5 Before spraying is commenced, the surface shall be free of all loose material, the surface as a whole shall be dry and any damp areas shall be completely free of standing water.

6 Blinding material, where required by the Contract, shall consist of a commercial grade of hard clean crushed rock, fine aggregate or sand: it shall contain not more than 15 per cent retained on a 6.3 mm sieve. It shall be applied to the binder and left unrolled. The rate of application shall be 5.5-7.0 kg/m^2.

7 All loose material on the sprayed surface, including any blinding material, shall be removed before any further layer of the pavement is laid.

921 Surface Texture of Bituminous Surface Courses

1 The texture depth of the surface of bituminous surface courses shall be measured by the volumetric patch technique described in IS EN 13036-1.

2 On high speed roads, unless otherwise stated in Appendix 7/1, the average

texture depth of each 1000 m section of carriageway lane or the complete carriageway lane where this is less than 1000 m, shall be not less than 1.5 mm. The average of each set of 10 individual measurements shall be not less than 1.2 mm.

3 On low speed roads where the surface course is Hot Rolled Asphalt, the rate of spread for chippings shall be at least 70% of that required to give shoulder to shoulder cover.

Measurement of Surface Texture

4 For newly laid surfaces measure the surface texture depth as soon as possible after the surfacing has been laid and before the surfacing has been opened to traffic. Make measurements on 50m lane lengths regularly spaced along the section and covering not less than one-third of the section tested. On each 50m length, take 10 individual measurements of the texture depth at approximately 5m spacings along a diagonal line across the carriageway lane width. Do not take measurements within 300mm of the longitudinal edge of the carriageway.

To reduce the variability, base the determination of the average texture depth of a test section on not less than six sets of ten individual measurements. For small schemes it may be practicable to carry out measurements over all the surface course or over alternate 50m lengths covering 50 percent of the work. Where this cannot reasonably be done make the test measurements over regularly spaced 50m lengths of carriageway lane, covering not less than one-third of the surfacing laid in one lane. On larger schemes, exceeding a kilometre in length, select test sections of carriageway lane 1000m long in the same way.

5 For rolled asphalt surface courses the surface texture may be measured using the TRL Mini Texture Meter provided it is calibrated with the volumetric patch technique described in IS EN 13036-1.

6 Whilst measurement of macrotexture depth for compliance purposes is to be by the volumetric patch technique specified in IS EN 13036-1 only, the TRL Mini Texture Meter may be used as a screening procedure, as recommended by BS 598: Part 105. In the event of dispute or discrepancy between the two methods, only results obtained using the volumetric patch technique will be considered for compliance purposes.

922 Not Used

923 Not Used

924 Resin Based High Skid Resistant Surface Treatment

1 High skid resistant surface treatments, made with aggregate of high polishing resistance and resin-based binders, shall consist of a film of binder sprayed on to a sound substrate and covered with aggregate to provide a textured, durable matrix of high skid resistance.

Binder

2 The binder shall contain an epoxy or other approved resin component. When cured the binder shall comply with sub-Clause 14 of this Clause.

Aggregate

3 The aggregate shall be calcined bauxite which has, when determined in accordance with IS EN 1097-8, a minimum polished stone value of $PSV72_{declared}$, unless otherwise described in Appendix 7/1. The grading of the aggregate shall be such that not more than 5% is retained on a 4 mm sieve and not more than 5% passes a 1 mm sieve. The aggregate shall be clean and free from foreign matter.

Mixing of Binder and Accuracy of Spraying

4 The binder shall be sprayed by a metered machine that accurately and continuously batches together the components of the binder; intimately mixing them before spraying. A control mechanism shall maintain each component within 5% by mass of the normal proportion specified by the resin manufacturer and a calibrated flow meter (or other approved means) shall be provided for each component. If the components of the binder are heated to facilitate spraying, the temperature shall not exceed the maximum recommended by the resin manufacturer. A temperature gauge accurate to ± 2°C

shall be used with all binders that require heating.

5 The vessels containing the components shall each be provided with an approved method of measuring the volume of material used.

6 The machine shall spray the binder, such that the amount collected on any longitudinal stretch of the surface 50 mm wide within the width of the spray shall not be less than 90% of the overall minimum requirement for the surface being treated (see sub-Clause 8 of this Clause). The mean amount of binder collected on any four adjacent 50 mm wide strips shall be not less than 95% of the overall minimum requirement. Before work commences, and thereafter at intervals not exceeding one month, the Contractor shall provide evidence that the sprayer and all metering gauges complies with the requirements of the Specification. If required, the test to measure the spray pattern shall be made in the presence of the Employer's Representative.

Preparation

7 The surface shall be vigorously brushed to remove dust, laitance and other loose matter. Any oil visible on the surface shall be removed by washing and scrubbing with a detergent solution followed by flushing with clean water or by another approved method. The surface shall be allowed to dry before application of the binder. Existing road markings, ironwork and road studs shall be suitably masked.

Application

8 The binder shall be sprayed on to a dry surface at a rate which will vary according to the texture and porosity of the surface. On a smooth close textured surface the amount of binder shall be not less than 1.35 kg/m^2 or such rate specified by the resin manufacturer; on a more rugous surface a greater rate of spread may be required. Heated binders shall be allowed to cool before application of the aggregate. A mechanically metered plant shall be used to cover the binder uniformly with an excess of aggregate. Rolling of the aggregate is not permitted.

9 Hand application of the binder, to areas not accessible to the mechanical sprayer, will be permitted if the Employer's Representative approves the proposed methods of batching, mixing and application of binder to the road surface. Similarly, in areas not accessible to the mechanical aggregate spreader, hand application of the aggregate will be permitted.

Aftercare

10 The material used as masking shall be removed together with the binder sprayed upon it and the remainder of the binder allowed to cure. During the curing period no disturbance or trafficking of the treated surface will be permitted. Before opening to traffic at the end of the curing period the excess aggregate shall be removed by vacuum sweeper or other approved means.

11 The Contractor shall have regard to the increase in cure time of the resin binder with decrease in temperature in order to allow sufficient time for the resin binder to cure between the end of the spray operation and the time when the road is to be opened to traffic. Details of cure time variation of the resin with respect to temperature shall be supplied by the resin manufacturer.

Checking and Testing

12 A check shall be made by the Contractor at the end of each working shift to determine the quantities used of each binder component. The check shall be made by means of dip-sticks or other approved devices. The measured volumetric quantities of the components shall be converted to mass units to estimate the average rate of spread of binder upon the surface, by dividing the total mass of the components by the measured area of the surface treated. The net aggregate coverage rate shall also be recorded.

13 The average accuracy of batching shall be determined from the known used masses of the components. The relative proportions of components so determined shall fall within the limits specified in sub-Clause 4 of this Clause.

14 The Contractor shall provide the Employer's Representative with samples of the binder, from the spraybar of the

sprayer, at a rate of not less than two samples for each shift worked or each 1,000 square metres completed, whichever is the lesser. Each sample shall be poured to a depth of 3.2 mm ± 0.4 mm, into a shallow tray of at least 150 mm x 150 mm which shall be supplied by the Contractor. The binder shall be cured, with no further mixing, at 23°C ± 5°C and after 7 days tested as described in BS 2782: Part 3, Method 320A: 1976 (1986) except that the rate of grip separation shall be 5 mm per minute with a tolerance of 20%. Although the test piece shall be cut to the dimensions shown in Figure 1, Method 320A, the requirement that the narrow parallel portion shall nowhere deviate by more than 2% from the mean shall be deleted. The conditioning period at 23°C ± 1°C shall be at least 2 hours immediately before testing takes place. The tensile strength of the specimens shall be not less than 10.5 N/mm^2 and the elongation at break not less than 30%.

15 The Contractor shall guarantee the integrity of the high friction surfacing materials and workmanship for a period of three years from the date of opening the surfacing to traffic. This guarantee shall exclude defects arising from damage caused by settlement, subsidence or failure of the carriageway on which the surfacing has been applied.

925 Testing of Bituminous Mixtures and Their Component Materials

1 The sampling, testing and analysis of bituminous mixtures shall comply with BS 598 except where otherwise stated in this series.

2 A bulk sample of coated chippings shall be obtained as described in BS 598: Part 100. Hot sand testing shall be carried out in accordance with BS 598: Part 108.

926 Not Used

927 Not Used

928 Not Used

929 Design, Compaction Assessment and Compliance of Base and Binder Course Macadams

Where a design mix is proposed for use in base or binder course macadams the following requirements shall apply:

1 The Contractor shall nominate a target aggregate grading and target binder content for his proposed mixture which shall fall within the limits of the appropriate table within BS 4987-1, for Group one or for Group two dense mixtures and comply with the appropriate Clause within this Specification. Additionally, for HDM mixtures, the target percentage of aggregate passing the 0.063 mm sieve shall not be less than 7.0%. For compliance purposes the binder content and aggregate grading limits shall be those obtained by applying the tolerances stated in Table 9/5 to the target binder content and target aggregate grading. The aggregate grading curve shall be smooth and continuous and shall not vary from the low limit on one size of sieve to the high limit on the adjacent sieve size or vice-versa.

2 The compaction of base and binder course macadams shall be assessed by measurement of:

(i) in situ and refusal air void contents of cores subjected to the Percentage Refusal Density (PRD) test procedure carried out in accordance with BS 598: Part 104; and

(ii) in situ density using a nuclear density gauge.

Job Mixture Approval Trial

3 At least three days before material from each source of macadam is first laid in the Works, the Contractor shall carry out a trial to demonstrate compaction plant and rolling procedures. Subject to the agreement of the Employers Representative the trial may be carried out off site. The trial area shall be not less than 30 m or more than 60 m long and of a width and thickness required in the Contract. If the trial is carried out on site and complies with this specification then it may form part of the Permanent Works. The materials, mixing and laying plant

proposed for the Works shall be used for the trial.

4 During the laying of the trial area, two samples of loose mixture shall be taken at three evenly spaced locations along the trial length, in accordance with BS 598: Part 100, six samples in total. The maximum density of one sample of mixture from each location shall be determined in accordance with IS EN 12697-5. The average value of maximum density ρ_{Max} expressed in Mg/m^3 shall then be used for subsequent calculation of the air void content of the compacted mixture. The remaining samples shall be analysed to determine their composition in accordance with BS 598: Part 102.

5 At three locations, four nominal 150 mm diameter cores shall be taken using a suitable coring machine, in accordance with BS 598: Part 100, twelve cores in total. Two of the locations shall be from the wheel-track zones of the completed traffic lane, the third location shall be agreed by the Employers Representative. For the purposes of this Clause the wheel-track zone shall be taken to be between 0.5 m and 1.1 m and between 2.55 m and 3.15 m from the centre of the nearside lane markings for each traffic lane. Two cores from each location shall be tested using the PRD test procedure in accordance with sub-Clause 2 of this Clause.

6 At or adjacent to the location of the cores, the density of the macadam shall be measured using a nuclear density gauge and the results correlated with the in situ air void contents determined in accordance with sub-Clause 7 of this Clause.

7 The air void contents of each core subjected to the PRD test procedure shall be determined, as follows:

(i) The in situ air void content shall be calculated using, as the bulk density ρ, the initial dried bulk density determined in accordance with BS 598: Part 104, and expressed in Mg/m^3;

(ii) The refusal air void content shall be calculated using, as the bulk density ρ, the refusal density determined in accordance with BS 598: Part 104, and expressed in Mg/m^3.

The air void contents shall be calculated to ± 0.1 per cent as follows:

$$\text{Air voids content} = (1 - \rho/\rho_{Max}) \times 100\%$$

where:
ρ is the bulk density in accordance with BS 598: Part 104 (Mg/m^3); and
ρ_{Max} is the maximum density in accordance with IS EN 12697-5 (Mg/m^3).

TABLE 9/5: Tolerances for Aggregate Grading and Binder Content to be applied to the Agreed Target Grading and Binder Content

Test Sieve (mm)	Tolerance for aggregate grading in percent by mass of aggregate passing test sieve	
	0/32 mm base course	0/20 mm binder course
63	±0	
40	±0	
31.5	±10*	±0
20	±12	±5*
14	±12	±10
10	—	±10
6.3	±8	±8
2.0	±7	±7
0.25	±6	±6
0.063	±3.5	±3.5
0.063 (HDM)	±2	±2
Binder Content	±0.6	±0.6

Note: Application of the above tolerances to the agreed aggregate target grading and binder content may result in limits outside those permitted by the appropriate table in BS 4987. Provided the target grading and target binder content of the mixture proposed for use, and agreed after trials, are within the limits contained in BS 4987, then the limits obtained by applying the above table shall prevail over those implied in BS 4987.

*The upper limit may be less than +5% (or +10%), depending on the agreed aggregate grading.

8 The percentage binder volume B_{vol} shall be calculated for each location in accordance with the following expression:

$$B_{vol} = B_{Mass} \times (\rho/\rho_{b})$$

where: B_{Mass} is the target binder content by mass added at the mixer expressed as a

percentage of the total mixture.

ρ is the average initial dried bulk density of macadam at each location determined from the pair of cores subjected to the PRD test procedure.

ρ_b is the density of the binder at 25°C.

9 The remaining pair of cores from each location shall be used for the measurement of Stiffness Modulus and Deformation Resistance, as follows:

(i) The in situ air void content of each core shall be calculated from the equation given in sub-Clause 929.7, using the dried bulk density ρ determined in accordance with BS 598: Part 104 and the maximum density ρ_{Max} determined in accordance with sub-Clause 929.4.

(ii) Each core shall be tested for Stiffness Modulus in accordance with DD 213: 1993.

(iii) Following the determination of Stiffness Modulus, one core from each location shall be tested for Deformation Resistance in accordance with DD 226: 1996, and the other core shall be tested similarly except that the DD 226 test procedure shall be modified in accordance with TRL Paper PA 3287/97. Within 28 days copies of the test sheets and results for stiffness modulus and deformation resistance measured for each core shall be supplied to the Employers Representative. Additionally if the trial area is on site, the exact location of the cores, their dried bulk densities, in situ air void contents, the composition of the mixture determined using the methods specified in BS 598: Part 102 and the percentage binder volume determined in accordance with sub-Clause 929.7 shall be reported. No limits are specified for the Stiffness Modulus, except for materials complying with Clause 902, or for Deformation Resistance.

10 The trial area shall be acceptable if the mixture complies with sub-Clause 11 of this Clause. If the trial area fails to comply with the requirements of Sub-Clause 11 and was intended to form part of the Permanent Works, it shall be removed. In the event that the trial area fails to comply, the Contractor may nominate an alternative target aggregate grading and target binder content and the trial shall be repeated until compliance has been demonstrated. The target aggregate grading and target binder content of the complying mixture shall be used in the Permanent Works.

11 Compliance Requirements

(i) The average in situ air void content of the core samples to be subjected to the PRD testing procedure shall not exceed 7.0% in binder course or upper base without a binder course, or 8.0% in other base layers.

(ii) The average value of in situ air void content of the pair of core samples from each location to be subjected to the PRD testing procedure shall not exceed 8.0% in binder course or upper base without a binder course, or 9.0% in other base layers.

(iii) The average air void content at refusal density of the core samples subjected to the PRD testing procedure shall be not less than 1.0%.

(iv) The minimum binder volume at each location shall be as stated in Table 9/6.

TABLE 9/6: Aggregate Size and Minimum Binder Volume

Mixture Size/Designation Size (mm)	Minimum Binder Volume (%) of the Total Volume of the Mixture
0/32	8
0/20	9.4

(v) The compositional analysis of aggregate grading and binder content carried out in accordance with BS 598: Part 102 shall demonstrate compliance with the requirements set out in sub-Clause 929.1.

(vi) The horizontal alignments, surface levels and surface regularity of the finished surface shall comply with Clause 702.

Sampling and Testing from the Permanent Works

12 The compaction of macadams laid in the Permanent Works shall be assessed by determination of:

(i) in situ air void content calculated from in situ density measured using a nuclear density gauge on a running basis; and

(ii) in-situ and refusal air void contents of pairs of cores taken every 500 lane metres and subjected to the Percentage Refusal Density (PRD) test procedure carried out in accordance with BS 598: Part 104.

13 The compaction of base and binder course macadams shall be continuously assessed using the nuclear density gauge with readings taken at 20m intervals in alternate wheel-tracks, commencing with readings at a location from which a pair of cores is to be extracted. Additional readings shall be taken 300 mm from the edge of the mat adjacent to each core location. The Contractor shall take corrective action as is necessary whilst the material is still above the minimum rolling temperature specified in BS 4987-2 if low densities are indicated at the time of laying.

14 Initially the calibrations of the nuclear density gauges established in accordance with sub-Clause 6 of this Clause shall be used. When results are available from loose samples and pairs of cores taken every 500 lane metres, each gauge shall be re-calibrated if the density measured by that gauge and the density of the cores show a different bias. Each gauge used shall be individually calibrated.

15 For material from each mixing plant, a pair of nominal 150 mm diameter cores shall be taken every 500 lane metres laid, one core from each wheel-track zone of the completed carriageway as defined in sub-Clause 929.5. Cores shall be extracted using a suitable coring machine, in accordance with BS 598: Part 100. Each core shall be subjected to the PRD test procedure carried out in accordance with BS 598: Part 104, and the air void contents shall be determined in accordance with sub-Clause 929.7 using the maximum density ρ_{Max} expressed in Mg/m^3 determined in accordance with sub-Clause 929.16.

16 Samples of uncompacted material shall be taken from the paver augers in accordance with BS 598: Part 100, Clause 6.3, as near to each location from which cores are to be taken as is practicable and:

(i) The maximum density of a sample of the mixture shall be measured in accordance with IS EN 12697-5. The value of maximum density so determined, ρ_{Max} expressed in Mg/m^3, shall be used for the subsequent calculation of the air void contents of the compacted mixture at that location.

(ii) The compositional analysis of a sample shall be carried out to determine the aggregate grading and binder content in accordance with BS 598: Part 102.

17 Each core extracted shall be examined for evidence of excessive voidage below the depth to which the nuclear density gauge penetrates. If excessive voidage is observed, further cores should be taken to determine its extent.

18 Each layer of macadam shall be sampled and tested separately. Where separate coring of each layer would unreasonably delay placing a second layer, subject to the approval of the Employers Representative, both layers may be cored together and the resulting core split prior to testing.

19 Cores shall be extracted without the use of excessive force. Cores shall not be taken until the material has cooled to a temperature of 40°C or less at mid-depth of the course to be cored. The walls and base of all holes from which core samples have been cut shall be dried and painted with hot bituminous binder or cold applied polymer modified intermediate or premium grade bitumen emulsion immediately prior to making good. Core holes shall be backfilled with dense bitumen macadam in accordance with BS 4987-1, or with coldlay 0/20 mm nominal size dense bitumen macadam binder course. Dense bitumen macadam incorporating fluxed binder shall not be used. The backfill material shall be compacted to refusal with a circular headed vibrating hammer, in layers not exceeding 75 mm. Where cores have been cut through the surface course, the last layer of backfill material shall

comply with the specification for the surface course.

20 Two copies of the final nuclear density test results obtained and their correlation with in situ air void contents shall be passed to the Employers Representative within 24 hours.

Compliance Requirements for the Permanent Works

21 For material from each mixing plant:

(i) The average in situ air void content calculated from any six consecutive nuclear density readings shall not exceed 7.0% in binder course or upper base without a binder course, or 8.0% in other base layers. If the average in situ air void content exceeds the limit specified, then six cores shall be taken from the same locations and the in situ air void contents determined. If the average in situ air void content of the cores also exceeds the limit specified, then defective lengths shall be removed and replaced such that compliance is re-established. Lengths of not less than 15 linear metres shall be removed and replaced, unless otherwise agreed by the Employers Representative.

(ii) The average in situ air void content of each pair of cores taken every 500 lane metres shall not exceed 8.0% in binder course or upper base without a binder course, or 9.0% in other base layers. If the average in situ air void content of a pair of cores exceeds the limit specified, then density readings with the nuclear gauge and if necessary further cores, shall be taken to determine the extent of the defective area to be removed. Lengths of not less than 15 linear metres shall be removed and replaced unless otherwise agreed by the Employers Representative.

(iii) The average values of air void content at refusal density of pairs of cores taken every 500 lane-metres and subjected to the PRD testing procedure shall be reported. If the average air void content at refusal of any three consecutive pairs of cores falls below 0.5% the Contractor shall cease laying. The Contractor shall nominate an alternative target aggregate grading and target binder content and a further Job Mixture Approval trial shall be carried out in accordance with this Clause. Laying shall not recommence in the Permanent Works until compliance has been demonstrated.

(iv) The compositional analyses of aggregate grading and binder content carried out in accordance with BS 598: Part 102 shall demonstrate compliance with the requirements set out in sub-Clause 929.1.

(v) The horizontal alignments, surface levels and surface regularity of the finished surface shall comply with Clause 702.

Binder Course Macadams Below Porous Asphalt Surface Course

22 Designed binder course macadams below porous asphalt shall comply with sub-Clauses 1 to 21 of this Clause except that every third pair of cores from the Permanent Works shall be taken across a longitudinal or transverse joint as agreed by the Employers Representative.

930 Heavy Duty Macadam Base with Grade 40/60 Penetration Binder (HDM50)

1 Heavy duty macadam base with grade 40/60 penetration binder designed and recipe mixtures shall comply with BS 4987 for heavy duty base, Table 9/1, sub-Clauses 2 to 6 of this Clause, and the requirements of Appendix 7/1.

Aggregate

2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987: Part 1. The aggregate shall be in a surface dry condition prior to mixing.

Filler

3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when limestone gravel is used as the coarse aggregate.

Binder

4 The binder shall be petroleum bitumen of paving grade 40/60 Pen complying with IS EN 12591.

Mixing

5 The material shall be mixed in a plant which has a facility to incorporate added filler during the mixing process. The maximum temperature of mixed macadam at any stage shall not exceed 185°C.

Laying

6 Compaction shall be carried out while the temperature of the mixed macadam is greater than or equal to 105°C.

931 Use of Rubber in Bituminous Materials

1 When rubber is described in Appendix 7/1 as a required additive to bituminous materials, manufacture and use of the rubberised material shall comply with the recommendations in Road Note 36: "Specification for the Manufacture and Use of Rubberised Bituminous Road Materials and Binders".

932 Dense Macadam Base with Grade 40/60 Penetration Binder (DBM50)

1 Dense macadam base with grade 40/60 penetration binder designed and recipe mixtures shall comply with BS 4987: Part 1 for dense base, Table 9/1, sub-Clauses 2 to 6 of this Clause, and the requirements of Appendix 7/1.

Aggregate

2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987: Part 1. The aggregate shall be in a surface dry condition prior to mixing.

Filler

3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when limestone gravel is used as the coarse aggregate.

Binder

4 The binder shall be petroleum bitumen of paving grade 40/60 complying with IS EN 12591.

Mixing

5 The material shall be mixed in a plant which has a facility to incorporate added filler during the mixing process. The maximum temperature of mixed macadam at any stage shall not exceed 185°C.

Laying

6 Compaction shall be carried out while the temperature of the mixed macadam is greater than or equal to 105°C.

933 Heavy Duty Macadam Binder Course with Grade 40/60 Penetration Binder (HDM50)

1 Heavy duty macadam binder course with grade 40/60 penetration binder designed and recipe mixtures shall comply with BS 4987, with Table 9/1 and with sub-Clauses 2 to 7 of this Clause, and the requirements of Appendix 7/1.

Aggregate

2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof. The quality of the fine aggregate shall comply with the requirements of BS 4987: Part 1. The

aggregate shall be in a surface dry condition prior to mixing.

Filler

3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when the gravel is limestone.

Binder

4 The binder shall be petroleum bitumen of 40/60 penetration grade complying with IS EN 12591.

Mixing

5 The material shall be mixed in a plant which has a facility to incorporate added filler during the mixing process. The maximum temperature of mixed macadam at any stage shall not exceed 185°C.

Laying

6 Compaction shall be carried out while the temperature of the mixed macadam is greater than or equal to 105°C.

934 Dense Macadam Binder Course With Grade 40/60 Penetration Binder (DBM50)

1 Dense macadam binder course with grade 40/60 penetration binder designed and recipe mixtures shall comply with BS 4987: Part 1 for dense binder course, Table 9/1, sub-Clauses 2 to 6 of this Clause, and the requirements of Appendix 7/1.

Aggregate

2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of Clause 901.3. The fine aggregate may be crushed rock or sand or mixtures thereof and the quality of the fine aggregate shall comply with the requirements of BS 4987: Part 1. The aggregate shall be in a surface dry condition prior to mixing.

Filler

3 When the coarse aggregate is crushed gravel, 2% by mass of total aggregate of Portland cement or hydrated lime shall be added. The percentage of fine aggregate shall be reduced accordingly. Cement or hydrated lime is not required when limestone gravel is used as the coarse aggregate.

Binder

4 The binder shall be petroleum bitumen of paving grade 40/60 complying with IS EN 12591.

Mixing

5 The material shall be mixed in a plant which has a facility to incorporate added filler during the mixing process. The maximum temperature of mixed macadam at any stage shall not exceed 185°C.

Laying

6 Compaction shall be carried out while the temperature of the mixed macadam is greater than or equal to 105°C.

935 Not Used

936 Not Used

937 Not Used

938 Porous Asphalt Surface Course

General

1 Porous asphalt is exclusively a bituminous surface course material used in road construction to reduce surface water spray and road-tyre noise. The mixture is gap-graded containing 14mm nominal size aggregate and the binder is polymer modified. The mixture shall satisfy the composition requirements as set out in the following sub-Clauses, and the mandatory tests specified in Table 9/11. The surface course is normally laid on an impervious binder course or other impermeable surfacing having sufficient crossfall and longitudinal gradients to facilitate surface water removal. The nominal compacted layer thickness is 45 mm. The layer is bonded to the

underlying layer with a polymer modified bonding coat.

Aggregate

2 The coarse aggregate shall consist of crushed rock or crushed gravel complying with the requirements of Clause 901.3. When tested in accordance with the procedures of IS EN 933-3, IS EN1097-2 and IS EN 1097-8, each source of coarse aggregate shall additionally have the properties described in Table 9/7 or as stated in Appendix 7/1. The fine aggregate shall be crushed rock fines or natural sands or a mixture thereof.

Table 9/7: Coarse Aggregate Properties

Property	**Category**
Polished Stone Value (PSV)	$PSV\ 60_{declared}$
Resistance to Fragmentation (Los Angeles Test)	LA_{25}
Aggregate Abrasion Value (AAV)	AAV_{10}
Flakiness Index (10 – 14mm fraction)	FI_{15}
Flakiness Index (6.3 – 10mm fraction)	FI_{20}

3 When sampled and tested in accordance with IS EN 12697-27, IS EN 12697-28 and BS 598 part 102, the target aggregate Grading shall fall within the envelope formed by the limits given in column 2 of Table 9/8. The agreed grading for the mixture shall be obtained by applying the tolerances given in column 3 to the target aggregate grading. The grading curve of the aggregates shall be broadly parallel to the limits of the envelope and shall not vary from the low limit on one size of sieve to the high limit on the adjacent sieve or vice-versa.

Filler

4 At least 2.0 percent by mass of the total aggregate shall be hydrated lime filler. The minimum calcium and magnesium hydroxide content of the hydrated lime shall be 90%.

Table 9/8 Target Aggregate Grading and permitted tolerances.

Column 1	**Column 2**	**Column 3**
ISO Sieve (mm)	Percent Passing	Tolerances around Target Grading
20	100	**
14	95 – 100	**
10	55 – 75	±10
6.3	15 – 25	±4
2	10 - 17	**
0.063	4 – 5.5*	**

Note: *Including 2% hydrated lime by weight of total aggregate. **Tolerances as for grading in column 2. Application of the above tolerances to the target grading may result in limits outside those permitted by the appropriate envelope in Column 2 of the table. This is acceptable.

Binder

5 The binder shall be preblended polymer modified bitumen and shall comply with the selected requirements of IS EN 14023 as detailed in Table 9/9. During storage the binder shall be agitated/circulated in an agreed manner to ensure the homogeneity of the binder. When tested in accordance with Clause 941, 'Modified Binder Storage Stability Test' preblended modified binders shall meet the original specification for softening point and penetration for that binder after the four day storage period. The supplier shall ensure the preblended modified binder is manufactured to the same specification as that for the sample submitted for the 'Binder Drainage Test', Clause 939.

Binder Content

6 The target binder content (polymer modified bitumen) shall be established from binder drainage tests as described in Clause 939. In addition, at the target binder content the porous asphalt mixture shall comply with the requirements of the Cantabro Wear Test as specified in sub-Clause 938.17, with the Water Sensitivity Test as specified in sub-Clause 938.16 and with the Relative Hydraulic Conductivity requirements as specified in Clause 938.15. The tolerance for the binder content to be used in the works shall not exceed ±0.3% of the target value. Notwithstanding the above requirements the found binder content on analysis shall not be less than 5% of the total mixture.

Additives

7 Inorganic or organic fibres may be used to assist in preventing binder draining from the aggregate. Adhesion agents or other additives may be added to the binder to improve the stripping resistance of the mixture.

Trials and Trial Sections

8 At least two months before surfacing is to commence the Contractor shall submit to the Employer's Representative, full details of the constituent materials of the mixture, of the test results and of the mixing and laying proposals that is intended to be used**.** At least one month prior to the commencement of laying porous asphalt in the permanent works the Contractor shall lay a trial length of at least 100m adjacent to the permanent site using the materials, mix composition, method of mixing, method of laying and layer thickness, intended to be used in the works. For the trial to be acceptable it shall, without remedial works, comply with all the requirements of this specification. If the trial length does not conform to all the requirements of this specification the contractor shall lay further trial lengths until such trials do conform to all the requirements of this specification.

Mixing

9 The constituent materials shall be accurately weighed into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles are completely coated. All weighing mechanisms shall be properly maintained within the accuracy's recommended by the manufacturer. The Contractor shall supply a service certificate showing that the weighing devices have been calibrated against standard loads, in accordance with the quality plan and audited to ISO 9001, within six months prior to the start of the contract. The mixing temperature shall be as shown in Table 9/10 and this is based on a required binder viscosity of 0.5 Pas. To minimize temperature fluctuations, production shall be continuous, and where practicable, not interrupted.

Transporting

10 Porous asphalt shall be transported to site in double-sheeted insulated vehicles with tight fitting covers. To facilitate discharge of porous asphalt, the floor of the vehicle may be coated with the minimum of liquid soap, vegetable oil, or other non-solvent solution. When a coating is used then, prior to loading the body shall be tipped to its fullest extent, with the tailboard open, to ensure drainage of any excess. The floor of the vehicle shall be free from adherent bituminous materials or other contaminants. Porous asphalt shall be delivered to site within the temperature range shown in Table 9/10.

Bonding Coat

11 On all occasions that porous asphalt is used the substrate should be sprayed with a polymer modified bitumen emulsion bonding coat. The rate of application of the bonding coat shall be such as to ensure that the residual bitumen coverage, after curing, is between 0.4kg/m² and 0.7kg/m². The bonding coat shall be allowed to break before porous asphalt is laid and shall be of a composition to prevent 'pick up' on the tyres of pavers and delivery trucks.

Laying

12 Porous asphalt shall be laid by machine and compacted within three hours of mixing. The thickness of the porous asphalt layer, after compacting, shall be 45 ±5 mm. Where more than one lane is to be covered, and where possible, porous asphalt shall be laid by at least two pavers working in echelon, so that longitudinal joints can be effectively rolled together whilst hot. The stagger between paving machines shall not exceed 20 metres. Bitumen coating shall not be applied to exposed longitudinal edges. ' Throwing-back' of material and walking on the uncompacted porous asphalt shall not be allowed. Except in circumstances approved by the Employer's Representative all construction plant must be kept off the surface before opening to traffic in order to prevent damage to and clogging of the material. Porous asphalt shall not be laid during rain or when standing water is present. Porous asphalt shall be laid within the limits of air temperature and wind speed stated in Figure 9/1. Laying shall not be permitted at any temperature if the average wind speed over the preceding hour exceeds 50km/h at 10m height (40km/h at 2m height). Wind speed shall be measured either by anemometer erected at a height

of 10m ±0.5m situated at the site office, or by portable anemometer erected at a height of 2m ±0.1m situated in close proximity to the laying works. The anemometer shall be fitted with a digital accumulative device.

Compacting

13 Porous asphalt shall be compacted using at least two 6-8 tonne, non-vibrating, steel wheel tandem drum rollers for each paving machine. If a vibratory type roller is used it shall be operated in the non-vibrating mode. To avoid pick-up, the rollers drum surfaces shall be initially clean and completely wetted prior to and during rolling. Rubber tyred rollers and 3-wheeled rollers shall not be used. Rolling shall commence at the highest mat temperature consistent with no shoving and shall be substantially completed within the temperature range given in Table 9/10. The first roller pass shall be on the low edge of the mat, followed by the high edge. Rolling of the rest of the mat shall then proceed from low to high side and shall continue until all roller marks have been removed**.**

Longitudinal and Transverse Joints

14 Wherever possible pavers shall be used in echelon, as described in sub-Clause 12 of this Clause, to eliminate longitudinal joints. Where exposed longitudinal joints are unavoidable they may be cold butted, provided that the edge of the porous asphalt layer laid previously has not been damaged and is clean. Where damage to edges has occurred they shall be trimmed by power saw with appropriate measures including suction extraction, to prevent clogging of the pores with detritus. Longitudinal joints shall be placed adjacent to pavement lane markings or outside wheel track zones and shall be formed by butting-up to the adjacent porous asphalt to form a tight joint. Transverse joints shall be formed against a 200 mm wide and 45 mm thick hard timber stop-end nailed to the road surface in advance of the paving operation. The cutting of edges shall be avoided but where transverse edge cutting is essential, only sawing with appropriate measures, including suction extraction shall be permitted. Nothing shall be done, nor any articles positioned, such as to impede the run-off water freely entering the drainage channel or filter drain provided to remove the water from the pavement surface edge. Where an impermeable surface is to be laid downstream of the porous asphalt, the lane ends of the porous asphalt shall be staggered across the carriageway in the direction of the drainage path in order to prevent excess rainwater from welling up over the transverse joint. Porous asphalt shall be designed to finish on a level grade or on an up-grade and shall not finish/commence at a junction.

Relative Hydraulic Conductivity

15 After the porous asphalt has cooled to ambient temperature, and before trafficking, the relative hydraulic conductivity of the material shall be measured, in accordance with the procedures specified at Clause 940. The average value, from any 5 consecutive determinations at 20m spacings in the near-side wheel track of each lane of a carriageway, shall be not less than $0.12s^{-1}$ and no single value shall be less than $0.08s^{-1}$.

Water Sensitivity

16 The water sensitivity shall be determined in accordance with IS EN 12697 Parts 12 & 23. The ratio of wet to dry strength shall not be less than 0.75. The specimen compacting procedure shall be such as to provide the air voids content expected in the field, i.e. in the range 20-28 percent without causing significant crushing of the large aggregate particles as observed from analysis of the specimens and measurement of any reduction in size. A reduction such that the grading no longer lies within the grading envelope shall not be acceptable.

Abrasion (Cantabro Wear Test)

17 When tested in accordance with the procedure described in NRA report RC 369 the wear of the mixture shall not exceed 25 percent at 18°C or 20 percent at 25°C.

(i) The Cantabro test shall be carried out on mixture specimens unconditioned by any simulated aging procedures or by soaking in water and,
(ii) The specimen compaction shall achieve maximum air voids up to 28 per cent without causing significant crushing of the coarse aggregate as defined in sub-Clause 16 of this Clause.

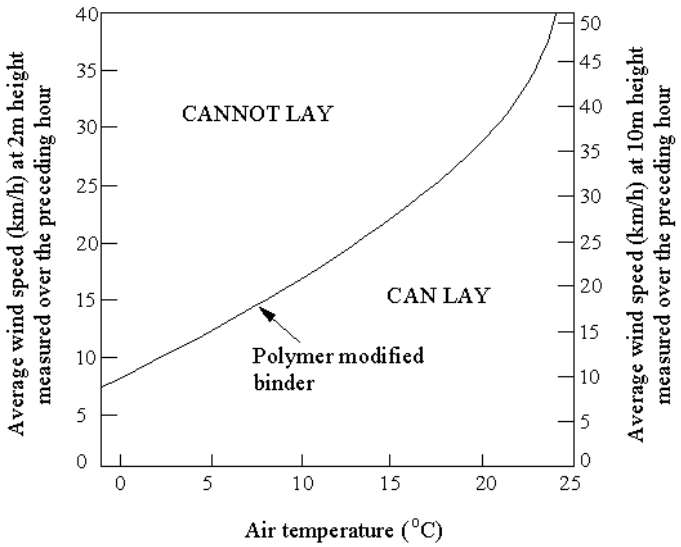

Figure 9/1: Limiting weather conditions for laying porous asphalt

Table 9/9: Properties of Polymer Modified Porous Asphalt Binder

Properties	Test Method	Specified Value
Penetration at 25°C 0.1mm	IS EN 1426	65 - 105
Softening Point, °C	IS EN 1427	>70
Fraass Brittle Point, °C	IP 80	< -15
Storage Stability, °C difference in softening point, top-bottom, after four days at 160°C	Clause 941	< 5
Resistance to hardening (Rolling Thin-film Test) Mass Change, (percent) Retained Penetration (Percent) Softening point increase °C Softening point decrease °C	ASTM D2872	< 1.0 > 60 < 8 < 2

Table 9/10: Mixing and Handling Temperatures

Binder Type	Mixing Temperature Range (°C)	Delivery Temperature Range (°C)	Minimum Compacting Temperature (°C)	
			Start	Finish
Polymer modified	In accordance with manufacturers requirements	145 - 170	140	115

Table 9/11: Mandatory Design Tests Required on Porous Asphalt Mixtures

Design Tests	Parameter	Performance Levels	Applicability of Test
Binder Drainage Test At 170 °C	Drainage characteristics of the binder from asphalt mixture	Target binder content	Design and Quality Control
Per Cent Air Voids	Void Content	Max. air void content 28 percent	Design
Relative Hydraulic Conductivity Test	Measurement of water outflow under specific conditions	Relative Hydraulic Conductivity Ave. 0.12 seconds (min value 0.8 s)	Design and Quality Control
Water Sensitivity Test*	Tensile strength test in accordance with IS EN 12697 Parts 12 & 23	Ratio wet to dry 0.75	Design
Cantabro Wear Test*	Per cent loss	Mass loss < 25 % at 18°C (20 % at 25°C)	Design

*The specimen compaction procedure shall be such as to provide a maximum air void content of 28 percent. The procedure shall not alter the determined grading of the mixture on any sieve by more than +/- 3 percent.

939 Binder Drainage Test

Scope

1 This test determines the target binder content for porous asphalt, which is the highest binder content at which excessive binder drainage will not occur during manufacture, transportation and laying.

Summary of method

2 The quantity of binder lost through drainage, after a specified time at the maximum mixing temperature, shall be measured in duplicate for mixes with the same aggregate contents but with different binder contents. The target binder content shall be defined as the value 0.3 per cent less than that at which 0.3 per cent binder drainage occurs, see also sub-Clause 9 below.

Apparatus

3 The apparatus shall consist of:

(i) Balance of not less than 2kg capacity, accurate to 0.1g

(ii) Oven, with fan-assisted air circulation, fitted with thermostatic control to maintain the temperature to ±3°C in the range of 80°C to 200°C and having sufficient internal volume to accommodate 10 drainage baskets and trays.

(iii) Mechanical mixing unit of more than 8 litres capacity, capable of combining 1500g of aggregate, filler and binder speedily and thoroughly, without loss, as described in BS 598: Part 107.

(iv) Whisk, as described in BS 598: Part 107.

(v) Drainage baskets, ten in number, constructed from perforated metal with 3.1 ± 0.1mm diameter holes and with 38 ± 3 per cent open area, on sides and base to form 100 ± 2 mm cubes, with feet, at each corner of the base, of 3 ± 0.5 mm diameter and 5 ± 1 mm height.

(vi) Spatula, with a blade approximately 150 mm long by 25 mm wide.

(vii) Metal trays, approximately 150 mm square and 10 mm deep, ten in number.

(viii) Metal boxes, approximately 150 mm by 150 mm by 150 mm, eleven in number.

(ix) Aluminium foil, of thickness 0.015 ± 0.005 mm.

Materials

4 Sufficient aggregates and binder to manufacture at least 20 kg of porous asphalt are required. The aggregates shall be dried and graded in the fractions appropriate to the specified grading.

Procedure

5 The procedure shall be as follows:

(i) The test shall be carried out at the maximum mixing temperature at which the modified binder viscosity is 0.5 Pas. In the absence of viscosity data, the test temperature shall be 170°C ±3°C.

(ii) Weigh eleven batches of 1.1 kg of combined aggregate, in the proportions for each fraction, to the nearest 1g to give a grading complying with the mid-point of the specified grading limits in Table 9/8, Clause 938. Place each batch in a separate tin.

(iii) Pre-heat the oven to the maximum mixing temperature and place the tins with aggregates in the oven for at least 3 ± 1 hours prior to use.

(iv) Pre-heat, stir and sub-divide the binder by the method stated in BS 598: Part 107.

(v) Wrap each tray with aluminium foil. Weigh each tray with foil to the nearest 0.1g (W1).

(vi) Pre-heat the mixing unit to the maximum mixing temperature for at least 1.5 ± 0.5 hours prior to use.

(vii) Transfer a 1.1kg batch of aggregate to the mixing bowl.

(viii) When natural rubber powder is to be used, add the required quantity to the mixing bowl. Fit the mixing bowl to the mixer and fit the whisk. Dry mix for 30 ± 3 s before adding the bitumen.

(ix) Stir the heated binder in its container and weigh by difference the required amount of binder to the nearest 0.5g, into the mixing bowl to give 4.5 per cent by mass in the unit.

(x) When natural rubber latex is to be used; after adding the bitumen fit the mixing bowl to the mixer and fit the whisk. Mix the aggregates and bitumen for 60 ± 6s. Stir the latex well and add the required quantity evenly over the mix.

(xi) Fit the mixing bowl to the mixer; fit the whisk and mix for another 60 ± 6s. Using the spatula, scrape around the top of the bowl and whisk and transfer the scraped material into the mix. Continue mixing for a further 60 ± 6s.

(xii) Discard the first mix.

(xiii) Repeat steps (vii) to (xi)

(xiv) Transfer the material to a basket, ensuring that the mixer bowl and whisk are scraped thoroughly using the spatula. Carry out this operation as rapidly as possible to minimize heat losses.

(xv) Place the basket with the mix on a pre-wrapped tray in the oven at the maximum mixing temperature for between 3 hours and 3.25 hours.

(xvi) Remove the basket and tray from the oven. Remove the basket from the drainage tray. When the tray has cooled sufficiently, weigh the tray and aluminium foil to the nearest 0.1g (W2).

(xvii) After placing the first mix in the oven, repeat the procedure in steps (xiii) to (xvi) for a duplicate sample at the same binder content.

(xviii) Repeat the procedure in steps (xiii) to (xvii) four times, but increasing the binder content in step (ix) to 5.0, 5.5 and 6.0 per cent by mass, respectively.

(xix) When a modifier other than natural rubber is used, the procedure for incorporating the modifier shall be according to the manufacturers' instructions.

Calculations

6 For each mix, the retained binder (per cent), R, shall be calculated from R% = 100 x B [1-D/(B+F)]/(1100+B) Where:

D is the mass of binder and filler drained [W2 - W1] (g)

B is the initial mass of binder in the mix (g)

F is the initial mass of filler in the mix (g)

7 If, for any pair of mixes at the same binder content, the difference in retained binder per cent exceeds 0.5 per cent of binder, the procedure in sub-Clause 5 and calculation in sub-Clause 6 of this Clause, for the pair of mixes at the same binder content, shall be repeated.

8 The mean retained binder shall be calculated for each binder content. The retained binder shall be plotted against the initial mixed binder content, together with the line of equality where the retained binder equals the mixed binder content. A smooth curve shall be drawn through the plotted values and extrapolated to intercept the line of equality in Figure 9/2. The critical binder content, the maximum mixed binder content, and the maximum retained binder content shall be recorded.

Determination of Target Binder Content

9 From Figure 9/2, the mixed binder content (M) shall be determined where the binder drainage is 0.3 per cent (yz). The target binder content shall be (M-0.3) per cent. As a check, the abscissa, (xy), should also equal 0.3 per cent between the line of equality and the point on the drainage curve where the binder drainage is 0.3 per cent (yz).

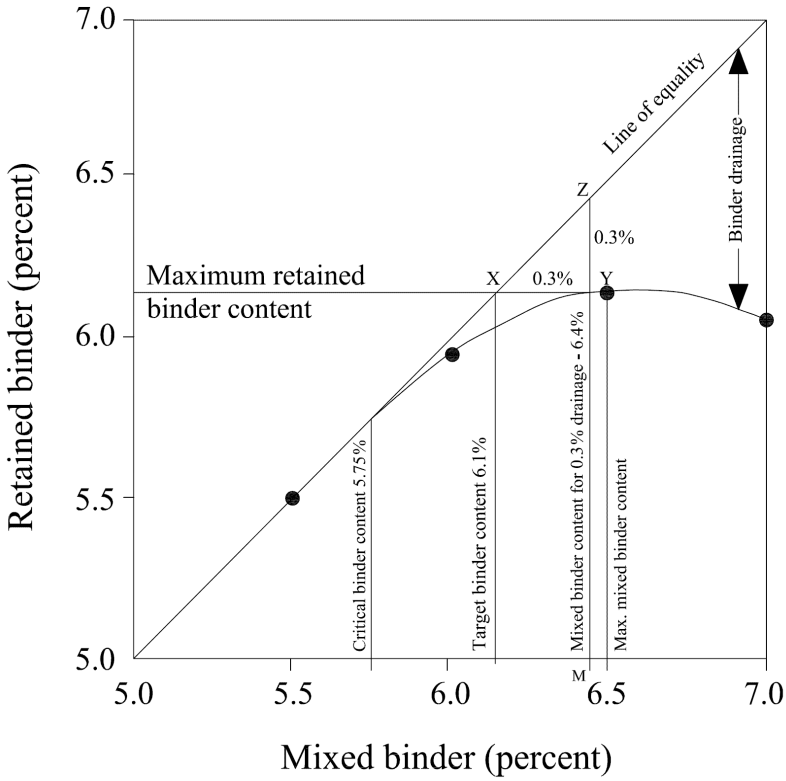

Figure 9/2: Binder drainage test plot – Diagram indicating definitions

940 Relative Hydraulic Conductivity Test

Scope

1 This test determines the in situ relative hydraulic conductivity, at specific locations, of a permeable road surfacing. An estimate of the average value for the surfacing is obtained from the mean value of a number of determinations on each section of road.

Summary of Method.

2 A radial-flow, falling-head, permeameter shall be used to determine the time taken for a specified amount of water, under known head conditions, to dissipate through an annular area of the surfacing. The reciprocal of the corrected outflow time shall be used to calculate the relative hydraulic conductivity of the surfacing.

Apparatus

3 The apparatus shall consist of:

(i) Radial-flow falling head permeameter and standing board, constructed to the requirements and critical dimensions as described in DD229: 1996.

(ii) Stopwatch, accurate to 0.1s.

(iii) Thermometer, with an accuracy of at least ± 1°C in the range 0 to 25 °C.

(iv) Clean water, in the range 0 to 25 °C.

Definitions

4 The outflow time shall be the time that elapses for an outflow of 2.0 litres through the permeameter, between the meniscus at the 2.5 litre mark and when it falls to the 0.5 litre mark**.** The series resistance time, r, shall be the outflow time(s), corrected to 20°C, when the outlet is not restricted by a surfacing. It shall be subtracted from measurements of outflow time when the permeameter is used on a surfacing. The parallel leakage time shall be the outflow time when the outlet is restricted by an impermeable surface. The relative hydraulic conductivity (HC) is the reciprocal of the outflow time, after correction to 20°C, less the series resistance time.

Apparatus Constants and Calibration

5 The following checks shall be performed before using the equipment:

(i) **Dimensions**

All dimensions shall comply with those given in DD 229.1996.

(ii) **Volume Calibration**

Stand the permeameter on a flat and level surface. After inserting the plunger, fill the standpipe with 500 ± 0.25 ml of water, using a calibrated volumetric flask of 500 ml capacity. Mark the standpipe permanently at the meniscus level. Now fill the standpipe with a further 2000 ± 0.6ml of water, using a calibrated volumetric flask of 2000 ml capacity, and again mark the standpipe permanently at the new meniscus level.

(iii) **Series Resistance Time, r.**

Place the permeameter on blocks, of not less than 80 ± 5 mm height, to expose the 100 mm diameter aperture in the base. Fit the plunger in the orifice. Fill the standpipe completely with clean water. Measure and record the temperature of the water in the standpipe to the nearest 1°C. Remove the plunger and hang by its rest on the top of the standpipe. Start the stopwatch when the meniscus falls to the 2.5 litre mark. Stop the stopwatch when the meniscus falls to the 0.5 litre mark. Record the outflow time and repeat the measurement a further nine times. Calculate the average outflow time and correct to 20°C by dividing by the appropriate temperature correction factor from Table 9/12. Record the series resistance time, r, as the corrected average outflow time, to the nearest 0.1s.

(iv) **Parallel Leakage Time**

Place the permeameter on a flat and level impermeable surface. Fit the standing board on the base. Two operatives of approximately similar mass, within the range 75 ± 25 kg shall stand, one on each side of the standing board. Fit the plunger in the orifice. Fill the standpipe completely with clean water. Remove the plunger and hang by its rest on the top of the standpipe. Allow air bubbles to rise to the top and, if necessary, add more water to bring the water level above the 2.5 litre mark after all bubbles have ceased rising. Start the stopwatch when the meniscus falls to the 2.5 litre mark. Stop the stopwatch when the meniscus falls to the 0.5litre mark, or end the test if the outflow time exceeds 10 minutes. If the outflow time is less than 5 minutes, leakage is excessive and the permeameter is unsuitable for use for this test.

Procedure

6 The procedure shall be as flows:

(i) Place the permeameter over the surfacing at the point where the relative hydraulic conductivity is to be measured. Fit the standing board on the base. Fit the plunger in the orifice. An operative shall stand on each side of the standing board, throughout the duration of the test, to hold the permeameter in place and compress the rubber annular disc to provide a seal.

(ii) Fill the standpipe completely with clean water. Measure the temperature of the water in the standpipe and record it to the nearest 1°C.

(iii) Remove the plunger and hang by its rest on the top of the standpipe. Allow air bubbles to rise up through the water in the standpipe until they no longer rise through the water, which is dissipating into the road surface.

(iv) Replace the plunger and refill the standpipe to at least 50 mm above the 2.5 litre mark. Without delay, remove the plunger and hang by its rest on the top of the standpipe. Start the stopwatch when the meniscus falls to the 2.5 litre mark. Stop the stopwatch when the meniscus falls to the 0.5 litre mark. Record the outflow time, t1, to the nearest 0.1s.

(v) Repeat step (iv) to obtain t2.

(vi) Calculate the average outflow time and the range, both to the nearest 0.1s. If the range exceeds 5 per cent of the average outflow time, repeat step (iv) until the range criterion is met by two successive outflow times and discard other readings. Correct the average outflow time to 20°C by dividing by the appropriate temperature correction factor from Table 9/12 and record the corrected average outflow time, t, to the nearest 0.1s.

Table 9/12: Temperature Correction Factors

Temperature of water (°C)	Temperature Correction factor
0	1.79
1	1.73
2	1.67
3	1.62
4	1.57
5	1.52
6	1.47
7	1.43
8	1.39
9	1.34
10	1.31
11	1.27
12	1.24
13	1.20
14	1.17
15	1.14
16	1.11
17	1.08
18	1.06
19	1.03
20	1.00
21	.98
22	.96
23	.94
24	.91
25	.89

(vii) The relative hydraulic conductivity (HC), corrected to 20°C is calculated from:

$$HC = 1/(t-r)\ s^{-1}$$

Where t is the average outflow time(s) corrected to 20°C;

r is the series resistance outflow time(s) corrected to 20°C.

(viii) Report the relative hydraulic conductivity, corrected to 20°C, to the nearest $0.01s^{-1}$.

Measurement of the Average Relative Hydraulic Conductivity of a Section.

7 The procedure shall be as follows:

(i) Measure the relative hydraulic conductivity as soon as possible after the surfacing has been laid and cooled to ambient temperature, but before the surfacing has been opened to traffic. The road shall be clean and free from loose material. Measurements can be made when the road is wet, but not if in a frozen state.

(ii) Make individual determinations of the relative hydraulic conductivity in the nearside wheel path at 20m intervals along each carriageway lane.

(iii) Calculate the running mean of each 5 consecutive measurements along each carriageway lane.

(iv) Report the average relative hydraulic conductivity and the individual results, all corrected to 20°C, of each running mean of 5 individual determinations along each carriageway lane to the nearest $0.01s^{-1}$.

(v) When an individual determination does not comply with the specified minimum requirement for relative hydraulic conductivity, further determinations shall be carried out at 5 m intervals in the wheel-path on either side of the noncomplying location to determine the extent of the non-complying length. If the non-complying length exceeds 20 m, rectification shall be carried out by removing the full depth of the course and replacing it with fresh material laid and compacted in accordance with the Specification. The area rectified shall be the full width of the paving laid in one operation, and at least 30 m long.

941 Modified Binder Storage Stability Test

Scope

1 This test determines the susceptibility of a preblended modified binder to separation or instability during prolonged storage at high temperature.

Summary of Method

2 A sample of modified binder shall be contained in a closed vessel of specific dimensions and shall be maintained at 160 ± 2°C for 4 days ± 2 hours. A binder sample shall then be taken from the top and bottom thirds of the vessel and both samples shall be tested for compliance with the binder specification.

Apparatus

3 The apparatus shall consist of:

(i) Cylinder, made of heat resistant glass, 190 ± 30 mm long and 65 ± 5 mm internal diameter having a removable lid, flush fitting to exclude air when the cylinder is filled with binder, and provided with three drain-valves, one at the base, the other two spaced equally down the side of the cylinder, to allow the sample to be divided into three equal portions as in sub-Clause 4 (vii) of the procedure. Alternatively, a thin-wall sheet metal tube or similar vessel such as a 500 ml beverage can, of similar dimensions to the glass cylinder, and having a similarly removable lid, fitted either with or without drain- valves.

(ii) Oven, electrically heated, fan assisted, and capable of maintaining a temperature of 160 ± 2°C, having interior dimensions not less than 330 mm from the top of the heating element to the top of the chamber and not less than 305 mm in width and depth.

(iii) Tube holder, made of metal, that will hold either the glass cylinder or sheet metal can, in a vertical position, such that the base of the cylinder or can is not in direct contact with the oven floor.

(iv) Apparatus for determining the penetration and softening point of bitumen in accordance with IS EN 1426 and IS EN 1427.

(v) Transfer dishes (3), made of metal, each of a capacity sufficient to hold at least one third of the test sample.

Test Procedure

4 The procedure shall be as follows:

(i) The bulk sample of modified binder shall be obtained by sampling in accordance with BS 3195-3 and IS EN 58.

(ii) Place the bulk sample of modified binder and the glass cylinder (or metal tube or equivalent vessel) in the preheated oven at 160 ± 2°C for a period not exceeding 3.75 ± 0.25 hours.

(iii) Remove the bulk sample from the oven and thoroughly mix by stirring to ensure obtaining a representative test sample.

(iv) Remove the glass cylinder (or metal tube or equivalent vessel) from the oven and completely fill with the modified binder test sample to allow no air space when the lid is fitted.

(v) Support the filled cylinder in a vertical position in the holder and transfer to the oven which shall be controlled at a temperature of 160 ± 2°C and allow to stand undisturbed for a period of 168 ± 2 hours.

(vi) If a vessel having drain-valves has been used for the test proceed using Method A below, otherwise proceed using Method B.

(vii) Method A

(a) Remove the glass cylinder (or alternative approved vessel) from the oven, keeping the cylinder vertical.

(b) Open the upper-most drain-valve and run off the top third portion of the test sample into a transfer dish for testing.

(c) Open the middle drain-valve and run off the middle third portion of the test sample into a suitable container and discard.

(d) Open the lower drain-valve and run off the bottom third portion of the test sample into a transfer dish for testing.

(viii) Method B

(a) Remove the tube or vessel containing the test sample from the oven and allow it to cool at room temperature for 2 ± 0.25 hours whilst maintaining the vessel vertical in the holder.

(b) When the vessel of modified binder has cooled to ambient temperature, remove it from the tube holder and make two cuts through the vessel and the sample at positions one-third and two-thirds of the length from, and parallel, to the base.

(c) Retain the top and bottom thirds of the test sample for further testing and discard the middle third.

(ix) Determine the penetrations and softening points of the top and bottom thirds of the test sample, in accordance with IS EN 1426 and IS EN 1427.

Reporting

5 For both the top and bottom thirds of the test sample the following shall be reported:

(i) The penetration to IS EN 1426.

(ii) The softening point, to IS EN 1427.

(iii) Whether Method A or Method B was used.

(iv) The location and date of obtaining the bulk sample, and the dates of test.

942 Thin Surface Course Systems

General

1 Hot laid thin surfacings are here defined as an application of a polymer modified bitumen emulsion bond coat overlaid by a hot bituminous mixture.

This specification is for hot laid thin surfacings with a compacted thickness of 20mm to 40mm, in which the aggregate particles are necessarily gap-graded to form a stone to stone contact and to provide an open surface texture.

Quality Control for Manufacture

2 The thin surfacing shall be manufactured by a company that is accredited to ISO 9001, or equivalent, and who can demonstrate quality control measures at least equivalent to sub-Clause 3, 4, 5 and 6 of this Clause.

3 The Contractor shall provide details of the thin surfacing manufacturer's quality control system. Unless otherwise agreed with the Employer's Representative, such a system shall include at least the following:

(i) an independent initial inspection of the manufacturing facility;

(ii) a Factory Production Control System;

(iii) continuous surveillance, assessment revision and approval of Factory Production Control;

(iv) procedures for tracing and rectifying defects;

(v) traceability of materials.

Initial Inspection

4 The Contractor shall demonstrate that the thin surfacing manufacturer satisfies at least the following requirements:

(i) a Quality Manual has been produced for the organisation's operations and processes;

(ii) the manufacturing processes are documented in the form of specific procedures in the Quality Manual;

(iii) a specific procedure for the receipt of incoming materials has been established by the manufacturer;

(iv) materials are traceable to test certification proving their conformance to specification, which shall be held on file for all thin surfacings;

(v) personnel are trained and qualified to operate the relevant manufacturing processes including ongoing testing as appropriate;

(vi) quality control measures are operated and records kept of all measurements on materials etc;

(vii) continuous surveillance of the processes and procedures are undertaken and reports produced to identify non-compliance with the Quality Manual.

Factory Production Control

5 The Contractor shall ensure that the manufacturer exercises continuous internal control of production. All elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures. This Production Control System documentation shall ensure a common understanding of Factory Production Control and enable the achievement of the required product characteristics and the effective operation of the Production Control System to be inspected. Factory Production Control shall be a documented procedure in the Quality Manual.

The manufacturer's documentation shall be appropriate to the technical description of the products and processes.

Production control operations shall comprise at least the following:

(i) the inspection of raw materials and constituents;

(ii) the prescribed frequency of inspections and tests to be carried out during manufacture;

(iii) the provision of reasonable handling and storage, so that the products and/or constituents remain in conformity with the technical specifications;

(iv) the control of equipment and machines required to manufacture the thin surfacing, including the necessary verification equipment (e.g. gauges);

(vi) assessment of the personnel qualified to carry out the relevant manufacturing processes.

Continuous Surveillance

6 The Contractor shall ensure the manufacturer provides evidence that they exercise continuous surveillance of their Quality Control system. This shall take the form of inspection reports highlighting the areas and procedures inspected and the outcome of these inspections.

Aggregate

7 The coarse aggregate shall comply with the requirements of Clause 901.3. When tested in accordance with the procedures of IS EN 933-3, IS EN 1097-2 and IS EN 1097-8, each source of coarse aggregate shall additionally have the properties described in Table 9/13 or as stated in Appendix 7/1. The fine aggregate may be crushed rock or sand or a mixture thereof but shall be subject to the approval of the Employers Representative.

Tabe9/13: Coarse Aggregate Properties

Property	**Category**
Polished Stone Value (PSV)	*PSV $60_{declared}$
Resistance to Fragmentation (Los Angeles Test)	LA_{25}
Aggregate Abrasion Value (AAV)	AAV_{10}
Flakiness Index	FI_{15}

* Unless otherwise stated in Table 3.1 of HD36 (NRA DMRB 7.5.1).

8 The maximum nominal aggregate sizes in the mixture shall be 0/14mm or 0/10mm. The requirements for the grading shall be expressed in terms of the target grading, which shall be within the maximum and minimum values stated in table 9/16 for the percentage passing the following sieves:

- 1.4D;
- D;
- Up to two optional sieves between D and 2mm;
- 2mm;
- One optional fine sieve between 2mm and 0.063mm; and
- 0.063mm;

The notation " D " refers to the nominal size sieve e.g. in a thin surfacing material 0/14mm the " D " refers to sieve size 14mm. The target proportions passing the various test sieves, expressed as percent by mass of total aggregate shall be provided by the contractor at least eight weeks before paving is to commence.

The ranges between maximum and minimum values, for the grading envelopes, shall be selected as a single value within the given limits (both included) from Table 9/17. At the target composition the mixture shall conform to the specified requirements.

This specification has adopted the changes in grading designation that have occurred as a result of the adoption of IS EN 13043:2002 – Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas.

Filler

9 The filler shall be crushed rock or limestone or hydrated lime or Portland cement as approved by the Employers Representative and not less than 75 percent shall pass the 0.063mm sieve. It shall conform to IS EN 13043, as appropriate.

Binder

10 The binder shall be preblended polymer modified bitumen and shall comply with the selected requirements of IS EN 14023 as detailed in Table 9/14. The tolerance for the binder content in the mix shall be ± 0.3 percent of the target binder content given by the Contractor. The permitted range of binder contents shall be 5.0 to 6.5 percent.

Bond Coat

11 On all occasions that hot applied thin surfacings are used the substrate should be sprayed with a polymer modified bitumen emulsion (PMBE). The rate of application of the bonding coat shall be such as to ensure that the residual bitumen coverage, after curing, is between 0.4kg/m^2 and 0.7kg/m^2. The bond coat and thin surfacing shall be applied either by a paving machine fitted with spray bar i.e. integrated paver or alternatively the bond coat can be applied separately provided that after a reasonable time period (10 to 20 minutes) it is resistant to "pick up" on the wheels of rubber tyred vehicles and the footwear of operatives. In this case it shall provide a strong bond between the substrate and the hot-mixed thin surfacing when the latter is applied by a conventional paving machine. Fine aggregate dust shall never be used to prevent "pick up" as this will inhibit bonding between substrate and the thin surfacing.

Additives

12 Inorganic or organic fibres may be used to assist in preventing binder drainage from the aggregate. The nature and properties of all additives e.g. cellulose, mineral or glass fibre etc. shall be declared. Fibres shall be added automatically into the mixer to ensure that a homogeneous dispersion of the fibres is achieved.

Material that is proposed for use as an additive shall have a proven established suitability for use in bituminous surfacing systems.

Mixture requirements

13 The target composition of the mixture in terms of its constituent materials, the percentages passing the specified sieves, the binder type and binder content and the percentage and type of additive shall be declared and documented.

The target aggregate grading and target binder content proposed by the Contractor shall be that which is required to satisfy the clauses of this specification. In addition compacted specimens at the

target composition shall meet the wheel tracking requirements of Table 9/18 and shall have a Water Sensitivity value of greater than 75 percent. The method of laboratory compaction is by the Gyratory compaction method in accordance with IS EN 12697-31.

The water sensitivity is a measure of retained stiffness and is expressed as the indirect tensile strength ratio (ITSR). The ITSR is calculated as the ratio of the indirect tensile strength of wet (water conditioned) specimens to that of dry specimens, expressed in percent. This test should be carried out in accordance with IS EN 12697-12 and at a test temperature of 25°C.

Trials

14 At least two months before surfacing is to commence the Contractor shall submit to the Employers Representative full details of the constituent materials of the mixture, all test results and the mixing and laying proposals including mix temperatures both at production and delivery to site. At least one month prior to the laying of thin surfacing in the permanent works the Contractor shall lay a trial length of at least 100m adjacent to the site using the materials, mix composition, method of mixing, method of laying including bond coating and layer thickness to be used in the main contract. For the trial to be acceptable it shall, without remedial works, comply with the full requirements of this specification. Alternatively, with the agreement of the Employers Representative, the trial may form part of the permanent works if the material installed complies with all the requirements of this specification. If the trial does not conform to all the requirements of this specification, the Contractor shall remove all non-compliant material from the permanent works and lay further trial lengths until full compliance with this specification is achieved.

Mixing

15 The materials including any added filler shall be accurately weighed into a mechanical mixer of approved type and thoroughly mixed in such a manner that all particles are completely coated. The Contractor shall supply a service certificate showing that all weighing devices have been calibrated in accordance with the quality plan and audited to ISO 9001, within six months prior to the contract.

Laying

16 Thin surface course materials shall not be laid during rain or when standing water is present. It shall be laid within the limits of air temperature and wind speed stated in Figure 9/3. The range of delivery and rolling temperatures shall be as stated in Table 9/15. Prior to laying operations the Contractor shall carry out any necessary remedial repairs. The type and extent of such repairs shall be agreed with the Employers Representative. Where necessary, existing surfaces shall be regulated, in accordance with the requirements of Clause 907, in advance of laying surfacing material to this clause.

Performance requirements

17 The Contractor shall guarantee the performance, surfacing materials and workmanship for a period of three years from the date of opening the surfacing to traffic or as otherwise specified in Appendix 7/1. In the event of failure of the surface to meet the performance specification for the guarantee period, the Contractor shall replace the material in accordance with this specification. The requirements for Skid Resistance and Texture Depth – initial and after three years in service shall be as stated in Table 9/19 and Table 9/20.

Skid resistance shall be measured using the SCRIM machine. This testing shall be carried out at a test speed of 50Km/h.

The texture depth of the surfacing after compaction and before opening to traffic shall be measured by the volumetric patch technique described in IS EN 13036-1 and shall conform to the requirements of Table 9/20. The initial measurements should be made over 50 metre lengths, regularly spaced along the section, and covering not less than one third of the area of surfacing. On each 50 metre lane length, 10 individual measurements shall be made at 5 metre intervals, along a diagonal line across the carriageway lane width, but not within 300mm of the carriageway edge.

Surface texture measurements made after periods in service shall be made in the nearside wheel track at 5 metre intervals in a longitudinal direction. These shall be carried out on both sides of the carriageway, i.e. in both traffic directions.

After five years in service visual assessment shall show no loss of the surfacing material due to attrition or debonding or ravelling or surface disintegration or cracking. The guarantee shall exclude defects arising from damage caused by settlement, subsidence or failure of the carriageway on which the material has been laid.

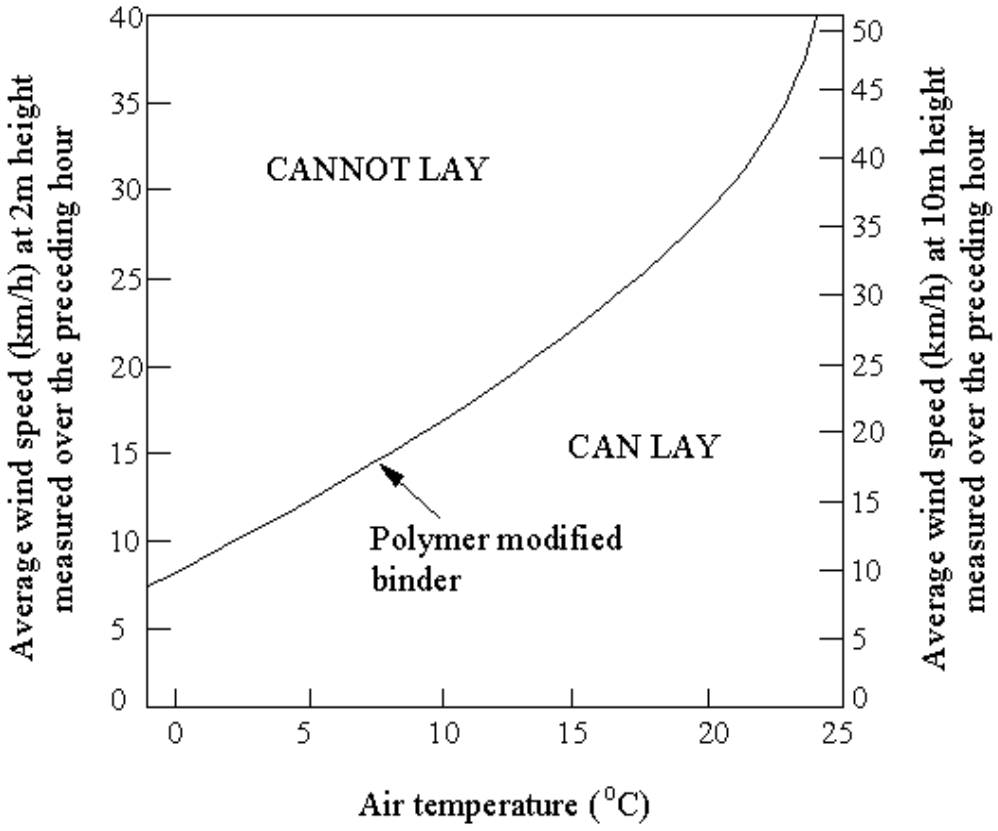

Figure 9/3: Limiting weather conditions for laying Thin Surfacing Materials.

Table 9/14: Properties of Thin Surface Course Polymer Modified Binder

Properties	Test Method	Specified Value
Penetration at 25°C 0.1mm	IS EN 1426	65 - 105
Softening Point, °C	IS EN 1427	>60
Fraass Brittle Point, °C	IP 80	< -15
Storage Stability, °C difference in softening point, top-bottom, after four days at 160°C	Clause 941	< 5
Resistance to hardening (Rolling Thin-film Test) Mass Change, (percent) Retained Penetration (Percent) Softening point increase °C Softening point decrease °C	ASTM D2872	< 1.0 > 60 < 8 < 2

Table 9/15: Mixing and Handling Temperatures

Binder Type	Mixing Temperature Range (°C)	Delivery Temperature Range (°C)	Minimum Compacting Temperature (°C)	
			Start	Finish
Polymer modified	In accordance with manufacturers requirements	145 - 170	140	115

Table 9/16: Overall Grading Limits of Target Composition and Composition tolerances

Nominal Size	0/10			Grading** Tolerances +/- for 0/10mm	0/14	Grading** Tolerances +/- for 0/14mm
Nominal Layer Thickness	20-30mm				20-40mm	
ISO Sieve (mm)	10A*	10B*	10C*		14	
20					100	
14	100	100	100		90-100	-8/+5
12.5						
10	90-100	90-100	90-100	-8/+5	35-50	7
8						
6.3						
4						
2	15-25	25-35	25-35	6	15-30	6
1						
0.063	4-6	7-9	10-12	2	6-12	2

Note: * Hot laid thin bituminous surfacings shall be designated by their nominal size i.e. the upper sieve size of the aggregate in the mixture, in mm and where relevant, by an indication of the type, A, B or C.

** Application of the above tolerances may result in limits outside those permitted by the appropriate envelope. This is acceptable.

Table 9/17: Ranges between maximum and minimum values for the selected grading envelope

Sieve	Ranges. Percent by mass	
	Smallest range	**Widest range**
First optional sieve between nominal sieve and 2mm	10	25
Second optional sieve between nominal sieve and 2mm	10	25
2mm	5	15
Optional fine sieve between 2mm and 0.063mm	4	15
0.063mm	2.0	6.0

Note: This table specifies the permitted width of the selected grading envelope e.g. in the first optional sieve the smallest range allowed between the minimum and the maximum percent passing that particular sieve is 10 percent and the widest range permitted between the sieves is 25 percent.

Table 9/18: Wheel Tracking requirements for site classifications

Classification	Test temperature	Maximum wheel tracking values	
Road category		**Rut rate (mm/hr)**	**Rut depth (mm)**
Very heavily stressed sites requiring high rut resistance	60°C	5.0	7.0
Moderately stressed sites requiring high rut resistance	45°C	2.0	4.0

Table 9/19: Requirements for Skid Resistance (sfc units)

Mean sfc (Initial)	Not more than 15% below	Minimum sfc (After 3 Years)
>0.55	0.55	0.50

Table 9/20: Requirements for Texture Depth.

Where maximum vehicle speed is:	**≤ 50km/h**		**> 50Km/h**	
Nominal stone size of mix (mm)	10	14	10	14
Initial, after laying				
Average for each lane Km or Surfaced length if less than 1 Km.	≥1.2mm	≥1.2mm	≥1.5mm	≥1.5mm
Average of each set of ten measurements	≥1.0mm	≥1.0mm	≥1.2mm	≥1.2mm
After 3 years				
Average for each lane Km or Surfaced length if less than 1 Km.	≥1.0mm	≥1.0mm	≥1.3mm	≥1.3mm
Average of each set of ten measurements	-	-	≥1.0mm	≥1.0mm

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