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PUBLISHED DOCUMENT

Guidance on the use of BS EN 13108, Bituminous mixtures – Material specifications

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Contents

Summary of pages
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Foreword

Publishing information

This Published Document is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 March 2015. It was prepared by Subcommittee B/510/1, *Asphalt products* and under the authority of Technical Committee B/510, *Road materials*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This Published Document supersedes PD 6691:2010, which is withdrawn.

Relationship with other publications

This Published Document gives non-contradictory, complimentary information for use in the UK with BS EN 13108.

Use of this document

This publication is not to be regarded as a British Standard.

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this Published Document is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The guidance in this Published Document is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is "should".

The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the Clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

Compliance with a Published Document cannot confer immunity from legal obligations.

0 Introduction

0.1 Overview of BS EN 13108

BS EN 13108 is based on a common format and common principles. The overall principle is to provide a way for the target composition of a mixture to be declared in a standard way and demonstrate that, at that target composition, it has certain defined properties. Each mixture formulation needs a declaration of the properties which are being claimed, demonstrated through a product-type testing procedure. In the simplest case it can be just grading and binder content. In more complex situations it can include performance-related properties, such as stiffness, deformation resistance and fatigue resistance. The demonstration of performance and conformity of the mixture on an ongoing basis requires the producer to undertake factory production control. This is a quality management procedure involving defined inspection and test regimes, and conformity criteria to prove that the mixture conforms to the declared target composition within defined tolerances.

BS EN 13108 offers a degree of choice in many aspects, such as ways of describing composition, types of constituents, properties, and means of specimen preparation for product-type testing. In many cases, this choice is indicated by the words "should be as specified". For BS EN 13108 to be practicably workable in the UK there needs to be standardization from amongst these choices so that producers know what to declare through product-type testing and purchasers know what to ask for. This Published Document gives the recommended choices for the mixtures most commonly used in the UK.

BS EN 13108 contains requirements only for the loose mixture, i.e. "in the back of the truck". The requirements for the laying of asphalts are retained in BS 594987, and conformity to BS 594987 is essential to ensure the durability of the finished work.

For recipe mixtures BS EN 13108 adopts the principle of a declared target composition selected from a permitted range which is different from the fixed composition envelope format of previous British Standards (which specified asphalt mixtures). This UK guidance gives recommendations for an approach to using BS EN 13108 to arrive at mixtures similar to those which have been traditionally used over many years. These are included as example specifications in Annex B, Annex C and Annex D of this Published Document.

BS EN 13108 includes provisions for the use of reclaimed asphalt in asphalt mixtures. BS EN 13108-8 provides a means of defining and classifying the properties of reclaimed asphalt. This Published Document gives guidance on a means of regulating the use of reclaimed asphalt.

0.2 Assessment and verification of constancy of performance

From 1 July 2013 the Construction Products Regulation 2013 [1] was fully implemented across all EU member states. It is a requirement of BS EN 13108 product standards that an asphalt product supplied in conformity with one of the parts of BS EN 13108 is assessed for product type and for conformity utilizing Part 20 and Part 21. This process is called assessment and verification of constancy of performance (AVCP). The end result of the AVCP process is the CE marking of the product confirming that it meets the performance requirements as detailed in the declaration of performance.

BS EN 13108-20 identifies the way in which the performance of a mixture composition to the requirements of the product standards is to be determined.

BS EN 13108-21 specifies procedures to be adopted during production to ensure product constancy and conformity with declared performance.

BS EN 13108-20 calls up test methods from the BS EN 12697 series of asphalt testing standards. Separate guidance on these test methods is given in PD 6692.

0.3 Mathematical nomenclature

To accord with European nomenclature protocols, the nature of mathematical notation adopted in this Published Document is that employed in the European Standard.

When denoting a decimal fraction, European notation employs a comma (,). For example, the "six point three" millimetre sieve (6.3 mm) is denoted as 6,3 mm.

1 Scope

This Published Document gives guidance on the use of BS EN 13108-1:2006, BS EN 13108-2:2008, BS EN 13108-4:2006, BS EN 13108-5:2006, BS EN 13108-7:2006, BS EN 13108-8:2005, BS EN 13108-20:2006 and BS EN 13108-21:2006.

Clause **1** to Clause **10** of this Published Document give general guidance and background information on BS EN 13108.

Annex A gives guidance on the importance of BS EN 13108 mixture specifications. Annex B contains an example specification which gives the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1. Annex C contains an example specification which gives the UK choice for specifying hot rolled asphalt in accordance with BS EN 13108-4. Annex D contains an example specification which gives the UK choice for specifying stone mastic asphalt in accordance with BS EN 13108-5.

This Published Document does not give guidance on BS EN 13108-6 as this standard is either rarely used in the UK or covered by other guidance.

This Published Document is applicable to mixtures for use on roads and other paved areas, including airfields. Detailed provisions for airfields are specified elsewhere.

NOTE 1 For airfield installations on the defence estate, guidance is given in the Defence Infrastructure Organisation Practitioner's Guide 06/11 [2].

NOTE 2 There are several asphalt mixtures in general use which have not been covered by British Standards but which are now covered in BS EN 13108. These are stone mastic asphalt, covered by BS EN 13108-5, and asphalt concrete for very thin layers (thin surfacing), covered by BS EN 13108-2.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS EN 1097-6, *Tests for mechanical and physical properties of aggregates – Determination of particle density and water absorption*

BS EN 1426 (BS 2000-49), *Bitumen and bituminous binders – Determination of needle penetration*

BS EN 12591, *Bitumen and bituminous binders – Specifications for paving grade bitumens*

BS EN 12697-3, *Bituminous mixtures – Test methods for hot mix asphalt – Part 3: Bitumen recovery: Rotary evaporator*

BS EN 12697-26, *Bituminous mixtures – Test methods for hot mix asphalt – Part 26: Stiffness*

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

BS EN 13108-1:2006, *Bituminous mixtures – Material specifications – Part 1: Asphalt Concrete*

BS EN 13108-4:2006, *Bituminous mixtures – Material specifications – Part 4: Hot Rolled Asphalt*

BS EN 13108-5:2006, *Bituminous mixtures – Material specifications – Part 5: Stone Mastic Asphalt*

BS EN 13108-7, *Bituminous mixtures – Material specifications – Part 7: Porous Asphalt*

BS EN 13108-8, *Bituminous mixtures – Material specifications – Part 8: Reclaimed asphalt*

BS EN 13108-20:2006, *Bituminous mixtures – Material specifications – Part 20: Type testing*

BS EN 13108-21:2006, *Bituminous mixtures – Material specifications – Part 21: Factory Production Control*

BS EN 13924, *Bitumen and bituminous binders – Specifications for hard paving grade bitumens*

Other publications

[N1] HIGHWAYS AGENCY. *Manual of Contract Documents for Highway Works – Volume 1: Specification for Highway Works*. 2015 [1)]

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this Published Document, the terms and definitions used in BS EN 13108, including the following, apply.

3.1.1 composition

3.1.1.1 mixture formulation

composition of a single mixture expressed as a target composition

NOTE 1 Two ways of declaring mixture composition are required because some countries traditionally work in terms of the theoretical percentages added in a laboratory mixture design, whereas others work in terms of the composition found on analysis.

NOTE 2 The protocol adopted in the UK is to always work in terms of composition found on analysis, i.e. output target composition.

3.1.1.2 output target composition

expression of a mixture formulation in terms of the constituent materials and the mid-point grading and soluble binder content to be found on analysis

NOTE This is usually the result of a production validation.

[1)] Available at: http://www.standardsforhighways.co.uk/mchw/vol1/index.htm [last viewed 24 March 2015]

3.1.2 measuring properties

*COMMENTARY ON **3.1.2***

BS EN 13108 makes a distinction between requirements based on tests considered to be pure engineering properties, which are described as performance-based, and those based on less rigorous and more simulative tests, which are called performance-related.

*There is a general desire to move toward specifying and measuring mechanical properties of asphalt in pure engineering terms, producing values which can be input to mechanistic analytical models to predict pavement performance. These are defined as performance-based requirements (see **3.1.2.1**). They include such things as triaxial tests for deformation resistance and tend to require complex and expensive test equipment.*

*Many of the tests used to measure mechanical properties of asphalt fall short of this fundamental ideal and are more simulative in nature. These tests are called performance-related requirements (see **3.1.2.2**). These include such things as wheel tracking tests and tend to be rather more practical.*

Virtually all of the tests used in the UK to measure properties of asphalt in standards and contracts are performance-related. The exception to this is the indirect tensile stiffness modulus (ITSM) test which, along with all methods for measuring stiffness, is classed as performance-based. This Published Document makes recommendations based on the state-of-the-art in the UK at the time of writing, but recognizes that it might be possible to move to a more performance-based approach in the future following appropriate research and evaluation.

3.1.2.1 performance-based requirement

fundamental engineering property that predicts performance and appears in primary performance prediction relationships

3.1.2.2 performance-related requirement

characteristic that has been found to correlate with a fundamental engineering property that predicts performance

3.1.3 types of specification

*COMMENTARY ON **3.1.3***

In line with the distinction between the empirical and the fundamental approach, and performance-based and performance-related test methods, BS EN 13108-1 offers two ways of defining the composition and properties in a mixture specification, intended to facilitate a steady transition from prescriptive standards to performance standards as knowledge and confidence increases: empirical specification and fundamental specification. The other parts of BS EN 13108 use the empirical approach. This Published Document follows established UK practice and is state-of-the-art at the time of publication, and gives recommendations only for empirical specifications.

3.1.3.1 empirical specification

combination of requirements for composition and constituent materials together with performance-related requirements

NOTE The empirical specification involves defining within fairly close limits what the composition of the mixture should be and then adding further requirements using performance-related tests, such as wheel tracking for deformation resistance. In contrast, a fundamental specification places very little limitation on the composition in terms of aggregate type, grading, binder type and binder content, but defines asphalt properties in terms of performance-based tests such as triaxial compression.

3.1.3.2 fundamental specification

combination of performance-based requirements together with limited requirements for composition and constituent materials, with more degrees of freedom than for an empirical specification

NOTE The working practice at time of publication in the UK is largely prescriptive and empirically based. Performance-based tests are used to rank the performance of mixtures of standard composition using values related by experience to performance in the road. This approach is followed in this Published Document.

3.1.3.3 bitumen paving grade
bitumen grade that provides the optimum performance for a particular type and size of asphalt mixture

NOTE An asphalt mixture manufactured using a preferred bitumen grade that has been professionally laid and compacted according to the requirements of BS 594987, will provide a layer with optimum performance characteristics. Whilst the use of softer/less viscous grades of bitumen facilitates compaction, the end result is a surface with a greater susceptibility to softening in warmer conditions with an increased risk of surface disruption caused by scouring and/or dynamic/static loading.

3.2 Abbreviations

For the purposes of this Published Document the following abbreviations apply.

AC	asphalt concrete
AVCP	verification of constancy of performance
BBA	Béton Bitumineux pour chaussées Aéronautiques
DBM	dense bituminous mixture

NOTE DBM was formerly known as dense bituminous macadam.

EME2	Enrobés à module élevé
FPC	factory production control
HDM	heavy duty mixture
HRA	hot rolled asphalt
HMB	high modulus base
ITSM	indirect tensile stiffness modulus
ITSR	indirect tensile strength ratio
MCHW 1	*Manual of Contract Documents for Highway Works – Vol. 1* [N1]
OCL	operational compliance level
PA	porous asphalt
RA	reclaimed asphalt
SMA	stone mastic asphalt
SuDS	sustainable drainage systems

4 Constituent materials

4.1 General

Clause **4** of each part of BS EN 13108 covers constituent materials. The general presumption is that all constituent materials conform to a European Standard or European Technical Assessment. BS EN 13108 does, however, recognize that some constituents, such as fibres and pigments, might not be covered by standards and, in those cases, evidence of satisfactory use should be demonstrated. This evidence should be included in the product type testing documentation for the appropriate mixture formulation.

4.2 Binder

4.2.1 Paving grade bitumen

Paving grade bitumen should be specified in accordance with BS EN 12591. The selection of the grade of binders for use with mixtures are included in the example specifications in Annex B, Annex C and Annex D of this Published Document.

4.2.2 Hard paving grade bitumen

Hard paving grade bitumen conforming to BS EN 13924 should only be used in EME2 base and binder course mixtures.

4.2.3 Polymer modified bitumen

Polymer modified bitumen is covered by a framework specification in BS EN 14023. Since this is not a performance specification, product-type testing of the asphalt mixture may demonstrate which grades are acceptable.

4.3 Aggregates

All aggregate requirements should be specified in accordance with BS EN 13043 as appropriate to the intended use, which means that the detail depends on traffic, climate and the economics of local geology.

NOTE Detailed recommendations for categories of all relevant properties are given in PD 6682-2.

BS EN 13043 requirements for shape, fines content, etc., are included in the example specifications in the annexes of this Published Document. In general, the grading requirements for asphalt mixtures are determined on the finished mixture and specific requirements on constituent materials are not appropriate, with the exception of fine aggregate for HRA.

NOTE The recommendations of PD 6682-2 are followed, where relevant, in this Published Document.

4.4 Reclaimed asphalt (RA)

*COMMENTARY ON **4.4***
For mixtures which include reclaimed asphalt, the following guidance is provided.

4.4.1 Requirements in BS EN 13108-8:2005 in relation to RA

There are only two definitive requirements in BS EN 13108-8 in relation to RA:

- "the upper sieve size *D* of the aggregate in the reclaimed asphalt shall not exceed the upper sieve size size *D* of the mixture"; and
- "the aggregate in the reclaimed asphalt shall conform to the requirements for aggregate in the mixture specification."

NOTE BS EN 13108-8 does, however, allow for additional requirements to be defined and specified appropriate to the intended use. BS EN 13108-8 is written as a means of classifying the properties of RA in a standard way in order to facilitate such specification.

4.4.2 Preferred properties of reclaimed asphalts

Annex B, Annex C and Annex D of this Published Document indicate the preferred properties of RA for use in UK mixtures.

4.4.3 Criteria for adoption in the UK

For the purposes of specification, the following criteria should be adopted:

- foreign matter – category F_5;
- binder properties – category P_{15}.

NOTE P_{15} is a general case, but reliable and consistent feedstocks of harder reclaimed materials might make them suitable for use by agreement with the client.

4.4.4 Limiting the amount of reclaimed asphalt (RA)

BS EN 13108-1, BS EN 13108-4 and BS EN 13108-5 also cover the possibility of limiting the amount of RA permitted to be added to the mixture. In line with current UK practice, the following limits normally apply:

- surface courses, 10%;
- all other materials, 50%.

NOTE *There are designs which meet project outcomes where more than 10% reclaimed asphalt may be used in surface course mixtures and more than 50% in other mixtures, but these are subject to greater levels of control.*

4.4.5 Total binder in the mixture

In cases where more than 10% for surface course mixtures, and 20% for other mixtures, by mass of the total mixture of RA is added to the mixture, the properties of the total binder in the mixture (calculated from the combination of the properties of the fresh binder and the properties determined on the recovered binder from the RA) should conform to the grade specification for the mixture. BS EN 13108-1, BS EN 13108-4 and BS EN 13108-5 give the option of carrying out this calculation on either penetration or softening point. In line with current UK practice the penetration method should be adopted.

NOTE Additional requirements are called up in the product standards when the binder from the RA or the binder for the mixture is modified. BS EN 13108-8 requires the producer to declare the feedstock binder type, ie paving grade or modified, and the properties. The determination of recovered binder softening point in addition to penetration might assist where historical records are not available.

5 Mixture composition

5.1 General

BS EN 13108-1 to BS EN 13108-7 (inclusive) require that:

- the grading is expressed in percentages by mass of total aggregate;
- the binder and additive content is expressed in percentages by mass of total mixture;
- the percentages passing the sieves, with the exception of the sieve 0,063 mm, are expressed to 1%; and
- the binder content, the percentage passing sieve 0,063 mm and any additive content are expressed to 0,1%.

5.2 Grading and sieves

5.2.1 Sieve series in use in Europe

Because two different sieve series are in use in Europe (6,3 mm, 10 mm, 14 mm, 20 mm in countries such as the UK, France and Spain, and 8 mm, 11 mm (11,2 mm), 16 mm, 22 mm (22,4 mm) in countries such as Germany, Netherlands and Scandinavia) the UK choice should be indicated. The sieves used in the UK are basic sieve set "plus set 2" conforming to BS EN 13043.

NOTE Detailed guidance on this can be found in PD 6682-2.

5.2.2 Full set of coarse sieves

The full set of coarse sieves is as follows: 4 mm; 6,3 mm; 8 mm; 10 mm; 12,5 mm; 14 mm; 16 mm; 20 mm; 31,5 mm; and 40 mm.

However, the 8 mm and 16 mm sieves are included only as a link with set 1 and the 12,5 mm sieve is not generally used in the UK. This means that the range of sieves, both coarse and fine, that should be used in asphalt specifications in the UK is: 0,063 mm; 0,125 mm; 0,250 mm; 0,500 mm; 1 mm; 2 mm; 4 mm; 6,3 mm; 10 mm; 4 mm; 20 mm; 31,5 mm; and 40 mm.

NOTE Whilst BS EN 933-1 suggests the need to use the full series for each grading determination on aggregates, for the purposes of determining the grading of asphalt mixtures it is not necessary to use sieves other than those used in BS EN 13108, as shown in the example specifications in the annexes of this Published Document.

5.3 Binder content

5.3.1 Binder content categories

The binder content categories in BS EN 13108 involve a correction factor for the density of the aggregate in the mixture. The principle is that the binder content category in the standard is based on an aggregate density in the mixture of 2,650 megagrams per cubic metre (Mg/m^3). If the aggregate is denser than 2,650 Mg/m^3 the actual binder content in the true mixture is reduced proportionally, or if the aggregate is less dense it is increased with the intention of providing the same binder volume in all mixtures regardless of aggregate density.

5.3.2 Denser aggregates

A consideration of UK mixtures and aggregates indicated that this approach could have been detrimental for some mixtures, as some of the denser aggregates in practice needed higher binder contents to ensure adequate durability. For this reason, the binder contents in the example specifications in this Published Document are those which are required as actual soluble binder contents on analysis of the finished mixture, with no density correction. This binder content is designated as the B_{act} target value.

NOTE For empirical mixtures, if experience with a particular aggregate combination indicates that a higher or lower target binder content than that stated in the example specifications in Annex B, Annex C and Annex D is required and this does not compromise the laying or measured characteristics of the mixture, the appropriate target binder content can be utilized when product-type testing the mixture.

5.3.3 CE marking

For the purposes of CE marking, these actual target binder contents (B_{act}) need to be corrected back to determine the B_{min} defined in BS EN 13108-1 to BS EN 13108-7 (inclusive).

5.3.4 Target values

To convert a B_{act} target value within this Published Document back to a B_{min} declared value from BS EN 13108-1 to BS EN 13108-7 (inclusive), the following formula is used:

$$B_{\text{min declared}} = \frac{\rho_b \times B_{\text{act target}}}{2,650} \quad (1)$$

where:

ρ_b is the mean particle density of the aggregate mixture, in Mg/m^3, determined in accordance with BS EN 1097-6.

The $B_{\text{min declared}}$ value calculated from this formula can only be in divisions of 0,2. A B_{min} declared value of 0,1 division, such as 5,3%, is rounded down to the nearest 0,2 value, 5,2%. Product type test reports should clearly include both values.

It is this back-corrected binder content B_{min} which is declared for CE marking purposes.

NOTE For the convenience of the recipients of CE marking, B_{act} can also be declared in a delineated area of the CE marking information sheet identified as "additional information".

6 BS EN 13108-1 asphalt concrete specification requirements

6.1 General

BS EN 13108-1 is a menu of specification requirements from which individual mixture specifications can be selected. Thus, choices should be made, and not all requirements are relevant to UK applications. Clause **5** discusses these requirements and indicates those that should be followed in the UK.

NOTE In Annex B, these recommended choices are presented in the form of an example specification. The current working practice in the UK for asphalt concrete is for an empirical specification with a relatively prescriptive requirement on composition, sometimes with additional requirements for performance-related properties. The example specification in Annex B of this Published Document follows this empirical approach.

6.2 General, empirical and fundamental requirements

6.2.1 General

BS EN 13108-1:2006 specifies:

- general requirements in **5.2**, which apply to all mixtures;
- empirical requirements in **5.3**, which apply only to empirically specified mixtures; and
- fundamental requirements in **5.4**, which apply only to fundamentally specified mixtures.

6.2.2 General requirements

6.2.2.1 Composition

BS EN 13108-1:2006, **5.2.1.1** requires that:

- the grading is expressed in percentages by mass of total aggregate;
- the binder and additive content is expressed in percentages by mass of total mixture;
- the percentages passing the sieves, with the exception of the sieve 0,063 mm, are expressed to 1%; and
- the binder content, the percentage passing sieve 0,063 mm and any additive content is expressed to 0,1%.

6.2.2.2 Grading

BS EN 13108-1:2006, Table 2 specifies very general grading requirements, in terms only of oversize, passing 2 mm and filler content applicable to all mixtures. These on their own are relevant only to fundamentally specified mixtures as they offer a very high degree of design freedom. Additional characteristic and optional sieves, which are of particular importance in characterizing the material and for FPC, are included in the example specification in Annex B.

6.2.2.3 Void content

Maximum and minimum void content categories should be selected from BS EN 13108-1:2006, Table 3 and Table 4. These void contents apply during product-type testing, and the method of mixing and specimen compaction/manufacture should be defined within the product-type testing document.

In the UK, experience with void content specifications for asphalt concrete mixtures used on roads is generally limited to dense base and binder courses produced under MCHW 1 [N1]. The example specification in Annex B of this Published Document translates these requirements in terms of BS EN 13108-1, using specimens taken from full-scale trial strips.

There might be scope for developing requirements for voids-related design of other dense type materials, but the criteria should be defined. In such cases these should be quoted as "no requirement" categories V_{maxNR} and V_{minNR}.

6.2.2.4 Coating and homogeneity

BS EN 13108-1:2006, **5.2.3** requires that the material when discharged from the mixer is homogenous in appearance, with the aggregate completely coated with binder, and without any evidence of balling of fine aggregate.

6.2.2.5 Water sensitivity

There may be specific applications where water sensitivity is appropriate. However, it is generally recommended that the "no requirement" category $ITSR_{NR}$ is adopted. The categories are given in BS EN 13108-1:2006, **5.2.4** in terms of the indirect tensile strength ratio that is determined from cylinder splitting testing of soaked and unsoaked specimens.

6.2.2.6 Resistance to abrasion by studded tyres

The requirement in BS EN 13108-1:2006, **5.2.5** is relevant only to those Scandinavian countries where studded tyres are used in winter. Since these are illegal in the UK, the requirement is not relevant.

The "no requirement" category Abr_{ANR} should be adopted in the UK.

6.2.2.7 Resistance to permanent deformation

BS EN 13108-1:2006, **5.2.6** specifies resistance to permanent deformation in terms of either the large (French) wheel tracking test or the small wheel tracking test. The small device is very similar to that previously defined in BS 598-110, but the test procedure and reporting differ.

In the UK, such requirements for asphalt concrete have hitherto applied only to dense asphalt concrete binder course mixtures under MCHW 1 [N1]. Categories for this application using cores from trial strips, are included in the example specification in Annex B. The "large device" is called up in the specification for EME2 and BBA using slab compacted specimens, and appropriate categories are included in the example EME2 and BBA specification in Annex B. Other than for these specific applications, the "no requirement" categories P_{NR}, WTS_{AIRNR} and PRD_{AIRNR} should be adopted in the UK.

6.2.2.8 Reaction to fire

There is a regulatory requirement in some countries for a Euroclass for reaction to fire if asphalt is to be laid in certain types of tunnel. This is not a regulatory requirement in the UK, so the "no requirement" category should be adopted.

6.2.2.9 Resistance to fuel and de-icing fluid for application on airfields

The requirements specified in BS EN 13108-1:2006 **5.2.8** and **5.2.9** only apply to airfields, therefore for use in other applications the "no requirement" category should be adopted.

6.2.2.10 Temperature of the mixture

Temperature limit requirements are given in BS EN 13108-1:2006, Table 11 (see **B.3.6** of this Published Document). Guidance on suitable minimum temperatures at delivery and for compaction is given in BS 594987:2015, Table A1.

6.2.3 Empirical requirements

6.2.3.1 General

BS EN 13108-1:2006, **5.3** specifies the more specific and prescriptive detailed requirements which apply to empirically specified mixtures.

NOTE These requirements refer only to the target composition.

Tolerances are applied during factory production control and are specified in BS EN 13108-21 (see also **13.3**).

NOTE The requirement for producers is to declare a target composition within the specified constraints on constituents, grading, binder content, etc., which meets all other specified requirements, such as voids and deformation resistance.

6.2.3.2 Grading

BS EN 13108-1:2006, **5.3.1.2**, requires the grading of the target composition to fall within the limits of a grading envelope. There are requirements in BS EN 13108-1:2006, Table 1 and Table 2, for which sieves are to be used, related to the upper size *D* of the mixture. There are also limitations on the number of additional sieves which can be called up, to limit the complexity of grading specifications. In the example specification given in Annex B, sieve selections have been made in accordance with these requirements.

BS EN 13108-1:2006, Table 12, imposes a minimum range or width on this specification envelope for designed mixtures. For recipe mixtures, the grading specifications in Annex B give a single point or a very narrow envelope from which to select for the target values for each of the sieves.

This, in combination with the tolerances from BS EN 13108-21, results in overall grading specification envelopes utilised for assessing the conformity of the mixture as defined in BS EN 13108-21 for factory production control.

6.2.3.3 Binder content

An empirical specification should include requirements for minimum and/or maximum binder contents, selected from tables and nominated in 0,2% increments (see BS EN 13108-1:2006, **5.3.1.3** for further information on binder content). In the UK, output target composition is used, therefore the binder content is the soluble binder content found on analysis.

The binder content requirement in BS EN 13108-1 contains a formula to correct binder content for density variations of aggregate. The main requirement is based on an aggregate particle density of 2,650 Mg/m^3. For lower density aggregates the binder addition is increased and for higher density aggregates it is reduced using the following formula:

$$\alpha = \frac{2{,}650}{\rho_b} \quad (2)$$

where:

ρ_b is the mean particle density of the aggregate mixture, in Mg/m^3, determined in accordance with BS EN 1097-6;

α is the compensation factor.

The mean particle density of the aggregate mixture should be calculated as the weighted mean of the apparent particle densities of the coarse and fine aggregate particle size fractions comprising the mixture formulation:

- 0,063 mm to 2 mm;
- 2 mm to 4 mm;
- 4 mm to 6,3 mm;
- 6,3 mm to 10 mm;
- 10 mm to 14 mm;
- 14 mm to 20 mm;
- 20 mm to 31,5 mm; and
- 31,5 mm to 40 mm.

Some care should be taken in the application of this correction factor as the effect might not be consistent with the mineralogical nature of aggregates used in the UK. To ensure that the performance and durability of mixtures sensitive to these

mineralogical differences are not compromised, the recommended binder content designated as B_{act} is presented in Annex B against the coarse aggregate type, in line with the methodology previously used.

NOTE The selection of the appropriate target binder content for the particular mixture takes account of a number of important factors. These particularly include the handling and laying characteristics of the mixture and the anticipated performance in the pavement. As already stated, two of the factors which significantly affect the target binder content selected for empirically specified mixtures are the relative density of the combined aggregates, and the surface characteristics and the mineralogical nature of the particular type(s) of aggregate used.

The correction factor is not applicable to slag aggregates, and provision is made for these in the annexes of this Published Document in terms of compacted bulk density.

6.2.3.4 Additives

If the specifier has requirements for additives these should be included in the specification, in accordance with BS EN 13108-1:2006, **5.3.1.4**.

6.2.3.5 Marshall values for application on airfields

Marshall test properties specified in BS EN 13108-1:2006, **5.3.2** are only for use on airfields. Thus, for use in other applications the "no requirement" categories S_{minNR}, S_{maxNR}, F_{NR} and Q_{minNR} are adopted in the UK.

6.2.3.6 Voids filled with bitumen

The requirements specified in BS EN 13108-1:2006, **5.3.3** are not generally adopted in the UK, other than for some asphalt concrete on airfield applications. For use in other applications the "no requirement" category VFB_{NR} should be adopted.

6.2.3.7 Voids in mineral aggregate

The requirements specified in BS EN 13108-1:2006, **5.3.4** are not generally adopted in the UK other than for some asphalt concrete on airfield applications.

It is therefore recommended that for use in other applications the "no requirement" category VMA_{NR} should be adopted.

6.2.3.8 Void content at ten gyrations

The requirements specified in BS EN 13108-1:2006, **5.3.5** are a measure of mixture workability and compactability. The "no requirement" category $V10G_{minNR}$ should be adopted.

6.2.4 Fundamental requirements

COMMENTARY ON 6.2.4.
BS *EN 13108-1:2006, **5.4** offers a less prescriptive approach to composition than previously specified in BS 4987, but also links with measurement of stiffness, deformation resistance and fatigue properties by performance-based test methods.*

6.2.4.1 Composition – grading and binder content

Grading is limited only by the general requirements of BS EN 13108-1:2006, Table 1 and Table 2. BS EN 13108-1:2006, **5.4.1.2** requires that binder content is greater than 3,0%.

6.2.4.2 Stiffness

For the purposes of BS EN 13108-1:2006, **5.4.2**, all stiffness test methods are considered equivalent. In the UK it is anticipated that stiffness of base and binder course mixtures might be determined, where required, on cored cylindrical specimens from trial strips using the indirect tensile stiffness modulus test in accordance with BS EN 12697-26:2012, Annex C.

Other than for these specific applications, the "no requirement" categories S_{minNR} and S_{maxNR} should be adopted.

NOTE It is anticipated that stiffness might be specified in conjunction with an otherwise empirical specification. There is provision for this within the standard and associated CE marking requirements.

6.2.4.3 Resistance to permanent deformation in triaxial compression test

It is not intended that triaxial testing for deformation resistance should be used in specifications in the UK. Therefore the "no requirement" category f_{cmaxNR} should be adopted.

6.2.4.4 Resistance to fatigue

Fatigue testing should not be used in specifications. Therefore the "no requirement" category $\varepsilon 6_{-NR}$ should be adopted.

6.2.4.5 Over-specification

The requirements specified in BS EN 13108-1:2006, **5.4.5** contain limitations on specifiers to prevent over-specification by the combination of inappropriate and unnecessarily onerous combinations of requirements.

6.2.4.6 Durability

Asphalt concrete produced in accordance with BS EN 13108-1 and laid in accordance with BS 594987 may be considered durable for a reasonable working life (the period of time during which the performance of the works should be maintained at a level compatible with the declared performance of the characteristics).

6.3 Identification

6.3.1 General

The product-type test report contains all the relevant detailed information and the information on the delivery ticket, as required by this Published Document, is that required to enable identification of the product and provide traceability to CE marking. If additional information is required on the delivery ticket, this should be specified in documents relating to the application of the product.

The delivery ticket should contain at least the following information relating to identification (as required by BS EN 13108-1:2006, Clause **7**):

- the manufacturer and mixing plant;
- mixture identification code;
- designation of the mixture;
- how to obtain the full details to ensure conformity with the European Standard;
- details of any additives (see **6.2.3.4**); and
- details of compliance with any clauses, where requested, for specific use on airfields specifications.

*NOTE Information concerning regulatory marking is made available by the manufacturer (for CE marking and labelling see BS EN 13108-1:2006, **ZA.3**). Characteristics that are not necessarily part of regulatory marking, for example, special requirements for airfields, may also be made available as agreed with the client.*

6.3.2 Mixture designation

6.3.2.1 General

The BS EN 13108-1 mixture designation consists of the minimum four sections, as below.

AC	*D*	base/bin/surf	binder

where:

AC	is asphalt concrete;
D	is the upper sieve size of the mixture, in mm;
base	is the base course;
bin	is the binder course;
surf	is the surface course; and
binder	is the designation of the binder used.

NOTE UK common practice previously included other descriptors for differentiating certain types of materials, e.g. dense bitumen macadam, open graded macadam, dense surface course and close graded surface course.

The descriptors in Annex B should be used in material designations on delivery tickets.

6.3.2.2 Examples of dense asphalt concrete and open graded asphalt concrete

Dense asphalt concrete with maximum aggregate size 20 mm for binder course with paving grade bitumen 100/150, designed target grading is designated as AC 20 dense bin 100/150 des.

Open graded asphalt concrete with maximum aggregate size 10 mm for surface course with paving grade bitumen 160/220 (empirically specified mixture) is designated as AC 10 open surf 160/220.

In some instances it might be appropriate to add and identify extra information, such as aggregate PSV, to this mixture designation, e.g. AC 10 open surf 160/220 PSV 60.

All mixtures are recipe unless they are designed. The descriptor "des" (for design) should be used to identify a mixture which has undergone type-testing for the determination of an appropriate target grading and binder content to achieve voids content and/or performance-related testing to validate mixture stiffness or deformation resistance. The descriptor "rec" (for "recipe") can be used to identify an empirical recipe based mixture.

7 BS EN 13108-2 asphalt concrete for very thin layers specification requirements

BS EN 13108-2 is a list of specification requirements from which individual mixture specifications can be selected. For UK application the selection of levels and classes should be made from within MCHW 1 [N1].

BS EN 13108-2 applies to surface courses to be laid at a thickness of 20 mm to 30 mm. The aggregate is generally gap-graded to form a stone-to-stone contact and provide an open surface texture. The thickness requirement limits

the size of aggregate used to 6,3 mm,8 mm or 10 mm (although the 8 mm size is not generally used in the UK), but with a selection of grading classes within the nominal aggregate size definition.

8 BS EN 13108-3 soft asphalt specification requirements

Soft asphalt is traditionally used in the cold northern regions of Europe where roads heave significantly during the winter under conditions of prolonged deep frost, and are then reshaped and rerolled in spring after the thaw. As there is no such application in the UK BS EN 13108-3 should not be used in this context and specific guidance on its use is not considered necessary in this Published Document.

9 BS EN 13108-4 hot rolled asphalt specification requirements

9.1 General

BS EN 13108-4 is a menu of specification requirements from which individual mixture specifications can be selected. Thus, specific choices should be made as not all requirements are relevant to all UK applications. This Clause discusses these requirements and indicates those that should be applied.

NOTE The *requirements are presented in Annex C in the format of an example specification.*

9.2 Composition

9.2.1 General

BS EN 13108-4:2006, **5.1** requires that:

- the mixture formulation is declared and documented;
- at the target composition the mixture conforms to the selected requirements;
- the grading is expressed in percentages by mass of total aggregate;
- the binder and additive content is expressed in percentages by mass of total mixture;
- the percentages passing the sieves, with the exception of the sieve 0,063 mm, is expressed to 1%; and
- the binder content, the percentage passing sieve 0,063 mm and any additive content is expressed to 0,1%.

9.2.2 Grading

BS EN 13108-4:2006, **5.2.2**, requires specifications to be presented as a grading envelope, and specifies that the target composition of the mixture falls within the grading envelope. There are requirements in BS EN 13108-4:2006, Table 2 and Table 4, for which sieves should be used, related to the upper size *D* of the mixture. There are also limitations on the number of additional sieves which can be called up, to limit the complexity of grading specifications.

In the example specification given in Annex C, sieve selections have been made in accordance with these requirements.

The example specifications are grouped as base and binder course and surface course mixtures. Additional guidance on recipe, design and performance related surface course mixtures is included in Annex C.

9.2.3 Binder content for base and binder course

For base and binder course, recipe and design surface course mixtures, the target and/or minimum binder content is defined in Table C.1, Table C.2A, Table C.2B and Table C.2C (see BS EN 13108-4:2006, **5.2.3**).

In the UK, "output target composition" is used, so the binder content is the soluble binder content found on analysis.

The binder content requirement contains a compensation formula to correct binder content for density variations of aggregate. The main requirement is based on an aggregate particle density of 2,650 Mg/m^3. For lower density aggregates the binder addition is increased and for higher density aggregates it is reduced using the following formula:

$$\alpha = \frac{2{,}650}{\rho_b} \quad (3)$$

where:

ρ_b is the mean particle density of the aggregate mixture, in Mg/m^3, determined in accordance with BS EN 1097-6; and

α is the compensation factor.

The mean particle density of the aggregate mixture should be calculated as the weighted mean of the apparent particle densities of the coarse and fine aggregate particle size fractions comprising the mixture formulation:

- 0,063 mm to 2 mm;
- 2 mm to 4 mm;
- 4 mm to 6,3 mm;
- 6,3 mm to 10 mm;
- 10 mm to 14 mm;
- 14 mm to 20 mm;
- 20 mm to 31,5 mm; and
- 31,5 mm to 40 mm.

Some care is necessary in the application of this correction factor as the effect might not be consistent with the mineralogical nature of aggregates used in the UK. To ensure that the performance and durability of mixtures sensitive to these mineralogical differences are not compromised, the recommended binder content is presented against the coarse aggregate type.

9.2.4 Binder volume

Only performance-related surface course mixtures should be made using the method of determining the quantity of binder in the mixture required by BS EN 13108-4:2006, **5.2.4** (see **C.2.5.1.4.2**).

9.2.5 Additives

If the specifier has requirements for additives these should be included in the specification, in accordance with BS EN 13108-4:2006, **5.2.5**.

9.3 Coating and homogeneity

BS EN 13108-4:2006, **5.3** requires that the material when discharged from the mixer is homogenous in appearance, with the aggregate completely coated with binder and no evidence of balling of fine aggregate.

9.4 Void content

BS EN 13108-4:2006, **5.4** requirements are only specified for performance-related surface course mixtures (see **C.2.5.1.4** of this Published Document).

9.5 Water sensitivity

There may be specific applications where water sensitivity is appropriate. However, it is generally recommended that the "no requirement" category $ITSR_{NR}$ is adopted.

BS EN 13108 4:2006, **5.5** specifies water sensitivity in terms of the ITSR determined from cylinder splitting testing of soaked and unsoaked specimens.

9.6 Reaction to fire

There is a regulatory requirement in some countries for a Euroclass for reaction to fire if asphalt is to be laid in certain types of tunnel. This is not a regulatory requirement in UK, so the "no requirement" category should be adopted.

9.7 Resistance to permanent deformation

BS EN 13108-4:2006, **5.7**, requirements for resistance to permanent deformation are only specified for performance-related surface course mixtures (see **C.2.5.1.4.4** of this Published Document).

9.8 Stiffness

For the purposes of BS EN 13108-4:2006, **5.8** all stiffness test methods are considered equivalent. In the UK it is not anticipated that stiffness of HRA mixtures shall be determined, so "no requirement" categories S_{minNR} and S_{maxNR} should be adopted in the UK.

9.9 Resistance to fuel for application on airfields

The BS EN 13108-4:2006, **5.9**, requirement applies to airfields, so for use in other applications the "no requirement" category should be adopted.

9.10 Resistance to de-icing fluid for application on airfields

The BS EN 13108-4:2006, **5.10** requirement applies to airfields, so for use in other applications the "no requirement" category β_{NR} should be adopted.

9.11 Temperature of the mixture and suitable minimum temperatures at delivery and compaction

BS EN 13108-4:2006, Table 16, specifies temperature requirements (see **C.2.6**).
BS 594987gives requirements on suitable minimum temperatures at delivery and for compaction.

9.12 Over-specification

BS EN 13108-4:2006, **5.12** contains limitations on specifiers to prevent over-specification by the combination of unnecessarily onerous combinations of requirements, in particular the means for specifying the quantity of binder or air voids in a mixture.

9.13 Durability

HRA produced in accordance with BS EN 13108-4 and laid in accordance with BS 594987 may be considered durable for a reasonable working life (the period of time during which the performance of the works are maintained at a level compatible with the declared performance of the characteristics).

9.14 Identification

9.14.1 General

As stated in BS EN 13108-4:2006, Clause **7**, the delivery ticket contains at least the following information relating to identification:

- the manufacturer and mixing plant;
- mixture identification code;
- designation of the mixture;
- how to obtain the full details demonstrating conformity with BS EN 13108-4;
- details of compliance with any clauses where requested for specific use on airfields specifications; and
- details of any additives (see **8.2.5**).

*NOTE Information concerning regulatory marking accompanies the product (for CE marking and labelling see BS EN 13108-4:2006, **ZA.3**), but characteristics that are not necessarily part of regulatory marking, for example, special requirements for airfields, could be made available by alternative means, i.e. retained by the dispatching depot if agreed with the client.*

9.14.2 Mixture designation

As in BS EN 13108-4:2006, Clause **7** mixture designations follow the model below:

HRA	grading designation	base/bin/surf/reg	binder

where:

HRA	is hot rolled asphalt;
grading designation	is taken from BS EN 13108-4:2006, Table 2 and Table 4 (Table C.1 and Table C.2A, Table C.2B and Table C.2C of this Published Document);
base	is base course;
bin	is binder course;
surf	is surface course;
reg	is regulating course;
binder	is the designation of the binder used.

9.14.3 Examples of mixture designation

HRA containing 50% of a coarse aggregate with maximum aggregate size 20 mm for binder course with paving grade bitumen 100/150 is designated as HRA 50/20 bin 100/150.

HRA containing 35% of a coarse aggregate with maximum aggregate size 14 mm and a Type F fine aggregate for surface course with paving grade bitumen 40/60, and designed in accordance with BS EN 13108-4:2006, Annex H, is designated as HRA 35/14F surf 40/60 des.

In some instances it might be appropriate to add and identify extra information, such as aggregate PSV, to this core description, e.g. HRA 35/14F surf 40/60 des PSV 65.

All mixtures are recipe unless they are designed. The descriptor "des" (for design) should be used to identify a mixture which has undergone product-type testing for the determination of an appropriate target grading and binder content. The descriptor "rec" (for "recipe") can be used to identify an empirical recipe based mixture. The descriptor "perf" (for "performance-related") can be used to identify mixtures which have undergone performance-related testing for resistance to permanent deformation.

10 BS EN 13108-5 stone mastic asphalt specification requirements

10.1 General

BS EN 13108-5 is a menu of empirical specification requirements from which individual mixture specifications can be selected. Thus, choices should be made and not all requirements are relevant to all UK applications. Clause **9** discusses these requirements and indicates those which are recommended as appropriate for use in the UK. The requirements are presented in Annex D in the format of an example specification.

BS EN 13108-5 applies to materials in which aggregate particles are generally gap-graded to form a stone-to-stone contact within a mastic of fine aggregate and binder. The size of aggregate used is limited to 6,3 mm, 10 mm, 14 mm or 20 mm.

10.2 Composition

10.2.1 General

BS EN 13108-5 requires that:

- the mixture formulation is declared and documented;
- at the target composition the mixture conforms to the selected requirements;
- the grading is expressed in percentages by mass of total aggregate;
- the binder and additive content are expressed in percentages by mass of total mixture;
- the percentages passing the sieves (with the exception of the sieve 0,063 mm) are expressed to 1%; and
- the binder content, the percentage passing sieve 0,063 mm and any additive content is expressed to 0,1%.

10.2.2 Grading

BS EN 13108-5:2006, **5.2.2** requires specifications to be presented as a grading envelope, and specifies that the target composition of the mixture falls within the grading envelope. BS EN 13108-5:2006, Table 2 specifies requirements for which sieves are to be used, related to the upper size of the mixture. There are also limitations on the number of additional sieves which should be called up, to limit the complexity of grading specifications.

In the example specification given in Annex D, sieve selections have been made in accordance with these requirements, as have the requirements of BS EN 13108-5:2006, Table 3, which limit the range of the selected grading envelope.

10.2.3 Target and minimum binder content

The target and/or minimum binder content is defined in Table D.1 (see BS EN 13108-5:2006, **5.2.3**).

In the UK, "output target composition" is used, so the binder content is the soluble binder content found on analysis.

The binder content requirement contains a compensation formula to correct binder content for density variations of aggregate.

The main requirement is based on an aggregate particle density and for higher density aggregates it is reduced using the following formula:

$$\alpha = \frac{2{,}650}{\rho_b} \quad (4)$$

where:

ρ_b is the mean particle density of the aggregate mixture, in megagrams per cubic metre (Mg/m^3), determined in accordance with BS EN 1097-6;

α is the compensation factor.

The mean particle density of the aggregate mixture should be calculated as the weighted mean of the apparent particle densities of the coarse and fine aggregate particle size fractions comprising the mixture formulation:

- 0,063 mm to 2 mm;
- 2 mm to 4 mm;
- 4 mm to 6,3 mm;
- 6,3 mm to 10 mm;
- 10 mm to 14 mm;
- 14 mm to 20 mm;
- 20 mm to 31,5 mm; and
- 31,5 mm to 40 mm.

Some care is necessary in the application of this correction factor as the effect might not be consistent with the mineralogical nature of aggregates used in the UK.

The selection of the appropriate target binder content for the particular mixture takes account of a number of important factors. These include, particularly, the handling and laying characteristics of the mixture, and its anticipated performance in the pavement.

Two of the factors which have a significant effect on the target binder content selected for empirically specified mixtures are:

- the relative density of the combined aggregates and the surface characteristics; and
- the mineralogical nature of the particular type(s) of aggregate used.

10.2.4 Additives

If the specifier has requirements for additives these should be included in the contract specification, in accordance with BS EN 13108-5:2006, **5.2.4**. In particular, for SMA this relates to the inclusion of fibres (see **D.2.2.4**).

10.3 Coating and homogeneity

BS EN 13108-5:2006, **5.3** requires that the material when discharged from the mixer is homogenous in appearance, with the aggregate being completely coated with binder and without evidence of balling of fine aggregate. Particular attention should be paid to the potential for binder drainage in these mixtures.

10.4 Void content

BS EN 13108-5:2006, **5.4**, offers a wide choice of void content categories. The recommended categories for use in the UK are given in **D.4**.

10.5 Voids filled with bitumen

The BS EN 13108-5:2006, **5.5** requirement is not generally adopted in the UK other than for some asphalt concrete on airfield applications. Therefore the "no requirement" categories VFB_{maxNR} and VFB_{minNR} should be adopted.

10.6 Binder drainage

The stone-dependent gap-graded nature of SMA has the potential to result in binder drainage, and this should be addressed in the design of the materials; for example, by the inclusion of polymer modified bitumen, binder modifiers or drainage inhibitors, such as natural or man-made fibres, in accordance with BS EN 13108-5:2006, **5.6**. The recommended category for use in the UK is given in **D.5**.

10.7 Water sensitivity

There may be specific applications where water sensitivity is appropriate. However, it is generally recommended that the "no requirement" category $ITSR_{NR}$ is adopted. Water sensitivity is specified in BS EN 13108-5:2006, **5.7** in terms of the indirect tensile strength ratio, determined from cylinder splitting testing of soaked and unsoaked specimens.

10.8 Resistance to abrasion by studded tyres

The BS EN 13108-5:2006, **5.8** requirement is relevant only to those Scandinavian countries where studded tyres are used in winter. Since these are illegal in the UK, the requirement is not relevant. It is therefore recommended that for resistance to abrasion by studded tyres, the "no requirement" category Abr_{ANR} should be adopted in the UK.

10.9 Resistance to permanent deformation

Resistance to permanent deformation is an important performance-related characteristic of SMA mixtures. The UK choice for the BS EN 13108-5:2006, **5.9** requirements can be found in Annex D.

10.10 Reaction to fire

There is a regulatory requirement in some countries for a Euroclass for reaction to fire if asphalt is to be laid in certain types of tunnel. This is not currently a regulatory requirement in UK, so the "no requirement" category should be adopted.

10.11 Resistance to fuel and de-icing fluid for application on airfields

The BS EN 13108-5:2006, **5.11** and **5.12** requirements apply only to airfields, so the "no requirement" categories should be adopted for use in other applications.

10.12 Temperature of the mixture and maximum temperatures at any stage

Temperature requirements are given in BS EN 13108-5:2006, Table 16 (see Table D.3 of this Published Document). The maximum temperatures at any stage are similar to those experienced in past use when related to binder grade. BS 594987 gives requirements on suitable minimum temperatures at delivery and for compaction.

10.13 Durability

SMA produced in accordance with BS EN 13108-5 and laid in accordance with BS 594987 may be considered durable for a reasonable working life (the period of time during which the performance of the works are maintained at a level compatible with the declared performance of the characteristics).

10.14 Identification

10.14.1 General

BS EN 13108-5:2006, Clause **7** requires that the delivery ticket contains at least the following information relating to identification:

- the manufacturer and mixing plant;
- mixture identification code;
- designation of the mixture;
- how to obtain the full details demonstrating conformity with BS EN 13108-5;
- details of any additives (see **9.2.4**);
- details of compliance with any clauses where requested for specific use on airfields specifications.

*NOTE Information concerning regulatory marking accompanies the product (for CE marking and labelling, see BS EN 13108-5:2006, **ZA.3**), but characteristics which are not necessarily part of regulatory marking, for example, special requirements for airfields could be made available by alternative means, i.e. retained by the dispatching depot if agreed with the client.*

10.14.2 Mixture designation

In BS EN 13108-5, mixture designations follow the model below.

SMA	*D*	binder

where:

SMA is stone mastic asphalt;

D is the maximum aggregate size;

binder is the designation of the binder used.

Within BS EN 13108-5, SMA is only identified as being a surface course mixture and, therefore, the identification of the structural layer in which the mixture is to be used is not required. However, within the UK, SMA is also used as a binder course or regulating material. Therefore, the identification of the structural layer after "D" and before "binder" is required as follows:

- surf is surface course;
- bin is binder course; and
- reg is regulating course.

NOTE As there has not been any previous British Standard for SMA, particular attention needs to be paid to the requirements for demonstrating conformity with BS EN 13108-5 by product-type testing and factory production control, and also CE marking where appropriate.

10.14.3 Examples of mixture designation

SMA with maximum aggregate size 20 mm for use as a binder course with paving grade bitumen 40/60 is designated as SMA 20 bin 40/60.

SMA with maximum aggregate size 10 mm for use as a surface course with paving grade bitumen 40/60 is designated as SMA 10 surf 40/60.

NOTE In some instances it might be appropriate to add and identify extra information, such as aggregate PSV, to this core description, e.g. SMA 10 surf 40/60 PSV 60.

11 BS EN 13108-6 mastic asphalt

Mastic asphalt is outside the scope of this Published Document and no guidance is given. Advice may be obtained from the Mastic Asphalt Council.

12 BS EN 13108-7 porous asphalt

*COMMENTARY ON Clause **12***
The use of PA as a surface course for conventional highways has been largely discontinued in the UK. It was typically a 20 mm product laid onto an impermeable substrate and gave benefits in terms of noise and spray reduction.

With the introduction of Sustainable Drainage Systems (SuDS) pavements, the demand for asphalt in a fully porous system has increased. In SuDs systems multiple layers of PA are typically laid on a highly voided structure to provide temporary storage for storm water.

SuDS PAs are generally proprietary products and guidance should be sought from manufacturers based on the specific requirements of each site.

NOTE Caution is advised when using conventional, open graded AC surface and binder course mixtures, covered by Annex B of this document, for SuDS systems.

13 BS EN 13108-8 reclaimed asphalt specification requirements

BS EN 13108-8 is a specification for the definition and classification of the properties of RA, principally for the purposes of its sale and purchase. It is, however, convenient to use these classifications as a way of defining the quality of RA as a feedstock for asphalt mixtures.

NOTE This has been done in the example specifications for asphalt mixtures in the annexes to this Published Document, which reflect the current practice.

The properties classified in BS EN 13108-8 are:

- size of asphalt particles;
- size of aggregate in RA;
- content of foreign matter (contamination); and
- binder hardness, expressed as one of mean penetration, mean softening point or mean viscosity of the recovered binder.

It should be noted that feedstock for asphalt plants in the UK has traditionally been defined as the RA (direct from source) and has been fully or partly processed to make it suitable for inclusion in the asphalt plant. The BS EN 13108-8 classifications should be used to define the RA at any stage between the raw planed or excavated material, and a fully processed feedstock for a mixing plant.

14 Assessment and verification of constancy of performance

14.1 General

14.1.1 Obligations of a producer of asphalt

*COMMENTARY ON **14.1.1***
The demonstration of performance and conformity of asphalt mixtures is covered by:

- *BS EN 13108-20, Type testing; and*
- *BS EN 13108-21, Factory production control.*

These were previously drafted in the context of a process of "Evaluation of Conformity" relating to BS EN 13108 and the Construction Products Regulations [1]. They are now used as part of the process of Assessment and Verification of Constancy of Performance (AVCP).

BS EN 13108-20 and BS EN 13108-21 specify the obligations of a producer of asphalt, so as to be able to make a "Declaration of Performance" that the material:

- meets the requirements of the essential characteristics as defined in Annex ZA of the relevant product standard; and
- conforms to a particular specification drawn from the relevant parts of BS EN 13108.

14.1.2 Product-type testing

Product-type testing is a procedure in which a given mixture formulation (target composition and set of constituents) is put through a series of tests to prove that it conforms to the detailed specification requirements of the applicable part of BS EN 13108. In particular this involves any performance-related properties for which performance and conformity is being claimed. Every detail and each

property should be validated, even for simple recipe mixtures, although there will be fewer requirements to demonstrate.

NOTE This is similar to a combination of a technical file, a mixture design report and/or a job standard mixture trial report.

The result of a product-type testing procedure is a type-test report. This is a formal document that relates only to the formulation which has been tested and which provides proof that the formulation conforms to the relevant specification detail. The product-type test report is made available to the purchaser of the product on demand in support of the Declaration of Performance.

14.1.3 Factory production control

Factory production control is a schedule for a quality system to ensure that, at the asphalt plant, a mixture formulation which has already been type-tested is manufactured consistently. It does not include requirements for measuring performance-related properties of the asphalt, other than a requirement that the validation carried out under initial product-type testing be repeated at not greater than five yearly intervals.

In summary, a mixture is in conformity with the European Standard if there is a valid type-test for the particular mixture composition covering all of the specified requirements and if it is produced at a plant conforming fully to the requirements of factory production control.

BS EN 13108 does not deal with the subject of acceptance testing as this is a contractual issue.

14.2 BS EN 13108-20 Type testing

14.2.1 General

The method for determining the product type for an asphalt mixture formulation should include:

- a declaration of the types/sources of constituent materials;
- test data showing conformity of constituent materials with relevant requirements;
- a declaration of the target composition of the mixture; and
- test data showing conformity of the mixture with any performance-related or performance-based requirements (such as void content, deformation resistance, stiffness).

NOTE 1 The product-type test is mixture-specific and not plant-specific. In UK terms it has always been implicitly necessary to have this information available, but not in such a formalized and generally applicable way.

BS EN 13108 has introduced the use of RA into British Standards. Whilst the use of RA has been quite common in the UK for many years, it was not formally permitted in the British Standards covering asphalt mixtures and was thus regulated through separate contract provisions. The incorporation of RA is now dealt with in the type-testing by a declaration of the type of RA to be used as a constituent and tests to validate the performance-related or performance-based properties across the range of additions intended.

When adding more than 10% RA a binder recovery should be carried out on the mixed asphalt and a determination of the penetration value of the recovered combined bitumen should be made.

For laboratory-mixed material, BS EN 13108 requires that the penetration is within the specified grade range and for plant-mixed material it is not more than one grade harder (see Table 12).

The requirements specified in BS EN 13108 introduce a "family approach" to avoid some unnecessary testing and validation. The essence of this is that if, for example, a particular mixture with 100/150 grade bitumen meets a given stiffness or deformation resistance category, then the same mixture, but with a harder grade such as 40/60, may be assumed also to conform without the need for testing of the mixture containing the harder bitumen grade.

The requirements specified in BS EN 13108-20 permit flexibility in terms of specimen preparation for the determination of performance-related and performance-based properties. It also permits specimens to be made from either laboratory-mixed or plant-mixed asphalt. However, since the methods of mixing and specimen preparation have a very significant effect on the results, it is necessary to have agreed protocols for this in the UK. For this reason, in the example specifications in Annex B, Annex C and Annex D, the methods of sample preparation and testing are clearly laid out. For laboratory-mixed and prepared specimens, these call up the relevant parts of BS EN 12697.

Since the results determined depend on the method of specimen preparation, a set of protocols showing the required UK selection of such procedures, linked to the required specification levels and classes, is included in BS 594987.

NOTE 2 The BS 594987:2015 annexes are generally based as far as possible on the standard procedures operating in the UK utilizing European Standard test methods. These Annexes are listed in Table 1.

Table 1 **References to protocols in BS 594987:2015**

BS 594987 Annex	Subject
C	AC dense/HDM/HMB design voids
D	AC dense/HDM/HMB deformation resistance
E	EME2 design properties
F	Performance HRA properties
G	SMA binder course properties
H	HRA surface course design

The particular requirements for the various material types are summarized in Table 2, Table 3 and Table 4.

Table 2 **Type-testing sample preparation and testing requirements for UK asphalt concrete mixtures conforming to BS EN 13108-1**

Material type	Property	Mixing	Sample preparation	Test method
Design AC dense, HMB, HDM base and binder course	Void content V_{min} in trial strip	BS 594987:2015, Annex C	BS 594987:2015, Annex C	BS 594987:2015, Annex C
	Void content V_{max} in trial strip	BS 594987:2015, Annex C	BS 594987:2015, Annex C	BS 594987:2015, Annex C
	Resistance to permanent deformation	BS 594987:2015, Annex D	BS 594987:2015, Annex D	BS 594987:2015, Annex D
EME2	Voids at *N* gyrations	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-31:2007, Gyratory compactor	BS EN 12697-31:2007, Gyratory compactor
	Water sensitivity	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-12:2008, Method B	BS EN 12697-12:2008, Method B
	Resistance to permanent deformation	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-33:2003, Large slab 3% to 6% voids	BS EN 12697-22:2003, Large device
	Void content V_{max} in trial strip	BS 594987:2015, Annex E	BS 594987:2015, Annex E	BS 594987:2015, Annex E
	Stiffness	BS 594987:2015, Annex E	BS 594987:2015, Annex E	BS 594987:2015, Annex E
	Resistance to fatigue	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-33:2003, Large slab 3% to 5% voids	BS EN 12697-24:2012, A/2PB-TZ 10 °C 25 Hz Trapezoidal method
BBA	Voids at *N* gyrations	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-31:2007, Gyratory compactor	BS EN 12697-5:2009, BS EN 12697-6:2012, Procedure B and BS EN 12697-8:2003
	Water sensitivity	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-12:2008, Method B	BS EN 12697-12:2008, Method B
	Resistance to permanent deformation	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-33:2003, Large slab 4% to 7% voids	BS EN 12697-22:2003, Large device
	Stiffness	BS EN 12697-35:2004	BS EN 12697-31:2007	BS EN 12697-26:2012, Annex C
	Resistance to fatigue	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-33:2003, Large slab 4% to 7% voids	BS EN 12697-24:2012, A/2PB-TZ 10 °C 25 Hz Trapezoidal method

Table 3 **Type-testing sample preparation and testing requirements for UK HRA mixtures conforming to BS EN 13108-4**

Material type	Property	Mixing	Sample preparation	Test method
Design HRA surface course	Design binder content	BS 594987:2015, Annex H	BS 594987:2015, Annex H	BS 594987:2015, Annex H
Performance-related HRA surface course	Void content V_{max} in trial strip	BS 594987:2015, Annex F	BS 594987:2015, Annex F	BS 594987:2015, Annex F
	Binder volume	BS 594987:2015, Annex F	BS 594987:2015, Annex F	BS 594987:2015, Annex F
	Resistance to permanent deformation	BS 594987:2015, Annex F	BS 594987:2015, Annex F	BS 594987:2015, Annex F

Table 4 **Type- testing sample preparation and testing requirements for UK SMA mixtures conforming to BS EN 13108-5**

Material type	Property	Mixing	Sample preparation	Test method
SMA surface course	Void content V_{min} and V_{max}	BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-30:2012, Impact compaction (2 × 50 blows)	BS EN 12697-8 Using bulk density to BS EN 12697-6:2003, procedure B SSD Using maximum density to BS EN 12697-5:2009, procedure A in water
	Resistance to permanent deformation (manufacturer choice)	BS 594987:2015, Annex G	BS 594987:2015, Annex G	BS 594987:2015, Annex G
		BS EN 12697-35:2004, Laboratory mixing	BS EN 12697-33:2003, Roller compaction (BS EN 13108-20:2006 Table C.1 ref. C.1.25)	BS EN 12697-22:2003 small device, method B in air
SMA binder course	Void content V_{max} in trial strip	BS 594987:2015, Annex G	BS 594987:2015, Annex G	BS EN 12697-8 Using bulk density to BS EN 12697-6:2003, procedure B SSD Using maximum density to BS EN 12697-5:2009, procedure A in water
	Resistance to permanent deformation	BS 594987:2015, Annex G	BS 594987:2015, Annex G	BS 594987:2015, Annex G

14.2.2 Mixture formulation and target composition

BS EN 13108 permits two ways of expressing target composition. In the UK, output target composition is always used. This continues the long-standing tradition of working to standards based on the composition on analysis.

Output target composition is one of the key parts of the type test report as it should be used as the target composition in factory production control.

14.2.3 Validity and changes in constituent materials

BS EN 13108-20:2006, **4.2** gives specific conditions for the ongoing validity of type-testing in terms of any changes in raw materials. These requirements are very specific and, where they refer to "type", "source" and "grade", this choice of wording is intentional and not accidental. No further guidance is needed.

14.2.4 Content of type-testing declarations

14.2.4.1 General

In all cases, even for mixtures which would be considered as recipe type mixtures, the following information is provided in a type-test report:

- a declaration of the types/sources of constituent materials;
- test data showing conformity of constituent materials with relevant requirements; and
- a declaration of the target composition of the mixture.

14.2.4.2 Properties of mixed asphalt

Where the specification with which conformity is being claimed includes requirements on properties of the mixture, test data should be provided to demonstrate conformity with those requirements. Table 2, Table 3 and Table 4 set out all the instances where such information should be used for the standard UK mixtures included in Annex B, Annex C and Annex D. They also include the appropriate references that should be used for specimen preparation and testing methods.

NOTE This problem does not affect EME2 or BBA mixtures using the large wheel tracking device.

14.3 BS EN 13108-21 Factory production control

14.3.1 General

The FPC standard comprises:

- requirements for a quality system to ensure that a mixture formulation which has previously been type tested is produced consistently with the required constituents, to the required composition and in accordance with the mixing requirements of the standard;
- a schedule of management responsibilities, inspection and testing requirements and frequencies for both materials and process for inclusion in producers' FPC systems;
- a set of rules for dealing with specific aspects of identified nonconformity;
- a normative Annex dealing with tolerances and test frequencies for use in assessment of conformity through compositional analysis of mixtures;

- a normative Annex dealing with the duties of bodies involved in the audit and surveillance of FPC systems;
- an informative Annex giving general background guidance on evaluation of conformity; and
- an informative Annex with provisions for testing of a limited range of mixture properties.

The FPC system specified in BS EN 13108-21:2006, Clause **4** to Clause **10** is a schedule for the system the asphalt producer should operate and document. It is very similar to the UK *National Highways Sector Schemes for Quality Management in Highway Works 14* [3], which has been in use for some time. The schedule interprets the fundamental requirements of BS EN ISO 9001 and makes them specific to the production and despatch of hot asphalt mixtures. It is, however, narrower in scope than BS EN ISO 9001 as it covers only the production processes and excludes requirements specifically applicable to the customer. Therefore, areas such as complaints, contract review and continual improvement should not be included in the FPC requirements.

NOTE 1 The interaction between FPC, CE marking and National Highways Sector Schemes for Quality Management in Highway Works 14 [3] is within the remit of the sector scheme committee, and guidance on any transition or changes can be obtained from the NHSS liaison committee and/or certification and notified bodies.

The product-type testing procedure should be repeated as part of FPC at not greater than five-year intervals.

NOTE 2 For the application of CE marking to asphalt production, the producer's FPC system is subject to initial inspection and continuous surveillance (audit) by a third-party notified body.

14.3.2 Factory production control schedule requirements (BS EN 13108-21:2006, Clause 4 to Clause 10)

BS EN 13108-21:2006 Clause **4** to Clause **10** specify the elements that should be included in a producer's FPC system.

A key difference in principle is to be found in BS EN 13108-21:2006, **4.1**. The Construction Products Regulation [1] and CE marking mean that it cannot be made obligatory for producers to operate BS EN ISO 9001 quality systems. The FPC requirements are, therefore, drafted so that they can be stand-alone, dealing only with the practical aspects of production and conformity, rather than the broader scope of customer relations and improvement which are covered by BS EN ISO 9001. Notwithstanding this, a producer required to have an FPC system might be required to operate a BS EN ISO 9001 quality management system to include the specific requirements of BS EN 13108-21, and those for CE marking.

14.3.3 Tolerances and test frequencies for finished asphalt (BS EN 13108-21:2006, Annex A)

*COMMENTARY ON **14.3.3***
BS EN 13108-21:2006, Annex A specifies the rules for the assessment of conformity based on compositional analysis and the required responses to compositional nonconformity within the FPC system. This system is used to measure and monitor the OCL for the asphalt production plant.

14.3.3.1 Target composition

BS EN 13108-1 to BS EN 13108-7 (inclusive) require the producer to declares a target composition for each mixture. This should be given as the result of type-testing and is a single value for the percentage that passes each relevant sieve and a single soluble binder content.

14.3.3.2 Tolerances

In BS EN 13108-21 tolerances are specified that should be applied to the target composition. Different tolerances apply to different mixture types and are given in BS EN 13108-21:2006, Table A.1.

14.3.3.3 Compliance specification

Application of the appropriate tolerances about the target composition gives an envelope to be used in the assessment of the conformity of individual test results. This test result conformity is then used in a statistically based system to assess the conformity of production.

14.3.3.4 Conformity of individual results or "means of four"

NOTE 1 The FPC standard provides two approaches to the assessment of conformity. Test results can be considered either individually or by taking the means of four consecutive results on the same material. The two approaches are not interchangeable and a choice has to be made about which is to be adopted.

The FPC standard system that should be used is the single result approach.

NOTE 2 The "mean of four" approach, which is in general use in France, can also be used but in a limited way to ensure the targeting of EME2 mixtures is close to the design values.

14.3.3.5 Consideration of the last 32 results

For the determination of the conformity of production it is necessary to consider the last 32 results from the plant. This ensures a reasonable degree of statistical significance.

14.3.3.6 Mean deviation from target

BS EN 13108-21 incorporates an additional measure in the determination of conformity. It is a requirement to monitor, on an ongoing basis, the mean deviation of key analysis parameters from target. This is intended to ensure that mixtures are initially targeted and thereafter maintained at the target composition during the production process.

For each analysis result, the deviation from the declared target is calculated for the sieves *D*, the characteristic coarse sieve (sieve closest to *D*/2), 2 mm, 0,063 mm and the soluble binder content. In the same way that the tolerances are applied, the permitted deviations are related to the type of material and the nominal size (*D*) of the aggregate. The permitted mean deviation values are contained in Table 5 (see also BS EN 13108-21:2006, Table A.1). These mean deviations should be recorded and analyzed separately for each of the material groups identified in Table 5.

For clarification, the deviation is signed, i.e. if a deviation of +1 is followed by a deviation of –1, the mean deviation (bias) is zero.

Table 5 **Permitted mean deviations from target (extracted from BS EN 13108-21:2006, Table A.1)**

Percentage passing	Individual samples Permitted mean deviation from target			
	Asphalts other than HRA		HRAs	
	$D < 16$ mm	$D \geq 16$ mm	$D < 16$ mm	$D \geq 16$ mm
D	±4	±5	±4	±5
D/2 or characteristic coarse sieve	±4	±4	±3	±4
2 mm	±3	±3	±2	±3
0,063 mm	±1	±2	±2	±2
Soluble binder content	±0,3	±0,3	±0,25	±0,3

NOTE Only the sieves in Table 5 are used in the assessment of the mean deviation from target. Falling outside these permitted deviations constitutes non-conforming product and requires action in accordance with the FPC system.

14.3.3.7 Operating compliance level (OCL)

BS EN 13108-21 works on the principle of varying the test frequency in response to the level of conformity of the mixtures produced. The OCL is based on the number of non-conforming results from the previous 32 and is derived from BS EN 13108-21:2006, Table A.2, as indicated in Table 6 for single results.

Table 6 **Determination of operating compliance level of plant for single results (extracted from BS EN 13108-21:2006, Table A.2)**

Number of tests in previous 32 not conforming	OCL
0–2	A
3–6	B
> 6	C

Additionally, if any of the mean deviations from target is outside the permitted limits, the OCL is marked down by one level (e.g. from A to B), requiring an increased test frequency.

14.3.3.8 Required test frequency

NOTE A degree of risk limitation is introduced by linking test frequency to the OCL. The minimum test frequency to be used in FPC is dependent on the OCL, as indicated in Table 7 (see also BS EN 13108-21:2006, Table A.3). There are three "levels": X, Y and Z. The lowest level, Z, is the minimum level required for CE marking. Level X and level Y are optional levels giving higher test frequencies which may be called up in contracts.

Level X for surface courses and Level Y for binder course and base should be used.

Table 7 **Minimum frequency for analysis of finished product (tonnes/test) (extracted from BS EN 13108-21:2006, Table A.3)**

Level	OCL A	OCL B	OCL C
X	600	300	150
Y	1 000	500	250
Z	2 000	1 000	500

14.3.3.9 Nonconformity action trigger

In the event that more than eight of the previous 32 results are found to be non-conforming, BS EN 13108-21 requires the plant should be subject to an immediate and comprehensive review to determine the corrective and preventive action.

14.3.4 Worked example of the application of tolerances to declared target gradings and binder content

The examples in this subclause indicate how tolerances are applied to target compositions within the BS EN 13108-21 FPC system.

The extract from BS EN 13108-21:2006, Table A.1 is reproduced here as Table 8, and defines the tolerances to be applied to the declared target grading values selected for each of the sieves and the soluble target binder content extracted and/or calculated from the tables in Annex B, Annex C and Annex D.

Table 8 **Tolerances to be applied to the declared target grading and binder content (extracted from BS EN 13108-21:2006, Table A.1)**

Percentage passing	**Individual samples** **Tolerance about target composition**			
	All asphalts other than HRA (%)		HRAs (%)	
	D < 16 mm	*D* ≥ 16 mm	*D* < 16 mm	*D* ≥ 16 mm
1,4*D* (100) [A)]	0 [A)] –2	0 [A)] –2	0 [A)] –2	0 [A)] –2
D	+5 –8	+5 –9	+5 –8	+5 –9
D/2 or Characteristic coarse sieve [B)]	±7	±9	±7	±9
2 mm	±6	±7	±5	±7
Characteristic fine sieve	±4	±5	±4 [C)]	±5
0,063 mm	±2	±3	±2	±3
Soluble binder content	±0,5	±0,6	±0,6	±0,6 [D)]

[A)] The content in this cell has been added to the Table for completeness. (It was originally a Note in BS EN 13108-21:2006, Table A.1).

[B)] This D/2 sieve is not appropriate for all mixes. Alternatively, for each product a sieve size might be indicated in the product standard which is of particular importance in characterizing the material.

[C)] For HRA mixtures with *D* = 4 mm and below, the tolerance to the characteristic fine sieve is ±10. For each asphalt mixture an appropriate characteristic coarse sieve size has been selected and applied to all the mixtures identified within the tables in Annex B, Annex C and Annex D.

[D)] The soluble binder content tolerance for coated chippings applied to hot rolled asphalt is ±0,3.

NOTE For HRA mixtures with D less than 16 and greater than 4 the tolerance to the characteristic fine sieve has been recognized as a typographical error and might be corrected to ±8 in the next revision of BS EN 13108-21.

The tolerances that should be applied depend on two criteria: the nominal size (*D*) and the type of mixture.

NOTE All asphalt mixtures, excluding HRA and mastic asphalt (mastic asphalt is not covered in this Published Document) are covered under two groupings:

- *Group 1:Large aggregate mixes where D > 16 mm, covering the 32 mm and 20 mm nominal sized mixtures.*
- *Group 2:Small aggregate mixes where D < 16 mm, covering the 14 mm, 10 mm, 6 mm, 4 mm and 2 mm nominal (D) sized mixtures.*

HRAs are split into these two sub groups where the large aggregate sub group has D that is > 16 mm and the small aggregate sub group has D that is < 16 mm. The nominal (D) sizes covered by each sub group are the same as for the asphalts.

For the purposes of the assessment of conformity, there are three groups of asphalt mixes: Group 1, Group 2 and Group 3 which brings together the two sub-groups for HRA.

14.3.5 Application of tolerances to sieves and soluble binder contents

*COMMENTARY ON **14.3.5***
BS EN 13108-21:2006, Table A.1, defines the assessment of conformity using two separate systems:

- *conformity of the individual samples; and*
- *conformity of the mean of four samples.*

In BS EN 13108-21:2006, Table A.1 the "individual sample" system [a)] should be applied, and this has been used in the examples in Table 9, Table 10 and Table 11 of this Published Document. These demonstrate the process of selecting target grading from the tables in Annex B and Annex C which, on completion of product-type testing, become the declared target gradings, and after applying the appropriate tolerances, form the conformity specification.

NOTE The example declared target grading and binder values in Table 9, Table 10 and Table 11 have been selected solely to demonstrate how the process works and are not recommended values for the mixtures concerned.

Table 9 **Example of a declared specification AC 32 HDM base 40/60 rec**

Test sieve	**Sieve designation**	**Target composition (Table B.11 of this Published Document)**	**Declared target grading/binder**	**Tolerances from BS EN 13108-21:2006, Table C.1 (Table 8 of this Published Document)**	**Conformity specification**
mm		%	%	%	%
40	1,4*D*	100 [A)]	100	0 –2	98–100
31,5	*D*	99–100	99	+5 –9	90–100
20	Characteristic coarse sieve	80–86	82	±9	73–91
6,3	Optional extra coarse sieve	52	52	±9 [A)]	— [A)]
2	2 mm	27–33	28	±7	21–35
0,250	Characteristic fine sieve	11–15	12	±5	7–17
0,063	0,063 mm	8,0	8,0	±3	5,0–11,0
Binder B_{act} (limestone aggregate)	—	4,0	4,0	±0,6	3,4–4,6

[A)] There is no requirement in BS EN 13108-21 to apply a conformity tolerance to an extra coarse or fine aggregate sieve. However, to monitor mixture consistency it could be appropriate to apply the same tolerance as that applied to the characteristic coarse or fine sieve.

Table 10 **Example of a declared specification AC 6 dense surf 160/220 PSV 60**

Test sieve mm	**Sieve designation**	**Target composition (Table B.16 of this Published Document)** %	**Declared target grading/binder** %	**Tolerances from BS EN 13108-21:2006, Table C.1 (Table 8 of this Published Document)** mm	**Conformity specification** %
10	1,4*D*	100	100	0 –2	98–100
6,3	*D*	98	98	+5 –8	90–100
—	Characteristic coarse sieve	—	—	±7	—
2	2 mm	42–56	51	±6	45–57
1	Optional extra coarse sieve)	24–46	40	±4 [A)]	— [A)]
0,250	Characteristic fine sieve	11–19	16	±4	12–20
0,063	0,063 mm	4,0–8,0	6	±2	4,0–8,0
Binder B_{act} (crushed rock aggregate)	—	6,2	6,2	±0,5	5,7–6,7

[A)] There is no requirement in BS EN 13108-21 to apply a conformity tolerance to an extra coarse or fine aggregate sieve. However, to monitor mixture consistency it could be appropriate to apply the same tolerance as that applied to the characteristic coarse or fine sieve.

14.3.6 BS EN 13108-21:2006, Annex D, additional testing of mixture characteristics

14.3.6.1 General

NOTE 1 The system of factory FPC in BS EN 13108-21 is based on the principle of controlling constituent materials, process and mixture composition to replicate consistently the formulations validated in product-type testing. It does not include in the normative part of the standard any requirement to monitor physical or mechanical properties of mixtures. BS EN 13108-21:2006, Annex D provides a method for limited testing of the finished product for the following properties:

- *void content;*

  NOTE 2 Where void content is a requirement, this is subject to monitoring within contracts.

- *properties of recovered binder (when incorporating RA); and*
- *indentation of cubes (for mastic asphalt).*

NOTE 3 Mastic asphalt is outside the scope of this guidance document so there is no specific guidance on these two aspects given in this Published Document.

Testing should be carried out in accordance with **14.3.6.2** of this Published Document where more than 10% of reclaimed asphalt is included in mixture formulations.

Table 11 **Example of a declared specification HRA 35/14F surf 40/60 des**

Test sieve	Sieve designation	Target composition (Table C.2A, Column 10 of this Published Document)	Declared target grading/binder	Tolerances from BS EN 13108-21:2006, Table C.1 (Table 8 of this Published Document)	Conformity specification
mm		%	%	mm	%
20	1,4*D*	100	100	0 –2	98–100
14	*D*	95–100	97	+5 –8	89–100
10	Characteristic coarse sieve	62–81	70	±7	63–77
2	2 mm	61	61	±5	56–66
0,5	Optional extra fine sieve	44–63	50	±4 [A)]	—
0,250	Characteristic fine sieve	16–46	40	±4	36–44
0,063	0,063 mm	8,0	8,0	±2	6,0–10,0
Binder B_{act}	—	6,4 [B)]	7,6 [C)]	±0,6	7,0–8,2

A) There is no requirement in BS EN 13108-21 to apply a conformity tolerance to an extra coarse or fine aggregate sieve. However, to monitor mixture consistency it could be appropriate to apply the same tolerance as that applied to the characteristic coarse or fine sieve.

B) This is a design mix, so the binder content in Annex C should be used as the minimum for a design mixture. If this was a recipe mixture this would be the recommended declared target binder.

C) This is the declared target binder content obtained principally from the Marshall mixture design protocol in BS 594987 and should be validated by any additional product-type testing prior to declaration.

14.3.6.2 Testing of recovered binder from mixtures containing reclaimed asphalt

When more than 10% of RA is being incorporated in mixtures, samples of the plant-mixed material should be taken at a frequency not less than once per 10 000 tonnes of mixed asphalt, and bitumen should be recovered from the samples in accordance with BS EN 12697-3 and tested for penetration in accordance with BS EN 1426 (BS 2000-49).

For mixtures incorporating paving grade bitumen, the penetration value of the recovered binder should not be not higher than the upper limit of the nominal grade of the mixture and not lower than the lower limit of the next harder grade (see Table 12).

Table 12 **Next harder grades for recovered binder assessment**

Nominal grade for mixture (dmm)	Next harder grade (dmm)
160/220	100/150
100/150	70/100
70/100	40/60
40/60	30/45
30/45	15/25

Annex A BS EN 13108 mixture specifications

The importance of the mixture specifications in BS EN 13108 is shown in Table A.1.

Table A.1 **Importance of mixture specifications**

BS EN 13108 Part number	Mixture specifications	Relevance to the UK
1	Asphalt concrete	Major importance, includes DBM and HDM.
2	Asphalt concrete for very thin layers	Important but in practice thin surfacings are dealt with by the contract specification.
3	Soft asphalt	No relevance, soft asphalt is not used in the UK.
4	Hot rolled asphalt	Major importance, covers all HRA.
5	Stone mastic asphalt	Important, includes SMA surface course and binder course.
6	Mastic asphalt	Important, but is outside the scope of this Published Document.
7	Porous asphalt	Limited relevance.

Annex B BS EN 13108-1 asphalt concrete – example specification

Figure B.1 in this Annex contains an example specification which gives the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1.

NOTE In Figure B.1 the word "shall" is used only to identify example requirements.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1**

B.1 General

Asphalt concrete mixtures shall conform to BS EN 13108-1. Conformity shall be established in accordance with BS EN 13108-20 and BS EN 13108-21.

B.2 Constituent materials

B.2.1 Binder

The binder shall be paving grade bitumen conforming to BS EN 12591:2009, polymer modified bitumen conforming to BS EN 14023:2010 or hard paving grade bitumen conforming to BS EN 13924:2006.

B.2.2 Bitumen

B.2.2.1 Paving grades

The preferred paving grades for asphalt concrete are 30/45, 40/60, 70/100, 100/150, 160/220 and 250/330.

NOTE 1 70/100 and 100/150 pen paving grade bitumen may be produced by blending in the mixer at the asphalt plant.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

The grades used for blending shall be not harder than 30/45 pen or 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 bitumen. 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 bitumen 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 2 Other grades may be in-plant blended provided that the resulting bitumen can be sampled and tested before it is added to the aggregate to ensure it conforms to BS EN 12591.

*NOTE 3 The grades of binders recommended here are suitable for machine-laid materials. For hand-laid mixtures and for deferred set and depot stock mixes, petroleum bitumen conforming to BS EN 12591:2009, Table 1, Grade 160/220 or 250/330 pen, to which a flux oil conforming to the requirements shown in **B.2.3** has been added, should be used.*

B.2.2.2 Polymer modified bitumen

Selection of an appropriate polymer modified bitumen shall be agreed between the supplier and user.

B.2.2.3 Hard paving grades

The preferred hard paving grade bitumen for EME2 mixtures shall be 10/20 and 15/25.

NOTE See BS EN 13924:2006 and its National Foreword for guidance on the selection of optional properties for the specification of hard grade binders in EME2 mixtures.

B.2.3 Fluxing of hand-laid materials

NOTE 1 The workability of mixtures for immediate hand laying may be enhanced by the addition of a flux to the mixture at the mixing plant. In some situations this might render the as-laid materials susceptible to early-life damage. 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 might result in the risk of a surface course with relatively poor resistance to marking which might be prone to serious damage from heavy point loads, power-steered vehicles and severe vehicle use.

The flux shall have the following characteristics:

- Distillation when tested in accordance with BS EN ISO 3405;
- 10% recovered, 150 °C min; and
- 90% recovered, 350 °C max.

NOTE 2 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, which might otherwise remain deformable for an unacceptably long time. The producer's guidance may be sought if necessary.

The addition of the flux shall not result in fluxed bitumen with a penetration value at 25 °C greater than 400 dmm.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

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

No flux shall be used in the production of dense base and dense binder course.

Fluxed mixtures shall be clearly identified on delivery notes by including the letter F in the mixture description, e.g. AC 6 med surf 160/220 F.

Deferred set and depot stock mixtures are intended to be workable at ambient temperature and are only suitable for use in temporary works or minor repairs.

NOTE 4 Due to the low viscosity of the binder, these mixtures are outside the scope of BS EN13108-1.

Deferred set and depot stock mixtures shall be clearly identified on delivery notes by including the letters DS in the mixture description, e.g. AC 6 med surf DS.

NOTE 5 If the intention is for these mixtures to harden or set, a flux with a proportion of volatile oil is often used.

NOTE 6 Proprietary binders are available for this purpose but are outside the scope of PD 6691.

B.2.4 Aggregates

B.2.4.1 Coarse aggregate

B.2.4.1.1 Type of coarse aggregate

Coarse aggregate shall be material substantially retained on a 2 mm test sieve, conforming to all appropriate requirements of BS EN 13043, and consisting 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 cement shall be used as a filler;

c) Blast furnace slag of known density. The compacted density of blast furnace slag is determined in accordance with BS 812-2. The sample to be tested is previously dried to constant mass at (105 ±5) °C. The test is conducted on material passing a 14 mm test sieve and retained on a 10 mm test sieve; and

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.

For EME2 mixtures, only crushed rock or steel slag shall be used.

B.2.4.1.2 Particle shape

The flakiness category for aggregates for all asphalt concrete mixtures shall be FI_{35} except that for BBA mixtures, it shall be FI_{25}.

B.2.4.1.3 Fines content

The fines content for coarse aggregates shall be:

a) for crushed rock/slag: f_{NR}; and

b) for gravel: f_1.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

NOTE 1 PD 6691 does not cover 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 European aggregate test methods and those previously used in the UK can be found in PD 6682-2; specification shall be in terms of the categories recommended in PD 6682-2.

Where there is a requirement specified for AAV and/or PSV for the coarse aggregate component of the mixture, the values shall apply to the aggregate proportion retained on the 4 mm sieve.

NOTE 2 The use of 2% by mass of the total aggregate of hydrated lime or cement filler reduces the risk of water stripping the binder from some aggregates, in particular flint gravel. This might 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 items a) and b) might be suitable for asphalt concrete, but are outside the scope of PD 6691.

B.2.4.2 Fine aggregate

B.2.4.2.1 Type of fine aggregate

The fine aggregate shall 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 **B.2.4.1.1**;

b) sand; or

c) a mixture of a) and b).

B.2.4.2.2 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.

B.2.4.2.3 Aggregates for BBA mixtures

*COMMENTARY ON **B.2.4.2.3***
The aggregate characteristics are particularly important for the design and performance of BBA mixtures.

The required characteristics of aggregates that shall be used in BBA mixtures are:

a) The combination of categories of resistance to fragmentation and wear shall include LA_{20} and $M_{DE}15$, LA_{25} and $M_{DE}20$, and LA_{30} and $M_{DE}25$;

NOTE The combination of LA_{20} and $M_{DE}15$ is applicable to surface course and LA_{30} and $M_{DE}25$ is applicable to binder course. LA_{25} and $M_{DE}20$ is applicable to both surface and binder course. Maximum compensation of 5 points between fragmentation and wear characteristics may be applied in certain circumstances; for example, LA_{30} is only acceptable for surface course if aggregate has corresponding $M_{DE}15$.

b) The percentage of crushed or broken particles in coarse aggregate for surface course shall be C95/1;

c) The fines content of coarse aggregate shall be $f_{1;}$

d) The flakiness shall be F_{25};

e) The angularity of fine aggregate for surface course shall be $E_{cs}35$ or $E_{cs}38$;

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

f) The quality of fines in fine aggregate shall be MB_F10.

g) Selection of appropriate PSV values is determined by the end-use.

B.2.4.3 Added filler

If added filler is used in dense, close graded, open graded and fine graded mixtures it shall consist of crushed rock, crushed slag, hydrated lime, cement or other material approved by the specifier.

If added filler is used in EME2 or BBA mixtures it shall be limestone, hydrated lime or cement. 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**.

For added filler used in EME2 and BBA mixtures the stiffening properties in accordance with BS EN 13043:2002, **5.3.3** shall be category $\Delta_{R\&B}$ 8/16.

NOTE Fillers with Delta Ring and Ball values above 16 but not greater than 20 may be used where there is a history of satisfactory use in asphalt.

For all other properties specified in BS EN 13043:2002, Clause **5**, the "no requirement" category shall be used.

B.2.4.4 Reclaimed asphalt (RA)

Where RA is to be used in asphalt concrete mixtures the following requirements shall apply.

a) All RA shall be classified in accordance with BS EN 13108-8.

b) The RA shall conform to the following categories:

1) foreign matter – category F_5;

2) binder properties, for additions greater than 20% of mixture – category P_{15}

NOTE 1 P_{15} is a general case, but reliable and consistent feedstocks of harder reclaimed materials might make them suitable for use, by agreement with the client.

In accordance with BS EN 13108-1:2006, **4.4**, unless otherwise indicated, the amount of RA added to the mixture shall not exceed the following:

- surface courses, 10%;
- all other materials, 50%.

Where, in accordance with BS EN 13108-1:2006, **4.2.2.2** or **4.2.2.3**, the level of RA addition requires the determination of combined binder properties, the penetration method shall be adopted.

NOTE 2 These limitations represent the current UK practice. There might be circumstances where it is appropriate not to permit the inclusion of RA or where higher percentage additions are acceptable. This may be done using the general provisions of BS EN 13108-1 on a case-by-case basis.

Proposals to incorporate RA in BBA mixtures shall be referred to the specifier.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.2.4.5 Additives

*COMMENTARY ON **B.2.4.5***
Additives permitted for inclusion may include fibres, pigments, adhesion agents and flux oil.

The suitability of such additives shall be demonstrated in accordance with BS EN 13108-1:2006, **4.1**.

*NOTE Specific guidance on the use of flux oil is given in **B.2.3**.*

B.3 Mixture specifications

B.3.1 Binder content

*NOTE 1 For the binder content reference should be made to **6.2.3.3** concerning the selection and correction of the binder content based on the mean particle density of the aggregate used in the mixture.*

NOTE 2 The binder content categories in BS EN 13108 involve a correction for the density of the aggregate in the mix. The principle is that the binder content category in the standard is based on an aggregate density in the mixture of 2,650 Mg/m^3. If the aggregate is denser than 2,650 Mg/m^3 the actual binder content in the mixture is reduced proportionally or if the aggregate is less dense it is increased. This has the intention of giving the same binder volume in mixtures regardless of aggregate density. However, a consideration of UK mixtures and aggregates indicates that this approach could be detrimental, as some of the more dense aggregates in practice needed higher binder contents for durability. For this reason, the binder contents in the example specifications in this guidance document are those which are required as actual soluble binder contents on analysis of the finished mixture, with no density correction. These are referenced as B_{act}.

NOTE 3 For the purposes of CE marking, these actual binder contents need to be corrected back to determine the B_{min} as is defined in BS EN 13108.

To convert the B_{act} target values within PD 6691 back to a B_{min} declared value from BS EN 13108-1 to BS EN 13108-7 (inclusive), the following formula shall be used:

$$B_{\text{min declared}} = \frac{\rho_b \times B_{act}}{2{,}650} \quad \text{(B.1)}$$

where:

ρ_b is the mean particle density of the aggregate mixture, in Mg/m^3, determined in accordance with BS EN 1097-6.

*NOTE 4 The mean particle density of the aggregate mixture should be calculated as the weighted mean of the apparent particle densities of the coarse and fine aggregate particle size fractions as described in **6.2.3.3**.*

The B_{min} declared value calculated from this formula shall be in divisions of 0,2. A B_{min} declared value of 0,1 division, such as 5,3%, shall be rounded down to the nearest 0,2 value, i.e. 5,2%.

B.3.2 Designed base mixtures

*COMMENTARY ON **B.3.2***
These mixtures include asphalt concrete base incorporating paving grade binders 160/220, 100/150, 70/100, 40/60 and 30/45.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.2.1 Aggregate grading

The aggregate grading of the target composition shall fall within the envelope given in Table B.1. 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 or vice versa.

Table B.1 **Aggregate grading target limits for 32 mm designed dense/HDM/HMB base mixtures (AC 32 dense/HDM/HMB base XX/YY des)**

Test sieve aperture size mm	**% by mass passing**
40	100
31,5	90–100
20	71–95
6,3	44–60
2	20–40
0,250	6–20
0,063 dense and HMB	2,0–9,0
0,063 HDM	7,0–11,0

B.3.2.2 Binder content

Binder shall conform to BS EN 12591, with the grade as indicated in Table B.2.

Table B.2 **Binder grades for design base and binder course mixtures**

160/220
100/150
70/100
40/60
30/45

The binder content of the target composition shall conform to Table B.3.

Table B.3 **Minimum target binder content for designed dense base mixtures**

Aggregate type	**Minimum target binder content** B_{act}
Limestone	3,8
Basalt	3,9
Other crushed rock	3,8
Blast furnace slag of bulk density in Mg/m^3	
1,44	4,2
1,36	4,6
1,28	5,0
1,20	5,6
1,12	6,0
Steel slag	3,8
Gravel	4,2

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.2.3 Void content

The void content of the mixture at target composition shall be determined from cores taken from a full-scale trial strip not less than 30 m long, and laid and compacted with full-scale plant. This trial and the sampling and testing protocol shall be in accordance with BS 594987:2015, Annex C.

The average void content category of core pairs shall be $V_{max\ 7}$.

The average void content category of sets of six cores compacted to refusal shall be $V_{min0,5}$.

B.3.2.4 Resistance to permanent deformation

If required, the resistance to permanent deformation at target composition shall be determined from tests with the small wheel tracking device on 200 mm diameter core specimens taken from a full-scale trial strip not less than 30 m long, and laid and compacted with full-scale plant. This trial and the sampling and testing protocol shall be in accordance with BS 594987:2015, Annex D.

The mean value of six core specimens shall conform to one of the categories in Table B.4.

Table B.4 **Limiting wheel tracking requirements for site classifications**

Classification		**Test temperature**	**Category WTS_{AIR}**	**Category PRD_{AIR}**
		Test method	**BS EN 12697-22:2003, small device**	**BS EN 12697-22:2003, small device**
No.	Description	°C	**Wheel track slope** mm/1 000 cycles	**Maximum proportional rut depth** %
1	Moderate to heavily stressed sites requiring high rut resistance	45	$WTS_{AIR\ 1,0}$	$PRD_{AIR\ 9,0}$
2	Very heavily stressed sites requiring very high rut resistance	60	$WTS_{AIR\ 1,0}$	$PRD_{AIR\ NR}$
3	Other sites	—	$WTS_{AIR\ NR}$	$PRD_{AIR\ NR}$

NOTE Classification 2 is intended for normal highway traffic. For very slow moving/stationary traffic in bus lanes, bus stops, major stop lines, docks and airport taxiways and stands, an enhanced deformation resistance might be necessary.

B.3.3 Designed binder course mixtures

B.3.3.1 General

These mixtures include asphalt concrete binder courses incorporating paving grade bitumen 160/220, 100/150, 70/100, 40/60 and 30/45.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.3.2 Aggregate grading

The aggregate grading of the target composition shall fall within the appropriate envelope given in Table B.5 and Table B.6. 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 or vice versa.

Table B.5 **Aggregate grading target limits for 32 mm designed dense/HDM/HMB binder course mixtures (AC 32 dense/HDM/HMB bin XX/YY des)**

Test sieve aperture size Mm	**% by mass passing**
40	100
31,5	90–100
20	71–95
6,3	44–60
2	20–40
0,250	6–20
0,063 dense and HMB	2,0–9,0
0,063 HDM	7,0–11,0

Table B.6 **Aggregate grading target limits for 20 mm designed dense/HDM/HMB binder course mixtures (AC 20 dense/HDM/HMB bin XX/YY des)**

Test sieve aperture size mm	**% by mass passing**
31,5	100
20	95–100
14	65–85
6,3	38–56
2	20–40
0,250	6–20
0,063 dense and HMB	2,0–9,0
0,063 HDM	7,0–11,0

B.3.3.3 Binder content

The binder content of the target composition shall conform to Table B.7. Binder shall conform to BS EN 12591 with grade as indicated in **B.3.2.2**.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

Table B.7 **Minimum target binder content for designed binder course mixtures**

Aggregate type	Minimum target binder content B_{act}
Limestone	4,2
Basalt	4,2
Other crushed rock	4,2
Blast furnace slag of bulk density in Mg/m^3	
1,44	4,4
1,36	4,8
1,28	5,2
1,20	6,0
1,12	6,4
Steel slag	4,0
Gravel	4,4

B.3.3.4 Void content

The void content of the mixture at target composition shall be determined from cores taken from a full-scale trial strip not less than 30 m long, and laid and compacted with full-scale plant. This trial and the sampling and testing protocol shall be in accordance with BS 594987:2015, Annex C.

The average void content category of core pairs shall be $V_{max\ 7}$.

The average void content category of sets of six cores compacted to refusal shall be $V_{min\ 0,5}$.

B.3.3.5 Resistance to permanent deformation

If required, the resistance to permanent deformation at target composition shall be determined from tests with the small wheel tracking device on 200 mm diameter core specimens taken from a full-scale trial strip not less than 30 m long, and laid and compacted with full-scale plant. This trial and the sampling and testing protocol shall be in accordance with BS 594987:2015, Annex D.

The mean value of six core specimens shall conform to one of the categories in Table B.5.

B.3.4 EME2 mixtures

B.3.4.1 Aggregate grading

The aggregate grading of the target composition shall fall within the envelope given in Table B.8. 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, or vice versa.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

Table B.8 **Aggregate grading target limits for 20 mm, 14 mm and 10 mm EME2 mixtures (AC 20/14/10 EME2 base/bin XX/YY des)**

Test sieve aperture size mm	AC 20 EME2	AC 14 EME2	AC 10 EME2
31,5	100	—	—
20	90–99	100	—
14	70–95	90–99	100
10	55–90	—	90–99
6,3	42–75	42–65	60–80
4	—	—	35–65
2	18–35	19–42	27–42
0,250	8–18	8–18	8–18
0,063	5,0–9,0	5,0–9,0	5,0–9,0

B.3.4.2 Binder content

The binder content of the target composition shall conform to Table B.9 and BS 594987:2015, Annex E. Binder shall conform to BS EN 13924 grade 10/20 or 15/25.

Table B.9 **Minimum target binder content, B_{act}**

Mixture type B_{act}	Minimum target binder content
AC 10 EME2	5,5
AC 14 EME2	5,3
AC 20 EME2	5,1

B.3.4.3 Void content

The void content of specimens of EME2 mixtures at target composition prepared in the laboratory in accordance with BS EN 12697-35 and compacted in the gyratory compactor in accordance with BS EN 12697-31, using the appropriate number of gyrations from Table B.10 shall be $V_{max\ 6,0}$.

Table B.10 **Number of gyrations**

Mixture type	Number of gyrations
AC 10 EME2	80
AC 14 EME2	100
AC 20 EME2	120

The void content of specimens of EME2 mixtures at target composition shall also be determined from cores taken from a full-scale trial strip not less than 30 m long, and laid and compacted with full-scale plant.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

This trial and the sampling and testing protocol shall be in accordance with BS 594987:2015, Annex E. The average void content category of core pairs shall be $V_{max\ 6,0}$.

B.3.4.4 Water sensitivity

For EME2 mixtures, when tested in accordance with BS EN 12697-12:2008, Method B, the retained strength of specimens manufactured at target composition shall not be less than 75%.

B.3.4.5 Deformation resistance

The deformation resistance of the mixture at target composition, tested in accordance with the large wheel tracking test in BS EN 12697-22:2003, large device, shall conform to category $P_{7,5}$.

NOTE Testing of materials on the large wheel tracking device requires the preparation of test specimens (slabs), compacted in accordance with BS EN 12697-33. This method permits the test laboratory to establish a roller compaction pattern, which is symmetrical, in order to satisfy the air void requirement.

For EME2, the target void content shall be 4,5%, with compaction of the slabs deemed to be acceptable for wheel tracking testing if the void content v, $3\% < v < 6\%$, when determined in accordance with BS EN 12697-8, BS EN 12697-6:2003, **9.2**, procedure A, bulk density – dry, and BS EN 12697-5.

B.3.4.6 Stiffness modulus

The mean ITSM, determined from cores taken from a full-scale trial strip not less than 30 m long, and laid and compacted with full-scale plant, shall conform to category $S_{min5500}$. This trial and the sampling and testing protocol shall be in accordance with BS 594987:2015, Annex E.

NOTE As experience is gained with these mixtures it might prove possible to achieve higher ITSM values. In this event, a higher minimum value may be used, which could justify a higher design stiffness for use in analytical pavement designs.

B.3.4.7 Fatigue properties

For EME2 mixtures with a richness modulus as defined in BS 594987:2015, Annex E, equal to or greater than 3,6, resistance to fatigue shall be $\varepsilon_{6\text{-NR}}$.

If resistance to fatigue is of particular importance it shall be specified as follows.

The resistance to fatigue of specimens prepared in accordance with BS EN 13108-20:2006, **6.4**, and tested in accordance with BS EN 12697-24:2012, Annex A (2PB-TZ, microstrain for 10^6 cycles at 10 °C and 25 Hz), shall conform to category $\varepsilon_{6\text{-}130}$.

The compaction of test specimens shall be selected from BS EN 13108-20:2006, Table C.1. The void content of the specimens shall be between 3,0% and 5,0%.

NOTE The French fatigue test is very lengthy and not generally available in the UK. Alternative fatigue methods might be practical and, as such are likely to be more widely available. Consideration of alternative fatigue data as equivalent, where a correlation with 2 PB-TZ test output is provided, may be given. EME2 is a very binder-rich mixture and the default category $\varepsilon_{-6\text{-}130}$ should be assumed without the need for fatigue testing. Enhanced fatigue performance may be achieved by ensuring a slightly richer mixture by specifying a slightly higher value for richness modulus.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.4.8 Recipe dense base and binder course

B.3.4.8.1 General

These mixtures shall include asphalt concrete base and binder courses incorporating paving grade binders 160/220, 100/150, 70/100 and 40/60.

B.3.4.8.2 Aggregate grading and binder content

The aggregate grading and binder content at the target composition shall fall within the appropriate envelope given in Table B.11. Binder shall conform to BS EN 12591, with the grade as indicated in **B.3.2.2**.

Table B.11 **Target limits for composition for recipe dense base and binder course mixtures (AC D dense/HDM base/bin XX/YY rec)**

Mixture description	**AC 32 dense base**	**AC 32 dense bin**	**AC 20 dense bin**
Test sieve aperture size mm	**% by mass passing**	**% by mass passing**	**% by mass passing**
40	100	100	—
31,5	99–100	99–100	100
20	80–86	80–86	99–100
10	—	—	61–63
6,3	52	52	47
2	27–33	27–33	27–33
0,250	11–15	11–15	11–15
0,063 dense	6,0	6,0	6,0
0,063 HDM	8,0	8,0	8,0
Aggregate type	**Binder content B_{act}**		
Limestone	4,0	4,6	4,6
Basalt	4,0	4,7	4,7
Other crushed rock	3,9	4,6	4,6
Blast furnace slag of bulk density in Mg/m^3			
1,44	4,4	5,4	5,4
1,36	4,8	5,8	5,8
1,28	5,2	6,2	6,2
1,20	5,8	6,6	6,6
1,12	6,2	7,0	7,0
Steel slag	4,0	4,2	4,2
Gravel	4,4	5,0	5,0

NOTE The specified binder content, B_{act}, is both minimum and maximum binder content for categorization purposes.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.4.9 Open graded binder course

The aggregate grading of the target composition shall fall within the appropriate envelope given in Table B.12. The binder content of the target composition shall conform to Table B.12.

The binder shall conform to BS EN 12591:2009 paving grade 160/220 or 250/330.

Table B.12 **Target limits for composition for open graded binder course mixtures [AC D open bin XX/YY (grav)]**

Mixture description	**AC 20 open bin XX/YY (crushed rock or slag)**	**AC 20 open bin XX/YY grav (gravel)**
Test sieve aperture size mm	**% by mass passing**	**% by mass passing**
40	—	—
31,5	100	100
20	99–100	99–100
14	59–71	59–71
6,3	24–26	26–28
2	13–16	13–16
0,250	—	—
0,063	3,0–6,0	4,0
Aggregate type	**Binder content B_{act}**	
Limestone	3,7	—
Basalt	4,0	—
Other crushed rock	3,8	—
Blast furnace slag of bulk density in Mg/m^3 1,44 1,36 1,28 1,20 1,12	 4,4 4,8 5,0 5,4 6,0	—
Steel slag	3,6	—
Gravel	—	5,0

NOTE The specified binder content, B_{act}, is both minimum and maximum binder content for categorization purposes.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.5 Recipe surface courses

B.3.5.1 Open graded surface course

The aggregate grading of the target composition shall fall within the appropriate envelope given in Table B.13. The binder content of the target composition shall conform to Table B.13.

The binder shall conform to BS EN 12591:2009 paving grade 160/220 or 250/330.

NOTE Handlay and deferred set mixtures may include flux oil as prescribed in ***B.2.3****.*

Table B.13 **Target limits for composition for open graded surface course mixtures (AC 14 or 10 open surf XX/YY)**

Mixture description	**AC 14 open surf**	**AC 10 open surf**
Test sieve aperture size mm	**% by mass passing**	**% by mass passing**
20	100	—
14	98–100	100
10	62–68	93–95
6,3	32–38	37–53
2	16–17	16–17
0,063	5,0	5,0
Aggregate type	**Binder content B_{act}**	
Limestone	4,6	5,0
Basalt	4,8	5,3
Other crushed rock	4,7	5,2
Blast furnace slag of bulk density in Mg/m^3		
1,44	5,0	5,6
1,36	5,4	5,8
1,28	5,8	6,2
1,20	6,2	6,8
1,12	6,6	7,2
Steel slag	4,4	4,8

NOTE The specified binder content, B_{act}, is both minimum and maximum binder content for categorization purposes.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.5.2 Close graded surface course

The aggregate grading of the target composition shall fall within the appropriate envelope given in Table B.14. The binder content of the target composition shall conform to Table B.14.

The binder shall conform to BS EN 12591:2009 paving grade 70/100, 100/150 (preferred grade), 160/220 or 250/330.

*NOTE Handlay and deferred set mixtures may include flux oil as prescribed in **B.2.3**.*

Table B.14 **Target limits for composition for close graded surface course mixtures (AC 14 or 10 close surf XX/YY)**

Mixture description	**AC 14 close surf**	**AC 10 close surf**
Test sieve aperture size mm	**% by mass passing**	**% by mass passing**
20	100	—
14	100	100
10	77–83	100
6,3	52–58	62–68
2	25–31	25–31
1	14–26	14–26
0,063	6,0	6,0
Aggregate type	**Binder content B_{act}**	
Limestone	4,9	5,2
Basalt	5,1	5,3
Other crushed rock	5,1	5,2
Blast furnace slag of bulk density in Mg/m^3		
1,44	5,6	6,2
1,36	6,0	6,6
1,28	6,6	7,2
1,20	7,0	7,6
1,12	7,6	8,2
Steel slag	4,8	5,0
Gravel	5,4 [A)]	5,4 [A)]

[A)] Higher binder contents might be necessary with some gravel types.

NOTE The specified binder content, B_{act}, is both minimum and maximum binder content for categorization purposes.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.5.3 Dense, medium graded and fine graded surface course

The aggregate grading of the target composition shall fall within the appropriate envelope given in Table B.15. The binder content of the target composition shall conform to Table B.15.

Table B.15 **Target limits for composition for dense, medium graded and fine graded surface course mixtures (AC D dense/med/fine surf XX/YY)**

Mixture description	**AC 6 dense surf**	**AC 6 med surf**	**AC 4 fine surf** [A]
Test sieve aperture size mm	**% by mass passing**	**% by mass passing**	**% by mass passing**
10	100	100	—
6,3	98	98	100
4	—	—	98
2	42–56	33–41	69–87
1	24–46	14–26	—
0,250	11–19	—	18–36
0,063	4,0–8,0	4,0–7,0	7,0–14,0
Aggregate type	**Binder content B_{act}**		
Limestone	6,0	5,3	6,2
Basalt	6,3	5,5	6,6
Other crushed rock	6,2	5,4	6,5
Blast furnace slag of bulk density in Mg/m^3			
1,44	6,6	6,2	6,8
1,36	7,0	6,6	7,2
1,28	7,6	7,2	7,6
1,20	8,0	7,4	7,8
1,12	8,4	7,8	8,2
Steel slag	5,6	5,0	6,2
Gravel [B]	5,4	6,0	Not permitted

[A] Up to 25% of the fine aggregate may be sand.

[B] Higher binder contents may be necessary with some gravel types.

NOTE The specified binder content, B_{act}, is both minimum and maximum binder content for categorization purposes.

The binder shall conform to BS EN 12591.

NOTE 1 Guidance on the selection of binder paving grades is given in Table B.16.

*NOTE 2 Handlay and deferred set mixtures may include flux oil as described in **B.2.3**.*

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

Table B.16 **Guidance on selection of binder grades**

Mixture description	AC 6 dense surf	AC 6 med surf	AC 4 fine surf
70/100	✓	—	—
100/150	✓[A)]	—	—
160/220	✓	✓[A)]	✓[A)]
250/330	✓	✓	✓

[A)] Preferred grade.

B.3.6 Temperature of the mixture

When using paving grade or hard paving grade bitumen, the temperature of the mixture at any stage, measured in accordance with BS EN 12697-13, shall not exceed the limits of Table B.17.

Table B.17 **Maximum temperature of the mixture**

Paving grade of binder	Maximum temperature °C
10/20, 15/25	200
30/45	195
40/60	190
70/100	180
100/150	170
160/220	165
250/330	160

When using modified bitumen or additives, different temperatures might apply, which shall be documented and declared as part of the regulatory marking.

NOTE See BS 594987 for requirements on suitable minimum temperatures at delivery and for compaction.

B.3.7 BBA mixtures

*COMMENTARY ON **B.3.7***
BBA has been the French standard asphalt surfacing used in airport pavements in France for many years, and more recently in the UK. The material properties are now specified in accordance with EN 13108-1. There are four types of BBA material: close- and gap-graded, each graded with 0/10 mm and 0/14 mm aggregate sizes. They can be used for binder and surface courses in new construction and overlay.

B.3.7.1 Aggregate grading

The aggregate grading of the target composition shall fall within the envelope given in Table B.18 and Table B.19. For type C mixtures, 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, or vice versa. For type D mixtures, the discontinuity in the grading shall be formed by omitting 4/6 or 2/6 mm aggregate sizes.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

NOTE This *is an empirical characteristic only and it should not be combined with the fundamental characteristics of stiffness modulus and fatigue properties.*

Table B.18 **Aggregate grading target limits for 14 mm and 10 mm BBA mixtures (AC 14 or 10 BBA C bin XX/YY des)**

Test sieve aperture size mm	**AC 14 BBA C**	**AC 10 BBA C**
20	100	—
14	90–100	100
10	—	90–100
6,3	50–65	62–77
4	—	—
2	30–40	32–42
0,250	10–25	10–25
0,063	5–8	5–8

Table B.19 **Aggregate grading target limits for 14 mm and 10 mm BBA mixtures (AC 14 or 10 BBA C/D surf XX/YY des)**

Test sieve aperture size mm	**AC 14 BBA C**	**AC 10 BBA C**	**AC 14 BBA D**	**AC 10 BBA D**
20	100	—	100	—
14	90-100	100	90–100	100
10	—	90–100	—	90–100
6,3	54–69	65–80	37–47	53–63
4	—	—	36–46	47–57
2	32–45	35–45	33–43	35–45
0,250	10–25	10–25	10–25	10–25
0,063	6–9	6–9	6–9	6–9

B.3.7.2 Binder content

Binder shall conform to BS EN 12591 paving grade bitumen 30/45, 40/60 or 70/100. Polymer modified bitumen shall conform to BS EN 14023.

The binder content of the target composition shall conform to Table B.20.

NOTE *This is an empirical characteristic only and it should not be combined with the fundamental characteristics of stiffness modulus and fatigue properties.*

Table B.20 **Minimum target binder content, B_{act}**

B_{act}	**Minimum target binder content**
AC 10 BBA C	5,4
AC 14 BBA C	5,2
AC 10 BBA D	5,2
AC 14 BBA D	5,0

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

B.3.7.3 Air voids content

The air voids content of specimens of BBA mixtures at target composition prepared in the laboratory in accordance with BS EN 12697-35 and compacted in the gyratory compactor in accordance with BS EN 12697-31 shall conform to Table B.21.

Table B.21 **Number of gyrations and percentage of air voids**

Mixture type	Number of gyrations	Percentage of air voids	
		V_{min}	V_{max}
AC 10 BBA C bin	60	4	8
AC 14 BBA C bin	80	4	8
AC 10 BBA C surf	60	3	7
AC 14 BBA C surf	80	3	7
AC 10 BBA D	40	5	9
AC 14 BBA D	60	5	9

B.3.7.4 Water sensitivity

The water sensitivity of BBA mixtures, when determined in accordance with Method B from BS EN 12697-12 at target composition, shall be a minimum of 70% for binder course and 80% for surface course.

B.3.7.5 Deformation resistance

The deformation resistance of the mixture at target composition, tested in accordance with the wheel tracking test in BS EN 12697-22, large device, shall conform to Table B.22.

Table B.22 **Proportional rut depth, P, at 60 °C and 10 000 cycles**

Performance class	Category P
0	P_{NR}
1	P_{15}
2	P_{10}
3	$P_{7,5}$

Testing of materials on the large wheel tracking device shall require the preparation of test specimens (slabs), compacted in accordance with BS EN 12697-33.

NOTE 1 This method permits the test laboratory to establish a roller compaction pattern, which is symmetrical, in order to satisfy the air void requirement.

NOTE 2 For BBA, the compaction of the slabs is deemed to be acceptable for the wheel tracking test if the air voids content is 4% < v < 7%, when determined in accordance with BS EN 12697-8, BS EN 12697-6, procedure B, bulk density – SSD, and BS EN 12697-5.

NOTE 3 For especially severe cases (e.g. slow, canalised traffic), test conditions have been adjusted by increasing the temperature to 65 °C and reducing the rate of loading to 0.1 Hz.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

NOTE 4 Consideration may be given to assessing alternative deformation resistance data based on test methods and conditions which are appropriate for the design requirements, and that give a correlation with the deformation resistance performance classes (see Table B.21).

B.3.7.6 Stiffness modulus

The stiffness modulus of the mixture at target composition, tested in accordance with the stiffness test in BS EN 12697-26:2012, Annex C, shall conform to Table B.23.

NOTE For BBA, the compaction of the specimens is deemed to be acceptable for the stiffness test if the air voids content is 4% < v < 7%, when determined in accordance with BS EN 12697-8, BS EN 12697-6, procedure B, bulk density – SSD, and BS EN 12697-5.

Table B.23 **Stiffness modulus at 15 °C**

Performance class	Category S_{min}
0	S_{minNR}
1	$S_{min5500}$
2	$S_{min5500}$
3	$S_{min7000}$

B.3.7.7 Fatigue properties

The resistance to fatigue of specimens prepared in accordance with BS EN 13108-20:2006, **6.4**, and tested in accordance with BS EN 12697-24:2012, Annex A (2PB-TZ, microstrain for 10^6 cycles at 10 °C and 25 Hz), shall conform to Table B.24 $\varepsilon_{6\text{-}130}$.

The compaction of test specimens shall be selected from BS EN 13108-20:2006, Table C.1. The air voids content of the specimens shall be between 4% and 7%.

Table B.24 **Acceptable strain in fatigue**

Performance class	Category
0	ε_{6NR}
1	$\varepsilon_{6\text{-}130}$
2	$\varepsilon_{6\text{-}100}$
3	$\varepsilon_{6\text{-}100}$

NOTE The *French fatigue test is very lengthy and not generally available in the UK. In addition, it is infrequently specified as a mixture design criterion for BBA and it should be ε6 NR, except in only very exceptional circumstances. Consideration of alternative fatigue data as equivalent, where a correlation with 2 PB TZ test output is provided, may be given.*

B.3.8 Temperature of the mixture

When using paving grade or hard paving grade bitumen, the temperature of the mixture at any stage, measured in accordance with BS EN 12697-13, shall not exceed the limits in Table B.25.

Figure B.1 **Example specification giving the UK choice for specifying asphalt concrete in accordance with BS EN 13108-1** *(continued)*

Table B.25 **Maximum temperature of the mixture**

Paving grade of binder	Maximum temperature °C
10/20, 15/25	200
30/45	195
40/60	190
70/100	180
100/150	170
160/220	165
250/330	160

When using modified bitumen or additives, different temperatures might be applicable. These shall be documented and declared as part of the regulatory marking.

NOTE See BS 594987 for requirements on suitable minimum temperatures at delivery and for compaction.

Annex C BS EN 13108-4 hot rolled asphalt – example specification

C.1 General

Figure C.1 in this Annex contains an example specification which gives the UK choice for specifying HRA in accordance with BS EN 13108-4.

NOTE In Figure C.1 the word "shall" is used only to identify example requirements.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4**

HRA shall conform to BS EN 13108-4. Conformity shall be established in accordance with BS EN 13108-20 and BS EN 13108-21.

C.2 Constituent materials

C.2.1 Binder

The binder shall be paving grade bitumen conforming to BS EN 12591, polymer modified bitumen conforming to BS EN 14023 or a blend of one of these with natural asphalt in accordance with BS EN 13108-4:2006, Annex B.

C.2.2 Paving grades

NOTE 1 The preferred paving grade for HRA is 40/60. The following grades are also suitable:30/45, 70/100, and 100/150.

NOTE 2 Blends of paving grade bitumen with natural asphalt (lake asphalt) with resultant nominal penetrations of 35, 50 and 70 are also suitable.

NOTE 3 70/100 and 100/150 pen paving grade bitumen may be produced by blending in the mixer at the asphalt plant.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

The paving grades used for blending shall be not harder than 30/45 or softer than 160/220, and shall conform to BS EN 12591. The producer shall be able to demonstrate that the plant is capable of adequately blending the bitumen. 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 bitumen 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 bitumen paving grades harder than 70/100 shall be produced by blending in the mixer.

NOTE 4 Other grades may be in-plant blended provided that the resulting bitumen can be sampled and tested before it is added to the aggregate to ensure it conforms to BS EN 12591.

C.2.3 Aggregates

C.2.3.1 Coarse aggregate

C.2.3.1.1 Type of coarse aggregate

The coarse aggregate shall be material substantially retained on a 2 mm test sieve, conforming to all appropriate requirements of BS EN 13043, and consisting 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.

c) Blast furnace slag, of known density. The compacted density of blast furnace slag is determined in accordance with BS 812-2. The sample to be tested is previously dried to constant mass at (105 ±5) °C. The test is conducted on material passing a 14 mm test sieve and retained on a 10 mm test sieve.

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.

C.2.3.1.2 Particle shape

The flakiness category for coarse aggregates shall be FI_{35}.

C.2.3.1.3 Fines content

The fines content for coarse aggregates shall be f_4.

NOTE 1 PD 6691 does not cover 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 can be found in PD 6682-2.

Specification shall be in terms of the categories recommended in PD 6682-2.

*NOTE 2 Aggregate types other than those referred to in a) to d) in **C.2.3.1.1** might be suitable for HRA but are outside the scope of PD 6691.*

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

C.2.3.2 Fine aggregate

C.2.3.2.1 Type of fine aggregate

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

a) sand;

b) fines produced by crushing material from one of the groups specified in **C.2.3.1.1**;

c) a mixture of a) and b).

C.2.3.2.2 Grading

For surface course mixtures the grading of the fine aggregate shall conform to the appropriate category:

a) for Type F surface course mixtures 0/2 mm: G_{A90}; and

b) for Type C surface course mixtures 0/4 mm: G_{A85}

C.2.3.2.3 Fines content

The fines content for fine aggregates shall conform to the appropriate fines category:

a) for Type F surface course mixtures: f_{10};

b) for Type C surface course mixtures: f_{16}; and

c) for base and binder course mixtures: f_{22}

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

C.2.3.3 Added filler

Added filler shall consist of limestone, hydrated lime or cement. 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**, the "no requirement" category should be used.*

C.2.3.4 Reclaimed asphalt

NOTE 1 The compulsory gap grading of the mixture means that the use of a continuously graded reclaimed asphalt is not recommended as it may change the characteristics of the mixture.

NOTE 2 If the reclaimed asphalt is screened to separate it into one or more coarse and fine fractions, and the properties of these fractions meet the specified requirements appropriate to the intended use, then reclaimed asphalt might be suitable. There might be circumstances and mixtures where it is appropriate not to permit the inclusion of reclaimed asphalt or where higher percentage additions are acceptable. This may be done using the general provisions of BS EN 13108-4 on a case-by-case basis.

Where reclaimed asphalt is to be used in HRA mixtures:

a) all reclaimed asphalt shall be classified in accordance with BS EN 13108-8;

b) the reclaimed asphalt shall conform to the following categories:

1) foreign matter:category F_5; and

2) binder properties:category P_{15}

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

NOTE 3 P15 is a general case, but reliable and consistent feedstocks of harder reclaimed materials might make them suitable for use, by agreement with the client.

In accordance with BS EN 13108-4:2006, **4.4**, unless otherwise expressly indicated (see Note 2), the amount of reclaimed asphalt added to the mixture shall not exceed the following:

- surface courses, 10%; and
- all other materials, 50%, except where either the mixture or the reclaimed asphalt contains a modified binder: 20%.

Where, in accordance with BS EN 13108-4:2006, **4.2.2.1** or **4.2.2.2** the level of reclaimed asphalt addition requires the determination of combined binder properties, the penetration method shall be adopted.

C.2.3.5 Additives

Additives permitted for inclusion may include fibres, pigments and adhesion agents. The suitability of such additives shall be demonstrated in accordance with BS EN 13108-4:2006, **4.1**.

C.2.3.6 Coated chippings

NOTE See Table C.5.for the specification of chippings.

C.2.4 Group 1 – Base and binder course mixtures

The grading and binder content of the target composition shall conform to Table C.1.

*NOTE See also **C.2.7**. for the specification of target composition and binder content.*

When the coarse aggregate is gravel, 2% by mass of total aggregate of cement or hydrated lime shall be added.

Table C.1 **Limits for target composition for base and binder course mixtures**

D **mm**	**50/10** [A)]	**50/14** [A)]	**50/20** [A)]	**60/20** [A)]	**60/32** [A)]
Sieve			**% by mass passing**		
40	—	—	—	—	100
31,5	—	—	100	100	99–100
20	—	100	99–100	99–100	59–71
14	100	98–100	74–91	39–56 [B)]	39–56
10	98–100	72–93	44–66	—	—
2 [C)]	40–50	40–50	40–50	37	37
0,5	17–51	17–51	18–50	13–39	13–39
0,25	14–31	14–31	15–30	10–25	10–25
0,063	3,0–6,0	3,0–6,0	4,0–5,0	4,0	4,0
Binder content % (m/m) of total mixture for	B_{act}				
Limestone	6,4	6,2	6,3	5,5	5,5

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

Table C.1 **Limits for target composition for base and binder course mixtures** *(continued)*

D **mm**	**50/10** [A)]	**50/14** [A)]	**50/20** [A)]	**60/20** [A)]	**60/32** [A)]
Sieve			**% by mass passing**		
Basalt	6,4	6,4	6,5	5,6	5,6
Other crushed rock or steel slag	6,4	6,4	6,4	5,7	5,6
Gravel	6,2	6,2	6,2	5,4	5,4
Blast furnace slag: bulk density in Mg/m^3					
1,44	6,6	6,6	6,6	5,6	5,6
1,36	6,6	6,6	6,6	5,8	5,8
1,28	6,8	6,8	6,8	6,0	6,0
1,20	6,8	6,8	6,8	6,0	6,0
1,12	7,0	7,0	7,0	6,2	6,2

[A)] Suitable for regulating course.

[B)] The upper compliance value of 65 (target + FPC) can be extended to 85 where evidence is available that the mixture so produced is suitable. To ensure consistency of finish of the laid mixture, supplies from any one source should be controlled within the requirements of FPC to the chosen upper target value.

[C)] For mixtures containing crushed rock fine aggregate, and in some instances sands or blends of sand and crushed rock fines, the minimum target binder content given may be reduced by up to 0,5%, where experience shows this to be advisable to avoid an over-rich mixture. Alternatively, a reduction in the target passing 2 mm of up to 5% is permitted.

C.2.5 Group 2 – Surface course mixtures

C.2.5.1 Composition, grading and binder content

C.2.5.1.1 General

The grading and binder content of the target composition of surface courses shall conform to Table C.2A, Table C.2B or Table C.2C, as appropriate (see **C.2.7**).

The requirements for a particular mixture shall be selected in accordance with:

- **C.2.5.1.2** for recipe surface course mixtures;
- **C.2.5.1.3** for design surface course mixtures; and
- **C.2.5.1.4** for performance-related surface course mixtures.

NOTE 1 Type F is characterized by a gap grading typical of traditional HRA surface course mixtures usually associated with the use of a fine sand, although other fine aggregates conforming to the grading may also be suitable.

NOTE 2 Type C is characterized by a coarser grading usually associated with the use of crushed rock or slag fine aggregates. However, natural sand may be used in part or in total.

NOTE 3 The designation Type F represents a finer grading of the fine aggregate used in this type of mix. A coarser grading of the fine aggregate is used in Type C mixes. The distinction between Type F and Type C mixtures is in grading only; no restriction should be placed on the source and type of fine aggregate.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

Table C.2A **Limits for target composition for surface course mixtures, Type F mixtures [A] – Design and recipe target aggregate gradings (HRA %/D F surf XX/YY des/rec)**

Column No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
D mm	**0/2F**		**15/10F**	**30/10F**	**0/10F**	**55/10F**		**30/14F**		**35/14F**		**55/14F**	
Sieve	**Passing Sieve** % by mass												
20	—		—	—	Not used in the UK	—		100		100		100	
14	—		100	100		100		93–100		95–100		98–100	
10	—		100	93–100		98–100		67–83		62–81		42–63	
6,3	100		82–88	67–83		42–63		—		—		—	
2	98–100		79	65		41		65		61		41	
0,5	80–90		59–83	49–68		29–43		49–68		44–63		29–43	
0,25	40–65		24–61	19–51		9–31		19–51		16–46		9–31	
0,063	14,0		12,0	9,0		6,0		9,0		8,0		6,0	
Minimum target binder content B_{act} % (m/m) of total mixture													
	9,8		Recipe only	Recipe only		5,5		6,5		6,4		5,5	

[A] For Type F surface course mixtures, the maximum percentage of aggregate passing a 2 mm sieve and retained on a 0,5 mm sieve shall conform to BS EN 13108-4:2006, Table 5.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

Table C.2B **Limits for target composition for surface course mixtures, Type F mixtures[A)] – Design and recipe target binder content (HRA %/D F surf XX/YY des/rec)**

Column No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
	0/2F		**15/10F**	**30/10F**	**0/10F**	**55/10F**		**30/14F**		**35/14F**		**55/14F**	
Binder content % B_{act} (m/m) of total mixture for:													
Crushed rock or steel slag													
Schedule 1A[A)]	10,2		8,8	7,7		—		7,7		7,3		—	
Schedule 1B[A)]	10,8		9,4	8,2		—		8,2		7,8		—	
Gravel													
Schedule 2A[A)]	10,2		8,8	7,4		—		7,4		7,0		—	
Schedule 2B[A)]	10,8		9,4	8,0		—		8,0		7,4		—	
Blast furnace slag: bulk density													
Schedule 3A[A)]													
1,44 Mg/m^3	—		9,0	7,8		—		7,8		7,6		—	
1,36 Mg/m^3	—		9,0	8,0		—		8,0		7,6		—	
1,28 Mg/m^3	—		9,2	8,0		—		8,0		7,8		—	
1,20 Mg/m^3	—		9,2	8,2		—		8,2		7,8		—	
1,12 Mg/m^3	—		9,4	8,2		—		8,3		8,0		—	
Schedule 3B[A)]													
1,44 Mg/m^3	—		9,4	8,4		—		8,4		8,0		—	
1,36 Mg/m^3	—		9,6	8,4		—		8,4		8,2		—	
1,28 Mg/m^3	—		9,6	8,6		—		8,6		8,2		—	
1,20 Mg/m^3	—		9,8	8,6		—		8,6		8,4		—	
1,12 Mg/m^3	—		9,8	8,8		—		8,8		8,4		—	

[A)] For Type F surface course mixtures, the maximum percentage of aggregate passing a 2 mm sieve and retained on a 0,5 mm sieve shall conform to BS EN 13108-4:2006, Table 5.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

Table C.2C **Limits for target composition for surface course mixtures, Type C mixtures – Design and recipe target aggregate gradings (HRA %/D C surf XX/YY des/rec)**

Column No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
D mm		**0/2C**					**55/10C**		**30/14C**		**35/14C**		**55/14C**
Sieve	**Passing sieve** % by mass												
20		—					—		100		100		100
14		—					100		93–100		95–100		98–100
10		—					98–100		67–83		62–81		42–63
6,3		100					42–63		—		—		—
2		98–100					40		66		59		40
0,5		40–55					19–31		29–41		24–41		19–31
0,25		25–35					9–31		19–36		16–26		9–31
0,063		14,0					6,0		9,0		8,0		6,0
Minimum target binder content, B_{act} % (m/m) of total mixture													
Limestone		9,0					5,5		6,5		6,4		5,5
Basalt		9,0					5,5		7,0		6,9		5,5
Other crushed stone		9,0					5,5		7.0		6,7		5,5

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

C.2.5.1.2 Recipe surface course mixtures

Recipe surface course mixtures shall be one of the following from Table C.2A:0/2F, 15/10F, 30/10F, 30/14F, or 35/14F.

The soluble binder contents used shall be related to the climatic conditions and the volume of traffic at the specific site. In the majority of cases mixtures conforming to Schedule 1A, Schedule 2A and Schedule 3A shall be used. In cold, elevated, wet conditions, or for more lightly trafficked roads, mixtures conforming to Schedule 1B, Schedule 2B and Schedule 3B shall be used.

The soluble binder content from Table C.2B shall be:

- Schedule 1A or Schedule 1B for crushed rock mixtures, including steel slag;
- Schedule 2A or Schedule 2B for gravel mixtures; and
- Schedule 3A or Schedule 3B for blast furnace slag mixtures.

C.2.5.1.3 Design surface course mixtures

Design surface course mixtures shall be one of the following from Table C.2A and Table C.2C:

- 0/2F, 30/14F, 35/14F, 55/10F, 55/14F; and
- 0/2C, 30/14C, 35/14C, 55/10C, 55/14C.

The soluble binder content shall be not less than either the appropriate minimum value from Table C.2A or Table C.2C or the design binder content determined in accordance with the protocol described in BS 594987:2015, Annex H (see **C.2.7**).

C.2.5.1.4 Performance-related mixtures

C.2.5.1.4.1 General

Performance-related surface course mixtures shall be 35/14F (see Table C.2A).

C.2.5.1.4.2 Binder volume

The minimum binder volume in accordance with BS EN13108-4:2006, **5.2.4**, and determined from the trial strip protocol in BS 594987:2015, Annex F, shall be category $B_{vol15,5}$.

C.2.5.1.4.3 Void content

The void content of the mixture at target composition determined in accordance with the trial strip protocol in BS 594987:2015, Annex F, shall be as follows:

- The average void content category of core pairs shall be $V_{max7,5}$; and
- The average void content category of sets of six cores shall be V_{max5}.

C.2.5.1.4.4 Resistance to permanent deformation

The resistance to permanent deformation at target composition determined from tests with the small wheel tracking device on 200 mm diameter core specimens in accordance with BS 594987:2015, Annex F, shall be as specified in Table C.3.

If called up in addition to other requirements, only the "no requirement" category shall apply to 0/2 mm mixtures.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

Table C.3 **Limiting wheel tracking requirements for site classifications**

Classification		**Test temperature**	**Category WTS_{AIR}**	**Category PRD_{AIR}**
			BS EN 12697-22:2003, small device	**BS EN 12697-22:2003, small device**
No.	Description	°C	**Wheel track rate** µm/cycle	**Maximum rut depth** mm
1	Moderate to heavily stressed sites requiring high rut resistance	45	$WTR_{AIR7,5}$	$RD_{AIR5,0}$
2	Very heavily stressed sites requiring very high rut resistance	60	$WTR_{AIR15,0}$	$RD_{AIR7,0}$
3	Other sites	—	WTR_{AIRNR}	RD_{AIRNR}

C.2.6 Temperature of the mixture

When using paving grade bitumen, the temperature of the mixture at any stage, measured in accordance with BS EN 12697-13, shall not exceed the limits in Table C.4.

Table C.4 **Maximum temperature of the mixture**

Paving grade of binder	**Mixture temperature** °C
30/45	195
40/60	190
70/100	180
100/150	170

When using modified bitumen or additives, different temperatures might be applicable, and these shall be documented and declared as part of the regulatory marking.

NOTE Requirements on suitable minimum temperatures at delivery and for compaction are given in BS 594987.

C.2.7 Target binder content

NOTE 1 For *the binder content reference should be made to **9.2.3** concerning the selection and correction of the binder content based on the mean particle density of the aggregate used in the mixture.*

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

NOTE 2 The binder content categories in BS EN 13108 involve a correction for the density of the aggregate in the mix. The principle is that the binder content category in the standard is based on an aggregate density in the mixture of 2,650 Mg/m^3. If the aggregate is denser than 2,650 Mg/m^3 the actual binder content in the mixture is reduced proportionally or if the aggregate is less dense it is increased. This has the intention of giving the same binder volume in mixtures regardless of aggregate density. However, a consideration of UK mixtures and aggregates indicates that this approach could be detrimental, as some of the more dense aggregates in practice needed higher binder contents for durability. For this reason, the binder contents in the example specifications in this guidance document are those which are required as actual soluble binder contents on analysis of the finished mixture, with no density correction. These are referenced as B_{act}.

NOTE 3 For the purposes of CE marking, these actual binder contents need to be corrected back to determine the B_{min} as is defined in BS EN 13108.

To convert the B_{act} target values within PD 6691 back to a B_{min} declared value from BS EN 13108-1 to BS EN 13108-7 (inclusive), the following formula shall be used:

$$B_{\text{min declared}} = \frac{\rho_b \times B_{\text{act}}}{2{,}650} \qquad \text{(C.1)}$$

where:

ρ_b is the mean particle density of the aggregate mixture, in Mg/m^3, determined in accordance with BS EN 1097-6.

*NOTE 4 The mean particle density of the aggregate mixture should be calculated as the weighted mean of the apparent particle densities of the coarse and fine aggregate particle size fractions as described in **9.2.3**.*

The B_{min} declared value calculated from this formula shall be in divisions of 0,2. A B_{min} declared value of 0,1 division, such as 5,3%, shall be rounded to the nearest 0,2 value i.e. 5,2%.

C.2.8 Coated chippings for application to surface course

C.2.8.1 General

*COMMENTARY ON **C.2.8.1***
This subclause specifies requirements for coated chippings for application to HRA. Surface courses with a nominal coarse aggregate content of 35% or less generally require application of coated chippings prior to rolling.

For specification purposes coated chippings shall be considered as a mixture and evaluation of conformity determined in accordance with BS EN 13108-20 and BS EN 13108-21.

C.2.8.2 Chippings

Chippings shall be coarse aggregate conforming to **C.2.3**, with a flakiness category of FI_{20}. The grading of chippings shall be as in Table C.5.

NOTE Table C.5 is not written strictly in accordance with BS EN 13108 such that the gradings shown are the effective compliance envelopes and exclude the application of theFPC tolerances from BS EN 13108-21. This is to ensure that the grading of chippings is controlled more tightly than BS EN 13108-21 permits in order to ensure performance based on many years' experience of UK application.

Figure C.1 **Example specification giving the UK choice for specifying HRA in accordance with BS EN 13108-4** *(continued)*

Table C.5 **Compliance grading of chippings**

Test sieve	**% (m/m) passing test sieve**	
mm	**14/20 size**	**8/14 size**
31,5	100	—
20	90–100	100
14	0–25	90–100
10	0–4	0–25
6,3	—	0–4
0,063	0–2,0	0–2,0

NOTE Appropriate categories of resistance to polishing and resistance to abrasion should be selected from BS EN 13043.

C.2.8.3 Binder content

Binder used to coat the chippings shall be either 30/45 or 40/60 grade conforming to BS EN 12591. The target binder content shall be not less than 1,5%.

C.2.8.4 Condition of binder coating

When tested in accordance with BS EN 12697-37, the proportion of retained sand shall be not less than 4,0% for $D \geq 16$ mm and 5,0% for $D < 16$ mm. Not more than 7,5% shall fail the visual assessment.

C.2.8.5 Assessment and Verification of Constancy of Performance

AVCP shall be carried out in accordance with BS EN 13108-4:2006, Clause **6**.

*NOTE See the requirements in **C.2.8.2**.*

C.2.8.6 Identification

Identification should be in accordance with BS EN 13108-4:2006, Clause **7**. The delivery ticket shall contain at least the following information relating to identification:

- the manufacturer and mixing plant; and
- the nominal size and source of the aggregate.

C.2.8.7 Storage of coated chippings

Immediately following manufacture, coated chippings shall be quenched to reduce their temperature and/or stored in stockpiles <1 m in height to minimize the risk of coking and excessive consolidation.

Annex D BS EN 13108-5 stone mastic asphalt – example specification

Figure D.1 in this Annex contains an example specification which gives the UK choice for specifying SMA in accordance with BS EN 13108-5.

NOTE In Figure D.1 the word "shall" is used only to identify example requirements.

Figure D.1 **Example specification giving the UK choice for specifying SMA in accordance with BS EN 13108-5**

D.1 General

SMA shall conform to BS EN 13108-5. Conformity shall be established in accordance with BS EN 13108-20 and BS EN 13108-21.

D.2 Constituent materials

D.2.1 Binder

The binder shall be paving grade bitumen conforming to BS EN 12591, polymer modified bitumen to BS EN 14023 or a blend of one of these with natural asphalt in accordance with BS EN 13108-4:2006, Annex B.

D.2.2 Paving grades

*COMMENTARY ON **D.2.2***
The preferred paving grade for SMA is 40/60. The following grades are also suitable: 70/100 and 100/150. 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 not 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 bitumen. 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 bitumen 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 to ensure it conforms to BS EN 12591.

D.2.2.1 Aggregates

D.2.2.1.1 Coarse aggregate

D.2.2.1.1.1 Type of coarse aggregate

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

a) Crushed rock or crushed gravel of one or more of the following groups: basalt, gabbro, granite, gritstone, hornfels, limestone, porphyry or quartzite.

b) 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.

Figure D.1 **Example specification giving the UK choice for specifying SMA in accordance with BS EN 13108-5** *(continued)*

NOTE Limestone coarse aggregate should not normally be used in surface course mixtures on public roads but may be used on other surfaces.

D.2.2.1.1.2 Particle shape

The flakiness category for coarse aggregates shall be FI_{20}.

D.2.2.1.1.3 Fines content

The fines content for coarse aggregates shall be f_4.

NOTE 1 PD 6691 does not cover 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 can be found in PD 6682-2.

Specification shall be in terms of the categories recommended in PD 6682-2.

*NOTE 2 Aggregate types other than those referred to in a) and b) in **D.2.2.1.1.1** may be suitable for SMA but are outside the scope of PD 6691.*

D.2.2.1.2 Fine aggregate

D.2.2.1.2.1 Type of fine aggregate

The fine aggregate shall substantially pass a 4 mm test sieve and be of one of the following types:

- crushed material from one or more of the groups specified in **D.2.2.1.1.1**; or
- flint gravel.

Limestone fine aggregate shall not be used in surface course mixtures on public roads.

D.2.2.1.2.2 Fines content

The fines content category for fine aggregates shall be f_{22}.

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

D.2.2.2 Added filler

Added filler used in the SMA shall consist of crushed rock, crushed slag, hydrated lime, 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**.

For all other properties specified in BS EN 13043:2002, Clause **5**, the "no requirement" category shall be used.

D.2.2.3 Reclaimed asphalt

Due to the grading of the mixture an all-in graded reclaimed asphalt shall not be used as it makes the grading of the mixture difficult to control.

NOTE *Where the reclaimed asphalt is screened to separate it into one or more coarse and fine fractions, and the properties of these fractions meet the specified requirements appropriate to the intended use, then reclaimed asphalt may be used.*

Figure D.1 **Example specification giving the UK choice for specifying SMA in accordance with BS EN 13108-5** *(continued)*

Where reclaimed asphalt is to be used in SMA mixtures:

- all reclaimed asphalt shall be classified in accordance with BS EN 13108-8;
- the reclaimed asphalt shall conform to the following categories:
  - foreign matter – surface course category F_1;
  - binder and base category F_5 ; and
  - binder properties for additions greater than 20% of mixture – category P_{15}.

NOTE P_{15} is a general case, but reliable and consistent feedstocks of harder reclaimed materials might make them suitable for use, by agreement with the client.

In accordance with BS EN 13108-5:2006, **4.4**, unless otherwise indicated, the amount of reclaimed asphalt added to the mixture shall not exceed the following:

- surface courses, 10%; and
- all other materials, 50%.

Where, in accordance with BS EN 13108-5:2006, **4.2.3** and **4.2.4** the level of reclaimed asphalt addition requires the determination of combined binder properties, the penetration method shall be adopted.

NOTE There might be circumstances where it might be appropriate not to permit the inclusion of reclaimed asphalt or conversely where higher percentage additions are acceptable. This may be done using the general provisions of BS EN 13108-5 on a case-by-case basis.

D.2.2.4 Additives

Additives permitted for inclusion may include fibres, special fillers, pigments and adhesion agents and the suitability of such additives shall be demonstrated in accordance with BS EN 13108-5:2006, **5.2.4**.

D.3 Composition

D.3.1 General

*NOTE 1 For the binder content reference should be made to **10.2.3** concerning the selection and correction of the binder content based on the mean particle density of the aggregate used in the mixture.*

NOTE 2 The binder content categories in BS EN 13108-1 to BS EN 13108-7 (inclusive) involve a correction for the density of the aggregate in the mix. The principle is that the binder content category in the standard is based on an aggregate density in the mixture of 2,650 Mg/m^3. If the aggregate is denser than 2,650 Mg/m^3 the actual binder content in the mixture is reduced proportionally or if the aggregate is less dense it is increased. This has the intention of giving the same binder volume in mixtures regardless of aggregate density. However, a consideration of UK mixtures and aggregates indicates that this approach could be detrimental, as some of the more dense aggregates in practice needed higher binder contents for durability. For this reason, the binder contents in the example specifications in this guidance document are those which are required as actual soluble binder contents on analysis of the finished mixture, with no density correction. These are referenced as B_{act}.

NOTE 3 For the purposes of CE marking, these actual binder contents need to be corrected back to determine the B_{min} as is defined in BS EN 13108-1 to BS EN 13108-7 (inclusive).

Figure D.1 **Example specification giving the UK choice for specifying SMA in accordance with BS EN 13108-5** *(continued)*

To convert the B_{act} target values within PD 6691 back to a B_{min} declared value from BS EN 13108-1 to BS EN 13108-7 (inclusive), the following formula shall be used:

$$B_{\text{min declared}} = \frac{\rho_b \times B_{act}}{2{,}650} \quad \text{(D.1)}$$

where:

ρ_b is the mean particle density of the aggregate mixture, in Mg/m^3, determined in accordance with BS EN 1097-6.

*NOTE 4 The mean particle density of the aggregate mixture should be calculated as the weighted mean of the apparent particle densities of the coarse and fine aggregate particle size fractions as described in **10.2.3**.*

The B_{min} declared value calculated from this formula can only be in divisions of 0,2. A B_{min} declared value of 0,1 division, such as 6,3%, shall be rounded to the nearest 0,2 value, i.e. 6,2%.

D.3.2 Grading and binder content

The grading and binder content of the target composition shall conform to Table D.1.

Table D.1 **Limits for target composition for SMA mixtures**

D **mm**	**6**	**10**	**14**	**20**
Sieve	Passing sieve % by mass			
31,5	—	—	—	100
20	—	—	100	94–100
14	—	100	93–100	—
10	100	93–100	35–60	25–39
6,3	93–100	28–52	22–36	22–32
4	26–51	—	—	—
2	24–39	20–32	16–30	15–26
0,5 [A)]	—	—	—	—
0,25 [A)]	—	—	—	—
0,063	8,0–14,0	8,0–13,0	6,0–12,0	8,0–11,0
Binder content percentage (m/m) of total mixture B_{act} [B)]	6,6	6,2	5,8	5,4

[A)] The 0,25 mm and 0,5 mm sieves are not included in BS EN 13108-5 but have traditionally been used in the UK for control of these mixtures, and it is advised that values are recorded.

[B)] Mixtures designed with polymer modified bitumens conforming to BS EN 14023 may result in a reduced actual target binder content to those shown in Table D.1.

Figure D.1 **Example specification giving the UK choice for specifying SMA in accordance with BS EN 13108-5** *(continued)*

D.4 Void content

D.4.1 Surface course

The void content of impact compacted specimens of the mixture at target composition prepared and tested as detailed in Table 4, shall be the average void content category of a set of three specimens: $V_{\text{min } 1,5}$; $V_{\text{max } 5}$.

D.4.2 Binder course

The void content of the mixture at target composition determined in accordance with the trial strip protocol in BS 594987:2015, Annex G, shall be:

- the average void content category of core pairs, $V_{\text{max } 6,0}$
- the average void content category of sets of six cores, $V_{\text{max } 4,0}$.

D.5 Binder drainage

The binder drainage (where required) of loose specimens of the mixture at target composition determined in accordance with BS EN 12697-18:2004, Clause **5**, Schellenberg method, shall be the average binder drainage category of a set of specimens, $D_{0,3}$.

D.6 Water sensitivity

*NOTE See **9.7**.*

D.7 Resistance to permanent deformation:surface, binder and regulating course

The resistance to permanent deformation at target composition determined from tests with the small wheel tracking device, method B specimens, prepared in accordance with **14.2.1**, Table 4, shall be as in Table D.2.

Table D.2 **Limiting wheel tracking recommendations for site classifications**

Classification		**Test temperature**	**Category WTS_{AIR}**
			BS EN 12697-22:2003, small device procedure B
No.	Description	°C	**Wheel track slope** mm/1 000 cycles
1	Moderate to heavily stressed sites requiring high rut resistance	45	WTS_{AIR1}
2	Very heavily stressed sites requiring very high rut resistance	60	WTS_{AIR1}
3	Other sites	—	WTS_{AIRNR}

Figure D.1 **Example specification giving the UK choice for specifying SMA in accordance with BS EN 13108-5** *(continued)*

D.8 Temperature of the mixture

When using paving grade bitumen, the temperature of the mixture at any stage, measured in accordance with BS EN 12697-13 shall not exceed the limits of Table D.3.

Table D.3 **Maximum temperature of the mixture**

Binder grade	Temperature °C
40/60	200
70/100	180
100/150	170

When using modified bitumen or additives, different temperatures may be applicable, which shall be documented and declared as part of the regulatory marking.

NOTE Requirements on suitable minimum temperatures at delivery and for compaction can be found in BS 594987.

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