

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

Part 1: Specification for constituent materials and for mixtures

ICS 75.140; 93.080.20

Committees responsible for this British Standard

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Institute of Asphalt Technology
Institution of Civil Engineers
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MoD — UK Defence Standardization
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Foreword

This part of BS 4987 has been prepared by Subcommittee B/510/1. It supersedes BS 4987-1:2003, which is withdrawn.

The clause and table numbers of specific mixtures in the 2003 edition have been retained wherever possible in this edition. The European asphalt standard terminology introduced in the 2001 edition has been retained. As the change from the use of BS 3690 to BS EN 12591, anticipated in the 2001 edition, took effect on 01.01.2002, this edition calls up the BS EN 12591 references only.

The clauses and tables which were removed in the 2001 and 2003 revisions are marked as “*Deleted*”.

This edition introduces the following changes.

— The concept of factory production control (FPC) tolerances is introduced in anticipation of future European Standards for asphalt. For grading, this concept involves the selection of a target percentage (%) passing value from between two specified values and the application of a tolerance around this value. The specification formed is used to assess product conformity through the analysis of production samples which are routinely taken in accordance with the factory production control (QMS) system and for samples which may be taken by other parties to assess product conformity.

Coated macadam mixes — **Indicative** FPC tolerances

	Small aggregates D < 16 mm	Large aggregates D ≥ 16 mm
D	– 8 + 5	– 9 + 5
D/2 or characteristic coarse sieve	±7	±9
2 mm (for compliance)	±6	±7
Characteristic fine sieve	±4	±5
0.063 mm	±2	±3

The following footnotes ^a and ^b appear in the relevant tables throughout the standard:

“^a The FPC tolerances shown are **indicative** of the levels to which the materials will have to conform when European Standards for asphalt are introduced. Currently, the only sieve that is required to meet the FPC tolerance in this British Standard (BS 4987) is the **2 mm sieve**. This is to ensure that mixtures utilizing crushed rock fine aggregate, natural sand or a combination of the two, that were acceptable in the 2001 edition of this specification, can be successfully specified in this 2005 edition.

The specification limits to be applied to the 2 mm sieve shall be such that when the FPC tolerances are applied to the selected target value passing the 2 mm sieve, the declared conformity grading values shall still fall within the overall grading, e.g. for 0/20 mm DBC conforming to Table 15, passing 2 mm sieve: coarsest declared grading would be 20–34 (27 ± 7), finest declared grading would be 26–40 (33 ± 7).”

“^b It may be beneficial for producers to record and/or report values obtained from these and other intermediate sieves for future development of this and related Standards. However, these values are not to be used for checking compliance with the specification.”

- In order to retain the characteristics of the current BS 4987 porous asphalt materials, the FPC tolerances are shown indicatively, but are not applied.
- The requirements for the aggregate grading of all mixtures have been revised in order to better align the change from the 3.35 mm to the 2 mm characteristic sieve introduced in the 2003 edition.

The 2003 edition introduced the following changes.

- The requirements for aggregates, the sieve sizes used for the definition of mixtures and the size designations of mixtures have been amended to align with BS EN 13043, which is being implemented in the UK on 01.01.2004. The introduction of BS EN 13043 implies the use of both different size designations and test methods. Detailed guidance and advice on the changes may be found in PD 6682-2 and PD 6682-9.
- Previous editions of the standard included 40 mm dense base (roadbase) mixtures which used a 37.5 mm sieve to control upper size. As the 37.5 mm sieve is no longer part of the sieve series used in the UK, these 40 mm mixtures are replaced by 0/32 mm size mixtures.
- All 28 mm base (roadbase) and binder course mixtures have been replaced by 0/32 mm size mixtures.
- Reference to the in-plant blending of bitumens has been added.

The 2001 edition introduced the following changes.

- High modulus base (roadbase) and binder course macadams are included.
- A design procedure is introduced, by reference, for dense base (roadbase) and binder course mixtures incorporating 40/60 and 30/45 pen paving grade bitumens.
- For dense, heavy duty and high modulus mixtures which are produced with several grades of bitumen, the nominal mid-point penetration value of the bitumen is included in the description of each mixture, e.g. DBM 50, HDM 50, HMB 35 (see Annex C for further information).
- The use of air voids in monitoring compaction is included. Percentage refusal density (PRD) is retained.

This standard comprises two parts:

- *Part 1: Specification for constituent materials and for mixtures;*
- *Part 2: Specification for transport, laying and compaction.*

Over the years, many coated macadam compositions have evolved. To encourage some rationalization a range of “preferred mixtures” has been included in Clause 5, Clause 6, Clause 7 and Clause 8. As mixtures suitable for most uses can be selected from this reduced range, the use of a preferred mixture is encouraged wherever possible.

The requirements for transporting coated macadam mixtures and for site work are included in BS 4987-2.

The requirements for the composition of all mixtures are based on the testing of the constituents and of the mixture by methods described in BS 598.

Provision is made to measure the compaction of macadam on the road 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.

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 to iv, pages 1 to 30, an inside back cover and a back cover.

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1 Scope

This part of BS 4987 specifies the requirements for all types of coated macadam (asphalt concrete) to be laid as base (roadbase) (group one), binder course (group two), surface course (group three) or porous asphalt surface course (group four) for roads and other paved areas excluding heavy duty airfield pavements. This standard does not include requirements for macadams incorporating bitumen emulsions as binders which are specified in BS 434-1.

NOTE The terms “base (roadbase)”, “binder course” and “surface course” are used throughout this standard in place of the traditional terms “roadbase”, “basecourse” and “wearing course” respectively to encourage use of the new terminology which will be used in European asphalt standards to be introduced in the near future.

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 410-1 (ISO 3310-1), *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*.

BS 410-2 (ISO 3310-2), *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*.

BS 598 (all parts), *Sampling and examination of bituminous mixtures for roads and other paved areas*.

BS 812-2, *Testing aggregates — Part 2: Methods for determination of density*.

BS 3690-1, *Bitumens for building and civil engineering — Part 1: Specification for bitumens for roads and other paved areas*.

BS 4987-2:2003, *Coated macadam for roads and other paved areas — Part 2: Specification for transport, laying and compaction*.

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

BS EN 58 (BS 2000-474), *Bitumen and bituminous binders — Sampling bituminous binders*.

BS EN 932 (all parts), *Tests for general properties of aggregates*.

BS EN 933 (all parts), *Tests for geometrical properties of aggregates*.

BS EN 1097 (all parts), *Tests for mechanical and physical properties of aggregates*.

BS EN 1367 (all parts), *Tests for thermal and weathering properties of aggregates*.

BS EN 1744 (all parts), *Tests for chemical properties of aggregates*.

BS EN 12591:2000, *Bitumen and bituminous binders — Specifications for paving grade bitumens*.

BS EN 13043, *Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas*.

BS EN ISO 3405 (BS 2000-1213), *Methods of test for petroleum and its products — Petroleum products — Determination of distillation characteristics at atmospheric pressure*.

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 the following apply.

3.1

test sieve

sieve conforming to BS 410-1 (ISO 3310-1) and BS 410-2 (ISO 3310-2)

3.2

traffic categories

3.2.1

traffic category

volume of commercial vehicles travelling in one direction counted over a 16 h period and expressed in commercial vehicles per day (c.v.d.)

3.2.2

traffic category A

volume of more than 250 c.v. per lane per day

NOTE These categories refer to existing traffic levels, not projected levels.

3.2.3

traffic category B

volume of up to 250 c.v. per lane per day

NOTE These categories refer to existing traffic levels, not projected levels.

3.3

commercial vehicle

vehicle with an unladen mass exceeding 1.5 t

4 Constituent materials

4.1 Binder

4.1.1 The binder shall be one of the following types.

- a) Petroleum bitumen conforming to BS EN 12591:2000, Table 1. 70/100 and 100/150 pen paving grade bitumen may be produced by blending in the mixer at the asphalt plant. The grades used for blending shall be no harder than 30/45 pen nor softer than 160/220 pen and shall conform to BS EN 12591. The producer shall be able to demonstrate that the plant is capable of adequately blending the bitumens. Measures for ensuring consistency of proportioning of the blend shall be included in plant quality management systems. These shall include evidence of type tests carried out on a laboratory blend of the bitumens to demonstrate conformity to BS EN 12591. The quality assurance/management systems shall also include the steps to be taken to demonstrate the continuing adequacy of the process following significant changes being made to those parts of the plant involved in the process of bitumen blending. No grades of bitumen harder than 70/100 pen shall be blended in the mixer.

NOTE Other grades may be in-plant blended provided that the resulting bitumen can be sampled and tested before it is added to the aggregate and to ensure it conforms to BS EN 12591.

- b) Petroleum bitumen conforming to BS EN 12591:2000, Table 1, Grade 160/220 or 250/330 pen, to which a flux oil, conforming to the requirements shown in Annex A (see **A.2**), has been added.

- c) For porous asphalt the binder shall be as described in Clause 8.

4.1.2 The grade of binder shall be as given in Clause 5, Clause 6, Clause 7 and Clause 8 for the individual mixtures.

NOTE 1 The recommended storage temperatures for binders are given in Annex B.

NOTE 2 The grades of binders specified in Clause 5, Clause 6, Clause 7 and Clause 8 are suitable for machine laid macadam. See **B.5.7** for guidance on grades of binders for hand laid mixtures and **A.6** for deferred set and depot stock mixes.

NOTE 3 See **B.5.5** for guidance on binders for use in porous asphalts, including modified binders.

4.1.3 When the addition of adhesion agents is made to bitumen, the mixtures shall have the relevant penetration required for bitumen given in Clause 5, Clause 6, Clause 7 and Clause 8.

NOTE The addition of adhesion agents to the bitumen or at the mixing stage (see also **B.2**) can reduce the risk of water stripping the binder from some aggregates.

4.2 Coarse aggregate

4.2.1 Type of coarse aggregate

The coarse aggregate shall be material substantially retained on a 2 mm test sieve and shall conform to all appropriate requirements of BS EN 13043 and shall consist of one of the following.

- a) Crushed rock of one or more of the following groups: basalt, gabbro, granite, gritstone, hornfels, limestone, porphyry or quartzite.
- b) Gravel of one or more of the groups in a) or flint, crushed or uncrushed, or combinations of both types.
When gravel other than limestone gravel is used, 2 % by mass of the total aggregate of either hydrated lime or Portland cement shall be used as a filler.
- c) Blast furnace slag conforming to BS EN 13043.
- d) Steel slag, either electric arc furnace slag or basic oxygen slag, with a compacted bulk density between 1.60 Mg/m³ and 1.80 Mg/m³ when tested in accordance with BS 812-2.

4.2.2 Particle shape

The flakiness category for aggregates shall be:

- a) for all macadams except porous asphalt FI₃₅;
- b) for porous asphalt FI₂₀.

4.2.3 Fines content

The fines content for coarse aggregates shall be:

- a) for crushed rock/slag f_{NR} ;
- b) for gravel f_1 .

NOTE 1 This standard does not include requirements for all the properties of aggregates, for example polishing resistance, abrasion resistance and resistance to fragmentation. Guidance on the specification of such requirements in accordance with BS EN 13043 and the relationship between the new European aggregate test methods and those previously used in the UK can be found in PD 6682-2. Specification should be in terms of the categories recommended in PD 6682-2. Further guidance is given in B.5.2.

NOTE 2 The use of 2 % by mass of the total aggregate of hydrated lime or Portland cement filler reduces the risk of water stripping the binder from some aggregates. This may also be achieved by the addition of adhesion agents to the bitumen or at the mixing stage.

NOTE 3 Aggregates other than those referred to in a) to d) in 4.2.1 may be suitable for coated macadams but are outside the scope of this standard.

4.3 Fine aggregate

4.3.1 Type of fine aggregate

The fine aggregate shall substantially pass a 2 mm test sieve and be of one of the following types:

- a) fines produced by crushing material from one of the groups specified in 4.2.1; or
- b) sand; or
- c) a mixture of a) and b).

4.3.2 Fines content

The fines content for fine aggregates shall be:

- a) for crushed rock/slag f_{NR} ;
- b) for sand f_{10} .

NOTE Guidance on fines quality can be found in PD 6682-2.

4.4 Added filler

If added filler is used in the macadam it shall consist of crushed rock, crushed slag, hydrated lime, Portland cement or other material approved by the specifier. The grading of added filler shall be in accordance with BS EN 13043:2002, **5.2.1**.

The loose bulk density in kerosene of added filler, with the exception of hydrated lime, shall be in accordance with BS EN 13043:2002, **5.5.5**.

NOTE For all other properties specified in BS EN 13043:2002, Clause 5 it is recommended that the “No Requirement” category is used.

4.5 Composition of mixtures

4.5.1 General

The conformity of composition of mixtures on analysis shall be determined in accordance with **4.5.1** for recipe mixes and **4.5.2** for designed mixtures.

NOTE There are two ways of specifying the composition of mixtures in this standard. The first, which applies to all surface courses including porous asphalt, all single course, all open graded binder course and to DBM and HDM where these are not specified as a design mixture, involves a “recipe” approach based on tables in this standard giving grading and binder content limits.

The second, which applies to all HMB and to DBM and HDM where these are specified as design mixtures, involves the supplier nominating a target grading and target binder content around which tolerances found in Table C.3 are applied.

4.5.2 Recipe mixtures

The binder content and aggregate grading of the freshly-mixed coated material, when sampled and tested in accordance with BS 598, shall conform to the relevant requirements for groups one, two, three and four as specified in Clause 5, Clause 6, Clause 7 and Clause 8 respectively of this standard. Freshly mixed designed material shall additionally conform to the requirements of **4.7**. All high modulus mixtures shall be designed.

NOTE 1 The binder contents for recipe mixtures given in tables in Clause 5, Clause 6, Clause 7 and Clause 8 are appropriate for most aggregates but it is not possible to cover the requirements of all aggregates in this way. Where the characteristics of the aggregates require a binder content other than those given, a new target binder content should be agreed between the manufacturer and the owner of the road or paved area based on trials and or evidence of satisfactory performance. The tolerance as specified in the relevant table in Clause 5, Clause 6, Clause 7 and Clause 8 should apply.

NOTE 2 The binder content of recipe dense binder course may be reduced by up to 0.5 % if the compaction is controlled by either air voids or the PRD test as described in BS 598-104 if agreed between the manufacturer and the specifier; this would normally apply to roads carrying category A traffic.

4.5.3 Design mixtures

The binder content and aggregate grading of the freshly-mixed coated material, when sampled and tested in accordance with BS 598, shall conform to the binder content and aggregate grading limits obtained by applying the tolerances stated in Table C.3 to the target binder content and target aggregate grading.

4.5.4 Use of blast furnace slag

Where the bulk density of the blast furnace slag used is between those densities specified for groups one, two, three and four, a proportional change shall be made to the binder content.

4.6 Terminology of dense, heavy duty and high modulus base (roadbase) and binder course mixtures

References to any designed dense mixtures in groups one and two, base (roadbase) and binder course mixtures, shall include the nominal aggregate size, the pavement layer in which it is to be laid, the mid-range penetration grade of the bitumen to be used in its production and the word “designed”. Mix descriptions for the complete ranges of both designed and recipe groups one and two mixtures shall be in accordance with Annex C (Table C.1). Additionally, recipe dense mixtures shall be described as shown in Table C.2.

NOTE Guidance on the use of designed dense mixtures and recipe dense mixtures is given in Annex B.

4.7 Design of dense (DBM 50), heavy duty (HDM 50) and high modulus base (HMB 35) base (roadbase) and binder course mixtures conforming to groups 1 and 2

4.7.1 The mixtures shall be designed in accordance with clause 929 of the *Specification for Highway Works:2003*, except as amended in **4.7.2**.

4.7.2 The target aggregate grading and target binder content shall be within the limits stated in Table 3 or Table 4, for mixtures within group one (see Clause 5) or Table 13, Table 14, Table 15 and Table 16 for dense recipe mixtures within group two (see Clause 6). Additionally, for heavy duty macadam (HDM 50) mixtures, the target percentage of aggregate grading passing the 0.063 mm sieve shall not be less than 7.0 %. In high modulus (HMB 35) base (roadbase) and binder course mixtures, grade 30/45 pen bitumen shall be used. For compliance purposes the binder content and aggregate grading limits shall be those obtained by applying the tolerances stated in Table C.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.

The average binder volume determined on the clause 929 trial area shall not be less than 8.0 % of the total volume of the mixture for 0/32 mm macadams and 9.4 % for 0/20 mm macadams.

5 Group one: dense base (roadbase) mixtures

NOTE 1 See 4.6 for the terminology used to refer to designed and recipe dense macadams.

NOTE 2 Guidance on the selection of designed or recipe mixtures is given in Annex B.

5.1 Clause deleted

Table 1 — Target aggregate limits for 40 mm size dense base (roadbase) designed mixtures —
Table deleted

Table 2 — Target bitumen content limits and grade for 40 mm size dense base (roadbase) designed mixtures —
Table deleted

5.2 0/32 mm size dense base (roadbase) including HMB 35, DBM 50, DBM 125, DBM 190 and HDM 50

For designed mixtures, the aggregate grading, bitumen content and grade of binder shall be determined in accordance with 4.7. For recipe mixtures they shall be in accordance with Table 3 and Table 4.

Table 3 — Aggregate grading for 0/32 mm size dense base (roadbase) recipe mixtures and target aggregate grading limits for designed mixtures

Test sieve aperture size mm	Indicative FPC tolerance ^a	Aggregate: crushed rock, slag or gravel % by mass passing
40		100
31.5	– 9/+ 5	90–100
20	±9	71–95
14	±9	58–82
6.3	±9	44–60
4	±9	Report value ^b
2	±7	20–40
1	±5	Report value ^b
0.25	±5	6–20
0.063	±3	2–9
0.063 HDM	±3	7–11

^a The FPC tolerances shown are **indicative** of the levels to which the materials will have to conform when European Standards for asphalt are introduced. Currently, the only sieve that is required to meet the FPC tolerance in this British Standard (BS 4987) is the **2 mm sieve**. This is to ensure that mixtures utilizing crushed rock fine aggregate, natural sand or a combination of the two, that were acceptable in the 2001 edition of this specification, can be successfully specified in this 2005 edition. The specification limits to be applied to the 2 mm sieve shall be such that when the FPC tolerances are applied to the selected target value passing the 2 mm sieve, the declared conformity grading values shall still fall within the overall grading, e.g. for 0/20 mm DBC to Table 15, passing 2 mm sieve: coarsest declared grading would be 20–34 (27 ± 7), finest declared grading would be 26–40 (33 ± 7).

^b It may be beneficial for producers to record and/or report values obtained from these and other intermediate sieves for future development of this and related Standards.

Table 4 — Bitumen content and grade for 0/32 mm size dense base (roadbase) recipe mixtures and target bitumen content limits for designed mixtures

Aggregate	Bitumen grade
	30/45 pen, 40/60 pen, 100/150 pen or 160/220 pen
	% by mass of total mixture (± 0.6 %)
Crushed rock (including limestone)	4.0
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	4.5
1.36	4.8
1.28	5.2
1.20	5.8
1.12	6.2
Steel slag	4.0
Gravel	4.5
40/60 pen is the preferred grade for machine laid DBM.	