British Standard

A single copy of this British Standard is licensed to

Rupert Heygate-Browne

03 September 2003

This is an uncontrolled copy. Ensure use of the most current version of this document by searching British Standards Online at bsonline.techindex.co.uk

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

BRITISH STANDARD

BS 4987-1:2003

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

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

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)
United Kingdom Accreditation Service

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

This British Standard, having been prepared by a BSI panel, was published under the authority of the Standards Board and comes into effect on 19 August 2003

© BSI 19 August 2003

First published September 1988
Second edition September 1993
Third edition June 2001
Fourth edition August 2003

Amendments issued since publication

Amd. No.	Date	Comments

The following BSI references relate to the work on this standard:
Committee reference B/510/1

ISBN 0 580 42382 4

Contents

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Foreword

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 It supersedes BS 4987-1:2001, which is withdrawn.

The clause and table numbers of specific mixtures in the 2001 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 revision and those removed in this revision are marked as "*Deleted*".

This edition introduces 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 bindercourse 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.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

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.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 25 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

© BSI 19 August 2003

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 3195-3 (EN 58), *Methods for sampling petroleum products — Part 3: Method for sampling bituminous binders.*

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 7392, *Method for determination of distillation characteristics of petroleum products* (ISO 3405).

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.*

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

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

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.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

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 1047.

d) Steel slag, either electric arc furnace slag or basic oxygen slag, with a compacted bulk density between 1.60 Mg/m^3 and 1.80 Mg/m^3 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 FI_{35};

b) for porous asphalt FI_{20}.

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.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

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.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

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 (roadhouse) designed mixtures — *Table deleted*

Table 2 — Target bitumen content limits and grade for 40 mm size dense base (roadhouse) 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	Aggregate: crushed rock, slag or gravel % by mass passing
40 mm	100
31.5 mm	90 to 100
20 mm	71 to 95
14 mm	58 to 82
6.3 mm	44 to 60
2 mm	24 to 36
0.250 mm	6 to 20
0.063 mm (DBM and HMB)	2 to 9
0.063 mm (HDM)	7 to 11

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

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.	

6 Group two: binder course mixtures

NOTE 1 See **4.6** for the terminology used to refer to dense macadams.

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

6.1 0/20 mm size open graded binder course

The aggregate grading and bitumen content shall be in accordance with Table 5 and Table 6.

NOTE This type of binder course is unsuitable for category A traffic.

Table 5 — Aggregate grading for 0/20 mm size open graded binder course

Test sieve aperture size	Aggregate	
	Crushed rock or slag	Gravel
	% by mass passing	
31.5 mm	100	100
20 mm	95 to 100	95 to 100
14 mm	50 to 80	55 to 85
6.3 mm	15 to 35	25 to 40
2 mm	6 to 20	6 to 16
0.063 mm	0 to 9	0 to 6

Table 6 — Bitumen content and grade for 0/20 mm size open graded binder course

Aggregate	Bitumen grade
	160/220 pen or 250/330 pen
	% by mass of total mixture (±0.6 %)
Crushed rock (excluding limestone)	4.0
Limestone	3.8
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	4.5
1.36	4.8
1.28	5.1
1.20	5.4
1.12	6.0
Steel slag	3.6
Gravel	5.0

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table 7 — Grade of binder for 20 mm size open graded basecourse — *Table deleted*

6.2 0/32 mm size single course

NOTE This type of mixture course may be used as a combined surface and binder course if blinded immediately after laying and surface dressed after an interval, or it may be used as a binder course (see **B.5.4**).

The aggregate grading and bitumen content shall be in accordance with Table 8 and Table 9.

Table 8 — Aggregate grading for 0/32 mm size single course

Test sieve aperture size	Aggregate	
	Crushed rock or slag	Gravel
	% by mass passing	
50 mm	100	100
40 mm	95 to 100	95 to 100
31.5 mm	75 to 100	80 to 95
14 mm	35 to 55	40 to 60
6.3 mm	20 to 30	30 to 45
2 mm	6 to 16	14 to 28
0.250 mm	2 to 10	5 to 15
0.063 mm	—	2 to 7

Table 9 — Bitumen content and grade for 0/32 mm size single course

Aggregate	Bitumen grade
	160/220 pen or 250/330 pen
	% by mass of total mixture (±0.6 %)
Crushed rock (excluding limestone)	3.9
Limestone	3.6
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	4.1
1.36	4.3
1.28	4.5
1.20	5.0
1.12	5.4
Steel slag	3.7
Gravel[a]	5.0
[a] With gravel aggregate, the bitumen shall be limited to 160/220 pen grade.	

Table 10 — Grade of binder for 40 mm size single course — *Table deleted*

6.3 *Clause deleted*

Table 11 — Aggregate grading for 40 mm size dense basecourse — *Table deleted*

Table 12 — Binder content and grade for 40 mm size dense basecourse — *Table deleted*

6.4 0/32 mm size dense binder course, including HMB 35, DBM 50, DBM 125, DBM 190 and HDM 50

For designed mixtures the aggregate grading, bitumen content and grade of bitumen shall be determined in accordance with **4.7**. For recipe mixtures, they shall be in accordance with Table 13 and Table 14.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Table 13 — Aggregate grading for 0/32 mm size dense binder course recipe mixtures and target aggregate grading limits for designed mixtures

Test sieve aperture size	Aggregate: crushed rock, slag or gravel % by mass passing
40 mm	100
31.5 mm	90 to 100
20 mm	71 to 95
14 mm	58 to 82
6.3 mm	44 to 60
2 mm	24 to 36
0.250 mm	6 to 20
0.063 mm (DBM and HMB)	2 to 9
0.063 mm (HDM)	7 to 11

Table 14 — Bitumen content and grade for 0/32 mm size dense binder course recipe mixtures and target bitumen content limits for designed mixtures

Aggregate	Bitumen grade
	30/45 pen, 40/60 pen, 100/150 pen and 160/220 pen
	% by mass of total mixture (±0.6 %)
Crushed rock (including limestone)	4.7
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	5.5
1.36	5.8
1.28	6.2
1.20	6.6
1.12	7.0
Steel slag	4.3
Gravel	5.0
40/60 pen is the preferred grade for machine laid DBM.	

6.5 0/20 mm size dense binder course, including HMB 35, DBM 50, DBM 125, DBM 190 and HDM 50

For designed mixtures, the aggregate grading, bitumen content and grade of bitumen shall be determined in accordance with **4.7**. For recipe mixtures, they shall be in accordance with Table 15 and Table 16.

Table 15 — Aggregate grading for 0/20 mm size dense binder course recipe mixtures and target aggregate grading limits for designed mixtures

Test sieve aperture size	Aggregate: crushed rock, slag or gravel % by mass passing
31.5 mm	100
20 mm	95 to 100
14 mm	65 to 85
10 mm	52 to 72
6.3 mm	39 to 55
2 mm	24 to 36
0.250 mm	7 to 21
0.063 mm (DBM and HMB)	2 to 9
0.063 mm (HDM)	7 to 11

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table 16 — Bitumen content and grade for 0/20 mm size dense binder course recipe mixtures and target bitumen content limits for designed mixtures

Aggregate	Bitumen grade
	30/45 pen, 40/60 pen, 100/150 pen and 160/220 pen
	% by mass of total mixture (±0.6 %)
Crushed rock (including limestone)	4.7
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	5.5
1.36	5.8
1.28	6.2
1.20	6.6
1.12	7.0
Steel slag	4.3
Gravel	5.0
40/60 pen is the preferred grade for machine laid DBM.	

7 Group three: surface course mixtures

NOTE Guidance on the selection of materials is given in Annex B.

7.1 0/14 mm size open graded surface course

The aggregate grading, bitumen content and grade of binder shall be in accordance with Table 17 and Table 18.

Table 17 — Aggregate grading for 0/14 mm size open graded surface course

Test sieve aperture size	Aggregate: crushed rock or slag % by mass passing
20 mm	100
14 mm	90 to 100
10 mm	55 to 75
6.3 mm	25 to 45
2 mm	10 to 18
0.063 mm	2 to 7

Table 18 — Bitumen content for 0/14 mm size open graded surface course

Aggregate[a]	Bitumen grade
	160/220 pen or 250/330 pen
	% by mass of total mixture (±0.5 %)
Crushed rock (excluding limestone)	4.8
Limestone	4.6
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	5.1
1.36	5.4
1.28	5.8
1.20	6.3
1.12	6.7
Steel slag	4.4
[a] See Annex B.	

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Table 19 — Grade of binder for 14 mm size open graded wearing course — *Table deleted*

7.2 0/10 mm size open graded surface course

The aggregate grading, and bitumen content shall be in accordance with Table 20 and Table 21.

Table 20 — Aggregate grading for 0/10 mm size open graded surface course

Test sieve aperture size	Aggregate: crushed rock or slag % by mass passing
14 mm	100
10 mm	85 to 100
6.3 mm	30 to 60
2 mm	10 to 18
0.063 mm	2 to 7

Table 21 — Bitumen content for 0/10 mm size open graded surface course

Aggregate[a]	Bitumen grade
	160/220 pen or 250/330 pen
	% by mass of total mixture (±0.5 %)
Crushed rock (excluding limestone)	5.3
Limestone	5.1
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	5.6
1.36	5.9
1.28	6.3
1.20	6.8
1.12	7.2
Steel slag	4.9

[a] See Annex B.

Table 22 — Grade of binder for 10 mm size open graded wearing course — *Table deleted*

7.3 0/14 mm size close graded surface course (preferred mixture)

The aggregate grading and bitumen content grade shall be in accordance with Table 23, Table 24 and Table 25 (see Annex B).

Table 23 — Aggregate grading for 0/14 mm size close graded surface course

Test sieve aperture size	Aggregate: crushed rock, slag or gravel % by mass passing
20 mm	100
14 mm	95 to 100
10 mm	70 to 90
6.3 mm	45 to 65
2 mm	19 to 33[a]
1 mm	15 to 30
0.063 mm	3 to 8

[a] May be increased to 38 when sand fine aggregate is used.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table 24 — Bitumen content for 0/14 mm size close graded surface course

Aggregate[a]	Bitumen content
	% by mass of total mixture (±0.5 %)
Crushed rock (excluding limestone)	5.1
Limestone	4.9
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	5.5
1.36	6.0
1.28	6.6
1.20	7.0
1.12	7.5
Steel slag	4.8
Gravel[b]	—

[a] See Annex B.
[b] The information on the bitumen contents required for these mixtures made with gravel is not sufficient for a single target value to be specified. The bitumen content to be used should be chosen within the range 5.5 % to 6.5 % and should be approved by the specifier. As a guide, lower values should be selected for pavements designed to carry category B traffic and higher values for footway work. The tolerance of ±0.5 % should apply to the selected and approved bitumen content.

Table 25 — Grade of bitumen for 0/14 mm size close graded surface course

Aggregate	Grade of bitumen	
	Category A traffic	Category B traffic
Crushed rock, slag	100/150 pen 160/220 pen or 250/330 pen	160/220 pen or 250/330 pen
Gravel	—	160/220 pen or 250/330 pen

NOTE 100/150 or 160/220 pen are the preferred grades.

7.4 0/10 mm size close graded surface course (preferred mixture)

The aggregate grading bitumen content and grade of binder shall be in accordance with Table 26, Table 27 and Table 28.

Table 26 — Aggregate grading for 0/10 mm size close graded surface course

Test sieve aperture size	Aggregate: crushed rock, slag or gravel % by mass passing
14 mm	100
10 mm	95 to 100
6.3 mm	55 to 75
2 mm	19 to 33[a]
1 mm	15 to 30
0.063 mm	3 to 8

[a] May be increased to 38 when sand fine aggregate is used.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Table 27 — Bitumen content for 0/10 mm size close graded surface course

Aggregate[a]	Bitumen content
	% by mass of total mixture (0.5 %)
Crushed rock (excluding limestone)	5.3
Limestone	5.2
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	6.1
1.36	6.5
1.28	7.1
1.20	7.6
1.12	8.1
Steel slag	5.0
Gravel[b]	—

[a] See **B.5.2**.
[b] The information on the bitumen contents required for these mixtures made with gravel is not sufficient for a single target value to be specified. The bitumen content to be used should be chosen within the range 5.5 % to 6.5 % and should be approved by the specifier. As a guide, lower values should be selected for pavements designed to carry category B traffic and higher values for footway work. The tolerance of ±0.5 % should apply to the selected and approved bitumen content.

Table 28 — Grade of bitumen for 0/10 mm size close graded surface course

Aggregate	Grade of bitumen[a]	
	Category A traffic	Category B traffic
Crushed rock and slag	100/150 pen, 160/220 pen or 250/330 pen	160/220 pen or 250/330 pen
Gravel	—	160/220 pen or 250/330 pen

[a] 100/150 pen or 160/220 pen are the preferred grades.

7.5 0/6 mm size dense surface course (preferred mixture)

The aggregate grading, bitumen content and grade of binder shall be in accordance with Table 29, Table 30 and Table 31.

Table 29 — Aggregate grading for 0/6 mm size dense surface course

Test sieve aperture size	Aggregate: crushed rock, slag or gravel % by mass passing
10 mm	100
6.3 mm	90 to 100
2 mm	36 to 52[a]
1 mm	20 to 50
0.250 mm	7 to 23
0.063 mm	2 to 10

[a] May be increased to 60 when sand fine aggregate is used.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table 30 — Bitumen content for 0/6 mm size dense surface course

Aggregate[a]	Bitumen
	% by mass of total mixture (±0.5 %)
Crushed rock (excluding limestone)	6.3
Limestone	6.0
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	6.5
1.36	7.0
1.28	7.5
1.20	7.9
1.12	8.3
Steel slag	5.7
[a] See **B.5.2**.	

Table 31 — Grade of bitumen for 0/6 mm size dense surface course

Traffic category	Grade of binder[a]
A	100/150 pen, 160/220 pen or 250/330 pen
B	160/220 pen or 250/330 pen
NOTE Experience with this material under category A traffic is limited	
[a] 100/150 or 160/220 pen bitumen are the preferred grades.	

7.6 0/6 mm size medium graded surface course (preferred mixture)

The aggregate grading, bitumen content and grade of bitumen shall be in accordance with Table 32 and Table 33.

Table 32 — Aggregate grading for 0/6 mm size medium graded surface course

Test sieve aperture size	Aggregate: crushed rock, slag or gravel % by mass passing
10 mm	100
6.3 mm	90 to 100
2 mm[a]	29 to 45
1 mm	10 to 30
0.063 mm	2 to 9
[a] When this mixture is to be laid cold or where a more pervious surface is required, the limits of the quantity of aggregate passing the 2 mm sieve shall be 17 % to 29 %.	

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Table 33 — Bitumen content and grade for 0/6 mm size medium graded surface course

Aggregate[a]	Bitumen grade
	160/220 or 250/330 pen
	% by mass of total mixture (±0.5 %)
Crushed rock (including limestone)	5.4
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	6.1
1.36	6.5
1.28	7.0
1.20	7.4
1.12	7.8
Steel slag	5.0
Gravel	5.9
NOTE Where this mixture is to be used on footways, playgrounds and similar non-trafficked areas the bitumen contents for bitumen given may be increased by up to 1 % if experience indicates this to be desirable.	
[a] See **B.5.2**.	

7.7 0/4 mm size fine graded surface course (previously known as 3 mm size fine graded surface course and formerly known as "fine cold asphalt")

The aggregate grading, bitumen content and grade of bitumen shall be in accordance with Table 34, Table 35 and Table 36.

Table 34 — Aggregate grading for 0/4 mm size fine graded surface course

Test sieve aperture size	Aggregate: crushed rock, or slag % by mass passing
6.3 mm	100
4 mm	90 to 100
0.500 mm	27 to 51
0.250 mm	16 to 36
0.063 mm	5 to 16
NOTE Up to 25 % by mass of the fine aggregate passing the 4 mm sieve may be sand.	

Table 35 — Bitumen content for 0/4 mm size fine graded surface course

Aggregate[a]	Bitumen content
	% by mass of total mixture (±0.5 %)
Crushed rock (excluding limestone)	6.5
Limestone	6.2
Blast furnace slag of bulk density in Mg/m^3 (BS 812-2)	
1.44	6.8
1.36	7.1
1.28	7.5
1.20	7.8
1.12	8.2
Steel slag	6.2
[a] See **B.5.2**.	

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table 36 — Grade of bitumen for 0/4 mm size fine graded surface course

Period	Grade of bitumen	
	Category A traffic	Category B traffic
Winter	250/330 pen	250/330 pen
Summer	160/220 pen or 250/330 pen	250/330 pen

7.8 Coated chippings for fine graded surface course (see Table 34, Table 35 and Table 36)

The chippings shall conform to the relevant requirements of BS EN 13043.

NOTE The chippings should normally be 8/14 mm or 6/10 mm nominal size. The chippings should be coated with 1 % to 2.5 % by mass, depending on the type and size of chipping, of a suitable bitumen binder of grade between 40/60 and 250/330 pen at 25 °C. To enable the chippings to carry the specified proportion of binder, up to 2.5 % of filler may be added.

7.9 Coated grit

Coated grit for blinding shall be in accordance with Table 34, Table 35 and Table 36, except that the soluble bitumen content for all aggregates shall be in the range 1.5 % to 3.5 %.

NOTE As delivered coated grit should be suitable for spreading by mechanical gritter. If stored it should remain suitable for a period of at least 7 days.

8 Group four: porous asphalt surface course mixtures

NOTE This type of macadam is not widely used in the UK; for guidance on its use, and modified binders, see **B.5.5**.

8.1 6/20 mm size porous asphalt surface course

The aggregate grading, bitumen content and grade of binder shall be in accordance with Table 37 and Table 38. The aggregate shall conform to flakiness category FI_{20} from BS EN 13043.

Table 37 — Aggregate grading for 6/20 mm size porous asphalt surface course

Test sieve aperture size	Aggregate: crushed rock, or steel slag % by mass passing
31.5 mm	100
20 mm	95 to 100
14 mm	55 to 75
6.3 mm	20 to 30
2 mm	5 to 10
0.063 mm	3.5 to 5.5[a]

[a] To include 2 % by mass of total aggregate of hydrated lime.

Table 38 — Bitumen content and grade for 6/20 mm size porous asphalt surface course

Aggregate	Bitumen grade[a] 100/150 pen or 160/220 pen % by mass of total mixture (±0.3 %)
Crushed rock (excluding limestone)	3.7 or 4.5 (modified)
Steel slag	3.7 or 4.5 (modified)
NOTE Guidance on the specification and use of binders is given in Annex B and Highways Agency Advice Note HD 37/99 [1].	
[a] Before any modification. In most applications, the use of un-modified bitumens is not advised since they lack durability. The use of modified bitumens is advised.	

8.2 2/10 mm size porous asphalt surface course

The aggregate grading, bitumen content and grade of binder shall be in accordance with Table 39 and Table 40. The aggregate shall conform to flakiness category FI_{20} from BS EN 13043.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Table 39 — Aggregate grading for 2/10 mm size porous asphalt surface course

Test sieve aperture size	Aggregate: crushed rock, or steel slag % by mass passing
14 mm	100
10 mm	90 to 100
6.3 mm	40 to 55
2 mm	15 to 21
0.063 mm	3 to 6[a]
[a] To include 2 % by mass of total aggregate of hydrated lime.	

Table 40 — Bitumen content and grade for 2/10 mm size porous asphalt surface course

Aggregate	Bitumen grade[a] 100/150 pen or 160/220 pen % by mass of total mixture (±0.5 %)
Crushed rock (excluding limestone)	5.2
Steel slag	5.2
NOTE Guidance on the specification and use of binders is given in Annex B and Highways Agency Advice Note HD 37/99 [1].	
[a] Before any modification. In most applications, the use of un-modified bitumens is not advised since they lack durability. The use of modified bitumens is advised	

9 Mixing

9.1 General

Coated macadam shall be mixed by either the batch process or in a continuous or drum mixer.

The moisture content of the mixed material when tested in accordance with BS 598 shall not exceed 1.0 % by mass of the mixture at the required temperature. On discharge from the mixer, the aggregate shall be completely coated with binder, with no evidence of balling of the fine aggregate.

9.2 Temperature of mixed macadam

Whichever method of mixing is adopted, the appropriate maximum temperature given in Table 41 shall not be exceeded.

NOTE 1 Regard should also be given to the minimum delivery and rolling temperatures given in BS 4987-2.

Where in-mixer fluxing is undertaken conforming to **4.1.1**b) and **B.5.7** the maximum mixing temperature shall be that shown in Table 41 for the appropriate base bitumen grade.

NOTE 2 Where greater amounts of flux are incorporated to produce deferred set or depot stock mixes (see **A.6**), maximum mixing temperatures lower than those given in Table 41 may need to be adopted.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table 41 — Maximum temperatures of mixture

Grade of bitumen	Type of macadam	Maximum temperature at any stage °C
250/330 pen 160/220 pen	Dense, close graded medium graded and fine graded surface course macadams **laid by hand**	140 150
160/220 pen 100/150 pen	Dense, close graded medium graded and fine graded surface course macadams laid by machine	150 160
250/330 pen 160/220 pen	Open graded and single course macadams (except porous asphalts)	115 125
160/220 pen 100/150 pen	Porous asphalts with penetration grade bitumen or modified by fibre addition (see note)	135 145
160/220 pen	Dense (asphalt macadams) (DBM 190) macadam base (roadbase) and binder courses	150
100/150 pen	Dense (asphalt macadams) (DBM 125) macadam base (roadbases) and binder courses	170
40/60 pen	Dense macadam (DBM 50) and heavy duty macadam base (roadbases) and binder courses	185
30/45 pen	High modulus base (roadbase) and binder course (HMB 35)	190
NOTE Temperatures for modified binders used in porous asphalt should be those recommended by the binder supplier and agreed by the highway owner's representative		

10 Sampling and testing

NOTE The tolerances and ranges specified in this part of BS 4987 are intended to provide for errors in sampling and testing when carried out by a skilled operator and for variations in the macadam due to plant inconsistencies and fluctuations in the grading of the aggregates. Attention is drawn to the difficulties inherent in obtaining representative samples of coated macadam for analysis and to the further (usually smaller) errors in the reduction of the sample and its analysis in the laboratory. It should be realized that when any sampling and testing procedure is used complete compliance with the specification may not always be achieved with every sample tested even when the material is satisfactory (see BS 598-102).

10.1 Binder

Bitumens shall conform to BS EN 12591 and shall be sampled and tested in accordance with BS 3195-3 (EN 58).

10.2 Aggregates and fillers

Coarse and fine aggregates and fillers shall conform to BS EN 13043. Any sampling and testing shall be in accordance with the methods referenced in BS EN 13043.

10.3 Coated macadam

Coated macadams shall be sampled and tested in accordance with BS 598. The grading of the mineral aggregate fraction of the mixture shall be determined by means of wet sieving. No wet/dry sieving correction shall be employed.

10.4 Coated chippings

Coated chippings shall be sampled from the stockpile when their temperature is below 130 °C and tested in accordance with BS 598.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Annex A (normative)
Fluxing of hand laid macadams [see **4.1.1**b)]

A.1 The workability of mixtures for immediate hand laying may be enhanced by the addition of a flux, conforming to the requirements of **A.2**, to the mixture at the mixing plant. In some situations this might render the as-laid materials susceptible to early-life damage (see **B.5.3** and **B.5.7**).

A.2 The flux shall have the following characteristics:

Distillation, EN ISO 3405:
10 % recovered, 150 °C min.
90 % recovered, 350 °C max.

NOTE This distillation range enables both involatile flux (flux oil) and partly volatile flux to be used. The latter is normally used when hardening, or setting, is required for depot stock material (see **A.6**), which might otherwise remain deformable for an unacceptably long time. The producer's guidance should be sought if necessary.

A.3 The addition of the flux shall not result in fluxed bitumen with a penetration softer than 400 pen.

NOTE For hand laid mixtures produced with grade 160/220 pen bitumen, the added flux oil will generally be less than 5 % of the mass of the added bitumen. For mixtures produced with 250/330 pen bitumen, the added flux will generally be less than 3 % of the mass of the added bitumen.

A.4 No flux shall be used in the production of dense base (roadbase) and dense binder course macadams.

A.5 Fluxed mixtures shall be clearly identified on delivery notes by including the letter F in the mixture description, e.g. 0/6 mm F medium graded surface course.

A.6 Deferred set macadams, for use as depot stock materials in temporary works, shall be clearly identified on delivery notes by including the letters DS in the mixture description, e.g. 0/6 mm DS medium graded surface course.

NOTE In the case of deferred set and depot stock mixtures which are not for immediate laying but intended to be used only in temporary works, the viscosity of the binder may need to be adjusted even further by adding increased amounts of flux oil at the mixing plant. For such materials to harden or "set" a flux with a proportion of volatile oil is often used.

Proprietary binders are available for this purpose but are outside the scope of this standard.

Annex B (informative)
Guidance on the selection of materials and mixtures

NOTE All references to bitumen are to BS EN 12591 grades.

B.1 General

The selection of the most suitable coated macadam mixture for a particular site depends upon many factors, particularly traffic, climate and the stiffness and thickness of the macadam to be laid.

Specifiers should select coated macadam mixtures wherever possible from those indicated as preferred mixtures in clause **5**, clause **6**, clause **7** and clause **8**, to encourage rationalization of the wide range of mixtures currently available.

The dense base (roadbase) and binder course mixtures designed to conform to **4.7** will have greater stiffness and higher resistance to deformation than the equivalent recipe mixtures.

NOTE BS EN 12591 does not include the nominal 100 pen grade previously specified in BS 3690. In preparing the previous edition of BS 4987, the BS EN 12591 grade 100/150 pen was adopted generally in place of 100 pen for surface course mixtures on the basis that this will give a marginally better workability and hence improved compaction and durability.

Where dense macadam base (roadbase) or binder course mixes are to be used in heavily trafficked/high loading situations the stiffer mixes based on 40/60 pen grade (HDM 50 or DBM 50) or 30/45 pen grade (HMB 35) should be used. Elsewhere, DBM 125 may be used. The design thicknesses of base (roadbase) is outside the scope of this standard but should be considered if DBM 125 base (roadbase) is to be used where DBM base (roadbase) made with 100 pen was previously used.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

B.2 Aggregate

As there are no satisfactory tests for determining the amount of deleterious materials in aggregates, any obviously degraded or dirty stone together with contamination, e.g. by roots, vegetation, particles of lignite, should be avoided.

Where experience indicates that an aggregate is prone to stripping, the addition of an adhesion agent or 2 % of Portland cement or hydrated lime will be beneficial.

B.3 Dense base (roadbase) and binder course mixtures

B.3.1 *Composition of dense mixtures*

The bitumen grade and bitumen content in dense base (roadbase) and binder course recipe mixtures should be selected from the appropriate tables in Clause **5** and Clause **6**. The bitumen content in designed dense mixtures should be determined in accordance with **4.7**. In addition, factors such as the nature of the aggregate, the length of haul from plant to site, the method of laying to be employed, and the climatic conditions at the time of laying should be considered.

NOTE In general, the harder grades are preferred under category A traffic.

Five types of dense bitumen macadam base (roadbase) are available, i.e. the mixtures incorporating 100/150 pen or 160/220 pen bitumen (DBM 125 and DBM 190), heavy duty macadam having a higher filler content and incorporating the harder 40/60 pen bitumen (HDM 50) and DBM 50 which has the same filler content as DBM 125 and DBM 190 but incorporates 40/60 pen bitumen. Also high modulus base (roadbase) which incorporates 30/45 pen bitumen and is described as HMB 35.

The mixtures incorporating 40/60 penetration grade bitumen should preferably be designed to conform to **4.7** but can be produced as recipe mixtures. Those incorporating 30/45 penetration grade bitumen shall be designed to conform to **4.7** (see **B.1**).

B.3.2 *Thickness of dense base (roadbase)*

No specific recommendations for the total thickness of coated macadam base (roadbases) are included in this standard as the subject is a complex one dependent upon a number of factors including the strength of the sub-base or formation, and the traffic requirements. Users of this standard can obtain guidance on this matter from publications dealing with pavement design.

B.4 Other binder course mixtures

B.4.1 *Composition of mixtures*

The open graded binder course mixture described in **6.1** should not be used for category A traffic (see **3.2**). For category A traffic one of the mixtures specified in **6.4** and **6.5** should be chosen; these mixtures are also suitable for category B traffic.

The single course mix specified in **6.2** is suitable either as a base (roadbase) or binder course, except under heavy traffic. Its principal use, however, is as a combined binder course and surface course on roads carrying light traffic. For this purpose it should be sealed by bituminous grit before being opened to vehicular traffic.

It is important when choosing a particular binder course mixture to relate the nominal and minimum thickness of the layer to be placed on the road to the nominal size of the mixture. The wrong size of aggregate can lead to problems in compaction and to consequent failures in performance, e.g. in strength and/or durability (see BS 4987-2:2003, **6.5**.) If more than one aggregate size is permitted, the smaller one is preferred. As with base (roadbase) mixtures (see **B.3.1**) five types of dense bitumen macadam binder course mixture are available: HMB 35, HDM 50, DBM 50, DBM 125 and DBM 190.

B.4.2 *Surface dressing*

Where a binder course is to be trafficked or left uncovered for any length of time it may be appropriate to surface dress it.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

B.5 Surface course mixtures

B.5.1 *Binder*

The type, grade and content of bitumen in surface course mixtures should be selected from Table 17, Table 18, Table 20, Table 21, Table 23, Table 24, Table 25, Table 26, Table 27, Table 28, Table 29, Table 30, Table 31, Table 32, Table 33, Table 34, Table 35, Table 36, Table 37, Table 38, Table 39 and Table 40, as appropriate, paying attention to the expected traffic condition (see **3.2**).

B.5.2 *Aggregate*

The choice of coarse aggregate, and coated chippings where required, depends primarily on the aggregate's suitability for the traffic and site conditions. In all circumstances on public roads and in certain off highway applications it is essential that the required level of skid resistance is maintained. To achieve this an aggregate with suitable resistance to the polishing effect of traffic should be used.

NOTE 1 The resistance to polishing of coarse aggregate should be specified in terms of the appropriate category from BS EN 13043. In most cases this should be done using the category $PSV_{declared}$ and quoting the required minimum PSV value.

The rate at which exposed aggregate is abraded by heavy vehicular traffic is important in determining the retention of texture by the surface course. The resistance to surface abrasion should be specified in terms of the appropriate category from BS EN 13043. In most cases this should be done using the category $AAV_{declared}$ and quoting the required maximum AAV value.

NOTE 2 Guidance on the selection of appropriate polished-stone value and aggregate abrasion value for carriageways is published by the Highways Agency in Departmental Standard HD 36/99 (1999) [2].

B.5.3 *Composition of mixtures*

The open graded surface course mixtures specified in **7.1** and **7.2** are the traditional coated macadam "carpets" which were widely used some years ago on all types of classified roads. Their durability is dependent on the overall flexibility of the road structure and on the intensity of traffic; it should also be remembered that they are readily permeated by water. In general it has to be expected that a surface treatment, e.g. surface dressing, will be required to extend its serviceable life.

The close graded surface courses specified in **7.3** and **7.4** were formerly known as "dense wearing course macadam"; a title that was misleading as the mixtures are not truly dense. If good durability is to be obtained with these mixtures, particular care should be paid to their compaction (see **B.5.6**). For most purposes 100/150 or 160/220 pen bitumen is appropriate for these mixtures, although 250/330 pen should be used in colder areas.

The dense surface course macadam specified in **7.5** has been used successfully for a number of years by various highway authorities for resurfacing of lightly trafficked rural roads and as a surface course on newly constructed playgrounds, footways, etc. 100/150 or 160/220 pen bitumen is generally appropriate for these mixtures, although in some cases specifiers may choose a softer grade.

The medium graded surface course specified in **7.6** is intended solely for light traffic, footways, school playgrounds, patching works, and similar circumstances.

The fine graded surface course specified in **7.7** was formerly known as "fine cold asphalt". It was re-named to prevent any possible confusion with hot rolled asphalt. It is generally regarded as only suitable for areas not carrying heavy traffic, e.g. car parks, playgrounds.

The use of power-steered vehicles may cause marking on newly laid surface courses or, especially in warm weather, abrasion of the surface.

B.5.4 *Application of coated grit*

The surface of newly compacted open surface course may be blinded by hand or mechanically with bituminous grit as specified in **7.9**. The material as delivered should be suitable for spreading by mechanical gritter.

If stored the material should remain in this condition for a period of not less than 7 days unless otherwise specified by the specifier. The rate of spread should normally be specified.

It should be appreciated that as the application of coated grit reduces the porosity of the macadam surface, evaporation of any volatile oils contained in the flux used for the mixture will be delayed. This will extend the set-off period of such mixtures rendering them susceptible to marking or softening for longer periods than with ungritted macadams.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

B.5.5 *Porous asphalt surface course*

6/20 mm size porous asphalt material should be used for highway applications while the 2/10 mm size should be used for other applications.

A greater life expectancy of the asphalt will be gained using higher bitumen contents and appropriate modifiers. It is expected that the bitumen content specified in Table 38 will require the use of a modifier to achieve the specified minimum bitumen content.

NOTE 1 Additional practical guidance is contained in the Highways Agency Advice Note HA 37/99 [1].

The binder drainage test specified in DD 232 should be carried out on the proposed modified binder and aggregates, to ensure the mixture will carry the specified percentage mass of binder. Suitable modifiers include natural rubber, styrene butadiene rubber, organic and inorganic fibres.

The binder supplier should demonstrate that his binder, and the selected modifier are compatible and stable.

NOTE 2 A storage stability test is also referred to in HA 37/99 [1].

With this material an impermeable substrate is necessary to facilitate the flow of water to the side of the road or paved area where suitable drainage should be provided. It is also important, because of its potential brittleness under undue flexure, that the road structure should be adequate for the expected traffic; rutting of the road structure could nullify the intended removal of water from the carriageway. Porous asphalt surface courses should not be treated with coated grit.

B.5.6 *Compaction of surface courses*

To ensure the optimum performance and durability of all mixtures it is essential to carry out properly the compaction procedure specified in BS 4987-2:2003, Clause **7**. It is particularly important to ensure the correct relationship between aggregate size in the surface course mixture and the thickness (both nominal and minimum) of the layer on the road (see BS 4987-2:2003, **6.5**).

B.5.7 *Hand laid macadams in lightly constructed permanent works*

The bitumen grades shown in Clause **6**, Clause **7** and Clause **8** are based on the assumption that the macadams are to be machine laid as described in BS 4987-2:2003, **6.3**. However, in some situations machine laying is either impractical or not economically viable, and hand laying will be necessary.

When a mixture in group three is to be hand laid in situations where double-handling of materials and/or severe inclement weather will cause heat loss, with subsequent laying and compaction difficulties, the use of less viscous grades of bitumen will enhance the workability of the materials. The bitumen grades given in Clause **6** and Clause **7** (except dense binder course) may therefore be adjusted by the addition to the mixer of a flux oil as described in Annex A. This will aid workability in laying and compacting [see **4.1.1**b)].

However, caution is advised in the use of bitumen containing flux in binder course to be overlaid with dense surface course and in close graded/dense surface course, as evaporation of any volatile oil can be severely impeded in these cases. This may result in the risk of a surface course with relatively poor resistance to marking and prone to serious damage from heavy point loads, power-steered vehicles and severe vehicle use.

An alternative option is to use a portable hot-box. This minimizes heat loss and protects the contained mixture from inclement weather. When using such equipment, care should be taken to avoid localized overheating or prolonged storage that might adversely affect the material.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

B.6 Recommended storage temperatures for bitumen

Table B.1 gives the recommended storage temperatures for bitumen.

Table B.1 — Recommended storage temperatures for bitumen

Grade	Recommended storage temperature °C
250/330 pen	130
160/220 pen	140
100/150 pen	150
40/60 pen	165
30/45 pen	170
NOTE Prolonged storage of bitumen at elevated temperatures may result in hardening. To reduce this risk, bitumen should be delivered to coating plants at temperatures below 200 °C and prolonged subsequent storage above the temperatures given in this table should be avoided. (It should be recognized that bitumen deliveries may result in short-term storage temperatures above those recommended in this table.)	

Annex C (normative)
Terminology of dense 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 range of designed groups one and two mixtures shall be as given in Table C.1. Recipe dense mixtures in these groups shall be identified as shown in Table C.2.

Table C.1 — Terminology for referring to designed dense mixtures in groups one and two

Clause no.	Mixture type and aggregate size	BS EN 12591 bitumen pen. grade reference (see Foreword)	Mixture description
	Base (roadbase)		
5.2	0/32 mm dense	40/60	0/32 mm DBM 50 designed base (roadbase)
5.2	0/32 mm heavy duty	40/60	0/32 mm HDM 50 designed base (roadbase)
5.2	0/32 mm high modulus	30/45	0/32 mm HMB 35 designed base (roadbase)
	Binder course		
6.4	0/32 mm dense	40/60	0/32 mm DBM 50 designed binder course
6.4	0/32 mm heavy duty	40/60	0/32 mm HDM 50 designed binder course
6.4	0/32 mm high modulus	30/45	0/32 mm HMB 35 designed binder course
6.5	0/20 mm dense	40/60	0/20 mm DBM 50 designed binder course
6.5	0/20 mm heavy duty	40/60	0/20 mm HDM 50 designed binder course
6.5	0/20 mm high modulus	30/45	0/20 mm HMB 35 designed binder course

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Table C.2 — Terminology for referring to recipe dense mixtures in groups one and two

Clause no.	Mixture type and aggregate size	BS EN 12591 bitumen pen grade reference (see Foreword)	Mixture description
	Base (roadbase)		
5.2	0/32 mm dense	40/60	0/32 mm DBM 50 recipe base (roadbase)
		100/150	0/32 mm DBM 125 recipe base (roadbase)
		160/220	0/32 mm DBM 190 recipe base (roadbase)
5.2	0/32 mm heavy duty	40/60	0/32 mm HDM 50 recipe base (roadbase)
	Binder course		
6.4	0/32 mm dense	40/60	0/32 mm DBM 50 recipe binder course
		100/150	0/32 mm DBM 125 recipe binder course
		160/220	0/32 mm DBM 190 recipe binder course
6.4	0/32 mm heavy duty	40/60	0/32 mm HDM 50 recipe binder course
6.5	0/20 mm dense	40/60	0/20 mm DBM 50 recipe binder course
		100/150	0/20 mm DBM 125 recipe binder course
		160/220	0/20 mm DBM 190 recipe binder course
6.5	0/20 mm heavy duty	40/60	0/20 mm HDM 50 recipe binder course

The tolerances for aggregate grading and bitumen content of dense macadams designed to conform to **4.7** shall be in accordance with Table C.3.

Table C.3 — Tolerances for aggregate grading and bitumen content of designed dense, heavy duty and high modulus base (roadbase) and binder course macadams

BS test sieve	Tolerance for aggregate grading in percent by mass of aggregate passing BS test sieve	
	0/32 mm base (roadbase)/binder course	0/20 mm binder course
40 mm	±0	—
31.5 mm	±10[a]	±0
20 mm	±12	±5[a]
14 mm	±12	±10
10 mm	—	±10
6.3 mm	±8	±8
2 mm	±7	±7
0.250 mm	±6	±6
0.063 mm (DBM and HMB)	±3.5	±3.5
0.063 mm (HDM)	±2	±2
Bitumen content	±0.6 %	±0.6 %
Application of the above tolerances to the agreed aggregate grading and bitumen content may result in limits outside those permitted by the appropriate tables in groups 1 and 2 of this specification. Provided the target grading and bitumen content of the mixture proposed for use, and agreed after trials, are within the limits contained in this part of BS 4987, then the limits obtained by applying the above table shall prevail over those implied in this part of BS 4987.		
[a] The upper limit may be less than +5 % (or +10 %), depending on the agreed aggregate grading.		

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

Annex D (informative)
Specifying coated macadam

D.1 General

The guidance given in this annex is intended to assist the specifier in clearly indicating requirements to the supplier, for the purposes of either quotation or order. It includes items specified in BS 4987-2.

The following information at least should be agreed between the specifier and the supplier at the time of any enquiry or order:

a) type and size of coated macadam (see **D.2**);

b) in respect of dense base (roadbase) and binder course mixtures, whether a mixture designed to **4.7** or a recipe mixture (see **B.1** and **B.3.1** and Table C.1 and Table C.2);

c) type of aggregate, e.g. crushed rock, limestone, slag or gravel (see **D.3**);

d) type and grade of binder (see **D.4**) including use of flux;

e) traffic category A or B (see **3.2**);

f) the method of laying (see **D.5**);

g) requirements for compaction (see BS 4987-2:2003, Clause **7**);

h) compacted thickness of course (see BS 4987-2:2003, **6.5**);

i) tack and bond coats (see BS 4987-2:2003, **5.5**);

j) any special requirements, e.g. coated chippings for fine graded surface course, coated gritting of open graded macadams, early trafficking.

NOTE It is recognized that mixtures need to be selected from a range of compositions which vary according to traffic load and other conditions of service. The specifier will have taken into account design and other requirements and the final selection of a particular composition will thus depend on engineering and cost considerations.

D.2 Type and size of coated macadam

The type and nominal size of coated macadam should conform to the requirements in clause **5**, clause **6**, clause **7** and clause **8**.

D.3 Type of aggregate

Where the specifier expresses a specific choice for the particular job, the type of aggregate should be stated. In particular any specific requirement regarding categories of polished-stone value (PSV) or aggregate abrasion value (AAV) should be clearly stated at the time of order or enquiry.

D.4 Type and grade of binder

Where the specifier expresses a specific choice of binder for the particular job, the grade of binder should be stated. In the case of hand laid mixtures see Annex A. Within the ranges given in Clause **5**, Clause **6**, Clause **7** and Clause **8** it is not possible to be more precise regarding the viscosity to be used as this depends on numerous factors, including the nature of the aggregate, traffic intensity, length of haul, volatility of flux, and climatic conditions at time of laying.

D.5 Method of laying

The method of laying may affect the grade of binder to be supplied. It is important therefore to state with the order, whether the work is to be laid by hand or machine.

In differentiating between the grades for machine laid and hand laid work, machine laid work includes any necessary associated hand laid work.

When there is doubt about the practicality of machine laying the advice of the contractor should be sought by the specifier.

D.6 Levels of surfaces other than highways

The specifier should specify any special requirements for levels and finish applicable to the use to which the area is to be put.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

© BSI 19 August 2003

Bibliography

Standards publications

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

BS 598-102:1996, *Sampling and examination of bituminous mixtures for roads and other paved areas — Part 102: Analytical test methods*.

BS 598-104:1989, *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 EN 1097-8:2000, *Tests for mechanical and physical properties of aggregates — Part 8: Determination of the polished stone value*.

PD 6682-2:2003, *Aggregates — Part 2: Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas — Guidance on the use of BS EN 13043*.

PD 6682-9:2003, *Aggregates — Part 9: Guidance on the use of European test method standards.*

DD 232:1996, *Method for determination of the maximum binder content of bituninous mixtures without excessive binder drainage.*

Other publications

[1] HIGHWAYS AGENCY. Advice Note HD 37/99, 1999. London: The Stationery Office.

[2] HIGHWAYS AGENCY. Departmental Standard HD 36/99, 1999. London: The Stationery Office.

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

Details and advice can be obtained from the Copyright & Licensing Manager. Tel: +44 (0)20 8996 7070. Fax: +44 (0)20 8996 7553. Email: copyright@bsi-global.com.

BSI
389 Chiswick High Road
London
W4 4AL

Licensed Copy: Rupert Heygate-Browne, Agip KOC, 03 September 2003, Uncontrolled Copy, (c) BSI