SERIES 900
ROAD PAVEMENTS - BITUMINOUS BOUND MATERIALS

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BITUMINOUS BOUND MATERIALS

901 Bituminous Roadbase and Surfacing Materials

General

1 Bituminous pavement courses shall be made using the materials described in Appendix 7/1.

Aggregates for Bituminous Materials

2 Aggregates shall be clean, hard and durable.

Hardness

Unless otherwise stated in Appendix 7/1, coarse aggregates for bituminous materials shall have the following properties:

(i) a ten per cent fines value not less than 140 kN for natural crushed and uncrushed aggregates and not less than 85 kN for blastfurnace slag when tested in a dry condition in accordance with BS 812: Part 111;

(ii) an aggregate impact value not greater than 30 per cent for natural crushed and uncrushed aggregates and not greater than 35 per cent for blastfurnace slag when tested in a dry condition in accordance with BS 812: Part 112.

Durability

When required in Appendix 1/5, the aggregate source shall be tested in accordance with BS 812: Part 121 and shall have a soundness value greater than 75, or such lower value as may be required in Appendix 7/1. Thereafter, for routine testing of such aggregates, the water absorption value of the coarse aggregate shall be determined as in BS 812: Part 2. If the water absorption value of the coarse aggregate is greater than 2%, or 4% for blastfurnace slag, the soundness test shall be carried out on the material delivered to site.

Cleanness

Unless otherwise stated in Appendix 7/1, the fraction of material passing 75 micron, 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 BS 812: Part 103.

Transporting

3 Hot bituminous materials shall be transported in clean insulated vehicles, unless otherwise agreed by the Overseeing Organisation, 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. When a fluid 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.

Laying

4 On each day, and at each location where hot bituminous material is laid, at least 300 tonnes from a plant approved by the Overseeing Organisation shall be placed before material from another approved plant is used. If the Contractor demonstrates that the materials from different plants are of equivalent quality and possess equivalent laying and compaction characteristics this requirement can be waived.

5 Wherever practicable, bituminous materials shall be spread, levelled and tamped by a self-propelled paving machine, which may be equipped with an averaging beam. 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 and it shall be so operated whenever practicable.

6 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 of the material.

7 Hot bituminous 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. Where there is no British Standard for the particular material it shall be laid in accordance with the requirements and recommendations of BS 594: Part 2, subject also to the requirements of sub-Clauses 8 to 27 of this Clause.

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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 BS 594: Part 2.

8 When laying basecourse or wearing 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.

9 With the exception of sand asphalt carpet, bituminous materials with a temperature greater than 125°C shall not be deposited on a bridge deck waterproofing system 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.

10 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.

11 Hand-raking of wearing 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.

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

Compaction

13 Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirements and compaction to be achieved.

14 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. Rolling shall continue until all roller marks have been removed from the surface.

15 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. Wearing course and basecourse 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.

16 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 Clause 929, 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.

17 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.

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

19 Unless otherwise specified in Appendix 7/1, the design, compaction assessment and compliance requirements for roadbase and basecourse macadams shall be in accordance with Clause 929.

Chippings

20 The application of coated chippings to areas of wearing course shall be by a 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 wearing course is permitted.

(iv) To correct uneven distribution of chippings.

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

Joints

22 Except where otherwise specified in this Series, where longitudinal joints are made in wearing courses, the material shall be fully compacted and the joint made flush in one of the following ways; only method (iii) shall be used for transverse joints:

(i) By heating the joint with an approved joint heater when the adjacent width is being laid, but without cutting back or coating with binder. The heater shall raise the temperature of the full depth of wearing course, to within the specified range of minimum rolling temperature and maximum temperature at any stage for the material, for a width not less than 75 mm. The Contractor shall have equipment available, for use in the event of a heater breakdown, to form joints by method (iii).

(ii) By using two or more pavers operating in echelon, where this is practicable, and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling.

(iii) 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 suitable hot bitumen, or cold-applied polymer modified intermediate or premium grade bitumen emulsion, or polymer modified adhesive bitumen strip with a minimum thickness of 2 mm, before the adjacent width is laid.

23 All joints shall be offset at least 300 mm from parallel joints in the layer beneath. Joints in the wearing course or porous asphalt 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.

General

24 When directed, the Overseeing Organisation may require the application of a bituminous tack coat spray, complying with Clause 920, to the surface on which laying is to take place.

25 Bituminous material shall be kept clean and uncontaminated. Except by prior agreement with the Overseeing Organisation 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 basecourse is to be blinded or surface dressed, that engaged on such surface treatment. If the binder film on a bituminous surface onto which a wearing course is to be laid becomes visibly worn or impregnated with dust as a result of additional trafficking, then a bituminous tack coat spray complying with Clause 920 shall be applied before laying takes place. 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.

26 Upper roadbase material, in pavements without basecourse, and basecourse material shall not remain uncovered by either the wearing course or surface treatment, whichever is specified in the Contract, for more than three consecutive days after being laid. With prior agreement with the Overseeing Organisation this period may be extended by the minimum amount of time necessary to allow for adverse weather conditions or for other reasons.

Regulating Course

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

902 Reclaimed Bituminous Materials

1 Reclaimed bituminous materials may be used in the production of bituminous roadbase, basecourse and wearing course. The mixed material shall comply with the requirements of this Series. The maximum amount of reclaimed materials permitted shall be 10% for hot rolled asphalt wearing course complying with BS 594 and 30%

for coated macadam basecourse and roadbase and hot rolled asphalt basecourse and roadbase complying with BS 4987 and BS 594 respectively.

2 When the amount of reclaimed bituminous materials comprises 10% by mass or less, compliance with sub-Clause 902.3 is not required. However, when it exceeds 10% by mass, the Contractor shall carry out the trials to demonstrate the mixed materials comply with the requirements of sub-Clause 902.3.

3 The virgin bitumen grade is specified in Appendix 7/1. 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 BS 2000: Part 49.

Specified Grade of Binder (Penetration)	Minimum Recovered Penetration Value of Binder after Mixing
50	30
100	60
200	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 598 and testing in accordance with BS 2000: Part 49.

5 All reclaimed bituminous materials shall be pre-treated before use such that the material is homogeneously mixed and the maximum particle size of reclaimed material does not exceed 40 mm.

6 Trials for dense bitumen macadam, heavy duty macadam and DBM50 shall be in accordance with Clause 929.

903 Dense Macadam Roadbase

1 Unless otherwise specified in Appendix 7/1, dense macadam roadbase shall comply with Clause 929. Dense macadam roadbase shall comply with BS 4987: Part 1 for dense roadbase, and with sub-Clauses 2 and 3 of this Clause, and the requirements of Appendix 7/1.

Filler

2 When the coarse aggregate is 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 lime is not required when limestone gravel is used as the coarse aggregate.

Binder

3 The binder shall be petroleum bitumen complying with BS 3690: Part 1. The penetration of the bitumen shall be either grade 100 penetration or grade 200 penetration as described in Appendix 7/1.

When produced in a drum-mix plant, the maximum temperature of the mix at any stage shall be 175°C when 100 penetration bitumen is used.

904 Rolled Asphalt Roadbase

1 Rolled asphalt roadbase shall comply with BS 594: Part 1 for roadbase, and with sub-Clauses 2 and 3 of this Clause, and the requirements of Appendix 7/1.

Filler

2 When the coarse aggregate is 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

3 Binder shall comply with BS 3690: Part 1 and have the penetration described in Appendix 7/1.

905 Rolled Asphalt Basecourse

1 Rolled asphalt basecourse shall comply with BS 594: Part 1 for basecourse mixtures, and with sub-Clauses 2 and 3 of this Clause, and the requirements of Appendix 7/1.

Filler

2 When the coarse aggregate is 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

3 Binder shall comply with BS 3690: Part 1 and have the penetration described in Appendix 7/1.

Rolled Asphalt Basecourse to Porous Asphalt Wearing Course

4 The material shall comply with sub-Clauses 1-3 of this Clause.

5 The material shall be produced, laid and compacted to provide a dense layer with a maximum of 6 per cent air voids in any location, including across joints between adjacent basecourse layers.

6 Compliance with this air void requirement shall be determined in the manner described in Clause 929 for basecourse macadam.

7 Areas of basecourse which do not comply with the specified air void requirements shall be removed and replaced as necessary.

906 Dense Macadam Basecourse

1 Unless otherwise specified in Appendix 7/1, dense macadam basecourse shall comply with Clause 929. Dense macadam basecourse shall comply with BS 4987: Part 1 for dense basecourse, and with sub-Clauses 2 and 3 of this Clause, and the requirements of Appendix 7/1.

Filler

2 When the coarse aggregate is 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

3 The binder shall be petroleum bitumen complying with BS 3690: Part 1. The penetration of the bitumen shall be either grade 100 or 200 as specified in Appendix 7/1. When produced in a drum-mix plant, the maximum temperature of the mix at any stage shall be 175ºC when 100 penetration bitumen is used.

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.

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 Unless otherwise described in Appendix 7/1, rolled asphalt shall be used for regulating courses where rolled asphalt is specified for the pavement layers, or is selected by the Contractor from the alternative materials listed in Appendix 7/1 for pavement layers. Bituminous materials for regulating courses shall meet the requirements for the appropriate material, as specified above.

4 Where the total depth of a regulating course exceeds 150 mm then the course shall be laid so that each regulating layer has a compacted thickness of between 75 mm and 150 mm.

908 Single Course Macadam

1 Single course macadam shall comply with BS 4987: Part 1 for 40 mm size single course and with sub-Clause 2 of this Clause, and the requirements of Appendix 7/1.

Filler

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

Binder

3 The binder shall be petroleum bitumen or cut-back bitumen complying with BS 3690: Part 1. The grade of binder shall comply with BS 4987: Part 1 and shall be as specified in Appendix 7/1.

909 Dense Macadam Wearing Course

1 Dense macadam wearing course shall comply with BS 4987: Part 1 for dense wearing course, and with this Clause, and the requirements of Appendix 7/1.

2 The traffic category shall be as stated in Appendix 7/1.

3 The source rock for coarse aggregate shall have the minimum polished stone value and maximum aggregate abrasion value determined in accordance with BS 812: Parts 113 and 114 respectively and specified in Appendix 7/1.

Binder

4 The binder shall be petroleum bitumen or cut-back bitumen complying with BS 3690: Part 1. The grade of binder shall comply with BS 4987: Part 1 and shall be as specified in Appendix 7/1.

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910 Rolled Asphalt Wearing Course (Recipe Mix)

1 Rolled asphalt wearing course shall comply with BS 594: Part 1 for wearing course recipe mixtures, and with sub-Clauses 2, 3 and 4 of this Clause, and the requirements of Appendix 7/1. The recipe mixture selected by the Contractor shall be notified to the Overseeing Organisation prior to its use in the Works.

Binder

2 The binder shall comply with the requirements of BS 3690: Part 1 or Part 3 (mixtures of bitumen and Lake Asphalt), and shall have the penetration described in Appendix 7/1. Grade 40 penetration HD bitumen may be used only if agreed by the Overseeing Organisation.

Coarse Aggregate Content

3 When determined in accordance with BS 812: Part 114, coarse aggregate shall have a polished stone value not less than 45. Nominal coarse aggregate content by mass of the total mix shall be as described in Appendix 7/1.

Coated Chippings

4 Coated chippings shall be 20 mm or 14 mm nominal size as described in Appendix 7/1 and shall comply with Clause 915.

911 Rolled Asphalt Wearing Course (Design Mix)

1 Rolled asphalt wearing course shall be designed in accordance with the procedures of BS 598: Part 107 and shall comply with BS 594: Part 1 for wearing course design mixtures, and with sub-Clauses 2 to 7 of this Clause, and the requirements of Appendix 7/1. The design mixture selected by the Contractor shall be notified to the Overseeing Organisation prior to its use in the Works.

Binder

2 The binder shall comply with the requirements of BS 3690: Part 1 or Part 3 (Mixtures of bitumen and Lake Asphalt). Grade 40 penetration HD bitumen may be used only if agreed by the Overseeing Organisation.

Coarse Aggregate

3 Coarse aggregate shall be crushed rock or slag with a polished stone value not less than 45 when determined in accordance with BS 812: Part 114. Nominal coarse aggregate content by mass of the total mix shall be as described in Appendix 7/1.

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 wearing 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: Part 1.

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 wearing course design mix. The nature and source of the coarse and fine aggregate may be changed only if the mix is redesigned and agreed by the Overseeing Organisation prior to its use in the Works. With the agreement of the Overseeing Organisation the source of the filler may be varied provided its characteristics remain essentially the same.

Coated Chippings

8 Coated chippings shall be 20 mm or 14 mm nominal size as described in Appendix 7/1 and shall comply with Clause 915.

912 Close Graded Macadam Wearing Course

1 Close graded macadam wearing course shall comply with BS 4987: Part 1, and the requirements of Appendix 7/1.

2 The traffic category shall be as stated in Appendix 7/1.

Coarse Aggregate

3 When determined in accordance with BS 812: Part 113 and Part 114, the source rock for coarse aggregate shall have the minimum polished stone value and maximum aggregate abrasion value described in Appendix 7/1.

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Binder

4 The binder shall be petroleum bitumen or cut-back bitumen complying with BS 3690: Part 1. The grade of bitumen shall comply with BS 4987: Part 1 and shall be as specified in Appendix 7/1.

913 Dense Tar Surfacing Wearing Course

1 Dense tar surfacing wearing course shall comply with BS 5273, and with sub-Clauses 2, 3 and 4 of this Clause, and the requirements of Appendix 7/1.

Binder

2 The grade of tar shall be as described in Appendix 7/1.

Coarse Aggregate

3 The nominal size of coarse aggregate and the minimum polished stone value, determined in accordance with BS 812: Part 113, shall be as described in Appendix 7/1. The coarse aggregate content for road use shall be 35% and for hardstanding areas shall be 50%.

Coated Chippings

4 Coated chippings shall be 20 mm or 14 mm nominal size as described in Appendix 7/1 and shall comply with Clause 915.

914 Fine Graded Macadam Wearing Course

1 Fine graded macadam wearing course shall comply with BS 4987: Part 1 for fine graded wearing course and, with sub-Clauses 2, 3, and 4 of this Clause, and the requirements of Appendix 7/1.

2 The traffic category shall be as stated in Appendix 7/1.

Coarse Aggregate

3 When determined in accordance with BS 812: Part 113 and Part 114, the source rock for coarse aggregate shall have the minimum polished stone value and maximum aggregate abrasion value described in Appendix 7/1.

Binder

4 The binder shall be petroleum bitumen or cut-back bitumen complying with BS 3690: Part 1. The grade of binder shall comply with BS4987: Part 1 and shall be as specified in Appendix 7/1.

Coated Chippings

5 Coated chippings applied to fine graded macadam wearing course shall be 14 mm or 10 mm nominal size, as described in Appendix 7/1, and shall comply with BS 4987: Part 1 and with sub-Clauses 915.2 and 915.3.

915 Coated Chippings for Application to Pre-mixed Surfacings

1 The chippings and the manner of coating, when used for rolling into the surface of rolled asphalt, dense tar surfacing or mastic asphalt, shall be in accordance with BS 594: Part 1, with sub-Clauses 2 and 3 of this Clause, and with sub-Clause 901.2.

2 The minimum polished stone value and the maximum aggregate abrasion value, determined in accordance with BS 812: Parts 113 and 114 respectively, and the nominal size of the chippings shall be as described in Appendix 7/1.

3 The polished stone value shall be determined in accordance with BS 812: Part 114. The aggregate shall be deemed to comply if the mean of the 3 most recent consecutive results from tests relating to the material to be supplied, carried out within the previous 6 months by a testing laboratory with the relevant UKAS accreditation within 6 weeks of sampling, is greater than or equal to the value described in Appendix 7/1.

916 Open Graded Macadam Wearing Course

1 Open graded macadam wearing course shall comply with BS 4987: Part 1 for open graded wearing course and with sub-Clause 2 of this Clause, and the requirements of Appendix 7/1.

Aggregate

2 When determined in accordance with BS 812: Part 113 and Part 114, the coarse aggregate shall have the minimum polished stone value and maximum aggregate abrasion value described in Appendix 7/1.

Binder

3 The binder shall be petroleum bitumen or cut-back bitumen complying with BS 3690: Part 1. The grade of binder shall comply with BS 4987: Part 1 and shall be as specified in Appendix 7/1.

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 dust, which 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 basecourse. 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 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 Overseeing Organisation 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 The material removed from the carriageway shall be run to spoil in tips provided by the Contractor, unless otherwise described in Appendix 2/3. 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 Overseeing Organisation.

918 Slurry Surfacing

1 The Contractor shall:

(a) be responsible for the design of the work, choice of materials, techniques and processes based on site and traffic data specified in Appendix 7/7 and the schedule of constraints on site availability in Appendix 1/13.

(b) provide a Design Proposal to achieve the performance requirements in terms of levels of defects as set out in this Clause and ensure that the slurry surfacing has an initial stability such that it is capable of withstanding the normal traffic for the site when first opened.

(c) state the Estimated Design Life of the slurry surfacing in the Design Proposal citing any similar previous works and performance.

(d) provide a Quality Plan, which will be audited by the Overseeing Organisation with respect to the Design Proposal.

(e) carry out the slurry surfacing in accordance with the Design Proposal; BS 434 or the procedures set out in the British Board of Agrément HAPAS Roads and Bridges Certificate as appropriate; and in accordance with this Clause to the thickness and tolerances specified in Appendix 7/7.

(f) guarantee the design, materials and workmanship against defects and against failure to meet the performance requirements of this Clause for a period of two years, or as otherwise specified in Appendix 7/7, from the date of completion of the work. The Overseeing Organisation will monitor the performance of the slurry surfacing during the guarantee period, and bring any defects to the attention of the Contractor.

The System

2 Slurry surfacings, except those in accordance with BS 434 shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, slurry surfacings that do not comply with BS 434 shall not be used without the approval of the Overseeing Organisation. The Contractor shall provide, with his Design Proposal, a Data Sheet giving details of the properties of each

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system proposed, including the data specified in this Clause and in Appendix 7/7.

Mixture Tests

3 The Contractor shall provide the data indicated in Appendix 7/7 and such other data as he may consider useful, to enable the Overseeing Organisation to assess the suitability of the product for the sites to be treated.

Aggregates

4 The aggregate shall be crushed rock, slag, gravel or calcined bauxite, complying with this specification and with a grading complying with the appropriate size in Table 9/1 or BS 434: Part 2. Where specified in Appendix 7/7 the coarse aggregate, where used, shall have a minimum Polished Stone Value (PSV) and maximum Aggregate Abrasion Value (AAV), determined in accordance with BS 812: Parts 113 and 114 respectively. The Contractor shall provide, before work commences, a test certificate, issued by a testing laboratory, accredited for those tests by UKAS, not more than six months previously, showing conformity with these requirements. In the Design Proposal the Contractor shall state the aggregate characteristics and sources to be used and provide an example of the target grading and binder content. The grading and binder content shall not differ from the proposed target values by more than the tolerance detailed in the Design Proposal. The grading shall in all cases fall within the limits of grading for the appropriate envelope in BS 434: Part 2 or Table 9/1 as detailed in the Design Proposal.

TABLE 9/1 Gradings for Slurry Surfacings

	0/4	0/2
sieve size mm	**passing %**	**passing %**
5.6 or 6.3	100	
4	80-100	100
2	50-80	70-100
1	35-60	50-80
0.063	4-16	5-18

Binder Tests

5 When required to provide test portions they shall be recovered from the emulsion binder in accordance with Clause 923.

6 The Recovered Binder shall be tested as follows:

(a) Vialit Pendulum cohesion curve in accordance with Clause 939.

(b) Penetration at 5^0 C (200g for 60 secs) and at 25^0 C (BS 2000, 100g for 5 secs).

7 The Contractor shall provide Product Identification Test results for the binder(s) proposed. These shall comprise rheological data as detailed in Clause 928 for Recovered Binder prepared in accordance with Clause 923.

Coloured Materials

8 Where required in Appendix 7/7 a coloured slurry surfacing shall be provided. All coloured slurry surfacings shall be approved by the Overseeing Organisation. They shall conform in all respects with the requirements of this Clause.

Equipment

9 The slurry surfacing machine, when used, shall be capable of uniform application to provide a continuous surface without ridges or segregation. Before laying begins the Contractor shall provide the Overseeing Organisation with a test certificate showing test results for rate of application carried out under his own Quality Assurance Scheme, demonstrating that the slurry surfacing machine has been tested, using the system to be used in the Contract, not more than six weeks before the commencement of the work, and that it complies with the requirements set out in his Design Proposal.

Weather Conditions

10 Any weather restrictions placed on the use of the slurry surfacing by the Contractor and BBA/HAPAS shall be detailed in the Proposal.

Health and Safety

11 Health and Safety information and safe handling guide shall be provided.

Preparation

12 Any necessary remedial work to the road surface and structure shall be completed either prior to or as part of the Contract and agreed as acceptable by the Overseeing Organisation and the Contractor before slurry surfacing commences.

13 Before slurry surfacing is applied, street furniture and, where directed road markings, shall be masked using self-adhesive masking material or other material firmly secured against the passage of the spreader box or the tools used for hand laying. Any packed mud or other deposits on the surface shall be removed, all organic growth shall be removed by suitable means, and the surface shall be swept free of all loose material.

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14 A bond coat may be applied prior to the slurry surfacing with or without grit or chippings in order to seal the existing substrate and enhance the bond to the existing road surface. The details of this treatment shall be as stated in the British Board of Agrément HAPAS Roads and Bridges Certificate. If no such certificates have been issued, such treatment shall be in accordance with the Contractor's method statement contained within his Design Proposal.

Traffic Safety and Management

15 Traffic safety and management shall be strictly in accordance with the requirements of Series 100 of this Specification and any site specific additional requirements specified in Appendix 1/17.

Mixing

16 The slurry shall be mixed in a continuous flow mixing machine and discharged directly into the spreader box. Where the material is to be hand laid the slurry may be supplied to site pre-mixed in suitable containers and steps shall be taken to ensure that the material in each container is of an even consistency throughout the container immediately prior to use.

Application

17 Application restrictions to be observed in the event of adverse weather shall be as specified in this Clause, BS 434, or the British Board of Agrément HAPAS Roads and Bridges Certificate as appropriate and any additional requirements specified in Appendix 7/7.

18 Transverse joints for machine laid areas shall be formed with spreading starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips.

19 Unless otherwise agreed with the Overseeing Organisation, longitudinal joints, where the material is laid on a road, shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.

20 Hand work around street furniture and other iron work shall meet the same performance requirements and form a homogeneous surface with the rest of the treated carriageway.

21 Footways and other confined areas may be spread by hand using squeegees and brooms. Transverse joints shall be formed with spreading starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips. Kerbs, edges and other areas not being treated shall be suitably masked with self adhesive masking material. Footways shall be finished by dragging a dampened broom transversely over the footway under its own weight.

22 All voids, cracks and surface irregularities shall be completely filled. Spreading shall not be undertaken when the temperature of the surface to be covered falls below 4°C or when standing water is present on the surface. In warm dry weather, the surface immediately ahead of the application, shall be slightly damped by mist water spray applied mechanically, or for hand laying by a hand operated pressure sprayer, unless otherwise agreed by the Overseeing Organisation.

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

24 The finished surface shall be free from blow holes and surface irregularities in excess of 3 mm beneath a 1 m straight edge due to scraping, scabbing, dragging, droppings, excess overlapping or badly aligned longitudinal or transverse joints, damage by rain or frost, or other defects which remain 24 hours after laying. Slurry surfacing which does not comply with this Clause or is non-uniform in surface texture or, where specified colour, 24 hours after laying shall be rectified by removal and replacement with fresh material or, if this is impractical, by having fresh material superimposed. Areas so treated shall be not less than 5 m long and not less than one lane wide (or the full width if less than a lane wide). All areas being worked on shall be kept free of traffic until agreed by the Overseeing Organisation.

25 The Contractor shall record the amount of slurry used and the area covered for each run or section completed and pass copies of the records to the Overseeing Organisation. The Contractor shall facilitate joint audit checks with the Overseeing Organisation if required.

Aftercare

26 Masking shall be removed after the slurry surfacing has been applied, without damage to the edge of the surfacing, and before opening the road or footway to traffic.

27 The Contractor shall remove surplus aggregate from the treated areas using a method agreed in the Quality Plan. The Contractor shall monitor the slurry surfacing closely for a minimum period of 2 hours and if necessary the lane shall be swept again. The monitoring shall continue until the slurry surfacing has reached

sufficient stability to carry unrestricted traffic. If there are signs of distress the Contractor shall reinstate traffic safety and management procedures or other such remedial action where necessary in order to prevent further damage.

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

As Built Manual

29 Not more than 30 days after completion of the work the Contractor shall provide a record of the progress of the work in the form of an As Built Manual incorporating all relevant information, including all test results, volumes of slurry used, record of traffic control carried out, weather information, unforeseen problems, a list of complaints, if any, from the general public or road users and any other information that the Overseeing Organisation may reasonably require to be included.

Performance Standards for Slurry Seal During the Guarantee Period

30 The extent of aggregate loss or other defects will be monitored by the Overseeing Organisation using a visual method of assessment. Any 100 metre long section of the Works shall have failed if an individual area of the substrate exceeding 0.1 m^2 within the section is exposed or if the total of all the areas of substrate exposed exceeds 0.2% of the area of the section. If there is a failed section, the Contractor will be invited to inspect the site in order to agree remedial measures.

31 Coloured materials shall retain their colour, at least to the level detailed in the British Board of Agrément HAPAS Roads and Bridges Certificate throughout the guarantee period.

32 Any section failing to meet the required standard shall be subject to remedial action by the Contractor.

919 Surface Dressing: Recipe Specification

1 The Contractor shall:

(i) carry out the surface dressing in accordance with the Overseeing Organisation's design described in Appendix 7/3 subject to the schedule of constraints on site availability set out in Appendix 1/13.

(ii) be responsible for the choice of materials, techniques and processes subject to the requirements described in Appendix 7/3. The tolerances permitted for this work shall be as specified in Appendix 7/3.

(iii) provide a Quality Plan, which may be subject to audit by the Overseeing Organisation with respect to the method of executing the work.

(iv) guarantee the materials and workmanship against defects and against failure to meet the specification for a period of one year, or as otherwise described in Appendix 7/3, from the date of completion of the work.

Materials and Equipment - The Binder

2 The binder shall be of the type and grade specified in the design. Modified binders shall be Intermediate Grade or Premium Grade Binder, having a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, modified binders shall not be used without the approval of the Overseeing Organisation. Conventional binders shall be cut-back bitumen complying with BS 3690: Part 1, or bitumen emulsion complying with BS 434: Part 1, Type K1-70. The recovery of the binder shall be carried out in accordance with Clause 923. The test to determine Vialit Pendulum Cohesion shall be carried out in accordance with the method in Clause 939. The Contractor shall provide a Binder Data Sheet giving details of the properties of each binder proposed, including those specified in Appendix 7/3 and in this Clause as follows.

(i) Vialit Pendulum cohesion curve:

(a) Emulsified binders:- for the binder before emulsification and after recovery from the emulsion.

(b) Cutback binders:- for the binder before addition of solvent, the cutback as supplied and after recovery.

(ii) Penetration at 5°C (200g for 60 secs) and at 25°C (BS 2000, 100g for 5 secs)

(a) Emulsified binders:- for the binder before emulsification and after recovery from the emulsion.

(b) Cutback binders:- for the binder before addition of solvent, and after recovery.

(iii) Penetration at 5°C (100g for 5 secs) for cut back binders as supplied. As an alternative to this the supplier may provide viscosity measurements at temperatures between 100°C and 160°C which are measured as part of his QA scheme.

(iv) Binder-Aggregate adhesivity by the Vialit Plate shock test of draft BS EN 12272-3 1997 using

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the proposed binder and aggregate as specified in Appendix 7/3; results from all the tests shall be provided.

(v) If the binder is a modified bituminous material, product identification shall be provided as described in sub-Clause 4 of this Clause.

(vi) Recommended spray temperatures and pressures for the binder sprayer to be used.

(vii) Viscosity of emulsion binders as supplied; either Redwood II at 85°C or STV 4 mm cup at 40°C.

(viii) Any weather restrictions placed on the use of the binder by the manufacturer.

(ix) Health and Safety information and safe handling guide.

3 The Contractor shall provide rheological product identification in accordance with Clause 928.

4 The binder sprayer shall be capable of uniform application at the designed rate of spread over a variable or fixed width sufficient to allow a full lane width to be dressed in a single pass. Before spraying begins the Contractor shall provide the Overseeing Organisation with a test certificate showing test results for rate of spread and accuracy of spread of binder carried out in accordance with the test methods in draft BS EN 12272-1 issued by a testing laboratory, holding UKAS accreditation for the tests, or tests under his own Quality Assurance Scheme, demonstrating that the binder sprayer has been tested, using the binder to be used in the Contract, not more than six weeks before the commencement of the work, and that it complies with the requirements set out in Appendix 7/3.

Materials and Equipment - Chippings

5 The chippings shall be crushed rock, slag or gravel complying with BS 63: Part 2, or calcined bauxite, and shall have a minimum Polished Stone Value and maximum Aggregate Abrasion Value, determined in accordance with BS 812: Parts 113 and 114 respectively, and as specified in Appendix 7/3 for each site. In his proposals the Contractor shall state the source and characteristics of chippings to be used and type of coating, if any. The Contractor shall provide, before work commences, a test certificate, issued by a testing laboratory, with UKAS accreditation, not more than six months previously, showing conformity with the requirements. When determined in accordance with BS 812: Part 105, at the frequency specified in Appendix 1/5, the flakiness index of the chippings shall not exceed 25.

6 The chipping spreader shall have controlled metering and be capable of variable or fixed width application to match the binder sprayer. Before a spreader is used, the Contractor shall provide to the Overseeing Organisation a test certificate showing test results for rate of spread and accuracy of spread of chippings in accordance with the test methods in draft BS EN 12272-1 issued by a testing laboratory, holding UKAS accreditation for the tests, or tests carried out under his own Quality Assurance Scheme demonstrating that the chipping spreader has been tested, using chippings similar to those to be used in the Contract, not more than six weeks before the commencement of the work, and that it complies with the requirements set out in Appendix 7/3. Spreaders for the secondary chippings in two layer dressings may be tailboard gritters or fixed width chipping spreaders used in echelon.

Preparation

7 Any necessary remedial work to the road surface and structure shall be complete prior to or as part of the Contract before surface dressing commences.

8 Before binder is applied, street furniture shall be masked using self-adhesive masking material. Oil, sand or similar materials shall not be used. Any packed mud or other deposits on the road surface shall be removed, and the road surface shall be swept free of all loose material.

9 Traffic safety and management shall in accordance with the requirements of Series 100 of this specification and any site specific additional requirements specified in Appendix 1/13.

Application

10 Binder shall be applied to the road surface at the rates specified in the design. The Contractor shall mark out areas where an adjusted binder rate is needed, because of localised conditions and note such changes in the As Built Manual. Application restrictions to be observed in the event of adverse weather shall be as specified below together with any additional limitations set out in Appendix 7/3.

(a) When there is precipitation.

(b) When there is free water on the surface.

(c) When the air temperature is at or below the values given in the table below.

(d) For emulsion binders when the relative humidity exceeds 80%.

(e) When the road surface temperature exceeds 35°C for roads carrying over 200 cv/lane/day or 40°C below that traffic level.

Air Temperature for Spraying

Binder	Uncoated chippings	Coated chippings
	min °C	min °C
cut-back bitumen 50 sec	10	8
cut-back bitumen 100 sec	15	10
cut-back bitumen 200 sec	18	13
bitumen emulsion	10	--
all modified binders	manufacturer's recommendation	manufacturer's recommendation

11 Transverse joints shall be formed with spraying starting and finishing on a protective strip not less than 1 metre wide at each end of the lane length being treated. Transverse joints shall be of binder overlap only and not wider than 100 mm. There shall be no ridges or bare strips.

12 Longitudinal joints shall coincide with lane markings. Longitudinal joints shall be of binder overlap only and not wider than 100 mm, unless quartering (using a part of the spraybar) when the overlap may be extended to a maximum of 300 mm. There shall be no ridges or bare strips.

13 The Contractor shall carry out the tests for rates of spread and accuracy of application of binder and chippings in accordance with the test methods in draft BS EN 12272-1 at the frequency specified in Appendix 1/5 and report the results to the Overseeing Organisation within 24 hours of carrying out the test. The Contractor shall facilitate duplicate testing by the Overseeing Organisation if required.

14 Rolling shall be performed by rubber coated vibratory steel rollers and/or pneumatic tyred rollers as specified in Clause 901. The rollers shall have fully operating sprinkler systems, spraying water or other release agent onto the drum or tyres, so that if the chippings start to move under the roller exposing binder the sprinklers are available immediately.

Aftercare

15 Masking shall be removed after the 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.

16 The Contractor shall monitor the dressing closely for a minimum period of 2 hours, or as specified in Appendix 7/3, 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 dressing.

17 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.

18 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

19 Not more than 30 days after completion of the work the Contractor shall provide a record of the progress of the work in the form of an As Built Manual incorporating all relevant information, including all test results; variations to the design and those necessitated by localised site conditions; weather information; unforeseen problems; a list of complaints, if any, from the general public or road users; and any such other information that the Overseeing Organisation may reasonably require to be included.

920 Bond or Tack Coats and Other Bituminous Sprays

1 A bond or tack coat shall be sprayed onto the existing surface prior to overlay in accordance with sub-Clauses 901.24 and 901.25. 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 Overseeing Organisation. For proprietary surfacings the bond coat shall be in accordance with the British Board of Agrément HAPAS Roads and Bridges Certificate for the surfacing.

2 The preparation of a surface for a bituminous spray, the application of a spray and blinding when specified, shall be carried out in accordance with BS 594: Part 2 or BS 4987: Part 2, and the recommendations of Road Note 39, as appropriate to the work and shall comply with any requirements specified in Appendix 7/4.

3 The binder shall be cut-back bitumen complying with BS 3690: Part 1 or bitumen emulsion complying with BS 434: Part 1 or modified binder as described in Appendix 7/4. The binder data sheet specified in Appendix 7/4 shall be completed by the Contractor. The binder shall be sprayed at the rate specified in Appendix 7/4.

4 Except where applied by hand held sprayer, the transverse distribution and rate of spread of binder shall be measured in accordance with Clause 922 and the rate of testing shall be as specified in Appendix 1/5. The accuracy of transverse distribution of the binder sprayer and the tolerance on the rate of spread of binder shall be Class 1. For small areas where application is by hand held sprayer, the rate of spread shall measured by calculating the volume applied per square metre.

5 Before binder spraying is commenced, the surface shall be free of all loose material and standing water. Where cut-back bitumen is to be used the surface shall be dry.

6 Blinding material, where required in Appendix 7/4 shall consist of hard clean crushed rock or slag fine aggregate or sand containing not more than 15% 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 to 7.0 kg/m^2.

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

921 Surface Texture of Bituminous Wearing Courses on High Speed Roads

1 The texture depth of the surface of bituminous wearing course shall be measured by the sand patch method described in BS 598: Part 105.

2 When 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 not be less than 1.5 mm. The average of each set of 10 individual measurements shall not be less than 1.2 mm.

922 Surface Dressing: Performance Specification

1 The Contractor shall be responsible for the design of the work, choice of materials, techniques and processes based on site and traffic data specified in Appendix 7/3 and the schedule of constraints on site availability in Appendix 1/13.

2 The Contractor shall:

(i) Provide a Design Proposal to:

(a) ensure the surface dressing is capable of withstanding the traffic, subject to the speed limit specified in Appendix 7/3, when first opened.

(b) achieve the performance requirements in terms of texture and levels of defects as set out in this Clause and in Appendix 7/3.

(ii) state the estimated design life of the dressing in the Design Proposal citing any similar previous works.

(iii) provide a Quality Plan, which may be subject to audit by the Overseeing Organisation with respect to the Design Proposal.

(iv) carry out the surface dressing in accordance with the Design Proposal to the tolerances specified in Appendix 7/3.

3 The Contractor shall guarantee the design, materials and workmanship against defects and against failure to meet the end product performance requirements for a period of two years, or as otherwise specified in Appendix 7/3, from the date of completion of the work. The Overseeing Organisation will monitor the performance levels of the surface dressing during the guarantee period, and bring any defects to the attention of the Contractor.

Materials and Equipment - The Binder

4 Modified binders shall be Intermediate Grade or Premium Grade Binder, having a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, modified binders shall not be used without the approval of the Overseeing Organisation. Conventional binders shall be cut-back bitumen complying with BS 3690: Part 1, or bitumen emulsion complying with BS 434: Part 1, Type K1-70. The recovery of the binder shall be carried out in accordance with Clause 923. The test to determine Vialit Pendulum Cohesion shall be carried out in accordance with Clause 939. The Contractor shall provide, with his Design Proposal, a Binder Data Sheet giving details of the properties of each binder proposed, including those specified in Appendix 7/3, and in this Clause as follows:

(i) Vialit Pendulum cohesion curves:

(a) Emulsified binders:

- for the binder before emulsification and after recovery from the emulsion.

(b) Cutback binders:

- for the binder before addition of solvent, the cutback as supplied, and after recovery.

(ii) Penetration at 5°C (200 g for 60 secs) and at 25°C (BS 2000, 100 g for 5 secs):

(a) Emulsified binders:

- for the binder before emulsification and after recovery from the emulsion.

(b) Cutback binders:

- for the binder before addition of solvent and after recovery.

(iii) Penetration at 5°C (100 g for 5 secs) for cut back binders as supplied. As an alternative to this the supplier may provide a viscosity measurement at between 100°C and 160°C which is measured as part of his QA scheme.

(iv) Binder-Aggregate adhesivity by the Vialit Plate Shock test method of draft BS EN 12272-3 1997 using the proposed binder and aggregate as specified in Appendix 7/3; results from all the tests shall be provided.

(v) If the binder is a modified bituminous material, product identification shall be provided as specified in sub-Clause 5 of this Clause.

(vi) Recommended spray temperatures and pressures for the binder sprayer to be used.

(vii) Minimum viscosity of emulsion binders as delivered; either Redwood II at 85°C or STV 4 mm at 40°C.

(viii) Any weather restrictions placed on the use of the binder by the manufacturer.

(ix) Health and Safety information and safe handling guide.

5 The Contractor shall provide rheological product identification in accordance with Clause 928.

6 The binder sprayer shall be capable of uniform application over a variable or fixed width sufficient to allow a full lane width to be dressed in a single pass. Before spraying begins the Contractor shall provide the Overseeing Organisation with a test certificate showing test results for rate of spread and accuracy of spread of binder carried out in accordance with the test methods in draft BS EN 12272-1 and issued by a testing laboratory, holding UKAS accreditation for the tests, or tests carried out under his own Quality Assurance Scheme, demonstrating that the binder sprayer has been tested, using the binder to be used in the Contract, not more than six weeks before the commencement of the work, and that it complies with the requirements set out in Appendix 7/3.

Materials and Equipment - The Chippings

7 The chippings shall be crushed rock, slag, or gravel, complying with BS 63: Part 2, or calcined bauxite, and shall have a minimum Polished Stone Value and maximum Aggregate Abrasion Value, determined in accordance with BS 812: Parts 113 and 114 respectively, and as specified in Appendix 7/3 for each site. In the Design Proposal the Contractor shall state the source and characteristics of chippings to be used and type of coating, if any. The Contractor shall provide, before work commences, a test certificate, issued by a testing laboratory, holding UKAS accreditation for the tests, not more than six months previously, showing conformity with these requirements. When determined in accordance with BS 812: Part 105 1989, at the frequency specified in Appendix 1/5, the flakiness index of the chippings shall not exceed 25.

8 The chipping spreader shall have controlled metering and be capable of variable or fixed width application to match the binder sprayer. Before a spreader is used, the Contractor shall provide the Overseeing Organisation with a test certificate showing test results for rate of spread and accuracy of spread of chippings carried out in accordance with the test methods in draft BS EN 12272-1, and issued by a testing laboratory, holding UKAS accreditation for the tests, or tests carried out under his own Quality Assurance Scheme, demonstrating that the chipping spreader has been tested, using the chippings similar to those to be used in the Contract, not more than six weeks before the commencement of the work, and that it complies with the requirements set out in Appendix 7/3. Spreaders for the secondary chippings in two layer dressings may be tailboard gritters or fixed width chipping spreaders used in echelon.

Preparation

9 Any necessary remedial work to the road surface and structure shall be complete prior to or as part of the Contract before surface dressing commences.

10 Before binder is applied, street furniture shall be masked using self-adhesive masking material. Oil, sand or similar materials shall not be used. Any packed mud or other deposits on the road surface shall be removed, and the road surface shall be swept free of all loose material.

11 Traffic safety and management shall be in accordance with the requirements of Series 100 of this Specification and any site specific additional requirements specified in Appendix 1/13.

Application

12 Restrictions to be observed in the event of adverse weather shall be as specified in Appendix 7/3.

13 Transverse joints shall be formed with spraying starting and finishing on a protected strip not less than 1 metre wide at each end of the lane length being treated.

Transverse joints shall be of binder overlap only and not wider than 100 mm. There shall be no ridges or bare strips.

14 Longitudinal joints shall coincide with lane markings. Longitudinal joints shall be of binder overlap only and not wider than 100 mm, unless quartering (using a part of the spraybar) when the overlap may be extended to a maximum of 300 mm. There shall be no ridges or bare strips.

15 The Contractor shall carry out the tests for rates of spread and accuracy of application of binder and chippings in accordance with the test methods in draft BS EN 12272-1 at the frequency specified in Appendix 1/5 and report the results to the Overseeing Organisation within twenty-four hours of carrying out the test. The Contractor shall facilitate duplicate testing by the Overseeing Organisation if required.

16 Rolling shall be performed by rubber coated vibratory steel rollers and/or pneumatic tyred rollers as specified in Clause 901. The rollers shall have fully operating sprinkler systems spraying water or other release agent onto the drum or tyres so that if the chippings start to move under the roller exposing binder the sprinklers are available immediately.

Aftercare

17 Masking shall be removed after the dressing has been applied and before opening the road to unrestricted traffic. The time period before unrestricted traffic may use the surface dressing shall not exceed that specified in Appendix 7/3. The Contractor shall remove surplus chippings from the road by suction sweeping before it is opened to unrestricted traffic.

18 The Contractor shall monitor the dressing closely for a minimum period of 2 hours, or as specified in Appendix 7/3, after the road is opened to traffic. The Contractor shall reinstate traffic safety and management procedures or other such 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 dressing.

19 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.

As Built Manual

20 Not more than 30 days after completion of the work the Contractor shall provide a record of the progress of the work in the form of an As Built Manual incorporating all relevant information, including: all test results; variations to the Design Proposal and those necessitated by localised site conditions; a record of traffic control carried out; weather information; unforseen problems; a list of complaints, if any, from the general public or road users; and any other information that the Overseeing Organisation may reasonably require to be included.

Performance Standards During the Guarantee Period

21 Surface Texture

The Contractor is responsible for maintaining the surface texture requirements set out in Appendix 7/3 throughout the guarantee period. When required, the Contractor shall design the surface dressing to limit the maximum texture after four weeks trafficking to that specified in Appendix 7/3.

The Overseeing Organisation will use the TRL High Speed Texture Meter (HSTM) or High Speed Road Monitor (HRM) or other suitable equipment to determine the Sensor Measured Texture Depth (SMTD). Measurements of SMTD shall be made in the nearside and offside wheel tracks of all lanes and callibrated against sand patch test values measured in accordance with BS 598: Part 105. The texture shall be maintained above the minimum sand patch test values specified in Appendix 7/3 for every 100 m lane length. The texture depths will be measured, initially, between three weeks and five weeks after completion of the Works, then after 11 months and before 13 months and finally after 22 months and before the end of the guarantee period at 24 months unless otherwise specified in Appendix 7/3.

22 Defects

The extent of chipping loss or other defects will be monitored by the Overseeing Organisation using a visual method of assessment. The performance standard is that any section of the works shall be deemed as having failed if the areas of defects do not comply with the classes specified in Appendix 7/3. If there is a failed section, the Contractor will be invited to inspect the site in order to recommend remedial measures.

In the event that the Contractor and Overseeing Organisation are unable to reach agreement on whether a section has failed by visual assessment, the level of defects shall be determined in accordance with the test methods in draft prEN 00227205:1997. Any section failing to meet the required standard as specified in Appendix 7/3 shall be subject to remedial action by the Contractor.

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923 Binder Recovery Method: Preparation of Recovered Binder from Bituminous Emulsions and Cut-Back Bituminous Binders

Scope

1 This Clause specifies the procedure for obtaining a quantity of recovered binder from cut-back bituminous binder or bituminous emulsion binder. The recovered binder may then be used for further testing.

Definition

2 For the purposes of the procedure specified in this Clause, 'recovered binder' shall be defined as "the material remaining after treatment of the original product under the conditions specified by this method".

Principle of the Test

3 A thin film of either cut-back or emulsion binder shall be rotated in glass bottles at a temperature of (85± 2) °C to evaporate water and/or the light solvent or highly volatile fraction. Nitrogen gas instead of air shall be jetted over the binder film in order to minimise ageing effects. The standard gas flow of 4,000± 200 ml/min shall be used.

Test Apparatus

4 The following test apparatus shall be used:

(a) Rolling thin film oven test (RTFOT) apparatus to ASTM D2872-88;

(b) A balance accurate to 0.1g;

(c) A timer capable of timing 100 minutes, accurate to 1 second in five minutes;

(d) Nitrogen gas supply;

(e) An oven to pre-heat the bottles to 140 ± 5 °C (For cutback binders only);

(f) A microwave oven.

Sample Preparation

5 For cut-back binder only: The binder shall not be heated after obtaining the sample. A convenient method of reducing the sample to test specimen size is to freeze the binder at -20 °C and break it into pieces as required. In order to ensure that a film of binder is distributed around each bottle, the bottles shall be pre-heated to 140 ± 5 °C and, after adding the binder pieces and weighing, shall be rolled gently on the bench before mounting in the carousel of the RTFOT apparatus.

6 For emulsion binders only: The RTFOT bottles shall be pre-heated to 85 ± 2 °C. The emulsion shall be thoroughly stirred immediately prior to decanting into the RTFOT bottles to ensure homogeneity, and after weighing the bottles shall be rolled on the bench to ensure distribution of the emulsion round the bottle.

Test Procedure

7 The procedure shall be as follows:

(i) Eight RTFOT bottles shall be selected, cleaned and weighed. The test oven shall be switched on and set to maintain a temperature of 85 ±2 °C. The Contractor shall wait until the oven temperature has stabilised.

(ii) Approximately 25± 0.5 g of binder shall be weighed out into each bottle. The weight of each bottle with binder shall be recorded to an accuracy of ± 0.1g. The samples shall be prepared in accordance with sub-Clause 5 or sub-Clause 6 of this Clause depending on the binder type.

(iii) Place each bottle into the carousel of the pre-heated oven and rotate the carousel with the nitrogen gas supply jet switched on, previously calibrated as detailed in ASTM D2872-88. Start the timer immediately. The sample preparation, in terms of:

(a) loading the bottles with binder;

(b) weighing; and

(c) rolling and mounting of all the bottles, shall be completed and rotation of the carousel commenced within a period not exceeding 20 minutes.

(iv) When 75 minutes have elapsed, the time shall be noted and the bottles removed from the carousel. Residual moisture may be present in samples of bituminous emulsion. This moisture shall be removed by heating gently to avoid spitting in a microwave oven until constant weight has been achieved. Weigh each bottle and record the weight loss to 0.1g. Report the percentage binder weight loss.

(v) The 'recovered binder' shall be obtained by scraping the bottles to remove the majority of material. The 'recovered binder' shall be transferred immediately, and before it cools to ambient, to other test apparatus such as a rheometer Vialit Cohesion Pendulum Tester, in order to minimise further changes to the binder, or is to be transferred to another location for testing or stored. Then a penetration pot shall be used and the binder surface sealed using aluminium foil to prevent further loss of volatiles and to minimise exposure to air. For transfer or storage the sample shall not be subjected to temperatures greater than ambient and the delay before testing shall not exceed 120 hrs.

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924 High Friction Surfaces

1 High friction surfacing systems shall have current British Board of Agrément HAPAS Roads and Bridges Certificates. If no British Board of Agrément HAPAS Roads and Bridges Certificates have been issued, then in the interim only high friction surfacing systems nearing completion of their BBA assessment shall be considered for approval by the Overseeing Organisation.

2 A high friction surfacing system with a current British Board of Agrément HAPAS Roads and Bridges Certificate shall only be installed by a Contractor approved by the BBA and the Certificate Holder as an Approved Installer for that system.

3 The high friction surfacing system BBA/HAPAS Type Classification required for each location shall be as specified in Appendix 7/1.

Aggregate

4 Aggregate used in high friction surfacing systems shall have the minimum polished stone value, determined in accordance with BS 812: Part 114, as specified in Appendix 7/1.

Installation and Quality Control Procedures

5 The installation and quality control procedures shall be in accordance with the British Board of Agrément HAPAS Roads and Bridges Certificate for each system and the current method statement agreed by the BBA. The results of all quality control checks carried out on site by the Contractor and quality assurance information compiled in accordance with the requirements of the British Board of Agrément HAPAS Roads and Bridges Certificate, including results from BBA surveillance visits, shall be made available to the Overseeing Organisation on request.

System Coverage

6 For each location where high friction surfacing is applied, the total quantities of each system component used, the measured area of the surface treated and the calculated coverage rate in kg/m^2 shall be reported to the Overseeing Organisation within three days of completion at that location. For systems in which aggregate is broadcast over a film of binder applied to the surface, the calculated coverage rate shall be that of the binder film and shall not include the mass of the aggregate.

Guarantee

7 The Contractor shall guarantee the high friction surfacing materials and workmanship for a period of two 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, but shall cover failure to meet the minimum requirements set out in Table 4 of the BBA/HAPAS 'Guidelines Document for the Assessment and Certification of High Friction Surfaces for Highways.'

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 specified otherwise in this Series.

2 The bulk density of blastfurnace slag shall be determined by the compacted bulk density test described in BS 812: Part 2 carried out on oven-dried aggregates passing the 14 mm and retained on the 10 mm BS sieves.

3 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 In Situ Recycling - The Remix and Repave Processes

1 Where milling is required, it shall be carried out in accordance with Clause 917, and as described in Appendix 7/5.

Heating and Scarifying

2 Surfaces to be treated shall be heated by plant with heating surfaces insulated and fully enclosed. The heated-width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilt onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.

3 The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of wearing course material specified in Appendix 7/5. A tolerance of ± 6 mm is permissible.

4 Where ironwork and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressings and large areas of road markings shall be removed by milling, planing, scarifying or similar.

5 The heated surface shall be evenly scarified to comply with the requirements of sub-Clause 3 of this

Clause. When ironwork is left in place or raised, the adjacent areas shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If ironwork needs to be relevelled, on completion of work, the new wearing course material shall be used to make good the road surface for a maximum width of 200 mm around the ironwork. Pre-coated chippings shall be applied to the surface of the hot-rolled asphalt.

6 During the reheating process the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

Rejuvenator

7 For Remix, when required, rejuvenator shall be uniformly sprayed across the full-width of the processed material. The machine shall incorporate a meter for continuous verification of quantities which shall be within ±5% of the specified rate. The volume of rejuvenator shall vary in relation to the operating speed of the machine, which shall be related to the volume of material mixed or scarified.

8 The rejuvenator shall be a non-emulsified aromatic extract. Its properties shall be verified using the Rolling Thin Film Oven Test as follows:-

Nominal 50 pen grade bitumen, of known penetration and softening point, shall be hardened in the Rolling Thin Film Oven in accordance with ASTM D2872. It shall then be rejuvenated back to its original penetration and re-tested. A sample shall then be re-subjected to hardening in the Rolling Thin Film Oven Test, as before. The penetration of the rejuvenated hardened bitumen, after the Rolling Thin Film Oven Test shall be not less than the penetration of the original 50 pen bitumen after the same test.

9 Rejuvenation of the existing pavement may also be performed by adding new hot-mix bituminous material containing a soft binder of suitable penetration for restoring the binder in the existing pavement to a nominal level of 50 pen.

Mixing

10 When required, new hot-mix material shall be mixed with the heated and scarified road pavement material in the pugmill within the Remix machine, observing the minimum mixing temperatures specified in BS 594.

11 After mixing, the recycled bituminous materials shall be automatically fed to a finishing unit, which spreads and levels the mixture to the specified thickness and cross-section. The new hot rolled asphalt surface shall be materials complying with Clause 910 or 911, in accordance with Appendix 7/5.

Additional Material: General

12 The proportion of new hot-mix bituminous material, and the proportion of existing bituminous pavement material, shall be as stated in Appendix 7/5, together with the amount the road surface level is to be raised (if any).

13 The type and quantity of the new hot-mix material shall be determined by the Contractor using the Mix Design procedure specified in BS 598, before work commences. Remix designs shall incorporate the stated proportion of material sampled from the existing road surface.

14 When additional coarse or fine aggregates or filler are required to be added, they shall comply with the requirements of the relevant Clause in the Series 900 and, if specified, with any additional requirements stated at Appendix 7/1. The amount of additional coarse or fine aggregate or filler to be added to the existing bituminous pavement material shall be notified to the Overseeing Organisation.

Additional Aggregate (Remix Process)

15 The coarse aggregate, fine aggregate and filler added to the Remixed material shall comply with the requirements of Clause 901 and Appendix 7/1.

New Surfacing (Repave and Remix/Repave Processes)

16 New surfacing material shall be hot rolled asphalt wearing course complying with Clause 910 or 911, as described in Appendix 7/5, or other wearing course material approved by the Overseeing Organisation.

17 The new surfacing material shall be laid on, and compacted with, the reprofiled surfacing, which shall be at a temperature within the range of 100°C to 150°C.

Binder

18 The binder shall be recovered from samples taken from each layer of material laid. The method of recovery shall be in accordance with BS DD 193 or an equivalent test. The penetration of the binder shall be in the range 30-60 pen.

Stability and Flow

19 The surfacing material shall be sampled from the paver hopper or augers in accordance with the requirements of BS 598. Care shall be taken that only the material forming the new surface layer is sampled. The sample shall be reduced on site by riffling or

quartering to approximately 5 kg and placed loose in an air-tight container.

20 The sample shall only be reheated once whilst within the container, as specified in BS 598: Part 107. As soon as the sample reaches the required temperature, the reheated material shall be remixed and three test specimens prepared in accordance with the procedures specified in BS 598: Part 107.

21 The mean stability and flow of the three specimens, measured in accordance with the procedures of BS 598: Part 107, shall comply with the requirements of Appendix 7/5.

Coated Chippings

22 Coated chippings shall be as described in Appendix 7/1 and shall comply with sub-Clause 915.2.

927 Micro-surfacing

1 The Contractor shall:

(a) be responsible for the design of the work, choice of materials, techniques and processes based on site and traffic data specified in Appendix 7/8 and the schedule of constraints on site availability in Appendix 1/13;

(b) provide a Design Proposal to achieve the end product performance requirements in terms of texture and levels of defects as set out in this Clause and in Appendix 7/8 and ensure that the micro-surfacing has an initial stability such that it is capable of withstanding traffic moving at the speed defined in Appendix 7/8 when first opened;

(c) state the Estimated Design Life of the micro-surfacing in the Design Proposal citing any similar previous works and performance;

(d) provide a Quality Plan, which may be subject to audit by the Overseeing Organisation with respect to the Design Proposal;

(e) carry out the micro-surfacing in accordance with this Clause, the Design Proposal and the procedures set out in the British Board of Agrément HAPAS Roads and Bridges Certificate to the tolerances specified in Appendix 7/8;

(f) guarantee the design, materials and workmanship against defects and against failure to meet the end product performance requirements of this Clause for a period of two years, or as otherwise specified in Appendix 7/8, from the date of completion of the work. The Overseeing Organisation will monitor the performance levels of the micro-surfacing during the guarantee period, and bring any defects to the attention of the Contractor.

The System

2 Micro-surfacings shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, micro-surfacings shall not be used without the approval of the Overseeing Organisation. The Contractor shall provide, with his Design Proposal, a Data Sheet giving details of the properties of each system proposed, including those specified in Appendix 7/8, and in this Clause as follows:

Mixture Tests

3 The Contractor shall provide the data indicated in Appendix 7/8 and such other data as he may consider useful, to enable the Overseeing Organisation to assess the suitability of the product for the sites to be treated.

Aggregates

4 The aggregate shall be crushed rock, slag, gravel or calcined bauxite, complying with this specification and with a grading complying with the appropriate size in Table 9/2. The coarse aggregate shall have a minimum Polished Stone Value (PSV) and maximum Aggregate Abrasion Value, determined in accordance with BS 812: Parts 113 and 114 respectively, and as specified in Appendix 7/8 for each site. The Contractor shall provide, before work commences, a test certificate, issued by a testing laboratory, accredited for those tests by UKAS, not more than six months previously, showing conformity with these requirements. In the Design Proposal the Contractor shall state the aggregate characteristics and sources to be used and provide an example of the target grading and binder content as detailed in Appendix 7/8. The grading and binder content shall not differ from the proposed target values by more than the tolerance detailed in the British Board of Agrément HAPAS Roads and Bridges Certificate. The grading shall in all cases fall within the limits of grading for the appropriate limiting envelope in Table 9/2.

TABLE 9/2 Gradings for Micro-surfacings

	0/10 either of		0/8 either of		0/6 either of	
sieve size mm	passing %	passing %	passing %	passing %	passing %	passing %
16	100					
12.5		100				
11.2	80-100					
10		70-100	100	100		
8	55-85	55-85	85-100	85-100	100	100
6.3		45-90		72-94		91-100
5.6	40-85		65-90		85-100	
4	30-75	30-75	50-80	50-80	70-95	70-95
2	20-55	20-55	30-60	30-60	40-70	40-70
1	15-40	15-40	20-45	20-45	25-50	25-50
0.063	3-10	3-10	3-12	3-12	4-14	4-14

Binder Tests

5 When required, test portions shall be recovered from the emulsion binder in accordance with Clause 923.

6 The recovered binder shall be tested as follows:

(a) Vialit Pendulum cohesion curve in accordance with Clause 939.

(b) Penetration at 5^0 C (200g for 60 secs) and at 25^0 C (BS 2000, 100g for 5 secs).

7 The Contractor shall provide Product Identification Test results for the binder(s) proposed. These shall comprise rheological data in accordance with Clause 928 for recovered binder prepared using the test procedure detailed in Clause 923.

Coloured Materials

8 Where required in Appendix 7/8 a coloured slurry surfacing shall be provided. All coloured micro surfacings shall be approved by the Overseeing Organisation. They shall conform in all respects with the requirements of this Clause.

Equipment

9 The micro-surfacing machine shall be capable of uniform application to provide a continuous surface without ridges or segregation. Before laying begins the Contractor shall provide the Overseeing Organisation with a test certificate showing test results for rate of application carried out under his own Quality Assurance Scheme, demonstrating that the micro-surfacing machine has been tested, using the system to be used in the Contract, not more than six weeks before the commencement of the work, and that it complies with the requirements set out in his Design Proposal.

Weather Conditions

10 Any weather restrictions placed on the use of the micro-surfacing by the Contractor and BBA/HAPAS shall be detailed in the Design Proposal.

Health and Safety

11 Health and Safety information and safe handling guide shall be provided.

Preparation

12 Any necessary remedial work to the road surface and structure shall be completed prior to or as part of the Contract and agreed as acceptable by the Overseeing Organisation and the Contractor before micro-surfacing commences.

13 Before micro-surfacing is applied, street furniture and where directed, road markings, shall be masked using self-adhesive masking material or other material firmly secured against the passage of the spreader box. Any packed mud or other deposits on the road surface shall be removed, and the road surface shall be swept free of all loose material.

14 Any bond coat to be applied prior to the micro-surfacing with or without grit or chippings in order to seal the existing substrate and enhance the bond to the existing road surface shall be in accordance with the British Board of Agrément HAPAS Roads and Bridges Certificate. If no such Certificates have been issued, such treatment shall be in accordance with the Contractor's method statement contained within his Design Proposal.

Traffic Safety and Management

15 Traffic safety and management shall be strictly in accordance with the requirements of Series 100 of this Specification and any site specific additional requirements specified in Appendix 1/13.

Application

16 Application restrictions to be observed in the event of adverse weather shall be as stated in the British Board of Agrément HAPAS Roads and Bridges Certificate and as specified in Appendix 7/8.

17 Transverse joints shall be formed with spreading starting and finishing on a protective strip not less than 100 mm wide at each end of the lane length being treated. Transverse joints shall be formed such that there shall be no ridges or bare strips.

18 Unless otherwise agreed with the Overseeing Organisation, longitudinal joints shall coincide with lane markings. Longitudinal joints shall be formed such that there shall be no ridges or bare strips.

19 Hand work around street furniture and other iron work should meet the same end performance requirements and form a homogeneous surface with the rest of the treated carriageway.

20 The surface profile of the micro-surfacing shall meet the requirements specified in Appendix 7/8.

21 The Contractor shall record the amount of micro-surfacing used and the area covered for each run or section completed and pass copies of the records to the Overseeing Organisation. The Contractor shall facilitate joint audit checks with the Overseeing Organisation if required.

Aftercare

22 On heavily trafficked roads the speed controls imposed on the traffic over the Contract section shall be maintained for a minimum period of 72 hours after completion of the works and not less than the period specified in Appendix 7/8.

23 Masking shall be removed, without damage to the edges of the surface, after the micro-surfacing has been applied and before opening the road to unrestricted traffic.

24 The Contractor shall remove surplus aggregate from the road by suction sweeping using a method agreed in the Quality Plan. Each lane shall be opened to restricted traffic flow to consolidate and help dry the surfacing; the section should then be closed, suction swept and re-opened, maintaining the speed restriction specified in Appendix 7/8. The Contractor shall monitor the micro-surfacing closely for a minimum period of 2 hours and if necessary the lane shall be swept again. The monitoring shall continue until the micro-surfacing has reached sufficient stability to carry unrestricted traffic. If there are signs of distress the Contractor shall reinstate traffic safety and management procedures or other such remedial action where necessary in order to prevent further damage to the micro-surfacing.

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

As Built Manual

26 Not more than 30 days after completion of the work the Contractor shall provide a record of the progress of the work in the form of an As Built Manual incorporating all relevant information, including all test results, volumes of micro-surfacing in each run, record of traffic control carried out, weather information, unforeseen problems, a list of complaints, if any, from the general public or road users and any other information that the Overseeing Organisation may reasonably require to be included.

Performance Standards for Micro-surfacing during the Guarantee Period Surface Texture

27 The Contractor is responsible for maintaining the surface texture requirements set out in Appendix 7/8 throughout the guarantee period. When required, the Contractor shall design the micro-surfacing to limit the maximum texture after four weeks trafficking to that specified in Appendix 7/8.

28 The Overseeing Organisation will use the TRL High Speed Texture Meter (HSTM) or High Speed Road Monitor (HRM) or other suitable equipment to determine the Sensor Measured Texture Depth (SMTD). Measurements of SMTD shall be made in the nearside and offside wheel tracks of all lanes and callibrated against sand patch test values measured in accordance with BS 598: Part 105. The texture shall be maintained above the minimum sand patch test values specified in Appendix 7/8 for every 100 m lane length. The texture depths will be measured, initially, between three weeks and five weeks after completion of the works, then after 11 months and before 13 months and finally after 22 months and before the end of the guarantee period at 24 months unless otherwise specified in Appendix 7/8.

Surface Profile

29 The surface profile of the micro-surfacing, when measured in accordance with the 700 Series, shall meet the requirements specified in Appendix 7/8 for both transverse and longitudinal profile.

Defects

30 The extent of aggregate loss or other defects will be monitored by the Overseeing Organisation using a visual method of assessment. The performance standard is that any section of the Works have failed if the areas of defects do not comply with the classes specified in Appendix 7/8 or the area of micro-surfacing where the substrate is visible in whole or in part exceeds individual areas of 0.1 m^2 or a total of 0.2% of the area in any 100 m long section. If there is a failed section, the Contractor will be invited to inspect the site in order to agree remedial measures.

31 Coloured materials shall retain their colour, to at least the level detailed in the British Board of Agrément

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HAPAS Roads and Bridges Certificate throughout the guarantee period.

32 In the event that the Contractor and Overseeing Organisation are unable to reach agreement on whether a section has failed by visual assessment, the level of defects shall be determined in accordance with the current agreed BBA/HAPAS test method.

33 Any section failing to meet the required standard as specified in Appendix 7/8 shall be subject to remedial action by the Contractor.

TABLE 9/3: Tolerances for Aggregate Grading and Binder Content to be Applied to the Agreed Grading and Binder Content

BS Test Sieve	Tolerance for aggregate grading in percent by mass of aggregate passing BS test sieve		
	40 mm roadbase/ basecourse	28 mm roadbase/ basecourse	20 mm basecourse
50 mm	±0	±0	
37.5 mm	±5*	±0	
28 mm	±12	±10*	±0
20 mm	—	±12	±5*
14 mm	±10	±12	±10
10 mm	—	—	±10
6.3 mm	±8	±8	±8
3.35 mm	±7	±7	±7
300 micron	±7	±7	±7
75 micron	±3.5	±3.5	±3.5
75 micron (HDM)	±2	±2	±2
Binder Content	±0.6	±0.6	±0.6

Note: Application of the above tolerances to the agreed aggregate grading and binder content may result in limits outside those permitted by the appropriate table in BS 4987. Provided the target grading and 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.

928 Determination of the Complex Stiffness Modulus (G*) and Phase Angle (δ) of Bituminous Binders using a Dynamic Shear Rheometer (DSR)

Scope

1 This Clause describes the test method for the determination of the Complex Stiffness Modulus (G*) and Phase Angle (δ) of a bituminous binder over a range of temperatures and frequencies when tested in harmonic, sinusoidal oscillatory shear mode using a dynamic shear rheometer (DSR) with parallel plate test geometry and where both plates can be controlled at the same temperature.

This Clause also describes a method for determining Phase Angle (δ) from a temperature sweep, where the temperature of the binder is raised at a known rate and tested at a fixed frequency. This is used to characterise the binder and provide an indication of binder modification.

2 It is applicable to unmodified and polymer modified binder as supplied, after the Rolling Thin Film Oven Test (RTFOT), after an Ageing Test or as recovered from a mixture.

For cut-back bitumens, bituminous emulsions and polymer variants the binder should be sampled from the delivery and a recovered binder prepared in accordance with Clause 923.

Modified binders containing fine mineral or organic matter (ie. <0.02 mm) may be tested, although levels in excess of 20% may not provide true values. Coarse aggregate particles or fibres may introduce surface effects, which interfere with the test.

3 A rheometer that can control the temperature of both plates shall be used.

Definitions

4 For the purposes of this Clause the following definitions apply

(i) Complex Stiffness Modulus (G*) or Dynamic Shear Modulus: Ratio of peak stress to peak strain in harmonic, sinusoidal oscillation mode.

(ii) Phase Angle (δ): The phase difference between stress and strain in harmonic, sinusoidal oscillation mode.

(iii) Isotherm: An equation or curve on a graph representing the behaviour of the material at a constant temperature.

(iv) Master curve: A composite curve at a single reference temperature constructed by shifting a series of overlapping isotherms at different temperatures. Within the temperature range covered by this clause the temperature shifts the isotherms of a visco-elastic parameter, such as G*, along the frequency axis without changing their shape. The distance through which one isotherm is shifted to overlap another is assumed to be a function of the difference in temperature and is called the 'Shift Factor'. It is also possible to construct a Master Curve of G* or δ against temperature at a constant frequency.

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(v) High Equi-stiffness Temperature(T_{2kPa}): the temperature at which G* is equal to 2 kPa at 0.4 Hz from the plot of G* vs. temperature as described in sub-Clause 25 of this Clause.

(vi) Low Equi-stiffness Temperature (T_{2MPa}): the temperature at which G* is equal to 2 MPa at 0.4 Hz from the plot of G* vs. temperature as described in sub-Clause 25 of this Clause.

(vii) $G^*_{(pen)}$: the Complex Stiffness Modulus at the penetration test temperature (25°C) and frequency (0.4 Hz) from the Master Curve.

(viii) $\delta_{(high)}$: the Phase Angle from the temperature equilibrated data at 60°C and at a frequency of 0.1 Hz (long loading time).

Apparatus

5 A dynamic shear rheometer capable of carrying out the test or tests is required. It is likely that at least two plate diameters will be needed to cover the range of moduli to be measured. The system used to control temperature must encompass both plates in order to minimise temperature gradients within the sample.

Laboratory oven to BS 2648 covering the range 50°C to 170°C (± 5°C)

Balance readable to 1mg (the mass is for guidance only therefore no precision is required)

Vials, 10 ml suitable for heating to 170°C

Silicone moulds (required for method B only), silicone release paper or other suitable material

Sundry normal laboratory equipment such as stirring rods, spatulas (temperature resistant non-metallic to avoid marking the plates) and suitable cleaning solvents.

Preparation of the Rheometer

6 The manufacturer's instructions shall be followed in sequence for the setting up of the rheometer, including the procedure for setting the gap. The rheometer and the temperature control system shall be calibrated and traceable to national standards, where applicable, at intervals not exceeding 13 months. For the purpose of this method the oscillation package shall be selected from the software menu. The temperature control system shall be capable of control to an accuracy including uncertainty of ± 0.5°C over at least the range of -5°C to +60°C.

7 Parallel plate geometry shall be used with appropriate combinations of plate diameter and gap to cover the range of stiffnesses developed over the temperature range required.

8 The method involves the heating of binder and suitable precautions should be taken when handling hot materials.

Determination of Complex Stiffness Modulus (G*) and Phase Angle (δ)

9 In all cases prolonged heating of the binder shall be avoided. The sample shall be prepared and loaded into the DSR in accordance with one of the three methods (A, B or C) detailed in this Clause. If prepared samples are stored in a refrigerator, they shall be warmed to a temperature at least 20°C above the softening point prior to use, to reverse any possible structural or physical hardening effects. The maximum temperature for binders recovered from cut-back bituminous binders or bituminous emulsions using Clause 923 shall be 100°C (preferably no higher than 85°C). This restricts the preparation of the sample to method C detailed in this Clause.

10 Before introducing the binder into the DSR clean the plates with a suitable solvent and dry. Metal scrapers shall not be used as they may damage the surface of the plates. Care shall be taken not to damage the plate surfaces or bend the shaft of the upper plate. It is recommended that the temperature of the bottom plate be set to about 20°C above the softening point of the binder or 90°C, whichever is the lower, to allow satisfactory bonding of the binder to the plates.

11 Method A

(i) Sample preparation: Heat the bulk binder to a pourable consistency below 175°C (typically 135°C-170°C depending on binder). The sample shall be stirred occasionally to ensure the binder is homogeneous and shall not be stored for longer than 1 hour at the target temperature. When sufficiently fluid pour directly into vials each with a volume of approximately 10 ml (three vials per geometry are normally sufficient, the third is then available for any re-testing that may be necessary). The vials shall be filled to the top and sealed with metal foil or silicone release paper unless they are being used immediately. Any storage of vials shall be at room temperature.

(ii) Sample loading: Pour sufficient binder from the vial for there to be a slight excess on the DSR bottom plate appropriate for the geometry being used. Any binder not poured from the vial shall be discarded. The time for transfer should be recorded.

(iii) Sample gapping: The plates shall be at the same temperature prior to setting the gap.

Lower the upper plate (or raise the lower plate) to the required nominal testing gap plus 0.025 mm (eg 1.025 mm for a nominal 1 mm gap). The sample shall be trimmed using a hot spatula or similar. After trimming the gap shall be closed by 0.025 mm to the required nominal testing gap. No further trimming shall be carried out.

12 Method B

(i) Sample preparation: Heat the bulk binder to a pourable consistency below 175°C (typically 135°C-170°C depending on binder). The sample shall be stirred occasionally to ensure the binder is homogeneous and shall not be stored for longer than 1hour. When sufficiently fluid pour a pre-calculated amount of binder directly into suitable moulds (typically silicone-based or PTFE material) or onto silicone release paper and allow to cool to ambient temperature. The disc may be prepared as a slice cut from a cooled larger cylindrical specimen with a hot knife. The binder specimen shall be sealed with silicone release paper and/or metal foil to minimise ageing and loss of volatiles

(ii) Sample loading: Place the weighed disc onto either the top or bottom plate. The time for transfer should be recorded.

(iii) Sample gapping: The plates shall be at the same temperature prior to setting the gap. The required gap shall be set immediately, no trimming is required with the special moulds.

13 Method C

(i) Sample preparation: Warm the binder sufficiently to be able to remove small quantities from the bulk using a suitable spatula or other tool. (A temperature around the softening point is usually found to be suitable). The binder shall not be heated above 100°C and not stored for longer than 1 hour at the target temperature. The binder shall be sealed with silicone release paper and/or metal foil to minimise ageing and loss of volatiles.

(ii) Sample loading: Weigh a pre-calculated amount of binder, to suit the geometry, directly onto one of the rheometer plates or, onto a silicone-based material for subsequent transfer to one of the plates. The time for transfer should be recorded.

(ii) Sample gapping: The plates shall be at the same temperature prior to setting the gap. The required gap shall be set immediately, no trimming is required.

14 The DSR shall be run in oscillatory mode. The sample shall be tested within the linear (elastic) region for the particular binder over the temperature range chosen.

15 Allow the sample and both plates to equilibrate at the test temperature for at least 15 minutes.

16 The test temperatures shall cover at least the following: -5°C, 5°C, 15°C, 25°C, 35°C, 45°C and 60°C to an accuracy of ± 0.5°C. The equilibration time at each temperature shall be a minimum of 15 minutes. The frequency range at each temperature shall be 0.1 Hz to 10 Hz and shall be a minimum of eleven suitably spaced frequencies including the nominal frequencies of 0.4 Hz, 1.0 Hz and 1.6 Hz (to an accuracy of ± 10%). Logarithmic steps provide an even spacing of points on the graphical output. In order to provide the temperature value within the range of results for the High Equi-stiffness Temperature some binders may require testing at temperatures above 60°C so a further frequency sweep at 70°C or higher may be necessary.

17 Testing shall commence at the estimated highest test temperature. Once temperature equilibration has been achieved the frequency sweep shall be commenced at either the lowest or the highest frequency and proceed in order through the range to the highest or lowest frequency. There shall be a minimum rest period of 5 seconds between each frequency.

18 The test temperature shall be successively lowered and testing carried out after the minimum equilibration of 15 minutes at each test temperature. Testing shall continue until the interaction of the stiffness of the test geometry and of the machine affects the results whereupon the test geometry shall be changed to a smaller diameter plate or larger gap or both. The test temperature at which this occurs shall be repeated using the new geometry.

Data Acceptability Criteria

19 A minimum of two binder samples shall be tested. If the Complex Stiffness Modulus (G*), read from the graphs at each equilibrated temperature and at a frequency of 1 Hz (the middle of the frequency range), resulting from the two samples differs by more than 15% or if the difference in Phase Angle, from graphs at each equilibrated temperature and at a frequency of 1 Hz, is more than 3 degrees then a further sample shall be tested.

Temperature sweep

20 At the completion of one of the test runs described in sub-Clauses 8-18 of this Clause a temperature sweep shall be carried out from the lowest test temperature to at least 60°C or the High Equi-stiffness Temperature,

whichever is the higher. The test frequency shall be 0.4 Hz (± 10%). Phase Angle shall be measured at temperature intervals not greater than 5.5°C (5.0 +0.5°C). The test geometry shall not be changed during this test. The rate of temperature increase shall be 2.5 ± 0.5°C per minute or a lesser fixed rate, which shall be stated with tolerances.

21 Alternatively the equilibrated temperature data from frequency sweeps may be used to provide values for Phase Angle at 0.4 Hz, although this will increase the number of equilibrated temperature frequency sweeps required (5°C intervals). Again only one geometry may be used in the test.

Expression of Results

22 A table of results, based on the individual test results, shall be produced which shall include the following information at each temperature:

(i) test temperature °C

(ii) test frequency Hz

(ii) strain %

(iv) Phase Angle (δ) Degrees

(v) Complex Stiffness Modulus (G*) Pascals

23 If the Data Acceptability Criteria are achieved, either initially or between any two of the three results, the mean of the two closest results shall be reported. If the Data Acceptability Criteria are not met after three test runs then all three results shall be reported.

24 The average isotherms of G* shall be constructed together with the master curve referenced to 25°C. An A4-size landscape graph of G*(Pascals) shall be produced, in decades from 10^{-1} to 10^{9}, against frequency (Hz), in decades from 10^{-7} to 10^{6}, as a master curve at 25°C and with separate curves for each temperature.

25 An A4-size landscape graph of G* shall be produced, in decades from 10^{1} to 10^{8} as a master curve at 0.4 Hz against temperature derived from the first graph and re-plotted with a linear temperature x-axis of -10°C to 100°C

26 The shift factors may be determined either mathematically or manually. The shift factors used in the generation of the master curve shall be presented in a tabular format.

27 An A4-size landscape graph for the temperature sweep plot of Phase Angle (δ) from 0 to 90 degrees against a linear temperature x-axis of -10°C to 100°C at a frequency of 0.4 Hz ± 0.04 Hz shall be produced.

28 The x-axes of the graphs shall have dimensions of at least 220 mm and the y-axes at least 150 mm.

29 The following test values shall be reported:

(i) T_{2kPa}: the High Equi-stiffness temperature

(ii) T_{2MPa}: the Low Equi-stiffness temperature

(iii) $G^*_{(pen)}$: the value of G* at the equilibrated temperature of 25°C and 0.4 Hz

(iv) $\delta_{(high)}$: the value of δ at high temperature 60°C and long loading time 0.1 Hz

Test Report

30 The test report shall contain at least the following information:

(i) A reference to this test procedure

(ii) The rheometer type, model and test geometries (plates and gaps) used

(iii) The compliance limitations of the machine/ geometry (including whether software corrections have been applied)

(iv) The type and identification of the product tested

(v) Sample history including when and where the sample was taken and whether it was treated to RTFOT and/or Ageing Test or was a recovered binder from emulsion or cutback in accordance with Clause 923

(vi) Strain (or stress) conditions of the test

(vii) Sample loading method and time for transfer

(viii) The results of the test as set out under sub-Clauses 22 to 29 of this Clause

(ix) Whether the Data Acceptability Criteria in sub-Clause 19 were met

(x) Any deviation, by agreement, or otherwise, from the procedure specified, including rate of temperature increase and tolerances for the temperature sweep described in sub-Clauses 20 and 21

(xi) Date of test

(xii) Name of the person responsible for the test

31 The test report, graphs and a copy of the data on 3.5 inch diskette in ASCII format, uniquely identified, shall be provided to the Overseeing Organisation within one week of completing the test or provided with the Contractor's Proposal.

Acceptable Variation of G* and δ and numerical tolerance for the High Equi-stiffness Temperature (T_{2kPa}) and the Low Equi-stiffness Temperature (T_{2MPa})

32 The Acceptable Variation of G* and δ shall be presented as two families of curves, above and below the curves produced in accordance with sub-Clauses 25 and 27, which represent the extremes considered by the Contractor to provide consistent performance. The Contractor shall state the maximum variation between different batches of the same product. A numerical tolerance shall be stated for the extremes of the High Equi-stiffness Temperature (T_{2kPa}) and the Low Equi-stiffness Temperature (T_{2MPa}).

929 Design, Compaction Assessment and Compliance of Roadbase and Basecourse Macadams

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: Part 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 75 micron 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 9/3 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 roadbase and basecourse 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 Overseeing Organisation the trial may be carried out off site. The trial area shall be not less than 30 m nor 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 BS DD 228: 1996, Issue 2. 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 Overseeing Organisation. 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 929.2.

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:

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

where ρ is the bulk density, and ρ_{Max} is the maximum density expressed in Mg/m^3 determined in accordance with sub-Clause 929.4 above.

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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 BS DD 213: 1993.

(iii) Following the determination of Stiffness Modulus, one core from each location shall be tested for Deformation Resistance in accordance with BS DD 226: 1996, and the other core shall be tested similarly except that the BS DD 226 test procedure shall be modified in accordance with TRL Paper PA 3287/97. The change in procedure results in the load being applied to the centre of the 150 mm diameter sample by a 100 mm diameter upper platen.

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 Overseeing Organisation. Additionally if the trial area is on site, the exact location of the cores, their dried bulk densities, in situ air 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 or 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 8.0%.

(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 9.0%.

(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 average binder volume at each location shall not be less than 7.0% of the total volume of the mixture.

(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 roadbase and basecourse macadams shall be continuously assessed using the nuclear density gauge with readings taken at 20 m 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: Part 2 if low densities are indicated at the time of laying.

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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 BS DD 228: 1996, Issue 2. 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 Overseeing Organisation, 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: Part 1, or with cold-lay 20 mm nominal size dense bitumen macadam basecourse. 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 wearing course, the last layer of backfill material shall comply with the specification for the wearing 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 Overseeing Organisation 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 8.0%. If the average in situ air void content exceeds 8.0% 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 8.0% 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 Overseeing Organisation.

(ii) The average in situ air void content of each pair of cores taken every 500 lane-metres shall not exceed 9.0%. If the average in situ air void content of a pair of cores exceeds 9.0% 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 Overseeing Organisation.

(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

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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.

Basecourse Macadams Below Porous Asphalt Wearing Course

22 Basecourse macadams below porous asphalt shall comply with sub-Clauses 1 to 21 of this Clause except that:

(i) every third pair of cores from the Permanent Works shall be taken across a longitudinal or transverse joint as agreed by the Overseeing Organisation.

(ii) The average in situ air void content calculated from any six consecutive nuclear density readings shall not exceed 7.0%.

(iii) The average in situ air void content of pairs of cores taken every 500 lane-metres shall not exceed 8.0%.

930 Heavy Duty Macadam Roadbase

1 Unless otherwise specified in Appendix 7/1, heavy duty macadam roadbase shall comply with Clause 929. Heavy duty macadam roadbase shall comply with BS 4987: Part 1 for dense roadbase, and with sub-Clause 2 of this Clause, and the requirements of Appendix 7/1.

Filler

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

Binder

3 The binder shall be petroleum bitumen complying with BS 3690:Part 1. The penetration of the bitumen shall be grade 50 pen.

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 Bitumen Macadam Roadbase With Grade 50 Penetration Binder

1 Unless otherwise specified in Appendix 7/1, dense bitumen macadam roadbase with Grade 50 penetration binder shall comply with Clause 929. Dense bitumen macadam roadbase with Grade 50 penetration binder shall comply with BS 4987: Part 1 for dense roadbase, and with sub-Clause 2 of this Clause, and the requirements of Appendix 7/1.

Filler

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

933 Heavy Duty Macadam Basecourse

1 Unless otherwise specified in Appendix 7/1, heavy duty macadam basecourse shall comply with Clause 929. Heavy duty macadam basecourse shall comply with BS 4987: Part 1 for dense basecourse, and with sub-Clause 2 of this Clause, and the requirements of Appendix 7/1. The traffic category shall be as stated in Appendix 7/1.

Filler

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

Binder

3 The binder shall be petroleum bitumen complying with BS 3690 : Part 1. The penetration of the bitumen shall be grade 50 pen.

934 Dense Bitumen Macadam Basecourse With Grade 50 Penetration Binder

1 Unless otherwise specified in Appendix 7/1, dense bitumen macadam basecourse with Grade 50 penetration binder shall comply with Clause 929. Dense bitumen macadam basecourse with grade 50 penetration binder shall comply with BS 4987: Part 1 for dense basecourse,

and with sub-Clause 2 of this Clause, and the requirements of Appendix 7/1. The traffic category shall be as stated in Appendix 7/1.

Filler

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

935 Not used

936 Not used

937 Not used

938 Porous Asphalt Surface Course

1 Porous asphalt shall comply with BS 4987: Part 1, with the relevant sub-Clauses of this Clause and the requirements of Appendix 7/1.

Aggregate

2 Coarse aggregate shall be crushed rock or steel slag complying with Clause 901. Mixtures from different sources shall be permitted. Crushed or uncrushed gravel shall not be permitted. When tested in accordance with the procedures of BS 812: Parts 105.1, 111, 113 and 114, each source of coarse aggregate shall additionally have the following properties.

Polished Stone Value (PSV) - as specified in Appendix 7/1
Ten Per Cent Fines Value (TPFV) - not less than 180 kN (dry)
Maximum Aggregate Abrasion Value (AAV) - 12
Maximum Flakiness Index (average of 20 mm and 14 mm size - 25%)

Fine aggregate shall comply with Clause 901 and shall be crushed rock fines or steel slag or natural sand or a blend.

Filler

3 At least 2.0% by mass of the total aggregate shall be hydrated lime filler.

Binder

4 Binder shall be as specified in Appendix 7/1. Bitumen shall be in accordance with BS 3690: Part 1 and shall be either 100 or 200 penetration grade, or if supplied pre-blended with a polymer or rubber modifier, it shall be within the 100-200 penetration grade range and shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, pre-blended modified binders shall not be used without the approval of the Overseeing Organisation.

5 The composition of the mix shall be such that when sampled either at the plant or on site and tested in accordance with sub-Clause 12 of this Clause, the aggregate grading shall fall within the envelope delineated by the limits given in Table 9/4, and the soluble binder content, adjusted in accordance with sub-Clause 12 of this Clause to take account of the insolubility of any polymer or rubber based modifier used, shall fall within the tolerances specified in sub-Clause 13 of this Clause for samples taken at the plant, and within the tolerances specified in sub-Clause 14 of this Clause for samples taken on site.

6 Target binder content of the mix shall be 4.5%. Binder drainage tests in accordance with BS DD 232: 1996 shall be carried out on the proposed aggregate/modified binder combination to determine the maximum target binder content (Tmax) of the mix. The proposed mix with a target binder content of 4.5% will be acceptable if the maximum target binder content (Tmax) is equal to or greater than 4.5%.

Binder Modifiers

7 Binder modifiers, including natural or man-made fibres, natural lake asphalt, natural rubber in latex or powder form, synthetic rubber, EVA or other similar materials which are added to or blended with the base bitumen at the mixing plant shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, binder modifiers shall not be used without the approval of the Overseeing Organisation.

8 Details of proposed modifiers shall be submitted to the Overseeing Organisation, including the penetration of the base bitumen, binder drainage test results, and the manufacturer's recommendations for the addition of the modifier homogenously into the mix. Information relating to mixing, storage, weather conditions for laying, and laying and compaction temperatures of the modified porous asphalt shall also be submitted. Pre-blended modified binders that are claimed to remain homogeneous in storage shall be tested for storage stability prior to the start of the contract in accordance with Clause 941. The mean of the differences in softening point, top to bottom, of not less than three pairs of samples shall not exceed 5°C. Pre-blended modified binders claimed to remain homogeneous that

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fail to meet this requirement and all other pre-blended modified binders shall be stored in accordance with a quality control procedure which follows the manufacturer's instructions detailing the mode of circulation or agitation in the tank storage necessary to ensure homogeneity is maintained. If polymer or rubber based binder modifiers are partially insoluble when analysis is carried out to determine the soluble binder content in accordance with BS 598: Part 102, using either of the extraction bottle methods, then test results shall be submitted that:

(i) establish the degree of insolubility of the modifier and

(ii) determine the adjustments to the measured soluble binder content that will be necessary.

If required by the Overseeing Organisation:

(a) Analysis of natural rubber content shall be carried out in accordance with the method described in TRRL Road Note 36 (Specification for the Manufacture and use of rubberised Bituminous Road Materials and Binders) or other agreed analysis method.

(b) Analysis of the polymer content of polymer modified porous asphalt shall be carried out in accordance with a method recommended by the polymer supplier or other agreed analysis method.

9 Prior to their use in the Contract, modifiers shall have proved satisfactory under similar circumstances elsewhere or shall have undergone appropriate performance trials. For the purpose of this sub-Clause, documented evidence of use or trials of the modifier, in any state of the European Economic Area, will be acceptable to the Overseeing Organisation provided the information obtained is at least equivalent to that obtained in UK trials, as published in TRL RR57 & RR 323.

10 If information to be provided under sub-Clause 9 of this Clause is inadequate or lacking in detail, the Contractor shall undertake a trial to demonstrate the suitability of the modifier if required to do so by the Overseeing Organisation.

11 The use of modifiers, shall be subject to the following:

(i) Natural Rubber

When selected, 5.0 ± 0.5 per cent natural rubber powder or latex, by mass of bitumen, shall be incorporated into the porous asphalt by addition at the pug-mill of the mixing plant by either of the methods stated below:

(a) Natural Rubber in Latex Form:

For each batch, after the bitumen has been added to the aggregates and mixed for 30 seconds, natural rubber latex containing 67% by mass of natural rubber shall be added to the mixture in the pug-mill, using a measured displacement pump, at 7.4% by mass of bitumen. For each batch, the latex shall be sprayed into the pug-mill over a period of 30 seconds. The porous asphalt shall be then mixed for a further minute.

(b) Natural Rubber in Powder Form:

For each batch, unvulcanized natural rubber powder containing 40% of inert filler shall be added to the aggregates in the pug-mill at 8.3% by mass of bitumen and dry mixed for 30 seconds before the bitumen is added. The porous asphalt shall then be mixed for a further two minutes.

(ii) Other Modifiers

(a) when selected the base binder shall be bitumen having a penetration within the range 100 to 200.

(b) when tested in accordance with Clause 941, pre-blended modified binders shall meet the original specification for softening point and penetration for that binder after the seven day storage period. The supplier shall ensure the pre-blended modified binder is manufactured to the same specification as that for the sample submitted for the Binder Drainage Test in accordance with BS DD 232: 1996.

12 Samples taken from the mixing plant in accordance with BS 598 Part 100 and prepared in accordance with BS 598 Part 101 shall be tested by the Contractor or by the supplier on behalf of the Contractor. Duplicate portions of all samples taken shall be supplied to the Overseeing Organisation. The analysis of the mixed material shall be in accordance with BS 598: Part 102 using either of the extraction bottle methods. An adjustment shall be made to the soluble binder content as measured to allow for partial insolubility of any polymer or rubber based binder modifier used, as detailed in information supplied in accordance with sub-Clause 938.8. This adjustment shall not exceed +0.3% by mass. No adjustment shall be made for mixes using fibres as the binder modifier.

13 When assessing compliance of samples taken at the mixing plant, the mean value of any ten consecutive determinations of soluble binder content, adjusted when necessary, shall not differ from the target binder content of 4.5% by more than ±0.3% nor shall any individual result differ by more than ±0.5%.

14 Additional samples shall be taken on site. These samples shall be taken only from the augers of the paver

in accordance with the appropriate method in BS 598: Part 100, except that when pavers are laying in echelon the samples shall be taken only from the accessible side of the paver. Duplicate portions of all samples taken shall be supplied to the Overseeing Organisation. The samples shall be tested as described in sub-Clause 938.12 but when assessing compliance the mean value of any ten consecutive determinations of soluble binder content shall not be less than 4.0% nor shall any individual result be less than 3.8%.

Mixing

15 Porous asphalt shall be mixed at a temperature not exceeding the relevant value given in Table 9/5. The mixing temperature for modified binder shall be as stated in the relevant specification submitted in accordance with sub-Clause 8 of this Clause but shall not exceed 160°C. If a drum-type plant is used, hydrated lime filler shall be the first constituent placed on the cold-feed belt or it shall be added directly to the drum using a screw-auger or similar device. Plastic bags, meltable below 100°C, may be used for the addition of modifiers or fillers. Bag ties shall be removed before the bag is added to the mixture.

Transporting

16 Porous asphalt shall be transported to site in double-sheeted insulated vehicles. 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.

Laying

17 A tack coat of bitumen emulsion complying with BS 434: Part 1 K1-70, or other equivalent type, shall be spray-applied at a rate of at least 0.4 l/m², in accordance with the requirements of Clause 920, to completely cover the surface where the porous asphalt is to be laid. The emulsion tack coat shall be allowed to break before porous asphalt is laid.

18 Porous asphalt shall be laid by machine and compacted within three hours of mixing to a thickness of 50 ± 5 mm. Laying shall commence on the low side of the carriageway or road, unless otherwise agreed. Only minimal hand-working of the porous asphalt shall be permitted after discharge from the paver and before rolling and shall only be carried out with wooden spreaders. Metal-toothed rakes shall not be permitted. Operatives shall not be permitted to walk on uncompacted porous asphalt.

19 Where more than one lane is to be covered, and where possible, porous asphalt shall be laid by pavers working in echelon. The stagger between paving machines shall not exceed 20 metres. Bitumen coating shall not be applied to exposed longitudinal edges.

20 Porous asphalt shall not be laid during rain or when standing water is present. Porous asphalt containing penetration grade bitumen binder modified with natural rubber shall be laid within the limits of air temperature and wind speed stated in Figure 9/1, or Figure 9/2 as appropriate. Laying shall not be permitted at any temperature if the average wind speed over the preceding hour exceeds 50 km/h at 10 m height (40 km/h at 2 m height). The weather conditions for laying porous asphalt containing other modified binders or additives shall be as stated in the relevant specification submitted in accordance with sub-Clause 8 of this Clause.

Compaction

21 Porous asphalt shall be compacted using at least two 6-8 tonne tandem, non-vibrating, steel-tyred rollers for each paving machine. 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 9/6. 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. The paving and rolling temperatures for porous asphalt containing other modifiers shall be as stated in the relevant specification submitted in accordance with sub-Clause 8 of this Clause.

Transverse and Longitudinal Joints

22 Transverse joints shall be formed against a 45 mm thick hard timber of adequate width to form a stable stop-end, fastened to the underlying surface. The cutting of edges shall be avoided but where transverse edge cutting is essential, only sawing shall be permitted. Longitudinal joints shall be placed adjacent to pavement lane markings or outside wheel path zones, unless otherwise agreed. Longitudinal joints shall be formed by butting-up to the adjacent porous asphalt to form a tight joint.

23 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.

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Relative Hydraulic Conductivity

24 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 BS DD 229: 1996 except that the procedure for measuring the relative hydraulic conductivity of a 100 m section road shall be as specified in this sub-Clause. 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. These determinations shall be made within each band laid by each paver along a series of diagonals each of which shall commence on the left 0.5 m from the longitudinal limit of the porous asphalt and progress to the right, each diagonal covering a 100 m length of carriageway and located as further specified below. These locations shall in all cases be taken facing in the direction of travel of traffic when the carriageway is opened or re-opened as a highway in its final configuration and shall be irrespective of the direction of laying. The sideways limits of each diagonal shall be 0.5 m from the edge of the porous asphalt or from the former or existing temporary edge of the porous asphalt as appropriate. The final diagonal in each paver band shall be geometrically constructed as if the limit of the porous asphalt had not been reached. Determinations shall be made at the limits of each diagonal and at 20 m intervals measured parallel to the carriageway centre-line, thereby providing 6 determinations on each complete diagonal. The last and first determinations shall each be not less than 0.5 m from the longitudinal limit of the 100 m section of porous asphalt. The running mean of each 6 consecutive individual measurements shall be calculated and reported as the average relative hydraulic conductivity and the individual results reported, all corrected to 20°C and to the nearest $0.01s^{-1}$. The average value from any 6 consecutive individual determinations of relative hydraulic conductivity and the value of any individual determination shall comply with the requirements of sub-Clause 25 of this Clause.

Compliance - Relative Hydraulic Conductivity

25 (i) The average relative hydraulic conductivity shall be not less than $0.12s^{-1}$.

(ii) Individual determinations shall not be less than $0.06s^{-1}$.

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 along the diagonal on which the non-compliance has been found. This shall be done on both sides of the non-complying location in order to determine the extent of the non-complying length. If necessary, further tests shall be carried out along adjacent diagonals. Further determinations lateral to the diagonal(s) shall be carried out to assist in determining the extent of the non-complying length. If the non-complying length exceeds 10 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 this Clause. The area rectified shall be the full width of the paving laid in one operation, and not less than 30 m long.

Road Markings and Reflecting Road Studs

26 Road markings and reflecting road studs shall comply with the requirements of Series 1200.

TABLE 9/4: Aggregate Grading Limits

BS SIEVE (mm)	Per cent by mass of total aggregate passing
28	100
20	100 - 95
14	65 ± 10
6.3	25 ± 5
3.35	10 ± 3
75 micron	4.5 ± 1.0

TABLE 9/5: Maximum Mixing Temperatures for Porous Asphalt

Binder	Maximum mixing temperature (°C)
200 penetration bitumen and natural rubber	150
100 penetration bitumen and natural rubber	160
Polymer modified binders, and fibre modified binders	As recommended by the bitumen producer

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TABLE 9/6: Temperature Ranges for Laying Porous Asphalt

Binder	Paver Discharge Temperature (Min)(°C)	Temperature for substantial completion of compaction (°C)
200 penetration bitumen and natural rubber	105	80
100 penetration bitumen and natural rubber	110	85
Polymer modified binders, and fibre modified binders	as recommended by the bitumen producer	

FIGURE 9/1: Limiting Weather Conditions for Laying Porous Asphalt containing 200 pen Bitumen with Natural Rubber

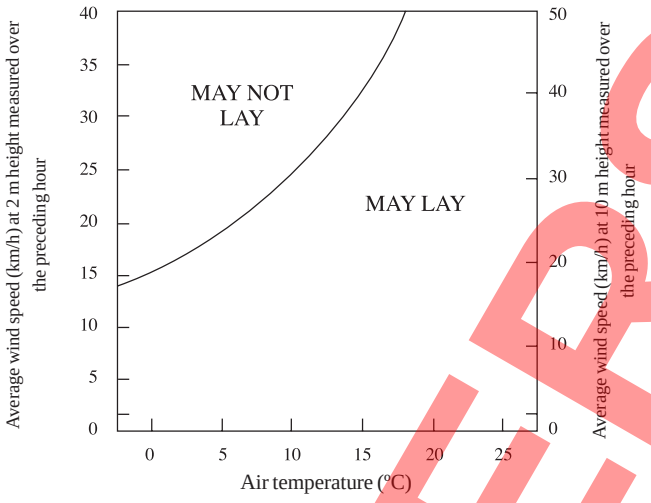
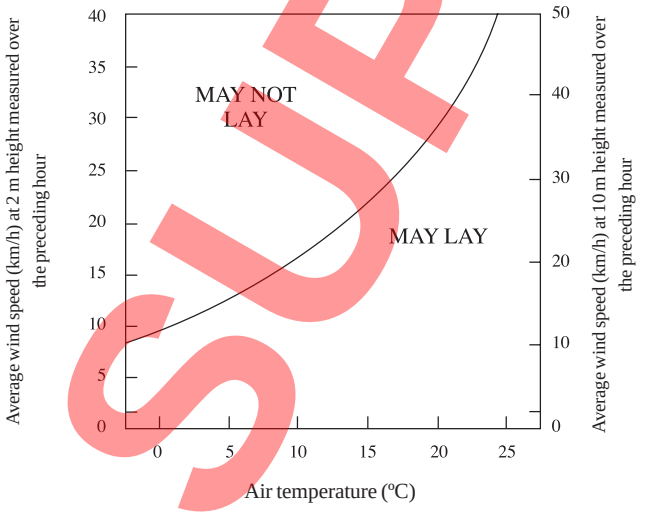


FIGURE 9/2: Limiting Weather Conditions for Laying Porous Asphalt containing 100 pen Bitumen with Natural Rubber



939 Determination of Cohesion of Bitumen and Bituminous Binders

Scope

1 This Clause specifies the Vialit Pendulum Test method for the measurement of the cohesion of bitumen and bituminous binders at temperatures in the range 0 to + 80°C, and determines the relationship between cohesion and temperature.

Definition

2 For the purposes of this Clause the following definition shall apply:

Cohesion: "the energy per unit area which is needed to break a film of bituminous binder under specified conditions of impact".

Principle of the Test

3 A steel cube of sides 10 mm shall be fixed to a steel support by a film of binder 1 mm thick. The assembly shall be brought to the test temperature, then the cube shall be dislodged by the impact of a swinging pendulum. For the operating principle of the pendulum, see Figure 9/3. The energy absorbed by rupture of the binder film shall be calculated from the swept angle after impact of the pendulum. The determination shall be performed at not less than six different temperatures covering the range over which the binder has a cohesion greater than a specified minimum; at each such temperature the test shall be performed in triplicate.

Test Apparatus

4 The test apparatus comprises:

(a) **The Cohesion Tester**

The cohesion tester comprises:

(i) A heavy rigid metal base provided with a bubble type level gauge and set in a horizontal position by means of height adjustment screws.

(ii) Two rigid vertical supports for the pendulum, attached to the base.

(iii) An adjustable quick-release clamping device to hold a test assembly firmly to the base. Positioning requirements for the test assembly are given in sub-Clause 6(a) of this Clause.

(iv) A pendulum, having the form and dimensions specified in Figure 9/4, capable of rotating freely on a horizontal shaft held in ball bearings in the supports in item (a)(ii) above. The longitudinal axis of the cube support holder shall be at right angles to the axis of the

pendulum fulcrum. The mountings for the bearings and the fixings for the cube support holder shall be adjustable. This is so that the impact edge of the pendulum can be closely adjusted for freedom of swing and height with respect to the test specimen.

(v) A pointer on the pendulum support shaft which is driven forward by the pendulum but is held by friction at the point of maximum swing until manually reset. The friction device shall be adjustable.

(vi) A circular scale for the pointer, graduated 0 to 360 degrees to the circle in 0.5 degree intervals, with zero at the lower balance position of the pendulum and 180 degrees at the upper balance position. Alternatively, the graduations may be in grads (or gon), graduated 0 to 400 grads to the circle in 0.5 grad intervals.

(vii) A removable protective cage, fitting to the base of item (a)(i) above, constructed to allow the pendulum to swing without impediment but to catch dislodged cubes. Suitable access (eg a hinged door) shall be provided to allow a test assembly to be positioned rapidly in the clamping device of item (a)(iii) above.

(b) **Cubes and Cube Supports**

Cubes and cube supports shall be made of steel to the forms and dimensions given in Figures 9/5 and 9/6. Three test assemblies (cube attached by film of binder to cube support) are needed for each test, and typically eight tests are needed to show the relation between cohesion and temperature. It is therefore useful to have at least 24 cubes and cube supports.

The mass of any cube shall be as specified in Figure 9/5. The masses of the individual cubes in a set used for testing any one sample shall not differ from the mean by more than 0.25 g. Adjustment to the weight of a cube may be made by drilling or filing the face opposite to the serrated face. The pitch of the serrations on the cube may differ from the pitch of the serrations on the cube support providing they are each compliant with Figures 9/5 and 9/6 respectively. The surface of the serrations will in all cases be 100 /2 mm^2 for each component.

(c) **Oven**

An oven to pre-heat the cubes and supports before application of binder. The temperature shall be set at 55°C ± 5°C.

(d) **Water Bath or Conditioning Oven**

A water bath capable of maintaining the set temperature within the range 0°C to + 80°C within a tolerance of ± 0.2°C, and large enough to allow at least twelve test assemblies to be positioned horizontally in the temperature-controlled area. For temperatures at or approaching 0°C, ethylene glycol shall be added to water baths to prevent freezing.

It is helpful, but not essential, to have several such pieces of equipment set at different temperatures, in which case it is not necessary for any single piece of equipment to be able to cover the entire temperature range, provided any temperature in the specified range can be achieved by at least one piece of equipment. It is not necessary for the several pieces of equipment to be of the same type.

(e) **Thermometer**

The thermometer shall be capable of measuring the temperature of the temperature conditioning equipment, readable and calibrated to 0.2°C or less. It will be helpful but not essential to have one such thermometer for each piece of temperature conditioning equipment.

Preparation of Apparatus

5 The procedure described in this sub-Clause shall be followed at the commencement of each day's testing. Ambient temperature shall be in the range 15°C to 35°C during preparation of the apparatus and during subsequent testing. The following procedure shall be used:

(i) Place the tester on a rigid, stable support and ensure that it is level.

(ii) Check that the impact edge of the pendulum is undamaged and straight; if necessary trim with a file.

(iii) First ensure the test apparatus is compliant with sub-Clause 4(iv) of this Clause. Set the pendulum hanging freely in the "down" position and ensure that the scale reading is 0 ± 0.25 degrees by adjustment of the scale if necessary. Adjust the position of the clamping device so that a test assembly is held in a position such that the impact edge of the pendulum is parallel to the bottom of the cube and just in contact with the cube over its full length at a height of 0.0 to 1.0 mm above the bottom edge of the cube.

(iv) Set the pendulum in the "up" position. Check that the scale reading is 182 ±2 degrees, and the release mechanism functions smoothly; if any adjustment is required repeat the above procedure.

(v) Perform tests with no test assembly in position until the swept angle from scale zero of the

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pendulum is constant to ± 0.5 degrees and a minimum of 160 degrees for six successive swings. If necessary, adjust the friction device of the pointer to achieve this.

(vi) Perform a series of tests using a cube and cube support with no binder until six results are obtained for which the swept angle after impact differs from the mean by no more than 1 degree, and record this mean value.

Preparation of Test Equipment and Binder Samples

6 Preparation of test equipment and binder samples shall include preparation of cubes and cube supports, preparation of the binder, and preparation of test assemblies, all as specified below.

Preparation of Cubes and Cube Supports

(a) At the commencement of a series of tests on a single binder, ensure that the cubes and cube supports are clean by washing in a suitable solvent, using a small brush to remove contamination from the serrated face. Dry the cubes and supports in an oven, and reject any which are visibly damaged. Pre-heat them in an oven for at least thirty minutes to a temperature of 55°C ± 5°C before applying the binder to be tested.

Preparation of the Binder

(b) Ensure that the laboratory sample is homogeneous and the test sample is representative of the laboratory sample from which it is taken in accordance with prEN 58.

Bring the binder to a temperature at which it can be spread on the serrated faces of the pre-heated cube and support; in the case of cutback bitumens this can usually be done without heating the binder, whereas heavily-modified bitumens require heating to a temperature at which their flow behaviour becomes predominantly viscous. Any limitations set by the binder supplier on heating times and temperatures shall be observed; if none are available the binder shall not be heated to a temperature greater than 50°C above its ring and ball softening point.

Preparation of Test Assemblies

(c) At least three test assemblies shall be prepared for each test temperature, and the following procedures shall be followed:

(i) Take one pre-heated cube and one pre-heated cube support which have been prepared as specified in sub-Clause 6(a) of this Clause. Apply pre-heated binder as specified in sub-Clause 6(b) of this Clause to both serrated faces, and spread it over the whole area. The total amount of binder applied shall be in excess of that needed for the test film (0.2 ml). Immediately place the cube on the support with the serrations facing each other and the locating flanges of the cube parallel to the edge of the support which will be parallel to the plane of movement of the pendulum when the assembly is inserted in the clamping device of the tester. Apply pressure to the cube and to the support so that the excess of binder is squeezed out and the locating flanges of the cube are in contact with the support. The time taken to perform the procedures in this sub-Clause shall not be greater than 2 minutes.

(ii) Repeat as in sub-Clause 6(i) above for each test assembly.

(iii) Remove the excess of binder from the cube faces of the test assemblies by scraping with a knife blade (which may be heated). The cube face which will be struck by the pendulum shall be cleaned if necessary using absorbent paper with a little solvent, taking care not to allow solvent to contaminate the exposed edge of the film of binder.

(iv) Place a set of three test assemblies in a water bath as specified in sub-Clause 4(d) of this Clause at the required test temperature for a duration of 30 to 120 minutes.

Selection of Test Temperatures

7 At high temperatures the binder behaves in a viscous manner; cohesion is low, falling asymptotically to zero as the temperature increases. At low temperatures the binder undergoes brittle failure on impact of the pendulum; cohesion is low, falling asymptotically to a low value as the temperature falls. At intermediate temperatures cohesion reaches a maximum value. Test temperatures shall be selected so that there is compliance with all the following five conditions:

(i) Not less than one result is between 0.2 and 0.4 J/cm^2 at the low temperature end of the curve.

(ii) Not less than one result is between 0.2 and 0.4 J/cm^2 at the high temperature end of the curve.

(iii) Not less than three results are within 3°C of the temperature of maximum cohesion, with at least one result on each side of the maximum.

(iv) Not less than two results are on the low temperature side of the peak, between 0.4 J/cm^2 and the peak value; and at least two results are on the high temperature side of the peak, between 0.4 J/cm^2 and the peak value.

(v) The difference between any two adjacent results shall be not more than 1.0 J/cm^2 and not more 15°C.

Measurements at different temperatures may be made in any order. If the cohesion properties of the sample are unknown, it is suggested that the first measurement be at approximately 35°C, followed by tests at approximately 10°C intervals both above and below this value until results below 0.4 J/cm^2 are obtained. Finally, measurements shall be made at intermediate temperatures to conform with the requirements above and to define the peak more accurately.

Procedure

8 The following shall be the test procedure:

(i) Set the pendulum in the "up" position; reset the dial pointer.

(ii) Open the door of the protective cage.

(iii) Transfer a test assembly from the temperature-controlled environment to the clamping device of the tester. Care shall be taken to ensure that the test assembly is moved without disturbance of the cube relative to the support. Close the door of the protective cage and release the pendulum. The time taken to perform the procedures in this sub-Clause 8(iii) shall not be greater than 20 seconds.

(iv) Record the swept angle of the pendulum after impact (α) to the nearest half degree - see Figure 9/3.

(v) Remove the detached cube and cube support from the protective cage. Examine the faces in contact with binder for evidence of adhesion failure. If an area of bare metal greater than 5 mm^2 is visible, record the fact. If necessary to achieve adequate adhesion the test may be repeated using higher temperatures than specified in sub-Clauses 6(a) and 6(b) of this Clause for the combined binder, cube and cube support.

(vi) Examine the impact edge of the pendulum. If any binder is adhering to the edge, remove it using absorbent paper and a little solvent.

(vii) Repeat twice steps (i) to (vi) above. All three tests at one temperature shall be performed within a five minute period.

(viii) Perform the zeroing tests required under sub-Clause 5(vi) of this Clause at a frequency of not less than twice per day.

When testing to resolve any dispute as to the cohesion of the bitumen or bituminous binder, six tests shall be performed at each temperature.

Calculation

9 The following symbols are used in this Clause:

E_B is the energy absorbed in breaking the binder (Joules)

E_K is the energy absorbed in imparting kinetic energy to the detached cube (Joules)

E_T is the total energy absorbed in breaking the binder and in imparting kinetic energy to the detached cube (Joules)

α is the swept angle after impact of the pendulum in degrees, or grads (or gons), as indicated by the pointer (0 degrees corresponds to the lowest position)

C is the cohesion* at the required test temperature (J/cm^2)

C_M is the maximum cohesion* value obtained (J/cm^2)

T_M is the temperature (°C) at which maximum cohesion occurs

M is the mass of the pendulum (gm)

R is the radius of the centre of gravity of the pendulum (cm)

A is the area of the binder on the sample (cm^2)

g is the acceleration due to gravity (cm/sec/sec)

Note: * See definition of cohesion in sub-Clause 2 of this Clause

10 Calculate the mean value of the swept angle after impact (α) from the three determinations at one temperature. This becomes the test result at that temperature. If one of the three determinations gives a value for α differing from the mean value by more than 3 degrees it shall be rejected, and the mean then calculated from the remaining two determinations. If these two determinations differ by more than 3 degrees all determinations shall be rejected and the test shall be repeated at that temperature in its entirety.

11 The total energy (E_T) is given by the following equation:

$$E_T = MgR(1 + \cos \alpha) = E_B + E_K$$

As M, g and R are all constant for a given instrument, rather than perform the above calculation for each test it

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is convenient to first construct a table giving values of E_T for a given angle α for each specific instrument. Then proceed as in sub-Clauses 12, 13 and 14 of this Clause.

12 Either (a) use the table constructed in sub-Clause 11 of this Clause to obtain the value of E_K, or (b) calculate the value of E_K, from the angle α measured in a test with no binder present on the test cube - see sub-Clauses 5(vi) and 8(viii) of this Clause. Then,

$$E_B = E_T - E_K$$

No correction is made either for the mass of binder adhering to the cube, or for the small permissible differences in the weight of cubes, or for the small initial angle of the pendulum.

13 The cohesion value C is given by

$$C = E_B/A$$

In this case, A = 1 cm^2 so the Cohesion (J/cm^2) is numerically equal to the energy value E_B (Joules).

14 Plot the cohesion value results from tests over the range of temperatures on a graph having linear axes for temperature and cohesion. The scales of the graph shall be such that temperature values can be resolved to 1°C and cohesion values can be resolved to 0.05 J/cm^2. Plot a smooth curve through the test values, and read off C_M and T_M from the curve.

Expression of Results

15 Results reported should be expressed to the following accuracies:

C_M to the nearest 0.05 J/cm^2

T_M to the nearest whole °C.

Test Report

16 The test report shall contain not less than the following information:

(a) A reference to this Clause;

(b) Details for the identification of the material tested;

(c) Date of test;

(d) The results obtained, including a graph of cohesion v temperature;

(e) Note of any adhesion failure at any temperature, as required in sub-Clause 8(v) of this Clause;

(f) Any deviation from the procedures specified (eg sample preparation temperature due to elastic behaviour).

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FIGURE 9/3:
Operating Principle of Pendulum

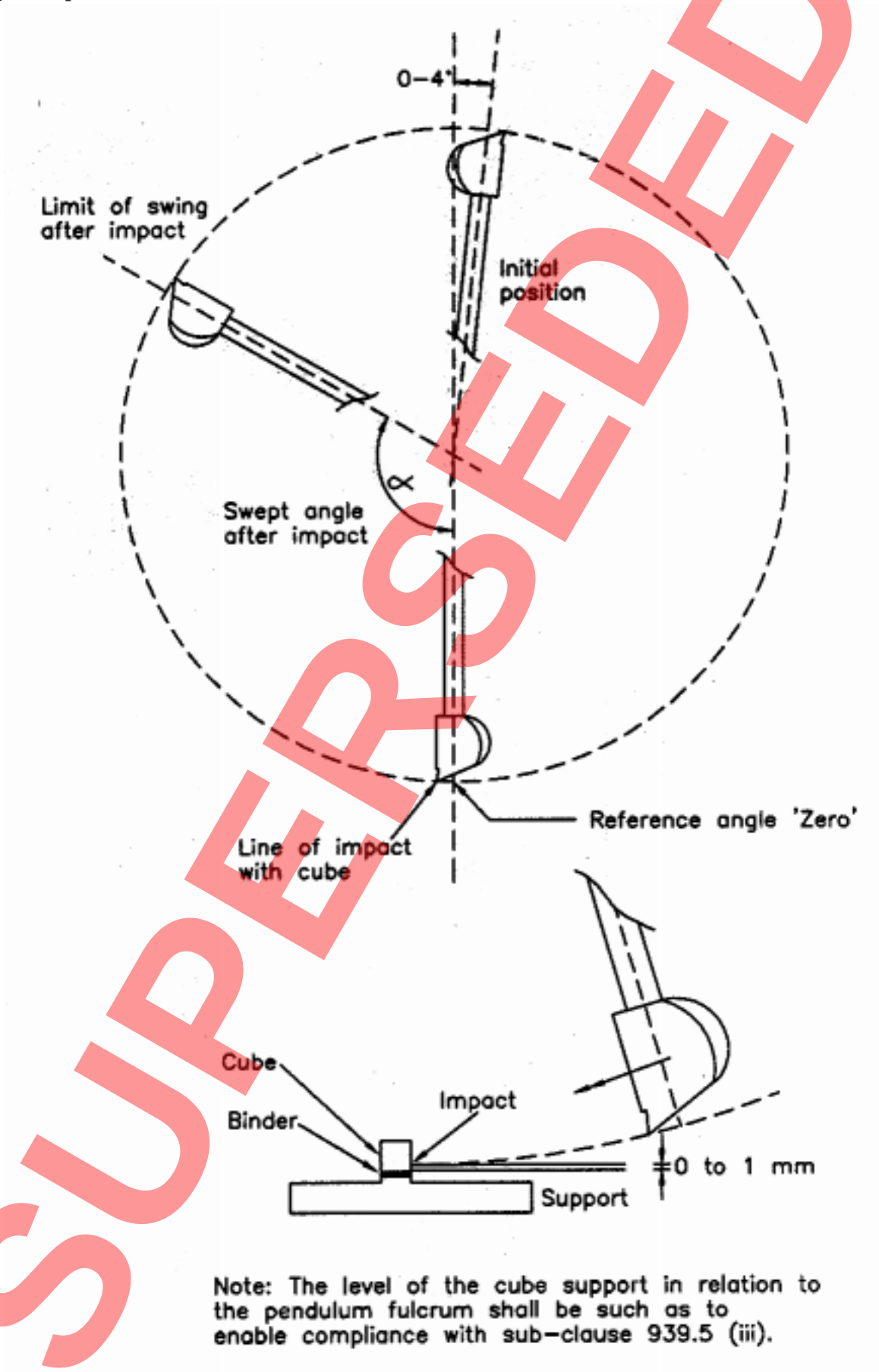

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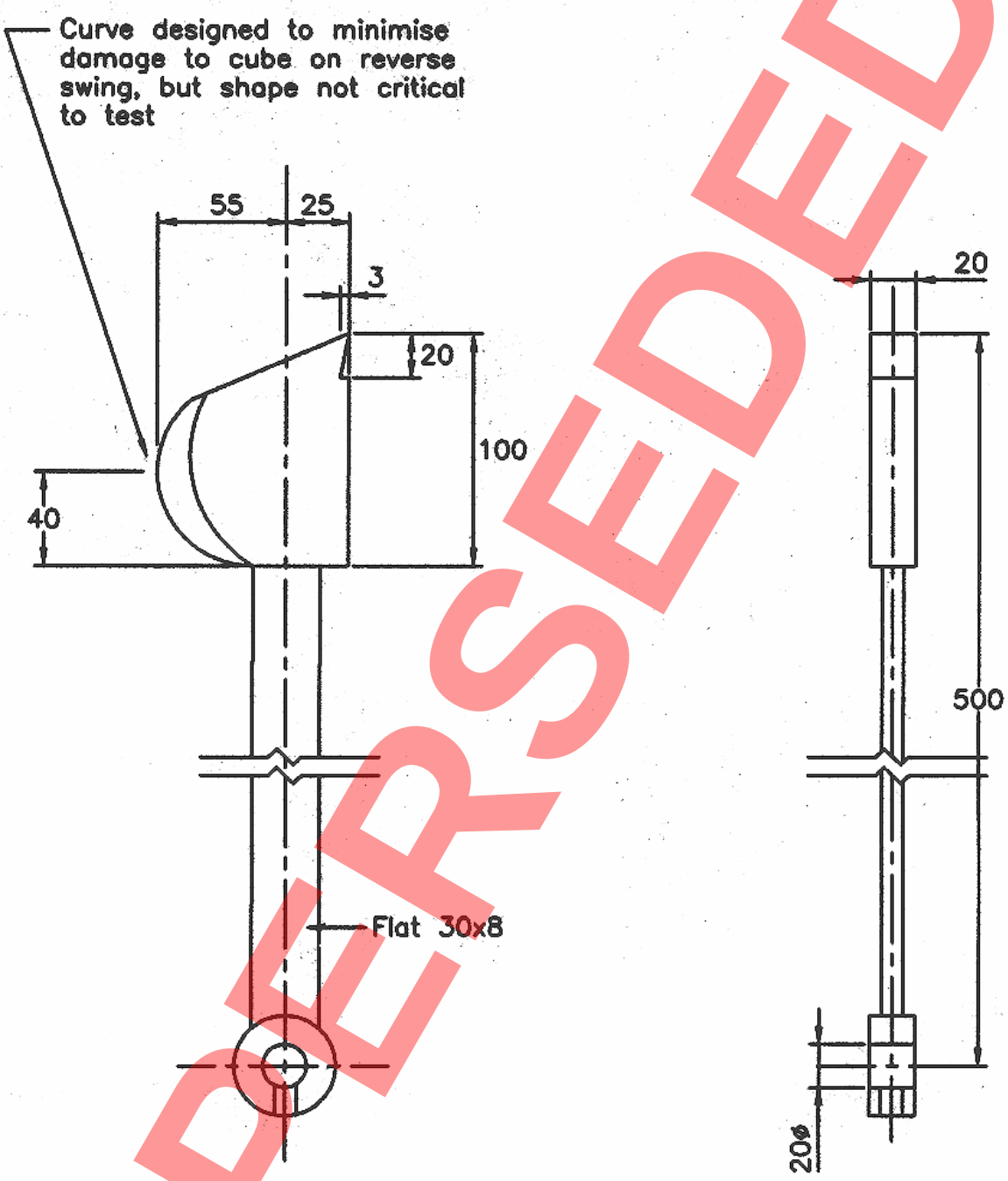
FIGURE 9/4:
Construction of Pendulum



All dimensions in millimetres

Material : steel
Tolerance ±0.5
Mass : 1900 ± 30g
Radius at point of impact : 500 ±1mm
Distance from centre of gravity to axis of rotation : 295 ±2mm

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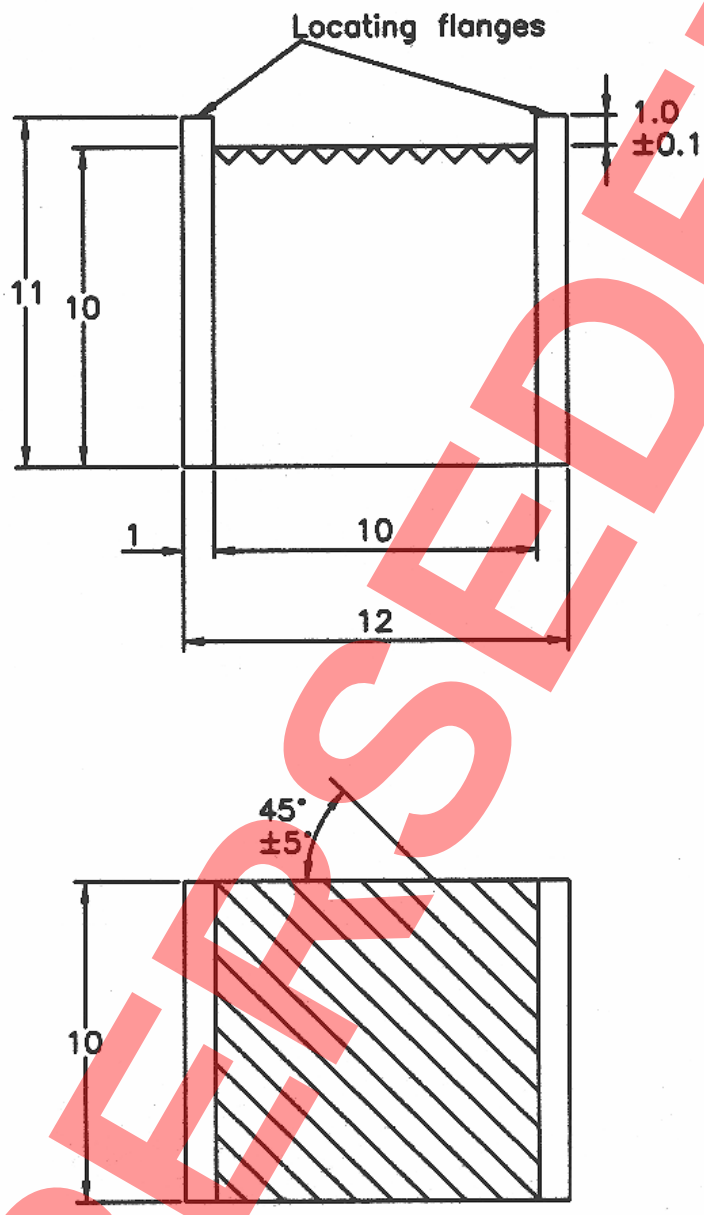
FIGURE 9/5:
Construction of Cube



All dimensions in millimetres

Material : steel
Mass : 9.50 ± 0.25g – to be adjusted if necessary by filing or drilling the face opposite the serrations
Tolerance ±0.5 except where indicated

Cross section and pitch of serrations as cross section in Figure 9/6, but their number will increase from that shown there because these are at 45°

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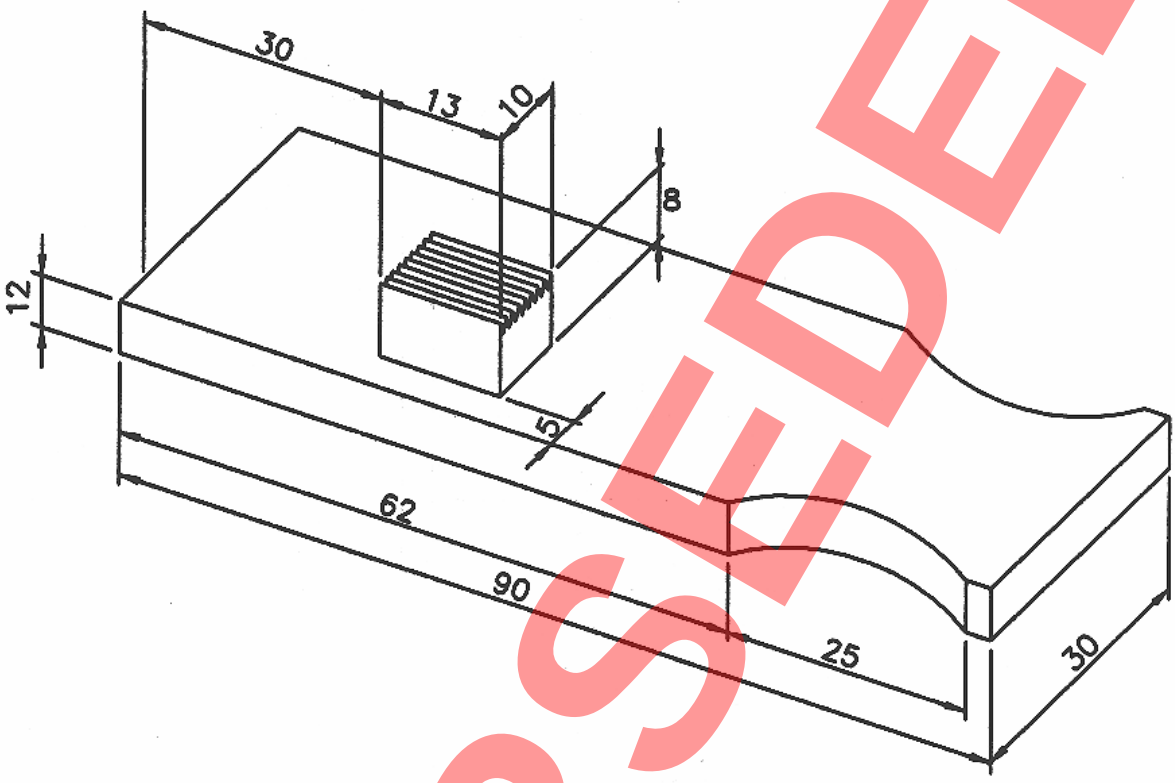
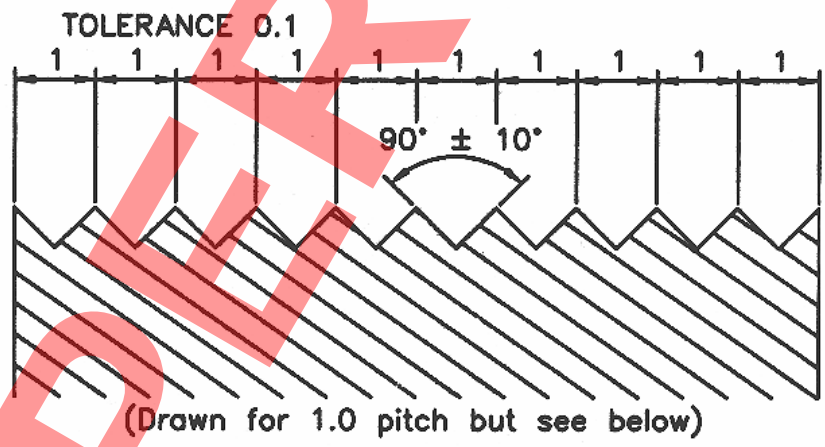
FIGURE 9/6:
Construction of Cube Support





All dimensions in millimetres

Material : steel
Serrations at a pitch of 1.0 ± 0.1, or 1.5 ± 0.1 or 2.0 ± 0.1 may be used.
Other dimensions to suit the individual apparatus
tolerance on overall height is ±0.1

940 Not used

941 Modified Binder Storage Stability Test

Scope

1 This test determines the susceptibility of a pre-blended 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 7 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-cocks, 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-cocks.

(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 BS 2000: Parts 49 and 58.

(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 3690: Part 1 Appendix B, Method B.1.1(b).

(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-cocks 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-cock and run off the top third portion of the test sample into a transfer dish for testing.

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

(d) Open the lower drain-cock 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 BS 2000: Parts 49 and 58.

Reporting

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

(i) The penetration, to the criteria of Table 1 of BS 2000: Part 49.

(ii) The softening point, to BS 2000: Part 58 for industrial grades of bitumen, to the nearest 0.5°C.

(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 Wearing Course Systems

1 Thin wearing course systems shall comply with sub-Clauses 2 to 26 of this Clause and the requirements of Appendix 7/1.

2 Thin wearing course systems shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, thin wearing course systems shall have type approval.

Aggregates and Filler

3 Coarse aggregate shall be crushed rock complying with Clause 901 and BS 63: Part 2: Table 2, unless stated otherwise in Appendix 7/1.

4 When tested in accordance with the procedures of BS 812, the coarse aggregate shall additionally have the following properties.

Polished Stone Value (PSV) - as specified in Appendix 7/1.

Ten Per Cent Fines Value (TPV) - not less than 180 kN, or as specified in Appendix 7/1.

Aggregate Abrasion Value (AAV) - not greater than 12, or as specified in Appendix 7/1.

Flakiness Index (I_F) - not more than 25 per cent.

5 Fine aggregate shall comply with Clause 901 and shall be either crushed rock fines or natural sand or a blend of both. Fine aggregate shall be added as required to suit the particular system.

6 Filler shall be crushed limestone complying with the requirements of BS 594: Part 1. Filler shall be added as required to suit the particular system.

7 When sampled and tested in accordance with the procedures of BS 598: Parts 100, 101 and 102, the aggregate grading shall fall within the envelope formed by the limits given in Table 9/7.

TABLE 9/7: Aggregate Grading

BS Sieve Size mm	Per Cent by mass of total aggregate passing	
	Nominal Size	
	14 mm	10 mm
20	100	
14	80-100	100
10	35-80	55-100
6.3	15-50	20-55
5.0	10-45	15-55
2.36	8-45	15-45
1.18	7-30	10-35
600 micron	5-25	7-30
300 micron	5-20	5-25
75 micron	0-15	0-15

8 The design and selection of aggregates, filler and bitumen proportions shall be the responsibility of the Contractor, who shall supply the necessary details to the Overseeing Organisation for record purposes.

Binder

9 The bitumen component of the binder shall be petroleum bitumen complying with BS 3690: Part 1. The penetration of the bitumen shall be grade 50, 70, 100 or 200 penetration, as selected by the Contractor, unless stated otherwise in Appendix 7/1. The bitumen may be modified by the addition of a polymer and/or fibres, as selected by the Contractor.

10 The choice of the bitumen grade and the penetration and softening point of the modified or unmodified binder shall be notified to the Overseeing Organisation before the commencement of work.

11 When sampled and tested in accordance with the procedures of BS 598: Parts 100, 101, and 102, the binder content of the surfacing material shall be in the range 3.5 to 7.5%, by mass of total mixture.

12 Where appropriate to the system, the target binder content shall be determined by the binder drainage test in BS DD 232:1996, except that the range to be tested shall be amended to suit the grading of the aggregates proposed for use. The target binder content determined in the laboratory may be adjusted to suit the mixing plant and the aggregate type which is used, subject to plant trial and delivery distance. The adjusted binder content shall be notified to the Overseeing Organisation prior to delivery and shall not be lower than that specified above. The mean value of any 10 consecutive determinations of soluble binder content shall not differ from the target binder content by more than $\pm$ 0.3% nor shall any individual result differ by more than $\pm$ 0.5%.

Tack or Bond Coat

13 The tack or bond coat shall be a hot-applied cationic bitumen emulsion complying with BS 434: Part 1, with a minimum bitumen content of 38%. To suit the particular system, it may be modified with a polymer. The choice of tack or bond coat shall be notified to the Overseeing Organisation before commencement of work.

Surface Preparation

14. Existing surfaces shall be cleaned using steel brooms and suction sweeping or other appropriate means. The surface may be moist but not wet; standing water shall not be present. All mud, dust, dirt and other debris and organic material shall be removed.

15. Where necessary existing surfaces shall be regulated in accordance with the requirements of Clause 907, in advance of laying surfacing material to this Clause.

16 Unless raised prior to surfacing, iron-work and reflecting road studs shall be located for lifting and relaying after completion of surfacing works. Gullies shall be covered prior to surfacing.

17 Where possible, existing road markings shall be removed.

Mixing

18 The material shall be mixed in accordance with the requirements of BS 4987: Part 1, such that an homogeneous mixture of aggregate, filler and bitumen is produced at a temperature of 150 to 180°C.

Transportation

19 Mixed materials shall be protected from contamination and undue heat loss by being transported to site in sheeted insulated lorries. To facilitate discharge of the materials, the floor of the lorry may be coated with the minimum of light vegetable oil or liquid soap or other non-solvent solution. When such coating is used, the lorry body shall be tipped to its fullest extent with the tailboard open to ensure drainage of any excess, prior to loading. The floor and sides of the lorry shall be free from adherent bituminous materials or other contaminants before loading the surfacing material.

Laying

20 Tack coat shall be spray-applied, in accordance with the requirements of Clause 920, at a rate selected by the Contractor and notified to the Overseeing Organisation before the commencement of work, to completely cover the surface where the material is to be placed. The particular spray rate shall be dependent on the proprietary system and the porosity of the surface being covered.

21 Bituminous materials shall be applied at a suitable temperature and compacted by at least two passes of a tandem roller, capable of vibration, and with the minimum dead weight of 6 tonnes, before the material cools below 80°C, measured at mid-layer depth.

Surface Texture

22 Where stated in Appendix 7/1, the texture depth of the surfacing shall be in accordance with the requirements of Clause 921 after compaction.

Details to be Supplied

23 The Contractor shall supply all the details required in this Clause to the Overseeing Organisation before commencement of work under this Clause and when requested during the work.

24 Checks shall be made at the end of each working day and records kept, to determine the quantities used of both tack coat and bituminous material.

25 The Contractor shall supply the Overseeing Organisation with test certificates stating the properties of the materials used. Samples of emulsion tack coat, modified or unmodified bitumen or mixed bituminous materials from either the spray bar or storage tank or the pavement surface or other suitable sampling point shall also be supplied if required by the Overseeing Organisation.

Guarantee

26 The Contractor shall guarantee the surfacing materials and workmanship for a period of not less than two 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 material has been laid, but shall include for fretting, stripping, loss of chippings and loss of texture to below 1 mm measured by the sand patch method described in BS 598: Part 105 along the inside wheel track.

943 Hot Rolled Asphalt Wearing Course (Performance-Related Design Mix)

1 The hot rolled asphalt shall be 35% stone content hot rolled asphalt wearing course material complying with Clause 901, with this Clause and the requirements of Appendix 7/1. The component materials shall be in accordance with Section 2, Constituent Materials, of BS 594: Part 1 except that binders may be modified as specified in sub-Clause 4 of this Clause. Transport and laying shall be in accordance with BS 594: Part 2.

Layer Thickness

2 The nominal thickness of the hot rolled asphalt wearing course layer shall be either 45 mm or 50 mm unless otherwise specified in Appendix 7/1.

Binder

3 The binder shall constitute not less than 15.5% by volume of the mixture at the target binder content. The binder content by volume (B_{Vol}, %) shall be calculated as follows:

$$B_{Vol} = B_{Mass} \times \frac{\rho_{mix}}{\rho_b}$$

where: B_{Mass} is the binder content as a proportion of the total mixture by mass (%) added at the mixer;

ρ_b is the density of the binder at 25°C (Mg/m^3);

ρ_{mix} is the bulk density of the compacted mixture without pre-coated chippings (Mg/m^3).

Bitumen shall comply with the requirements of BS 3690: Part 1 or Part 3. Grade 40 penetration HD bitumen shall only be used if approved by the Overseeing Organisation. Bitumen processed during refining to provide a binder with enhanced properties without the addition of a modifier, shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, such binders shall not be used without the approval of the Overseeing Organisation.

Binder Modifiers

4 Binder modifiers, if required, may be combined with the base binder prior to mixing or blended with the other component materials of the mixture at the mixer. Binder modifiers or pre-blended modified binders shall have a British Board of Agrément HAPAS Roads and Bridges Certificate. In the event that no such Certificates have been issued, binder modifiers or pre-blended modified binders shall not be used without the approval of the Overseeing Organisation.

5 Information on the properties of modified binders, whether the modifier is preblended with bitumen, the bitumen is modified during refinery processing or modified by addition into the asphalt mixer, as specified in Appendix 7/1, and proposals to use Grade 40 penetration HD bitumen shall be submitted to the Overseeing Organisation and approval obtained prior to the date for the return of tenders.

Coarse Aggregate

6 Coarse aggregate shall be crushed rock or slag with a polished stone value not less than 45 when determined in accordance with BS 812: Part 114.

Aggregate Grading

7 The aggregate grading shall conform to that given in Column 3/3, Table 3 of BS 594: Part 1.

Job Mixture Approval

8 Details of the proposed mixture design from each asphalt mixing plant shall be submitted to the Overseeing Organisation. The information may be obtained from either a job mixture trial or from the use of the mixture on a previous contract carried out in accordance with this Clause, and shall include all the following particulars:

(i) binder grade;

(ii) quantities of binder and aggregate;

(iii) aggregate source and grading;

(iv) proprietary name and generic type of any binder modifier or binder modified by processing;

(v) quantity of any binder modifier added at the mixer;

(vi) modified binder and mixture data requirements specified in Appendix 7/1.

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9 If a modified binder including any proportion of the modifier, is not fully recovered on analysis for determination of binder content, details of alterations to the test method and/or the correction necessary to the results together with any supporting data shall be submitted to the Overseeing Organisation with the proposed mixture design for approval to implement them.

10 The mixture shall be approved by the Overseeing Organisation as the Job Standard Mixture provided that:

(i) the mixture design proposed complies with sub-Clause 1 of this Clause**,**

(ii) test results submitted demonstrate that the binder content by volume of the mixture compacted without pre-coated chippings complies with sub-Clause 3 of this Clause,

(iii) information submitted in accordance with sub-Clause 8 of this Clause on the mixture design proposed is complete,

(iv) information submitted in accordance with sub-Clause 9 of this Clause has been approved by the Overseeing Organisation,

(v) test results submitted demonstrate that a nuclear density gauge has been calibrated for the compacted mixture with pre-coated chippings, using sand to fill surface depressions,

(vi) test results submitted establish the correlation between the air voids content, as measured from cores in accordance with sub-Clause 23 of this Clause, and density determined using the calibrated nuclear density gauge,

(vii) test results submitted demonstrate compliance with sub-Clauses 26, 27 and 28 of this Clause.

11 If the mix design or constituent materials of a Job Standard Mixture are changed, details of the revised mixture shall be submitted for approval in accordance with sub-Clauses 8, 9 and 10 of this Clause. Job Mixture trials may be carried out on or off site, however material laid for a Job Mixture trial on site shall not form part of the wearing course in the Permanent Works. If carried out off site trials may be arranged independently or in conjunction with other Works.

Mixing, Transporting and Laying

12 The hot rolled asphalt shall be mixed, transported and laid in accordance with BS 594: Part 2.

Sampling from the Laid Material

13 Samples of uncompacted material shall be taken from the paver as near to where the cores are to be taken as is practicable from the paver augers in accordance with BS 598: Part 100, Clause 6.3.

14 Six 200 mm diameter cores shall be cut, where practical from the centre of the lane, out of material from each mixing plant:

(i) from the first 1.0 km length of hot rolled asphalt from a mixing plant laid in the Permanent Works; or

(ii) within 3 days of laying hot rolled asphalt from a mixing plant in the Permanent Works, where less than 1.0 km length has been laid, whichever occurs first. Thereafter, for material from each mixing plant, not less than one 200 mm diameter core shall be cut from the centre of the lane every 1 lane-kilometre laid or one 200 mm diameter core from a day's production if less than one lane-kilometre is laid.

15 The 200 mm diameter cores shall be cut within three days of laying the material unless they have been cut under the requirements of either sub-Clause 24 or sub-Clause 25 of this Clause. The cores shall be transported as soon as possible to the laboratory. If the storage period is less than 4 days, the storage temperature shall be within the range 0°C to 25°C. For storage beyond 4 days, the temperature shall be within the range 0°C to 5°C. Cores shall be stored on a flat face on a horizontal surface and shall not be stacked. Site storage of cores where unavoidable, and conditions of transportation shall be as close as is practicable to the laboratory conditions. The storage temperatures and times, including whilst the cores are on site, shall be recorded.

16 Pairs of 150 mm diameter cores shall be cut at the same chainages as the 200 mm diameter core. One core of each pair shall be taken from the centre of the lane, adjacent to the 200 mm diameter core, and one whose centre is between 500 mm and 1000 mm of the edge of the mat.

17 Cores shall be taken after the hot rolled asphalt has cooled to ambient temperature and not less than 12 hours after laying, and before trafficking unless otherwise specified in Appendix 7/1. The walls and base of all holes from which core samples have been cut shall be painted with hot bitumen or cold applied polymer modified intermediate or premium grade bitumen emulsion immediately prior to making good. Core holes shall be backfilled with materials compacted to refusal with a circular headed vibrating hammer in layers not exceeding 75 mm thick. Hot basecourse or roadbase material similar to the existing pavement or cold-lay 20 mm nominal size dense bitumen macadam basecourse shall be used for layers more than 50 mm below the

surface unless otherwise specified in Appendix 7/1. Wearing course material shall be either hot rolled asphalt as supplied to the Contractor or cold-lay 6 mm size dense bitumen macadam wearing course unless otherwise specified in Appendix 7/1. Dense bitumen macadams incorporating fluxed binders shall not be used to reinstate core holes.

Tests and Calculations

18 Density readings using where possible the nuclear density gauge calibrated as described in sub-Clause 10 of this Clause shall be taken at not more than 50 m centres along each lane, including areas immediately adjacent to where each core is taken.

19 Initially, the calibration of the nuclear density gauge for the mixture being laid which has been submitted in accordance with sub-Clause 10 of this Clause shall be used. Once results are available, the gauge shall be re-calibrated using the results for bulk density and air voids content from the first six pairs of 150 mm diameter cores. Thereafter, the gauge should be re-calibrated if the density from the nuclear density gauge and from the cores show any significant bias.

20 For each uncompacted sample, the compositional analysis shall be carried out in accordance with BS 598: Part 102, corrected by any correction factor approved under sub-Clause 9 of this Clause.

21 Each six consecutive 200 mm diameter cores of material from the same mixing plant shall form a set of cores on a running basis. For each set, the wheel-tracking rate and the rut depth shall be determined in accordance with the procedure in BS 598: Part 110 at the test temperature specified in Appendix 7/1.

22 For each 150 mm diameter core, the bulk density shall be determined in accordance with the procedure in BS 598: Part 104, Clause 4 except that the pre-coated chipping shall not be removed. The bulk density at a chainage shall be the mean from the two cores taken at a chainage. Subsequent to determining the bulk density, the maximum density shall be determined from the pair of the cores in accordance with BS DD 228 Issue 2.

23 The air voids content of each pair of 150 mm diameter cores shall be calculated to ± 0.1% as follows:

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

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 DD 228 Issue 2 (Mg/m^3).

Additional Sampling and Testing

24 If the density readings taken with the nuclear density gauge indicate that the air voids content may be less than 1% when using the calibration relationship derived from sub-Clause 19 of this Clause, one 200 mm diameter core shall be cut at that chainage and the wheel-tracking rate and rut depth determined in accordance with sub-Clause 21 of this Clause.

25 If the density readings taken with the nuclear density gauge indicate that the air voids content may not comply with the requirements for a pair of cores set out in sub-Clause 28 when using the calibration relationship derived from sub-Clause 19 of this Clause, two 150 mm diameter cores shall be cut at that chainage and the air voids content determined in accordance with sub-Clauses 22 and 23 of this Clause.

Compliance Requirements

26 When determined in accordance with BS 598: Part 102:

(i) the binder content on analysis shall not differ from the target binder content by more than ± 0.6%; and

(ii) the aggregate grading shall not differ from that given in Column 3/3, Table 3 of BS 594: Part 1.

27 The mean wheel-tracking rate and mean wheel-tracking rut depth of any six consecutive determinations shall be less than the values specified in Appendix 7/1. Individual values of wheel-tracking rate and rut depth shall not exceed the values specified in Appendix 7/1 by more than 50%.

28 The air-voids content shall be not more than 7.5% for a pair of cores at a chainage and shall be not more than 5.5% for the mean of any six consecutive determinations from pairs of cores from material from the same mixing plant.

Reporting Results

29 Where specified in Appendix 1/5 that the Contractor is responsible for the testing, individual determinations, including the location of samples, and results from all tests shall be given to the Overseeing Organisation in writing within two weeks of the material being laid.

Surface Regularity

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

Weather Conditions

31 The weather conditions specified in Clause 708 shall not apply to hot rolled asphalt laid in accordance with this Clause. When modified binders are to be used, the weather conditions applicable for laying the mixture shall be submitted to the Overseeing Organisation with the details of the modified binder required under sub-Clause 5 of this Clause and shall include information on early trafficking, particularly in hot weather. See also sub-Clause 34 of this Clause.

Coated Chippings

32 Coated chippings shall be 20 mm or 14 mm nominal size as described in Appendix 7/1 and shall comply with Clause 915.

Surface Texture

33 The surface texture on high-speed roads shall comply with Clause 921.

Trafficking Newly Laid Surfacing

34 The Contractor shall ensure the pavement material has adequately cooled and hardened before the road is opened to traffic. Unless otherwise agreed by the Overseeing Organisation, the road shall not be opened to traffic if its surface temperature exceeds 25°C unless the maximum temperature within the mat has fallen below 35°C.

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