British Standard

BRITISH STANDARD

BS 4987-2:2003

Coated macadam (asphalt concrete) for roads and other paved areas —

Part 2: Specification for transport, laying and compaction

ICS 75.140; 93.080.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/510, Road materials, to Subcommittee B/510/1, Coated macadam and hot asphalt, upon which the following bodies were represented:

British Civil Engineering Test Equipment Manufacturer's Association
County Surveyors' Society
Department for Transport
Institute of Asphalt Technology
Institution of Civil Engineers
Institution of Highways and Transportation
Mastic Asphalt Council Ltd.
Quarry Products Association
Refined Bitumen Association
Road Surface Dressing Association
Scottish Office (Roads Directorate)
Society of Chemical Industry
Transport Research Laboratory (TRL)
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Contents

Foreword

This part of BS 4987 has been prepared by Subcommittee B/510/1. It supersedes BS 4987-2:2001, which is withdrawn.

The 2001 edition of BS 4987-2 introduced a number of technical changes, including the deletion of references to tar and cut-back bitumen and changes to bitumen grades to introduce the grades now specified in BS EN 12591 (for further details see BS 4987-1:2003). It also introduced the terms "base (roadbase)", "binder course" and "surface course" in place of the previous terms "roadbase", "basecourse" and "wearing course" in order to introduce users of this standard to these terms which will be used in future European asphalt standards.

This edition introduces changes to mix terminology consequent on the implementation of the European standards for aggregates. It also introduces new requirements and advice for tack coats and bond coats in **5.5**.

This standard comprises two parts:

Part 1: Specification for constituent materials and for mixtures;

Part 2: Specification for transport, laying and compaction.

Requirements for transporting coated macadam mixtures and for site work are covered by this part of BS 4987. Requirements are also given for resurfacing work including the covering of concrete and sett paving, and for the use of tack coats.

Provision is made to measure the in situ compaction of certain types of macadam in terms of either air voids or the percentage refusal density (PRD) as described in BS 598-104.

It has been assumed in the drafting of this part of BS 4987 that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Annexes A and B are informative.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 2 to 13 and a back cover.

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1 Scope

This part of BS 4987 specifies requirements for the transport, laying and compaction of coated macadam mixtures conforming to BS 4987-1 from the time that they leave the mixing plant until they are placed on the road ready to receive a superimposed layer or traffic. It also includes requirements for preliminary work at the laying site needed to ensure that the substrate is ready to receive the coated macadam.

This standard does not include requirements for macadams incorporating bitumen emulsion binders.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 434-1:1984, *Bitumen road emulsions (anionic and cationic) — Part 1: Specification for bitumen road emulsions.*

BS 434-2, *Bitumen road emulsions (anionic and cationic) — Part 2: Code of practice for use of bitumen road emulsions.*

BS 598-100, *Sampling and examination of bituminous mixtures for roads and other paved areas — Part 100: Methods for sampling for analysis.*

BS 598-104, *Sampling and examination of bituminous mixtures for roads and other paved areas — Part 104: Methods of test for the determination of density and compaction.*

BS 598-109, *Sampling and examination of bituminous mixtures for roads and other paved areas — Part 109: Methods for the assessment of the compaction performance of a roller and recommended procedures for the measurement of the temperature of bituminous mixtures.*

BS 4987-1:2003, *Coated macadam for road and other paved areas — Part 1: Specification for constituent materials and for mixtures.*

BS 6100, *Glossary of building and civil engineering terms.*

HIGHWAYS AGENCY. *Specification for Highway Works*. London: The Stationery Office.

3 Terms and definitions

For the purposes of this part of BS 4987, the terms and definitions given in BS 6100 and BS 4987-1 apply.

4 Transport and delivery

4.1 Transport

4.1.1 Coated macadams other than those to be laid cold shall be transported to the site in insulated lorries and shall be sheeted so as to prevent an excessive drop in temperature and to ensure their protection against adverse weather conditions.

4.1.2 Diesel oil shall not be used on the floor of the vehicle to facilitate the discharge of the mixed materials.

In the case of porous asphalt, only soap solution, water or a proprietary release agent shall be used.

NOTE Sealing grit, sand, soap solution or a proprietary release agent may be used on the floor of the vehicle to facilitate discharge of the mixed material. The amount used should be kept to a minimum by brushing.

4.2 Delivery

The macadam shall be delivered at a temperature which enables the material to be compacted in accordance with the requirements of clause **7**.

NOTE For recommended suitable delivery temperatures see Annex A (Table A.1).

5 Preparatory works at the laying site

5.1 General

NOTE The surface on which the coated macadam is to be laid should be of adequate strength to bear the equipment which will be used to lay the coated macadam. It is desirable that some form of permanent lateral support should be given to the layer of coated macadam.

The surface on which the coated macadam is to be laid shall be free from ice, standing water, loose materials and foreign matter. Any previous layer shall be compacted using a roller exerting at least as great a load per unit width of roll as that to be used for rolling the coated macadam.

5.2 Surface level tolerances

The sum of the deviations in the level of different pavement layers shall not result in a reduction of the nominal surface course thickness by more than 12.5 % from that specified.

For road sites or similar areas the permitted deviation of the level of the finished surface at any point on the constructed surface of the pavement layer from the true surface level shall not exceed the following values:

a) sub-base to receive base (roadbase): $^{+10}_{-30}$ mm;

b) base (roadbase) to receive surface course: ±8 mm;

c) base (roadbase) to receive binder course: ±15 mm;

d) binder course to receive surface course on roads: ±6 mm;

e) binder course to receive surface course on areas other than roads, e.g. car parks, playgrounds: ±10 mm.

5.3 Resurfacing

5.3.1 *General*

5.3.1.1 Where an existing surface is to be used as a base (roadbase) or binder course, the maximum depression under a 3 m straightedge placed longitudinally or under a template placed transversely shall not exceed:

a) 25 mm when the resurfacing is to consist of two course work; or

b) 13 mm when the resurfacing is to be a single surface course.

If improvement of the surface is required, it shall be carried out by planing and/or by the addition of a regulating course.

NOTE 1 All weak areas to be surfaced should be strengthened, major inequalities of profile remedied and depressions filled and thoroughly compacted prior to the laying of the macadam resurfacing.

NOTE 2 Every effort should be made to prevent water standing at the level of the bottom of the new material.

5.3.1.2 If the existing surface exhibits an excess of bitumen, this excess shall be removed.

5.3.2 *Overlaying existing concrete*

Where coated macadam is to be laid on existing concrete with defective joints, in addition to the general requirements given in **5.3.1** the joints shall be made good by cleaning out and refilling with a joint-filling material. This material shall be compacted flush with the surface.

NOTE 1 The material used should not be adversely affected by or itself adversely affect the surfacing.

NOTE 2 In some cases, special treatment of the joints and cracks may be necessary. It is particularly important to ensure that there is no relative movement between adjacent slabs.

NOTE 3 The thicker the layer of coated macadam used, the longer the delay in the appearance of reflective cracking.

5.3.3 *Overlaying existing sett paving*

Where coated macadam is to be laid on existing sett paving, the following special measures shall be taken in addition to the general requirements given in **5.3.1**.

a) All loose and weak areas of sett paving shall be removed and replaced with an equivalent thickness of either binder course or cement concrete.

b) Excessive bitumen or pitch used to grout the sett joints shall be removed.

c) To ensure the best possible key, all joints shall be cleaned of foreign matter to a depth of at least 15 mm.

d) Bitumen emulsion conforming to class A1-40 or K1-40 of BS 434-1:1984 shall be applied at a uniform rate.

NOTE If required, the bitumen emulsion can be covered with 2.8/6 mm chippings at approximately 6 kg/m2.

5.4 Adjustment of levels

When coated macadam is to be used to adjust the levels of the base or underlying surface, whether to provide super-elevation or for any other purpose, binder course mixtures shall be used. Layer thicknesses shall be in accordance with Table 6.

NOTE 1 For thicknesses greater than 100 mm base (roadbase) mixtures may be used.

NOTE 2 If the total thickness of the regulating course is less than 40 mm, the use of regulating course hot rolled asphalt conforming to BS 594-1 or stone mastic asphalt binder course conforming to *Specification for Highway Works*:2003, Clause 937 is recommended.

5.5 Tack coat and bond coat emulsions

5.5.1 *General*

NOTE Tack coats and bond coats are used to promote adhesion between layers of asphalt used in the construction of a paved area or used to bond a new surface course to an existing road surface when carrying out road maintenance. The choice of tack coat or bond coat depends on the condition of the substrate, the stiffness and binder content of the layers and type of site. This clause also provides requirements for the use of bond coats at high application rates, where required to improve the relative impermeability of the surface of a lower layer/existing surface.

This clause covers all bituminous materials in roads and paved areas and includes requirements for asphalt and macadam materials with a wide range of binder contents.

Further guidance is contained in BS 434-2.

5.5.1.1 *Tack coats*

Tack coats shall be K1-40 or K1-60 bitumen emulsions conforming to BS 434-1.

NOTE K1-70 emulsion, formulated with bitumen having a maximum penetration value of 220 dmm and less than 3.0 % w/w of added volatile flux oil may also be used.

Tack coats are conventional bitumen emulsions used to enhance the adhesion between layers of asphalt, which might otherwise be impaired due to minor dust problems or insufficient free bitumen on the surface of the layer being overlaid. Their use shall be as specified in accordance with **5.5.2**.

5.5.1.2 *Bond coats*

Bond coats are proprietary materials and shall have a BBA/HAPAS certificate[1)] detailing the performance claims made for the product.

NOTE 1 The certificates include guidance on application rates for the benefit of designers and specifiers. They are generally formulated to enable application at heavier application rates than are possible with tack coats and to provide greater cohesion.

Their use shall be as specified in accordance with **5.5.2**.

NOTE 2 For certificates stating claimed performance for bond coats see the BBA website: www.bbacerts.co.uk.

NOTE 3 The provisions of this clause are not applicable to thin surface course systems produced under BBA/HAPAS certification, in which the bond coats are an integral part of the system.

NOTE 4 Further general information on the specification of bond coats for motorways and trunk roads can be found in *Specification for Highway Works*:2003, Clause 920.

NOTE 5 Until such time that BBA/HAPAS certificates are available, producers of the bond coat should provide performance data for any claims made, detail the rates of spread required, which should be at least those included in Table 3, Table 4 and Table 5, and provide product identification in accordance with the BBA/HAPAS SG4 Guideline Document for bond coats.

1) British Board of Agrément, P.O. Box 195, Bucknalls Lane, Garston, Watford, Herts WD25 9BA. www.bbacerts.co.uk.

5.5.2 *Application*

A tack coat or bond coat shall be applied prior to the laying of a new surface course, unless this is to be laid on a binder course or base (roadbase) which itself is still in its "as-laid" clean condition and which has been laid within the previous seven days.

A tack coat or bond coat shall be applied, when specified, at other layer interfaces.

Rates of application of tack coat shall be specified in accordance with Table 1 and Table 2.

NOTE 1 If a tack coat or bond coat is not required under the surface course laid on fresh binder course or base (roadbase) then this should be specified.

NOTE 2 Application rates in this standard are quoted in kg/m^2 of residual bitumen. This differs from previous standards, which quoted rates in l/m^2 of total emulsion. For example, the rate 0.15 kg/m^2 residual bitumen would approximately equate to 0.35 l/m^2 of K1-40 or 0.25 l/m^2 of K1-60 emulsion.

Rates of application of bond coat shall be in accordance with the rates detailed in the BBA/HAPAS certificate, or in the absence of such certificates, as specified in accordance with Table 3, Table 4 and Table 5.

NOTE 3 The use of bond coat, in preference to tack coat, should be considered in the following circumstances.

— Where the designer or specifier wishes to achieve greater confidence in the adhesion between layers the use of a cohesive (premium grade) bond coat at the rates recommended in Table 3 and Table 4 may be appropriate. For example, between layers where bonding is likely to be difficult such as high stiffness modulus bases or aged and partly uncoated aggregate surfaces. This is likely to be particularly relevant in the case of heavily-trafficked or high stress roads and other paved areas.

— Where the designer or specifier wishes to improve the relative impermeability of the surface of a lower layer, the use of a cohesive (premium grade) bond coat at the rates recommended in Table 5 may be appropriate. For maximized improvement, (for example that required for bridge structures between the installed bridge deck waterproofing membrane and a stone mastic asphalt overlay) special hot-applied bond coats may be required at much higher rates of spread.

— Where the laying of the asphalt involves temporary trafficking by pedestrians or vehicles of the tack/bond coat, the use of "non-tack" bond coat may be appropriate. The rate of application should be as specified in Table 3, Table 4 or Table 5 as applicable to the particular application.

— The use of bond coat should be considered when overlaying concrete with 100 mm or less thickness of asphalt. Rates of application should be in accordance with Table 4 or Table 5.

Table 1 — Recommended target rates of application of tack coat in kg/m^2 of residual bitumen for newly laid asphalt — New construction

Binder content upper layer	Binder content lower layer		
	≤4 %	4.1–5.0 %	≥5.1 %
≥5.1 %	0.15	0.15	0.15
4.1–5.0 %	0.20	0.15	0.15
≤4%	0.25	0.20	0.15

Table 2 — Recommended target rates of application of tack coat in kg/m^2 of residual bitumen for existing surfaces — Maintenance

Binder content upper layer	Nature of lower layer/existing surface (see Note)		
	Fretted/binder lean	Planed asphalt	Binder rich
≥5.1 %	0.20	0.15	0.15
4.1–5.0 %	0.25	0.20	0.15
≤4%	0.25	0.25	0.20
NOTE "Binder lean" is regarded as an asphalt estimated to have less than 4 % binder content or where a surface to be treated has partly coated exposed aggregate or where there is some evidence of cracking. "Stiff bases" are those where the recovered penetration is less than 20 pen (dmm). "Normal asphalts — slightly permeable" are those dense and close-textured materials judged to have less than 10 % air-voids.			

Table 3 — Recommended target rates of application of bond coat in kg/m² of residual binder for newly laid asphalt — New construction

Binder content upper layer	Binder content lower layer		
	≤4 %	4.1–5.0 %	≥5.1 %
≥5.1 %	0.15	0.15	0.15
4.1–5.0 %	0.30	0.25	0.25
≤4%	0.40	0.35	0.30

Table 4 — Recommended target rates of application of bond coat in kg/m² of residual binder for existing surfaces — Maintenance

Binder content upper layer	Nature of lower layer/existing surface (see Note)		
	Fretted/binder lean/concrete	Planed asphalt	Binder rich
≥5.1 %	0.50	0.40	0.25
4.1–5.0 %	0.60	0.50	0.35
≤4%	0.60	0.60	0.40
NOTE "Binder lean" is regarded as an asphalt estimated to have less than 4 % binder content or where a surface to be treated has partly coated exposed aggregate or where there is some evidence of cracking. "Stiff bases" are those where the recovered penetration is less than 20 pen (dmm). "Normal asphalts — slightly permeable" are those dense and close-textured materials judged to have less than 10 % air-voids.			

Table 5 — Recommended target rates of application of bond coat in kg/m2 of residual binder for improving the relative impermeability of the surface of a lower layer/existing surface

Binder content upper layer	Nature of lower layer/existing surface (see Note)		
	Fretted/binder lean/concrete/stiff bases	High stiffness modulus bases	Normal asphalt — slightly permeable
≥5.1 %	0.60	0.60	0.50
4.1–5.0 %	0.60	0.60	0.50
≤4%	0.80	0.70	0.60
NOTE "Binder lean" is regarded as an asphalt estimated to have less than 4 % binder content or where a surface to be treated has partly coated exposed aggregate or where there is some evidence of cracking. "Stiff bases" are those where the recovered penetration is less than 20 pen (dmm). "Normal asphalts — slightly permeable" are those dense and close-textured materials judged to have less than 10 % air-voids.			

Tack coats and bond coats shall be applied at a uniform rate.

NOTE 1 For continuous laying works, specification of application by metered mechanical spraying equipment, spray tanker or spraying device integral with the paving machine should be considered. For small scale works and inaccessible areas application may be by hand held sprayer.

After application, the emulsion shall be allowed to "break" (i.e. turn from brown to black), before the asphalt is laid, unless it is applied by a paver with an integral spray bar. Any emulsion accumulating in hollows shall be dispersed by brushing and allowed to break before it is over-laid.

NOTE 2 Further general guidance on the specification of the application of tack coats and bond coats on motorways and trunk roads, including application tolerances and accuracy of spread, can be found in the *Specification for Highway Works*:2003, Clause 920. Over-application or ponding should be avoided, as this might result in the slippage or instability of the uppermost layer.

BBA/HAPAS certified bond coats shall be applied as specified on the certificate.

6 Laying

6.1 Personnel

The laying operation shall be controlled by trained and experienced personnel.

6.2 Laying in adverse conditions

6.2.1 Laying shall not be carried out if free-standing water is present on the surface to be covered.

NOTE Laying should be avoided as far as is practicable during heavy rain. If the wet weather threatens to be prolonged laying of the coated macadam should be suspended.

6.2.2 Laying shall be carried out with due regard to ambient weather conditions so that materials can be properly compacted (see Note 2). The coated macadam shall not be laid on any surface which is frozen or covered with ice or snow. Laying shall cease when the air temperature reaches 0 °C on a falling thermometer, except in calm dry conditions, when laying shall cease if the air temperature reaches –3 °C on a falling thermometer.

NOTE 1 When, however, the surface is dry and free from ice, laying may proceed at air temperatures at or above –1 °C on a rising thermometer.

NOTE 2 The control of compaction time does not lend itself to simple rules. The following factors, which affect the rate of cooling of asphalt layers and hence the time available for compaction, should be taken into consideration and working practices adjusted accordingly.

a) *Layer thickness*. Layer thickness should be taken into consideration as, for example, thicker layers cool more slowly. Binder course and base (roadbase) layers of 60 mm or more thickness provide adequate time for compaction under most weather conditions. Thinner layers need more care.

b) *Wind speed*. Wind speed has a greater effect on the rate of cooling than air temperature.

c) *Ambient temperature*. Ambient temperature should be taken into consideration but is of less significance than wind speed.

d) *Time available*. The time available for compaction is also dependent on the type of binder in the mixture and the temperature of the mixture as it is laid.

NOTE 3 Further guidance is given in Transport Research Laboratory publication, Research Report 4, (Daines 1985) [1].

6.3 Machine laying

6.3.1 The paver shall be capable of laying the coated macadam continuously so as to produce an even and compact surface to the required widths, thicknesses, profiles, cambers and crossfalls without causing segregation, dragging, burning, surface defects or irregularities and of being operated at such a speed as to permit continuous laying as far as supply and site conditions allow.

NOTE 1 A means of imparting an initial compaction should be fitted, together with the necessary apparatus for supplying heat to any finishing screed.

NOTE 2 Continuous inspection of the finished surface should be carried out as it is laid and any defects immediately rectified before any rolling takes place, but there should be no unnecessary scattering back by hand of the macadam on machine laid work.

NOTE 3 Supplies of coated macadam should be phased with due regard to the laying operation on the site. When machine laying, the macadam should be laid as soon as possible after delivery and should normally be supplied continuously to the paver.

6.3.2 Narrow strips remaining alongside machine work, if laid by hand, shall be rolled at the same time as the machine laid work, with allowance being made for extra surcharge to and compaction of hand laid strips.

6.3.3 Macadam remaining in hoppers, conveying and spreading mechanisms, tampers and screeds shall be cleaned off at the end of each working day. On no account shall cleaning solvent be allowed to come into contact with any bituminous layer.

6.4 Hand laying

On delivery to the site the coated macadam shall be deposited in heaps, on a clean hard surface and sheeted to protect it from loss of heat and adverse weather. Alternatively it shall be protected in a portable hot box or taken directly from the delivery vehicle.

NOTE 1 In the latter case, the vehicle should be kept sheeted wherever possible to reduce heat loss and protect the macadam from adverse weather conditions.

The macadam shall be spread in a layer of uniform thickness and even texture and thoroughly compacted immediately.

NOTE 2 Every precaution should be taken to minimize segregation and to avoid contamination.

6.5 Thickness

The nominal thickness of a layer and the minimum thickness of a layer at any point shall conform to the thicknesses given for the material in Table 6.

Table 6 — Specified nominal and minimum layer thicknesses for coated macadam

Material description	BS 4987-1 reference	Nominal size mm	Nominal layer thickness mm	Minimum thickness at any point mm
Fine graded surface course	**7.7**	0/4	15 to 25	10
Medium graded surface course[a]	**7.6**	0/6	20 to 25	15
Dense surface course[a]	**7.5**	0/6	20 to 30	15
Porous asphalt surface course	**8.2**	2/10	30 to 35	25
Open graded surface course	**7.2**	0/10	30 to 35	25
Close graded surface course[a]	**7.4**	0/10	30 to 40	25
Open graded surface course	**7.1**	0/14	35 to 55	30
Close graded surface course[a]	**7.3**	0/14	40 to 55	35
Porous asphalt surface course	**8.1**	6/20	45 to 60	40
Open graded binder course	**6.1**	0/20	45 to 75	40
Dense, heavy duty and high modulus binder course[a]	**6.5**	0/20	50 to 100	40
Dense, heavy duty and high modulus binder course	**6.4**	0/32	70 to 150	55
Dense, heavy duty and high modulus base (roadbase)[a]	**5.2**	0/32	70 to 150	55
Single course	**6.2**	0/32	70 to 105	65[b]

NOTE Thicknesses in excess of those given in the table can provide better compaction if adequate equipment is used but may lead to problems with surface irregularity and level control.

[a] Preferred mixture.
[b] 80 mm if used as a single course with no subsequent surface course.

6.6 Contour and falls

When the coated macadam is laid on a surface prepared in accordance with Clause **5**, the new road surface, on completion of rolling, shall conform to the required levels and shape within the tolerances given in Table 7.

Table 7 — Accuracy of finish

Coated macadam	Maximum permissible depth of the gap beneath a 3 m straightedge used longitudinally or a template used transversely	
	Machine laid mm	Hand laid mm
Base (roadbase)	25	25
Binder course	13	13
Surface course	7	10

NOTE 1 The finished surface should be laid as follows unless specified otherwise.

a) *Cross-fall*. In the case of roads with a straight cross-fall this fall should be not steeper than 3 % nor flatter than 2 %.
b) *Camber*. With roads to be cambered, the average fall of the finished surface from the crown to the channel should not be more than 3 % nor less than 2 %.
c) *Longitudinal fall*. Longitudinal drainage falls in the channel should have a gradient no flatter than 0.8 %.

NOTE 2 As a means of ensuring reasonable riding quality after patching operations the surface of the compacted patch should be flush with or slightly proud of the surrounding surface; it should not be left below the surrounding level, otherwise ponding will occur.

The accuracy of finish in the longitudinal direction shall be determined by measuring the gap under a 3 m straightedge placed in any position on the road surface parallel to the centre line. The depth of the gap at any place between the points at which the straightedge is in contact with the road, shall not exceed the dimensions given in Table 7. The transverse profile shall conform to the same standard of accuracy, using a template instead of the straightedge.

NOTE 1 Special consideration should be given to the requirements for applicable levels and finish for surfaces other than highways and these requirements should be appropriate for the use to which the area is to be used.

NOTE 2 Attention should be paid to drainage.

6.7 Joints

6.7.1 The following surface course joints shall be made by cutting back the edge to a vertical face that exposes the full thickness of the layer, discarding all loosened material and painting the vertical face completely with a thin uniform coating of hot applied 40/60 or 70/100 paving grade bitumen or, if approved by the specifier, cold applied thixotropic bitumen compound of similar grade, before the adjacent width is laid:

a) all transverse joints;

b) joints where the coated macadam abuts an existing surface;

c) all longitudinal joints in mixes containing paving grade bitumen.

6.7.2 All other joints [e.g. base (roadbase) and binder course] shall be treated in such a way as to ensure adequate compaction and bonding.

NOTE 1 Care should be taken to avoid surplus bitumen on the surface after the joint is made and in particular the practice of painting the finished joint should be discouraged.

NOTE 2 When treating joints in porous asphalt care should be taken not to impede the flow of water across the joints. For this reason the joints should not be painted and should be cut back only where unavoidable. Where possible, porous asphalt lanes should be laid in echelon.

6.7.3 All joints shall be offset at least 300 mm from parallel joints in the layer beneath.

NOTE When requested by the specifier the contractor should provide a layout of the proposed joint pattern.

6.8 Manhole covers and projections

The vertical faces of manholes, gulleys, kerbs, channels and similar projections against which the coated macadam is to abut shall be cleaned and painted with a thin uniform coating of hot applied 40/60 or 70/100 paving grade bitumen or, if approved by the specifier, cold applied thixotropic bitumen compound of similar grade, before coated macadam is laid.

The coated macadam shall be tamped around and against such projections by means of tampers and the finished surface shall be either left flush with the top of, or not more than 3 mm above, such projections.

NOTE Manholes, gulleys and similar projections should only be raised to their final level after the laying of the binder course but before the laying of the surface course.

7 Compaction

7.1 General

As this standard covers a wide range of mixtures which are laid in a variety of circumstances, compaction shall conform to one of the following requirements according to the scale and nature of the work:

a) requirements for end result compaction of high modulus, heavy duty and dense base (roadbase) and binder course macadam (see **7.4**); or

b) requirements for the compaction of machine laid coated macadam (see **7.2**); or

c) requirements for the compaction of coated macadam in hand laid and patching work (see **7.3**).

NOTE 1 End result compaction is more appropriate for machine laid work on major road contracts (see **7.4.1**).

NOTE 2 The specifier should state which of these options is required.

7.2 Compaction of machine laid coated macadam

7.2.1 *Personnel*

Rollers and other compaction equipment shall be operated by skilled, experienced personnel.

7.2.2 *Equipment*

7.2.2.1 All rollers shall be fitted with smooth quick acting reverse mechanisms. Smooth steel wheeled rollers shall have wetting devices of at least the width of the rolls.

7.2.2.2 Rollers shall be one of the following types:

a) dead weight having smooth steel wheels with a rear width of roll of not less than 450 mm and weighing between 6 t and 12 t; or

b) vibratory of equivalent mass; or

c) pneumatic tyred of equivalent mass.

Surface course and binder course mixtures shall be surface finished with a smooth steel wheeled roller, which can be a vibratory roller operating in a non-vibrating mode.

NOTE 1 Vibratory rollers of lower mass than specified in b) may be used if they are capable of achieving at least the standard of compaction achieved by dead weight rollers of standard mass.

NOTE 2 A method of assessing the performance of rollers is given in BS 598-109.

NOTE 3 It is important to ensure that the frequency and amplitude of vibration and the speed of travel of vibratory rollers are correctly matched to layer thickness and mixture composition.

7.2.3 *Number of rollers*

The number of dead weight rollers used on a normal site shall be:

a) at least one operational roller at all times;

b) a second roller when the daily tonnage exceeds either:

1) 100 t of surface course; or

2) 150 t of base (roadbase) or binder course;

c) a third roller when the daily tonnage exceeds either;

1) 150 t of surface course; or

2) 450 t of base (roadbase) or binder course.

NOTE 1 The number of rollers should be sufficient to enable these rollers, while travelling at a low but steady speed, to make sufficient passes to compact the coated macadam adequately.

NOTE 2 When assessing the required numbers of other types of rollers, such as vibratory rollers, the results of tests carried out in accordance with BS 598-109 should be considered. If the proposed rollers are shown to achieve a greater compactive output than the standard dead weight combination then the number of rollers may be reduced accordingly.

7.2.4 *Method of compacting*

The coated macadam shall be rolled as soon as it can be without causing undue displacement of the coated macadam.

In the case of dense, heavy duty and high modulus base (roadbase) and binder course mixtures, compaction shall be substantially completed while the temperature of the mixed material is greater than the appropriate temperature given in Table 8, when measured in accordance with BS 598-109.

Table 8 — Minimum rolling temperatures for dense, heavy duty and high modulus binder course and base (roadbase) macadams

Binder type and grade	Minimum rolling temperature °C
160/220 pen bitumen	60
100/150 pen bitumen	75
40/60 pen bitumen	105
30/45 pen bitumen	110

NOTE 1 Guidance on delivery temperatures and on rolling temperatures for mixtures other than heavy duty and dense base (roadbase) and binder course is given in Table A.1.

NOTE 2 Care should be taken to guard against surface cracking occurring as a result of rolling temperatures close to the appropriate minimum temperature. Finishing rolling may be carried out at a temperature below that given in Table 8, but no vibration should be employed.

NOTE 3 Rolling should normally be in a longitudinal direction with the driven rolls nearest to the paver. The roller should first compact the macadam adjacent to the joints and then work from the lower to the upper side of the layer overlapping on successive roller passes. The rolling pattern should be such as to ensure that compaction is as uniform as possible across the road width. In order to achieve this at least half of the roller passes should be along the edges of the layer. Rollers should not stand on freshly laid coated macadam if this might lead to deformation of the surface.

7.3 Compaction of coated macadam in hand laid and patching work

In areas where the methods described in **7.2** are impractical for reasons of restricted access, limited working area or restricted width of surfacing and for situations where the underlying construction will not support a heavy static roller, one of the following alternative methods of compaction shall be used:

a) on footpaths and similar areas, either static rollers of 2.5 t deadweight or vibrating rollers of a minimum deadweight of 750 kg unless it can be demonstrated that an equivalent compactive effort can be provided by a vibrating roller of a lesser deadweight;

b) in trenches and other extremely restricted areas vibrating plate compactors.

NOTE 1 In all cases the procedure adopted should be as close as is practicable to that specified in **7.2** for the larger scale work.

NOTE 2 The compaction achieved will depend on the workability and temperature of the mixture at the time of handling, and compaction should commence as soon as possible without causing undue displacement and should continue until subsequent passes result in no further roller marks.

7.4 End result compaction of high modulus, heavy duty and dense base (roadbase) and binder course macadam

7.4.1 *General*

End result compaction of coated macadam shall be specified for all works intended to carry heavy slow moving vehicles and on roads and other works which carry more than light traffic. It shall be measured in terms of its percentage refusal density (PRD), in accordance with BS 598-104 (see **7.4.2**) or its air void content, in accordance with BS 4987-1:2003, **4.7** (see **7.4.3**).

NOTE 1 Both methods use cored samples cut from the macadam after the completion of laying. Non-destructive testing using nuclear density metres enables a very rapid, non-destructive assessment to be made of the degree of compaction of newly laid work.

NOTE 2 Compaction should be substantially completed while the temperature of the mixed material is greater than the appropriate temperature given in Table 8.

7.4.2 *Percentage refusal density (PRD)*

Compaction shall be measured either in areas of 1 000 m^2 or, where there is less than 1 000 m^2, on the material laid in any one day. Within each area, three pairs of 150 mm diameter cores shall be cut after the material has cooled to ambient temperature. The cores shall be cut in accordance with BS 598-100. The cores from each pair shall be adjacent and located on a line parallel to the direction of laying. All the core pairs shall be taken from the wheel-track zones of the finished road pavement. For the purposes of this clause, the wheel-track zones 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 marking for each running lane.

The PRD of each core shall be determined in accordance with the method described in BS 598-104. The mean of each group of three consecutive core-pair results shall be not less than 93 PRD. No single core-pair shall be included in more than one group.

7.4.3 *Air void content*

The in situ air void content of each core shall be determined in accordance with BS 4987-1:2003, **4.7**. The average in situ air void content of the three core pairs shall not exceed the values stated in *Specification for Highways Works*:2003, Clause 929.

7.4.4 *Reinstatement of core holes*

The walls and bases of all holes formed by taking core samples shall be painted with either hot 40/60 or 70/100 paving grade bitumen and the holes shall then be filled with coated macadam or asphalt well rammed in layers not exceeding 50 mm thick.

NOTE 1 If end result compaction is required, the specifier may decide whether or not to require full compliance testing on every sample area of 1 000 m². On areas from which cores are not to be taken, a nuclear density gauge may be used to ensure that the specified level of compaction is being maintained. These gauges may be used on a relative basis having first established the gauge density reading equivalent to the maximum stated values of air voids in *Specification for Highway Works*:2003, Clause 929 or 93 PRD whichever is specified. (Details of such a compaction compliance scheme are given in Transport and Road Research Laboratory Supplementary Report 754 [2].)

Alternatively, the gauge density reading may be established for the maximum stated values of air voids in the *Specification for Highway Works*:2003, Clause 929 and the gauge used in a similar manner. The densities measured in this way should be used for acceptance and control purposes only and in cases of doubt or dispute, compliance should be judged only on values determined from the specified coring and testing procedure.

NOTE 2 Hot bitumen does not adhere to wet surfaces. The core walls should therefore be carefully dried before being painted. Alternatively, especially formulated suitable proprietary polymer modified bitumen bond coat emulsion should be used in place of hot bitumen.

8 Application of coated grit

If the surface of newly compacted open graded surface course coated macadam is to be blinded with coated grit, it shall be carried out either by hand or mechanically with bituminous grit as specified in BS 4987-1:2003, **7.9** (see also the guidance given in BS 4987-1:2003, **B.5.4**).

NOTE The rate of spread is normally specified.

9 Opening to traffic

The completed surface course macadam shall not be opened to traffic until it has cooled sufficiently for traffic not to cause undue damage.

If coated macadams, other than surface course mixtures, are to be used as temporary running surfaces, the skidding resistance shall be maintained either by the choice of suitable aggregate or by surface dressing.

NOTE Open textured binder course macadams should not be used as temporary running surfaces because of the risk of ingress of dirt.

Annex A (informative)
Recommended delivery and rolling temperatures for coated macadam

The recommended delivery and rolling temperatures for coated macadam are shown in Table A.1.

Table A.1 — Recommended delivery and rolling temperatures for coated macadams other than dense, heavy duty and high modulus binder course and base (roadbase) macadams

Type of mixture including binder type and grade		Minimum temperature of mixture in lorry within 30 min after arrival on site °C	Minimum temperature immediately prior to rolling °C
Bitumen			
Dense, close graded, medium graded surface courses and fine graded	250/330 pen 160/220 pen[a]	100 110	80 85
Dense and close graded surface course	100/150 pen	120	95
Open graded and single course	250/330 pen 160/220 pen	85 95	65 75
Porous asphalt	160/220 or 100/150 pen	110	85
NOTE 1 See Table 8 for temperatures of dense, heavy duty and high modulus binder course and base (roadbase) macadams.			
NOTE 2 Fluxed and deferred set mixtures (see BS 4987-1:2003, Annex A) may be delivered/rolled at lower temperatures than those in this table.			
[a] For slag macadam, temperatures 10 °C lower than those recommended may be used.			

Annex B (informative)
Approximate rates of spread of coated macadam

Table B.1 is for guidance only. It shows the approximate ranges of cover of various compacted thicknesses of coated macadam.

Table B.1 — Approximate rates of spread of coated macadam

Average thickness of course	Approximate rate of spread	
	Open graded and single course macadams and porous asphalts	Dense, heavy-duty, high modulus, close graded, medium graded and fine graded macadams
mm	m^2/t	m^2/t
20	20 to 27	18 to 24
25	17 to 22	15 to 19
30	14 to 17	13 to 15
35	12 to 16	11 to 13
40	12 to 15	10 to 12
45	10 to 13	9 to 11
50	9 to 12	8 to 10
60	8 to 10	7.0 to 8.5
65	7 to 10	6.0 to 7.5
75	7 to 8	5.0 to 6.5
100	4.5 to 6.0	4.0 to 5.0

The ranges given take into account the fact that the covering capacity per tonne is influenced by such factors as the density and grading of the aggregates, condition of substrate and degree of compaction. They apply only when the accuracy of finish of the substrate is within the limits in **5.2**. On more irregular substrates, heavier rates of spread are to be expected.

Bibliography

Standards publications

BS 594-1:2003, *Hot rolled asphalt for roads and other paved areas — Part 1: Specification for constituent materials and asphalt mixtures.*

Other documents

[1] DAINES, M.E. *Cooling of bitumous layers and time available for their compaction*. Crowthorne: Transport Research Laboratory, 1985 Transport and Road Research Laboratory Research Report 4[2)].

[2] TRANSPORT RESEARCH LABORATORY. *Nuclear gauges for measuring density of dense roadbase macadam: report of a working party*. Crowthorne: Transport Research Laboratory, 1982 Transport and Road Research Laboratory Supplementary Report 754[2)].

[2)] Available from TRL Limited, PO Box 303, Wokingham, Berkshire RG45 6AU.

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