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PUBLISHED DOCUMENT

Asphalt –

Guidance on the use of BS EN 12697 “Bituminous mixtures – Test methods for hot mix asphalt”

ICS 93.080.20

British Standards

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Foreword

Publishing information

This Published Document was published by BSI and came into effect on 31 October 2006. It was prepared by Subcommittee B/510/1, *Hot asphalt and coated macadam*, 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.

Relationship with other publications

This Published Document gives guidance on the use and application of a series of European Standards for asphalt. These European Standards were prepared by CEN/TC 227/WG1, *Bituminous Materials*, and have been adopted as British Standards. Conflicting British Standards relating to asphalt will be withdrawn at the latest by January 2008.

PD 6692 gives guidance on the use of the various parts of European Standard BS EN 12697, *Tests for bituminous materials*, prepared by CEN/TC 227/WG1/TG2, that specify test methods for asphalt.

This package includes European Standards that supersede conflicting parts of BS 598. The parts of BS 598 that are superseded by the parts in this European Standard are listed in Annex A and will be withdrawn on 1 January 2008.

NOTE Users of the different parts of BS 598 should contact BSI Customer Services for confirmation of their withdrawal.

Guidance on the various parts of European Standard BS EN 13108, *Bituminous mixtures – Material specification*, is given in PD 6691.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

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 British Standard cannot confer immunity from legal obligations.

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Introduction

This Published Document provides guidance on the use of the European Standards specifying test methods for asphalt. The guidance is aimed primarily at potential UK users of the test methods, but will also be of interest to all in the UK associated with the manufacture and use of asphalt throughout Europe.

Most of the European test methods for asphalt are based on national test methods from European countries, including UK test methods specified in British Standards. PD 6692 gives a description of each of these European test methods along with guidance on their relevance and familiarity to UK users.

Some general features of the European Standards for asphalt are outlined in Clause **2**. These features make fundamental changes to the way in which asphalts are specified and tested in the UK. Clauses **3** to **7** give guidance on each of the European test method standards for asphalt in BS EN 12697, with the scope of each European Standard reproduced in full.

For European test methods that are based on British Standards, only a brief description of the test method is given along with guidance about any changes that have been introduced and how they affect UK users. Some of the European test methods are similar, in part or in name, to existing British Standard test methods; however, the differences are significant enough to necessitate a more detailed description of the test and how its implementation affects UK users.

For European test methods that are relatively new to the UK and are likely to be widely used in the future, a detailed description of the test methods is given in an attempt to anticipate the effects of the introduction of these new test procedures. Other tests, which are also unfamiliar to UK users but are not likely to be widely used in the UK, are described only for completeness.

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1 Scope

PD 6692 gives guidance on the use of each of the European test method standards for asphalt, BS EN 12697. The tests are divided up into five groups:

a) test methods required for testing the constituent materials, as identified in Annex A of BS EN 13108-20;

b) test methods called up in at least four of the standard specifications for the different types of asphalt, BS EN 13108-1 to BS EN 13108-7, as identified in Annex B of BS EN 13108-20 (see Table 1);

c) test methods called up in only specific standard specifications, as identified in Annex B to BS EN 13108-20;

d) test procedures used to support called up test methods BS EN 12697-30 to BS EN 12697-33, as identified in Annex C of BS EN 13108-20, plus BS EN 12697-35;

e) test methods and procedures not called up in the asphalt standards.

Where standards fit into more than one category, they will be described in the first and subsequently cross-referenced. The sections describing each test are listed in Table 1.

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Table 1 **Asphalt tests in BS EN 12697 called up in asphalt specifications BS EN 13108**

BS EN 12697			**BS EN 13108**						
Part	**Description**		**Part 1**	**Part 2**	**Part 3**	**Part 4**	**Part 5**	**Part 6**	**Part 7**
	Title	**Subclause**	**AC**	**BBTM**	**Soft A**	**HRA**	**SMA**	**MA**	**PA**
1	Soluble binder content	**3.1**	✓	✓	✓	✓	✓	✓	✓
2	Particle size distribution	**3.2**	✓	✓	✓	✓	✓	✓	✓
3	Bit. recovery: rotary evap.	**3.3**							
4	Bit. recovery: fract. column	**3.4**							
5	Maximum density	**4.3**	✓	✓	✓	✓	✓		✓
6	Bulk density	**4.4**	✓	✓	✓	✓	✓	✓	✓
7	Bulk density, gamma rays	**7.1**							
8	Void characteristics	**4.5**	✓	✓	✓	✓	✓		✓
10	Compactibility	**7.2**							
11	Affinity, aggregate and bitumen	**5.1**							✓
12	Water sensitivity	**4.6**	✓	✓		✓	✓		✓
13	Temperature measurement	**7.3**							
14	Water content	**7.4**							
15	Segregation sensitivity	**7.5**							
16	Abrasion by studded tyres	**4.7**	✓	✓		✓	✓		
17	Particle loss of PA specimen	**5.2**							✓
18	Binder drainage	**5.3**					✓		✓
19	Permeability of specimen	**5.4**							✓
20	Indentation, cube or Marshall	**5.5**						✓	
21	Indentation using plates	**5.6**						✓	
22	Wheel tracking	**5.7**	✓			✓	✓		
23	Indirect tensile test	**6.1**							
24	Resistance to fatigue	**5.8**	✓						
25	Cyclic compression test	**5.9**	✓					✓	
26	Stiffness	**5.10**	✓			✓			
27	Sampling	**6.2**							
28	Preparation of samples	**6.3**							
29	Dimensions of a specimen	**7.6**							
30	Impact compactor	**6.4**							
31	Gyratory compactor	**4.8**	✓	✓		✓	✓		✓
32	Vibratory compactor	**6.6**							
33	Roller compactor	**6.7**							
34	Marshall test	**5.11**	✓						
35	Laboratory mixing	**6.8**							
36	Thickness of a pavement	**7.7**							
37	Hot sand test for chips	**7.8**							
38	C'n equipment and calibration	**7.9**							
39	Binder content by ignition	**4.9**	✓	✓	✓	✓	✓	✓	✓
40	*In situ* drainability	**7.10**							
41	Resistance to de-icing fluids	**4.10**	✓	✓		✓	✓	✓	✓
42	Foreign material	**7.11**							
43	Resistance to fuel	**4.11**	✓	✓		✓	✓	✓	✓

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2 Overview of European Standards defining test methods for asphalts

2.1 "Back of the lorry"

Unlike previous British Standards for asphalt, the harmonized European Standards are intended to define the material arriving on site, i.e. still in the "back of the lorry" and before placement and compaction. Therefore, there is greater emphasis on laboratory tests to define the properties that the asphalt could achieve rather than site tests to confirm that the *in situ* material has achieved the specified level of performance. As such, there is greater emphasis on laboratory-based tests and on methods to achieve repeatable preparation of the samples than has been the case in the UK previously.

2.2 CE Marking

The European Standard specifications for asphalt define the means of assessing a material against the essential requirements set out in the mandate for those documents. Generally, the assessment is defined in terms of the tests required to be undertaken and the classes that materials can be allocated to depending on the results of those tests. The set of classes that a material meets for each of essential requirements defines its CE mark. Because the system is intended to apply across Europe without the need for retesting in each country, the tests have to be uniquely defined for each situation.

The tests required for CE Marking and the available classes that can be claimed are dependent on the asphalt type being considered and, hence, are given in the relevant part of BS EN 13108-1 to -7. However, the test conditions under which those tests should be performed, when not given in the test method itself, are given in BS EN 13108-20, *Bituminous mixtures – Material specifications – Type testing*. This European Standard has normative annexes for:

- summary of properties and test methods for bituminous mixtures;
- methods of sample preparation;
- test procedures and conditions.

2.3 Status of tests

Tests can be categorized by their status within the system, although not formally defined in any part of BS EN 12697. The options are:

- *Category 0*: Test method not covered by a European Standard test method;
- *Category 1*: Test method covered by a European Standard test method but not called up by a European Standard material specification;
- *Category 2*: Test method covered by a European Standard test method that is called up by a European Standard material specification but is not applied for CE Marking of the material;
- *Category 3*: Test method covered by a European Standard test method that is called up by a European Standard material specification and is applied for CE Marking of the material;

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In these definitions, "test method" includes the test parameters used. For example, with the wheel tracking test, the small size device with BS 598-110 frequency and load is category 0, the extra large device is category 1 and the small scale device to Procedure A is category 2 for SMA and category 3 for HRA. As noted in this example, the categories can change depending on the material being assessed.

For the purposes of distinguishing whether a test, including test parameters, covered by BS EN 12697 is categorized as 1, 2 or 3, the test parameters have to be in Annex D of BS EN 13108-20 and the part of BS EN 13108 specific to the mixture type for category 2 and the Table relevant to the mixture type of Annex B to EN 13108-20 for category 3.

2.4 Empirical and fundamental tests

The ultimate aim of the European Standard specifications for asphalt was to specify the material in terms of fundamental, performance based properties. However, given the differences in knowledge and experience with fundamental specifications for asphalt mixtures in Europe, it was not possible to restrict the specifications to the fundamental approach. Therefore, it was planned to provide two ways of specifying asphalt:

- *the empirical approach*, specifying asphalt in terms of compositional recipes and requirements for constituent materials with additional requirements based on performance related tests;
- *the fundamental approach*, specifying asphalt in terms of performance-based requirements linked to limited prescription of composition and constituent materials, offering a greater degree of freedom.

It was envisaged that, as users gain experience with performance based testing, there would be a shift towards greater use of the fundamental approach to specification.

The definitions underpinning this dual approach are:

a) performance-based requirement;

b) requirement for a fundamental engineering property (e.g. stiffness, fatigue properties) that predicts performance and appears in primary performance prediction relationships;

c) performance-related requirement;

d) requirement for a characteristic (e.g. wheel tracking properties, Marshall properties) that has been found to correlate with a fundamental engineering property that predicts performance;

e) empirical specification;

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

g) fundamental specification;

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

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However, only the European Standard for asphalt concrete, BS EN 13108-1, has been written including the fundamental specification approach, the other standards being restricted to the empirical specification approach. Furthermore, there is often some confusion as to whether some tests provide performance-based requirements or performance-related requirements, particularly the simulative tests.

3 Guidance on test methods required for testing the constituent materials

3.1 Guidance on the use of BS EN 12697-1 – Soluble binder content

3.1.1 Scope of BS EN 12697-1

BS EN 12697-1 "describes test methods for the determination of the soluble binder content of samples of bituminous mixtures. The test methods described are suitable for quality control purposes during the production of plant mix and for checking compliance with a product specification. The analysis of mixtures containing modified binders are outside the scope of this document."

3.1.2 Summary of method

3.1.2.1 General

The standard provides a unified approach to the examination of asphalt mixtures that allows some divergence in the detail of procedures followed by individual laboratories. The determination of binder content comprises:

- binder extraction by dissolving the sample in a hot or cold solvent;
- separation of the mineral matter from the binder solution;
- determination of the binder content by difference or by binder recovery;
- calculation of the soluble binder content; and
- if required, correction for any insoluble portion of the binder.

The standard includes a definition of binder content that does allow for there being an insoluble portion.

The basic operations for both binder extraction and separation of the mineral matter are given, together with guidance on the choice of the alternative items of equipment in an informative annex. The test methods with the different equipment are given in a second, normative, annex with a third, informative, annex giving details of the method for determining the residual mineral matter in the binder extracted by incineration.

The methods covered for binder extraction are:

- hot extractor (paper filter) method;
- hot extractor (wire mesh filter) method;

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- Soxhlet extractor method;
- bottle rotation machine method;
- centrifuge extractor method;
- cold mix dissolution of bitumen by agitation method;

The methods covered for the separation of mineral matter are:

- continuous flow centrifuge method;
- pressure filter method;
- bucket centrifuge Type 1[1)] method;
- bucket centrifuge Type 2 method;

The methods covered for determining the soluble binder content are:

- method by recovery from a portion using a volume calculation;
- method by recovery from a portion using a mass calculation.

All combinations of these methods permitted under the first Annex are considered to give the same result. Furthermore, other methods and equipment, including automated equipment, can be used provided that it can be demonstrated that they provide the same results as one of the given methods within the limits of the precision given in the standard. This assumption is generally correct provided the same solvent is used, but no agreement could be reached across Europe as to which solvent that should be because of the hazards associated with all of them. In the UK, it is recommended to continue to use methylene chloride

Another, informative, annex has been added that gives guidance on determination of soluble binder content of mixtures with polymer-modified binders. This annex could be regarded as being in conflict with the scope, but the number of potential different approaches necessary to cover all possible polymers and situations together with the increase in uncertainty of the result when some polymers are used make it important that analysis of polymer-modified mixtures should not be strictly in accordance with this European Standard.

3.1.2.2 The hot extractor (paper filter) method

The hot extractor (paper filter) is the same as the British Standard hot extractor method, except that there is a modified condenser to allow for solvents with a density less than unity.

3.1.2.3 The hot extractor (mesh filter) method

The hot extractor (mesh filter) is a glass or metal extractor, fitted with a condenser and suitable extraction cup. The test portion is weighed into dried extraction thimbles made of fibrous material in the extraction cup. The extraction cup is placed in the extraction apparatus and the binder extracted by boiling the solvent until the condensed solvent becomes colourless. After extraction, the mineral aggregate with its container is removed and dried to constant mass. The solution is filtered through filter paper, or centrifuged, to remove any fine material and the mass of insoluble matter determined.

[1)] The bucket centrifuge Type 1 is the bucket centrifuge described in Annex E of BS 598-102:2003.

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3.1.2.4 The Soxhlet extractor method

The Soxhlet extractor is a glass extractor, consisting of a flask, an extraction case with tap and vapour tube, and a condenser. The flask and dry extraction case are weighed before the test portion is added and the extraction case reweighed. The case with the test portion is placed on a gauze in the extractor, which has been filled with solvent. The extractor tap is then opened and a heater switched on. The extraction is stopped when the solvent collected in the extractor becomes colourless. The mineral aggregate with its container is then removed and dried to constant mass. The solution is filtered through filter paper, or centrifuged, to remove any fine material and the mass of insoluble matter determined.

3.1.2.5 The bottle rotation machine method

The bottle rotation machine method is the same as the British Standard extraction bottle method, with procedures for both binder determination by difference (procedure 1) and binder portion recovered (procedure 2).

3.1.2.6 The centrifuge extractor method

The centrifuge extractor consists of a bowl, an apparatus in which the bowl may be revolved, a container for collecting the solvent thrown from the bowl and a drain for removing the solvent. A weighted test portion is placed into the bowl and covered with solvent for sufficient time for the solvent to disintegrate the test portion before being placed in the extraction apparatus. The filter discs are dried to constant mass and allowed to cool in a desiccator before being weighed. The mass of a filter ring is determined and it is fitted around the edge of the bowl. The cover is clamped on the bowl tightly and a beaker is placed under the drain to collect the extract. The centrifuge is operated until solvent ceases to flow from the drain, further solvent is added and the procedure repeated until the extract is colourless.

The extract and washings are collected in a suitable container. The filter ring is removed from the bowl and dried. The contents of the bowl are removed into a metal tray and dried to constant mass. The mass of the extracted aggregate is calculated from the mass of the aggregate in the tray plus the increase in mass of the filter rings.

3.1.2.7 The cold mix with dissolution by the agitation method

For the cold mix with dissolution by the agitation method, a weighed mass of asphalt is placed in a container at a temperature of less than 90 °C to which solvent is added. The mass of the solvent is:

- 1.6 times the mass of the sample if it contains more than 5% of binder;
- 0.8 times the mass of the sample if it contains 5% or less;
- 3 to 5 times the mass of the sample if it is mastic asphalt.

The sample is shaken for at least 30 min and then left to settle.

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3.1.2.8 The continuous flow centrifuge method

The continuous flow centrifuge is a high-speed continuous flow centrifuge. Two clean and dry centrifuge cups are weighed separately and one is placed in the centrifuge whilst the other is retained. The sieve that is fitted to the feed funnel is also weighed.

The feed funnel is fitted centrally above the centrifuge funnel and the binder solution obtained from the binder extraction process is fed into the feed funnel. The feed funnel tap is adjusted to give the required flow rate into the running continuous centrifuge. The filler collected in the centrifuge cup is re-washed using as small a quantity of solvent as possible until the decanted solvent becomes colourless. The centrifuged effluent is collected and the cup containing the extracted filler removed and placed in an oven for drying.

The procedure is then repeated with the second cup except at a different flow rate. After the centrifuging is completed, the cup and feed funnel sieve are placed with the first cup in the oven for drying. The filler collected is calculated from the difference in weights of the two cups and the mineral matter retained is determined from the weight of the sieve.

3.1.2.9 The pressure filter method

The pressure filter has a dry, pre-weighed filter paper fitted into it. A nest of test sieves is supported above a funnel mounted above the pressure filter. The binder solution obtained from the binder extraction process is decanted through the test sieves into the pressure filter, being forced through the filter paper using air pressure. The receptacle containing the washed aggregate is rinsed to remove as much of the mineral matter as possible; the washings are passed through the sieves and the pressure filter until the solvent is clear.

The clean aggregate is transferred from sieves to a tray and the solvent evaporated from the aggregate, the sieves and the receptacle. Any mineral matter in the receptacle is transferred to the tray with the remainder of the aggregate. The mass of the aggregate in the tray is weighed and the filter paper, complete with any mineral matter, is removed from the pressure filter and dried to constant mass. A filtering aid is permitted.

3.1.2.10 The bucket centrifuge type 1 method

The bucket centrifuge type 1 (for use with samples from the bottle rotation machine) is as described in Annex E of the British Standard for the extraction bottle method: binder directly determined.

3.1.2.11 The bucket centrifuge type 2 method

The bucket centrifuge type 2 (for use with agitated samples) uses higher speeds of not less than 40 000 m/s^2 for at least 30 min for mastic asphalt and for at least 15 min for other types of mixture.

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3.1.2.12 Binder content of mixtures containing modified binders

With regard to the binder recovery methods, the following is recommended.

- For the hot extractor (paper filter and wire mesh filter) and Soxhlet extractor methods, extraction should not be stopped when the solvent collected becomes colourless but to continue for a period of approximately 10% of the time taken for the solvent to become colourless. The hot extractor should have a transparent inspection window in order to determine the completion of extraction.
- For the bottle rotation machine method, the minimum rolling times should be increased, although the rotation speed of the bottles should not exceed 20 rev/min because of the risk of crushing the aggregate.
- For the centrifuge extractor method, extraction should be continued for an extra 200 ml addition of solvent after the extract has become colourless.
- For cold mix dissolution of modified binder by agitation, the container should be shaken for at least 45 min instead of 30 min. However, this method cannot be applied if the solubility of the modified binder is insufficient.

With regard to the separation of mineral matter methods, the following is recommended.

- For the continuous flow centrifuge, re-washing of the filler collected in the centrifuge cup should be repeated once more, after the decanted solvent has become colourless.
- The use of the pressure filter is not recommended for polymer modified binder because of risks of clogging.
- For the methods for bucket centrifuges type 1 and type 2, no changes are needed.

3.1.3 Equivalent British Standard

BS 598-102:2003.

3.1.4 Principal differences

All the methods in BS 598-102 are included, with the extraction bottle method being combined into the bottle rotation machine, and the hot extractor method becoming the hot extractor (paper filter). No adjustment factors for the binder or filler contents are applied in the European Standard for the proportion of fine aggregate found relative to the design quantity.

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3.1.5 Implications for UK

The loss of the adjustment factors on the binder and filler contents for the deviation from the design quantity of fine aggregate will either produce tighter tolerances on gradings for recipe aspects of any specification or will require revision of the tolerances applied. Nevertheless, the European Standard does permit the procedures currently being used whilst allowing additional ones that have been proven elsewhere. Therefore, the implementation should allow greater flexibility without having any detrimental effects on the current or developing UK approaches to asphalt specification, providing due allowance is made for the loss of the correction factors.

With regard to polymer-modified binders, the use of which is increasing, there is a need to have defined procedures for assessing the binder contents of such mixtures. However, there is limited detail in the Annex to the European Standard, in particular with respect to recommendations about suitable solvents and/or additional procedures for each type of polymer currently used.

3.2 Guidance on the use of BS EN 12697-2 – Determination of particle size distribution

3.2.1 Scope of BS EN 12697-2

BS EN 12697-2 "specifies a procedure for the determination of the particle size distribution of the aggregate of bituminous mixtures by sieving. The test is applicable to aggregates recovered after binder extraction in accordance with EN 12697-1. NOTE Fibres, solid (non-soluble during extraction) additives and (some) binder modifiers influence the test result."

3.2.2 Summary of method

The standard references BS EN 933-1 for extracting the binder by solvent to obtain the aggregate with a rider that, if there is insufficient material available, all the material shall be used. The particle size distribution is then obtained by sieving. If the material has been thoroughly washed during extraction so that it has a limited fines content, dry sieving can be used but it has to be verified against wet sieving for each specific mixture.

3.2.3 Equivalent British Standard

BS 598-102:2003, **5.1.5**, **5.2.6** and **5.3.6**.

3.2.4 Principal differences

Both standards refer to the aggregate analysis standard. BS 598-102 requires sieving of all the coarse aggregate but only a sample of the fine aggregate, whereas BS EN 12697-2 leaves that aspect to the aggregate standard, BS EN 933-1.

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3.2.5 Implications for UK

There are no significant implications for the United Kingdom in having this aspect in a separate standard. other than with regard to the requirement for wet sieving, or verification that dry sieving gives equivalent results to wet sieving for each mixture. These implications will be resolved in the next revision of BS EN 12697-2.

3.3 Guidance on the use of BS EN 12697-3 – Binder recovery: rotary evaporator

3.3.1 Scope of BS EN 12697-3

BS EN 12697-3 "describes a test method for the recovery of soluble bitumen from bituminous pavement materials in a form suitable for further testing. The procedure is only suitable for the recovery of paving grade bitumens, for which this European Standard is the reference method. The fractionating column procedure (see EN 12697-4) is the reference method for mixtures containing volatile matter such as cut-back bitumen."

3.3.2 Summary of method

The bitumen is separated from the sample by dissolving in dichloromethane. After removal of undissolved solids from the bitumen solution, the bitumen is recovered from it by vacuum distillation using a rotary evaporator. The bitumen is in solution for less than 24 h.

3.3.3 Equivalent British Standard

BS 2000-397:1995.

3.3.4 Principal differences

BS EN 12697-3 is based on BS 2000-397 and, therefore, there are no significant differences. The main difference is that the sample is agitated and left to stand prior to centrifuging/filtering out the insoluble matter rather than being rotated gently.

3.3.5 Implications for UK

None.

3.4 Guidance on the use of BS EN 12697-4 – Binder recovery: fractionating column

3.4.1 Scope of BS EN 12697-4

BS EN 12697-4 "describes a test method for the recovery of soluble bitumen from bituminous mixtures from pavements in a form suitable for further testing. The procedure is suitable for the recovery of penetration grade bitumen and is also suitable for mixtures containing volatile matter such as cutback bitumen but the results may be less precise. NOTE There is limited experience of recovery when polymer-modified bitumen is used."

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3.4.2 Summary of method

The binder is separated from the sample by dissolving in dichloromethane. After removal of undissolved solids, the binder solution is concentrated by atmospheric distillation in a fractionating column. The last traces of solvent are removed from the concentrate by distillation at an elevated temperature and reduced pressure with a stream of carbon dioxide gas. When cutback bitumens containing very volatile fluxes are being recovered, the carbon dioxide gas is omitted.

3.4.3 Equivalent British Standard

BS 2000-105:1991

3.4.4 Principal differences

BS EN 12697-4 is based on BS 2000-105 and, therefore, there are no significant differences. The only omission is the advice on preparation of the binder solution, but this was only advice in BS 2000-105.

3.4.5 Implications for UK

The inclusion of this test method in the suite of tests will reinstate the situation in the United Kingdom because the fractionating column method, which is required for mixtures containing volatile matter such as cutback bitumen, was withdrawn when the rotary evaporator method, BS 2000-397, became a full British Standard.

4 Guidance on test methods called up in several standard specifications for asphalt

4.1 Guidance on the use of BS EN 12697-1 – Soluble binder content

See **3.1**.

4.2 Guidance on the use of BS EN 12697-2 – Determination of particle size distribution

See **3.2**.

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4.3 Guidance on the use of BS EN 12697-5 – Determination of the maximum density

4.3.1 Scope of BS EN 12697-5

BS EN 12697-5 "specifies test methods for determining the maximum density of a bituminous material (voidless mass). It specifies a volumetric procedure, a hydrostatic procedure and a mathematical procedure. The test methods are intended for use with loose bituminous mixtures containing paving grade bitumens, modified binders or other bituminous binders used for hot mix asphalt. The tests are suitable for either fresh or aged bituminous mixtures. NOTE 1 Samples can be supplied as loose material or as compacted material. NOTE 2 General guidelines on selection of a test procedure to determine the maximum density of a bituminous mixture is given in [an] Annex".

4.3.2 Summary of methods

4.3.2.1 Volumetric method

The volumetric method is the reference method for maximum density. The sample is broken up into coarse aggregate and agglomerations of not more than 6 mm diameter in order to expose any occluded voids. The volume of the material is measured as the de-aired water displaced in a pyknometer, after evacuating any air by the application of a partial vacuum. Boiled water or a suitable organic solvent can be used instead of de-aired water. The maximum density is then calculated from that volume and the dry mass of the sample.

4.3.2.2 Hydrostatic method

The sample is broken up into coarse aggregate and agglomerations of not more than 6 mm diameter in order to expose any occluded voids. The material is then weighed in air and water. If required, a partial vacuum can be applied or the water used can have been boiled. The maximum density is calculated from the dry and wet masses.

4.3.2.3 Mathematical method

The maximum density is calculated from the densities of the constituent components and their relative proportions in the mixture.

4.3.3 Equivalent British Standard

DD 228:1996 (incorporating Amendment 1) and BS 598-104: 2005, Annex E.

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4.3.4 Principal differences

In the British Standards, the mathematical method is included in part of the Annex to BS 598-104 rather than DD 228. Relative to these standards, BS EN 12697-5:

- does not limit the maximum size of sample;
- allows heating to only 110 °C rather than 120 °C in order to break up samples;
- allows the test to be carried out at any temperature, with correction by using the density of water at that temperature, rather than standardizing on 25 °C;
- calibration of the pyknometer is not required for the hydrostatic test; and
- in the hydrostatic test, the application of a vacuum is not mandatory.

4.3.5 Implications for UK

The differences are not significant in terms of the overall applicability of the test other than, possibly, the dropping of the vacuum conditions for the hydrostatic test. Therefore, there should not be any adverse implications in adopting BS EN 12697-5.

4.3.6 Other comments

Comparison tests have been carried out in France, with several laboratories using each of the different procedures in BS EN 12697-5. Their conclusions were that the hydrostatic method should be dropped on the basis of the wider spread of results (possibly due to there not being a mandatory requirement to use a vacuum) so that the method with the solvent was the most reliable. However, the methods with water did not produce totally unacceptable results and, for CE marking purposes, the volumetric procedure with water has been selected.

4.4 Guidance on the use of BS EN 12697-6 – Determination of bulk density of bituminous specimens

4.4.1 Scope of BS EN 12697-6

BS EN 12697-6 "describes test methods for determining the bulk density of a compacted bituminous specimen. The test methods are intended for use with laboratory compacted specimens or specimens from cores cut from the pavement after placement and compacting. This European Standard describes the following four procedures, the choice of which is used being dependent on the estimated content and accessibility of voids in the specimen:

a) bulk density – dry (for specimens with a very closed surface);
b) bulk density – saturated surface dry (SSD) (for specimen with a closed surface);
c) bulk density – sealed specimen (for specimen with an open or coarse surface);
d) bulk density by dimensions (for specimen with a regular surface and with geometric shapes, i.e. squares, rectangles, cylinders etc.)

NOTE [An] Annex … (informative) gives general guidance on selecting the appropriate procedure."

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4.4.2 Summary of method

The thickness of specimens has to be not less than both 20 mm and twice the nominal aggregate size. General guidance on which of the four methods to select is given in an Annex although the relevant methods to be used for CE Marking for different materials are set out in BS EN 13108-20.

The “dry” procedure is for specimens with a very dense surface. The specimen is weighed in air when dry (either at the start of the test or after drying at the end) and in water. The density is calculated from the two masses together with the density of the water at the test temperature.

The “saturated surface-dry” (“SSD”) procedure is for specimens with a dense surface. The specimen is weighed in air when dry (either at the start of the test or after drying at the end), in water after being allowed to soak until at constant weight and after removal from the water and being wiped so as to be surface dry. The density is calculated from the three masses together with the density of the water at the test temperature.

The “sealed specimen” procedure is for specimens with an open or coarse surface. The specimen is weighed in air when dry, sealed with paraffin wax, shrinkage foil or latex emulsion (taking care not to enclose any air bubbles between the specimen and the seal folds) before being re-weighed dry and then in water. No distinction is made between sealing materials that fill at least the larger of the surface voids, such as paraffin wax, and those that span across those voids, such as shrinkage foil. The density is calculated from the three masses together with the density of the water at the test temperature.

The “by dimensions” procedure is for specimens with regular geometric shapes (cuboids or cylinders). The specimen is weighed in air when dry and its dimension measured. The density is calculated from the mass and the dimensions.

4.4.3 Equivalent British Standards

Clause **4** of BS 598-104:2003 and Clause **8** of BS 598-107:2004.

4.4.4 Principal differences

BS 598-104 contains both the “dry” and “sealed specimen” methods for cores while BS 598-107 contains the “dry” procedure for laboratory compacted specimens. The requirement to remove pre-coated chippings before testing cores, given in BS 598-104, is not in BS EN 12697-6.

4.4.5 Implications for UK

The test procedures in BS EN 12697-6 are more comprehensive than those in BS 598-104 and BS 598-107 and will allow the various densities to be measured in a standardized form. However, the loss of the requirement to remove pre-coated chippings before testing will need to be allowed for in future specifications.

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4.4.6 Other comments

Comparison tests have been carried out in France, with several laboratories using each of the procedures in BS EN 12697-6 other than by dimensions. Their conclusions were that the three methods are equivalent, based on the inter-laboratory spread. For low voids contents, they gave the same results whilst for "intermediate" voids contents (6% to 12%), the method using paraffin wax gave result midway between those with the other two methods. The maximum divergences were of the order of 0.03 Mg/m^3, which equates to approximately 1% of air voids.

4.5 Guidance on the use of BS EN 12697-8 — Determination of voids characteristics of bituminous specimen

4.5.1 Scope of BS EN 12697-8

BS EN 12697-8 "describes a procedure for calculating two volumetric characteristics of a compacted bituminous specimen: the air voids content (V_m) and the voids content in the mineral aggregate filled with binder (*VFB*). The method is suitable for specimens which are laboratory compacted or specimens from cores cut from the pavement after placement and compacting. These volumetric characteristics can be used as a mix design criteria or as parameters for evaluating the mixture after placing and compacting in the road."

4.5.2 Summary of method

The procedures are simple calculations. The air voids content is calculated from the difference between the maximum density and bulk density measurements, as a proportion of the maximum density. The voids in the mineral aggregate filled with binder is calculated from the binder content, the voids in the mineral aggregate, the bulk density of the specimen and the density of the binder. For this calculation, the voids in the mineral aggregate is calculated from the air voids content, the binder content of the specimen and the bulk densities of the specimen and the binder.

4.5.3 Equivalent British Standard

None, but the procedure for air voids content is given in a sub-clause repeated in Clauses **929** and **937** of the *Specification for Highway Works* [1].

4.5.4 Principal differences

None.

4.5.5 Implications for UK

The method for air voids content is needed because more specifications are incorporating limits for air voids contents whilst there is less need for the voids in the mineral aggregate filled with binder. However, the standardization of both is useful.

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4.6 Guidance on the use of BS EN 12697-12 – Determination of the water sensitivity of bituminous specimens

4.6.1 Scope of BS EN 12697-12

BS EN 12697-12 "describes a test method for determining the effect of saturation and accelerated water conditioning on the indirect tensile strength of cylindrical specimens of bituminous mixtures. This method can be used to evaluate the effect of moisture with or without anti-stripping additives including liquids, such as amines, and fillers, such as hydrated lime or cement."

4.6.2 Summary of method

Not less than six cylindrical test specimens are measured, weighed and their volumes and bulk densities calculated. The set is then divided into two subsets with the subsets having approximately the same average length and the same average density. The "dry" subset is stored at 20 °C whilst the "wet" subset is placed in a desiccator filled with distilled water at 20 °C in a vacuum for half an hour and then at atmospheric pressure for a further half hour. The volumes of the wet specimens are recalculated and any whose volume has increased by more than 1% rejected. The wet samples are then stored in a water bath at 40 °C for a further 68 h (nearly three days).

All samples are conditioned to 25 °C in either a water bath or thermostatically controlled air chamber for not less than two hours. Using a water bath, the dry specimens are sealed in a soft plastic bag or other watertight protection while, using an air chamber, the wet specimens are in leak-proof, soft plastic bags filled with water. The indirect tensile strength of each specimen is then measured in accordance with the relevant standard (see **6.1**). The indirect tensile strength ratio is calculated as the ratio of the mean indirect tensile strength of wet subset to that of the dry subset, in per cent.

4.6.3 Equivalent British Standard

None, although there is a protocol developed under the Department of Transport LINK programme on Transport Infrastructure and Operations led by the University of Nottingham, and subsequently modified by Specialist Group 3 of the British Board of Agrément-Highway Authorities Product Approval Scheme for use with thin surfacing systems [2].

4.6.4 Principal differences

In the protocol, the test is the non-destructive indirect tensile stiffness modulus test conforming to DD 213:1993 carried out on a single specimen with the indirect tensile stiffness modulus being measured initially and after each conditioning cycle. In BS EN 12697-12, the test is the destructive indirect tensile test and separate samples are used, only one conditioning cycle is used and averages of at least three specimens are determined. The conditioning in the protocol starts similarly with 30 min in a vacuum, but thereafter it is more extreme but for a shorter period.

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4.6.5 Implications for UK

The need for a test on water sensitivity has not been a high priority in the United Kingdom because of the adequate supply of sources of aggregates that are not sensitive to moisture with the bitumens marketed here. Nevertheless, the standardization of a suitable test will be beneficial. The test in the United Kingdom is not dissimilar, but the method in BS EN 12697-12 has limitations because there are doubts that a single conditioning cycle will sufficiently distinguish mixtures that are sensitive to moisture.

4.7 Guidance on the use of BS EN 12697-16 – Abrasion by studded tyres

4.7.1 Scope of BS EN 12697-16

BS EN 12697-16 "describes test methods (method A and method B) for determining abrasion by studded tyres, tested on cylindrical specimens of bituminous mixtures. NOTE Method A originates from the 'Prall'-method, which has been improved by comprehensive research work. According to Swedish research work, the method correlates with abrasion in the field. Method B originates from Finnish experience and correlates with abrasion in the field."

4.7.2 Summary of method

For Method A, a cylindrical specimen at a temperature of 5 °C is agitated in an abrasion apparatus with 40 steel balls for 15 min. The abrasion value is determined as the loss of volume of the specimen.

For Method B, a cylindrical specimen at a temperature of 5 °C is agitated by an abrasion apparatus with a rotation unit with three studded rubber tyres for two hours. The abrasion value is determined as the loss of volume of the specimen.

4.7.3 Equivalent British Standard

None.

4.7.4 Implications for UK

Studded tyres are not permitted in the United Kingdom, so this standard will not apply in this country.

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4.8 Guidance on the use of BS EN 12697-31 – Specimen preparation by gyratory compactor

4.8.1 Scope of BS EN 12697-31

BS EN 12697-31 "specifies the method for compaction of cylindrical specimens of bituminous mixtures using a gyratory compactor. Such compaction is achieved by combining a rotary shearing action and an axial resultant force applied by a mechanical head. The method can be used for:

a) determination of the air voids content of a mixture for a given number of gyrations;

b) derivation of a curve density versus number of gyrations;

c) preparation of specimens of given height at a predetermined density, for subsequent testing of their mechanical properties.

For purposes a) and b), the performance based procedure of the Annex … specifies a calibration chain so that the result of the test should be independent from the type of gyratory compactor used. For purpose c), compliance with [the] Annex … may not be necessary. This European Standard applies to bituminous mixtures (both those made up in [the] laboratory and those resulting from work site sampling), with a maximum aggregate size not larger than 31.5 mm."

4.8.2 Summary of method

The mixture is prepared in accordance with the relevant standard and, if a core, heated sufficiently to be able to break it up in order to sample the required mass of material. Cylindrical moulds and inserts in the gyratory compactor are heated to the test temperature for at least two hours. The mould is filled with the required mass of the bituminous mixture and retained within an insert. The filled mould is kept at the test temperature for between half and two hours.

Compaction is achieved by the simultaneous action of a low static compressive force and the shearing action resulting from the motion of the centre-line, which generates a conical surface of revolution, while the ends of the test piece remain perpendicular to the axis of the conical surface at all times. The angle is kept constant, within a prescribed tolerance, throughout the test. During the test, the cross-section and the mass of the specimen remain constant but its height, which is continuously monitored, reduces.

The angle through which the sample is turned is calibrated for a particular gyratory compaction machine using three reference mixtures. The speed of rotation is between 6 and 32 revs/min and the test temperature is specified in BS EN 12697-35:2004.

The density of the material is derived from the height of the specimen. If the method is used to prepare specimens at a predetermined density, the compaction process is ended when the height attained corresponds to the required density.

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4.8.3 Equivalent British Standard

None.

4.8.3.1 Implications for UK

Compaction of specimens by gyratory compactor is one of the methods recognized in BS EN 13108-20. Furthermore, with the introduction of gyratory compaction machines becoming more common in UK laboratories, there is a need for a standard method for their use and BS EN 12697-31 will satisfy that need. The important issue is the use of BS EN 12697-31 in specifications and in other test methods in relation to the equivalence of the various methods of compaction (impact, gyratory, vibratory and slab), which will also become more commonplace.

4.8.4 Other comments

An inter-laboratory pre-normative trial has been carried out to show that the different types of gyratory compactor currently available produce the same result but require slightly different nominal angles through which to rotate the specimen. This procedure is included as an Annex for calibration. Alternative calibration methods with specially designed equipment rather than standard mixtures are also given as annexes.

4.9 Guidance on the use of BS EN 12697-39 – Binder content by ignition

4.9.1 Scope of BS EN 12697-39

BS EN 12697-39 "describes a test method for the determination of the binder content of samples of bituminous mixtures by ignition. As such, it is an alternative to the more traditional method of extracting the binder using solvents. The method can be used for evaluation of mixture composition because the remaining aggregate can be used for determining aggregate gradation and density provided excessive breakdown of the aggregate particles does not occur at the temperature reached. The results can be used for process control or checks on the compliance of mixtures. However, the need for calibration of a mixture before an analysis can be carried out makes this method easier to use with regularly used mixtures rather than with an extensive range of different mixtures from different aggregate sources. The test method is equally suitable for the analysis of mixtures containing unmodified or modified binders because the method has to be calibrated for each mixture being checked when calibration on mixtures is used. In case of doubt/dispute, the determination of the calibration value based on laboratory-prepared bituminous mixtures (see …) is the reference method."

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4.9.2 Summary of method

The test method determines the binder content of bituminous mixtures by ignition in a furnace at a specified test temperature, usually 540 °C. The binder content is obtained by calculation that includes a calibration factor. Calibration factors are determined for particular mixtures or aggregates, where applicable. Two test methods are described; Method A utilizes a furnace with an internal balance; Method B permits the use of a furnace and an external balance.

4.9.3 Equivalent British Standard

DD 250:1999.

4.9.4 Principal differences

BS EN 12697-39 is based on DD 250 and, hence, the differences are minor.

4.9.5 Implications for UK

The test is environmentally more acceptable than traditional solvent methods, and its inclusion in BS EN 12697 will permit and encourage its future usage.

4.9.6 Other comments

There are serious concerns about:

- the applicability of the method because of the need to calibrate each mixture; and
- the universality of the method because of the potential for damage of aggregate particles from certain sources.

Hence, the scope includes advice that the method is suitable for routine compliance only of regularly used mixtures and the lack of any significant breakdown of aggregate particles at the test temperature needs to be checked if the particle size distribution is to be evaluated.

4.10 Guidance on the use of BS EN 12697-41 – Resistance to de-icing fluids

4.10.1 Scope of BS EN 12697-41

BS EN 12697-41 "specifies a test method to determine the resistance of bituminous materials to de-icing fluids such as solutions of acetate and formate. The procedure determines the surface tensile strength of a specimen of asphalt after storage in de-icing fluid. This European Standard is primarily used as a test on asphalt to be laid on airfields, but it can be used for asphalt to be laid on roads or other paved areas."

4.10.2 Summary of method

An asphalt cylinder is sawn perpendicular to the diameter into which a hole is drilled to a depth of about 5 mm to form the test surface. Four specimens are stored and four are not stored in the de-icing fluid. A steel plate is bonded to the test surface of each specimen in turn. The plate is pulled off with a tensile force increasing at a rate of 200 N/s, the force being applied perpendicular to the test specimen surface. The tensile force at failure load and the mode of failure are recorded. The results are compared with those for specimens which have not been stored in the de-icing fluid.

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4.10.3 Equivalent British Standard

None, although there is a sensitivity to diesel (or other fluid) test defined by Specialist Group 3 of the British Board of Agrément-Highway Authorities Product Approval Scheme for use with thin surfacing systems [2].

4.10.4 Principal differences

The BBA-HAPAS procedure uses retained stiffness which is a totally different approach to that of BS EN 12697-41.

4.10.5 Implications for UK

The test is intended primarily for airfields, but the availability of a standardized test should also be of use for highways.

4.11 Guidance on the use of BS EN 12697-43 – Resistance to fuel

4.11.1 Scope of BS EN 12697-43

BS EN 12697-43 "specifies a test method to determine the resistance of a bituminous mixture or pavement to fuels. The procedure involves initial soaking of a test specimen made in the laboratory or cored from a pavement in a fuel, followed by a brushing period with a steel brush mounted in a Hobart mixer. The material loss of the specimen is a measure of the resistance to that fuel for that bituminous mixture.
NOTE The test is normally carried out with jet fuel."

4.11.2 Summary of method

A cylindrical test specimen with a known mass is partially immersed into a bath with the specified fuel for a specified period of time. For mixtures with paving grade bitumen, this period is 24 h whilst, for mixtures with polymer-modified bitumen, it is 72 h. After removal from the bath, cleaning with water and drying for 24 h in a ventilated oven at 25 °C, the loss of mass of the specimen is measured and the immersed surface is visually inspected. The type of damage and the material loss of the immersed surface are also recorded. Then the test specimen is put in a steel mould with the previously immersed surface uppermost. At the bottom of the specimen, a pneumatic cylinder pushes the immersed surface onto a steel brush which moves in epicycloid passages over the surface. After 30 s, the brushing stops and the specimen is removed from the mould. The loss of mass is measured and the brushed surface is visually inspected. The specimen is then put back into the mould and the procedure is repeated for another 30 s and then for 60 s, with the brushed surface being measured and visually inspected after each brushing.

The total brushing time is 120 s (two brushing periods of 30 s and one of 60 s). The material loss after the immersion and/or the brush test is a measure for the resistance to that particular fuel.

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4.11.3 Equivalent British Standard

None, although there is a sensitivity to diesel (or other fluid) test defined by Specialist Group 3 of the British Board of Agrément-Highway Authorities Product Approval Scheme for use with thin surfacing systems.

4.11.4 Principal differences

The BBA-HAPAS procedure uses retained stiffness which is a totally different approach to that of BS EN 12697-43.

4.11.5 Implications for UK

The test is intended primarily for airfields, but the availability of a standardized test should also be of use for highways.

5 Guidance on test methods called up in specific standard specifications for asphalt

5.1 Guidance on the use of BS EN 12697-11 – Determination of the affinity between aggregate and bitumen

5.1.1 Scope of BS EN 12697-11

BS EN 12697-11 "specifies procedures for the determination of the affinity between aggregate and bitumen and its influence on the susceptibility of the combination to stripping. This property is intended to be of assistance to the designer for mixture design rather than as a type test. Susceptibility to stripping, as determined by these procedures, is an indirect measure of the power of a binder to adhere to various aggregates, or of various binders to adhere to a given aggregate. The procedures can also be used to evaluate the effect of moisture on a given aggregate-binder combination with or without adhesion agents including liquids, such as amines, and fillers, such as hydrated lime or cement.

In the rolling bottle method, the affinity is expressed by visual registration of the degree of bitumen coverage on uncompacted bitumen-coated mineral aggregate particles after influence of mechanical stirring action in the presence of water. NOTE 1 The rolling bottle test is a simple but subjective test and suitable for routine testing. It is not appropriate for aggregates that are easily abraded.

In the static test method, the affinity is expressed by visual registration of the degree of bitumen coverage on uncompacted bitumen-coated mineral aggregate particles after storage in water. NOTE 2 The static test is a simple but subjective test that is less precise generally but can cope with high PSV-aggregates.

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In the boiling water stripping test method, the affinity is expressed by determining the degree of bitumen-coverage on uncompacted bitumen-coated aggregate after immersion in boiling water under specified conditions. NOTE 3 The boiling water stripping test is an objective test and has a high precision. However, it is a more specialist test because it requires greater skill of the operatives and uses chemicals as reagent. The latter point may also imply extra health and safety considerations. NOTE 4 The boiling water stripping test procedure can be used for any binder-aggregate combinations in which the mineral aggregate is calcareous, silico-calcareous or siliceous by nature."

5.1.2 Summary of method

5.1.2.1 Rolling bottle method

The aggregate is sieved and the 8/11 mm fraction (or the 5.6/8 mm fraction if the former is not available) is separated. This fraction is washed, dried and mixed with bitumen to obtain a uniform coverage over the whole of the surface area of the aggregate. The bitumen-coated aggregate is placed loosely so as to be distributed across a metal plate or sheet of silicone paper and then stored at ambient temperature (not defined) overnight. The sample is then divided into three and each part is transferred to a bottle filled with water in which there is a glass rod with rubber tube attached. The bottles are sealed and placed on a rolling-bottle device. The bottles are rolled for six hours, the water removed and, if necessary, with the aid of a magnifying glass, the proportion of bitumen coverage estimated by two technicians, independently. The aggregate is replaced into the bottles, which are then refilled with the same water. The bottles are again rolled, with the binder coverage being re-measured after a total of 24 h, 48 h and 72 h.

5.1.2.2 Static test method

The bitumen coated aggregate is immersed in distilled water for 48 h and the number of particles that are no longer completely coated assessed.

5.1.2.3 Boiling water stripping test method

The aggregate is sieved in accordance with BS EN 12697-2. The 7 mm to 14 mm fraction (or alternatively another fraction) is washed, dried and mixed with bitumen to obtain uniform, total coverage. The bitumen coated aggregate is subjected to stripping in boiling water under specified conditions, using a simple device in which no local overheating can occur. By contact with a chemical reagent, the consumption of which is proportional to the uncoated surface of the aggregate, the degree of bitumen coverage is determined with reference to a calibration curve established by a well-defined procedure. The reagent used is hydrochloric acid for calcareous aggregates and hydrofluoric acid for silico-calcareous or siliceous aggregates.

5.1.3 Equivalent British Standard

None for hot mixtures, although the static method is called up as an appendix in the Defence Estates specifications for asphalt materials to be used on military airfields [3] and there is the immersion tray test for determining the concentration of adhesion agent required for binders in Road Note 39 for surface dressings [4].

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5.1.4 Principal differences

The three test methods in BS EN 12697-11 are completely different. The static method was based on the Defence Estates method and there are no significant technical differences.

5.1.5 Implications for UK

The static method is called up in BS EN 13108-7, porous asphalt, for use on airfields, which is the only instance. Therefore, the test will no longer be available for identifying suitability for other types of asphalt used on airports. The use of this test for porous asphalt, the most sensitive of mixture to poor affinity, should not change.

Based on limited trials in the United Kingdom, the rolling bottle method is not suitable for mixtures with high polished-stone value aggregates because the aggregate particles abrade, removing the binder film with the abraded aggregate to leave aggregate exposed which is then taken as binder stripping. This limitation is acknowledged in a note to the scope.

The use of the boiling water stripping test method is not encouraged, particularly for routine testing, because of the health and safety implication of using hydrochloric acid and, more particularly, hydrofluoric acid as reagents.

5.2 Guidance on the use of BS EN 12697-17 – Particle loss of porous asphalt specimen

5.2.1 Scope of BS EN 12697-17

BS EN 12697-17 "describes a test method for determining the particle loss of porous asphalt mixtures. Particle loss is assessed by the loss of mass of porous asphalt samples after turns in the Los Angeles machine. This test enables the estimation of the abrasiveness of porous asphalt. The test applies to laboratory compacted porous asphalt mixtures the upper sieve size of which does not exceed 25 mm. It does not reflect the abrasion action by studded tyres."

5.2.2 Summary of method

At least five 100 mm diameter cylinders of porous asphalt are prepared and their masses, bulk densities and air voids contents determined. Each specimen in turn is placed in a Los Angeles machine without any steel balls at the test temperature, usually between 15 °C and 25 °C. The specimens are rotated at between 30 and 33 rpm for 300 turns and re-weighed. The particle loss is then calculated from the average difference between the initial and final masses as a proportion of the initial masses.

5.2.3 Equivalent British Standard

None.

5.2.4 Implications for UK

The test is called up in BS EN 13108-7 and so is part of the design procedure for porous asphalt. If the use of that mixture type were to increase significantly in the United Kingdom, then the availability of the

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test procedure and the performance of any mixture in this test will be important.

5.3 Guidance on the use of BS EN 12697-18 – Binder drainage

5.3.1 Scope of BS EN 12697-18

BS EN 12697-18 "describes two test methods:

- basket method (**5.3.2.1**);
- Schellenberg method (**5.3.2.2**)."

The basket method "describes a method for determining binder drainage of bituminous mixtures. This method directly measures binder drainage, but when carried on bituminous mixtures with fibres or mixtures whose mortar content is higher than in porous asphalt some clogging of the holes in the drainage baskets can occur, limiting the drainage of the binder."

The Schellenberg method "describes a method for determining binder drainage of bituminous mixture. It is applicable to asphalt materials that are not porous asphalt or for those porous asphalt incorporating fibres."

Both methods "can be used either for determining the binder drainage for different binder content, or with a single binder content, eliminating the successive repetitions. It also enables the effects of varying fine aggregate types and the effect of any anti-draining additive to be quantified."

5.3.2 Summary of methods

5.3.2.1 Basket method

The quantity of binder lost by drainage, after three hours at the maximum mixing temperature expected at the mixing plant, is measured for duplicate samples of the mixture with the same aggregate grading but with different binder contents. The test results are the data pairs of binder content and mean binder drained.

5.3.2.2 Schellenberg method

Three batches of 1 kg of aggregate are prepared to the specified grading and placed in separate tins. Three beakers are weighed and heated to the test temperature, which is the maximum mixing temperature for that mixture or 15 °C above the mixing temperature in the laboratory-mixing standard. Each batch of aggregate is mixed with the required amount of binder and any additives, put in a beaker and returned to the oven for one hour. At the end of that time, the temperature of the mixture in one beaker is measured; this beaker is not used again in the test. The other two beakers are removed from the oven and upturned for 10 s. After cooling, the beakers are reweighed with the remaining (drained) material. If the remaining material is more than 0.5% of the original mass, it is washed with solvent over a 1 mm sieve. The mean drained material is calculated. The procedure is repeated at three binder contents at 0.3% intervals.

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5.3.3 Equivalent British Standard

DD 232:2005.

5.3.4 Principal differences

Part A of BS EN 12697-18 is similar to DD 232 whilst Part B is totally different, being simpler and probably less precise. The test temperature in Part A of BS EN 12697-18 is the maximum expected temperature at the plant rather than being related back to an equi-viscous temperature with values provided for unmodified bitumen, as in DD 232.
In BS EN 12697-18, the test is carried out at the minimum permitted binder content and at two increments of 0.5% above that whereas, in DD 232, the test is carried out at five binder contents around the expected maximum binder content. BS EN 12697-18 does not define the maximum binder content or any other single value, leaving that to the material specifier.

5.3.5 Implications for UK

BS EN 12697-18 is called up in BS EN 13108-5 for stone mastic asphalt and BS EN 13108-7 for porous asphalt whereas DD 232 was only required for porous asphalt.

There is nothing in Part A of BS EN 12697-18 to conflict with current UK practice except the definition of the test temperature, but it would allow less rigorous analysis with the reduction from a minimum of five to three pairs of measurements. The implementation of BS EN 12697-18 requires more explanation of how to make use of the results whenever it is called up in a job specification for determining the minimum binder content.

The use of a separate test for mixtures other than porous asphalt without fibres, in particular stone mastic asphalt, seems unnecessary unless it is assumed that the requirements are less severe and only need a simpler test.

5.4 Guidance on the use of BS EN 12697-19 – Permeability of specimen

5.4.1 Scope of BS EN 12697-19

BS EN 12697-19 “describes a method for determining the vertical and horizontal permeability of a cylindrical specimen of bituminous mixtures. The standard applies to specimens cored out of the road, specimens from laboratory made slabs or laboratory specimens prepared with a compaction device provided the specimen is not less than 2.5 times the nominal maximum particle size of the aggregate in the mixture. The nominal diameter of the specimens should be either 100 mm or 150 mm unless the nominal maximum particle size of the aggregate exceeds 22 mm, when the nominal diameter shall be 150 mm diameter (sic).”

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5.4.2 Summary of method

5.4.2.1 Vertical permeability

A specimen is placed in a rubber cuff that is inflated and pressed firmly around the wall of the specimen to form a seal. The bottom of the specimen is left clear and the specimen rests on a platform in a water-bath above a collecting reservoir so that the top of the specimen is level with the rim of the water bath. A column of water with a constant height is applied to the specimen and the water is allowed to permeate through the specimen for a controlled time. The vertical permeability, k_v, is then calculated from the flow rate of the water in accordance with Darcy's law. The test is carried out at ambient temperature with no correction in the calculation for any change in viscosity of water.

5.4.2.2 Horizontal permeability

A plastic tube is glued to the upper face of the specimen and the tube is placed in a rubber cuff which is inflated and pressed firmly around it to form a seal. The bottom of the specimen is sealed to the bottom of a platform in a water-bath above a collecting reservoir so that the bottom of the tube is level with the rim of the water bath. A column of water with a constant height is applied to the specimen and the water is allowed to permeate through the specimen for a controlled time. The horizontal permeability, k_h, is then calculated from the flow rate of the water in accordance with a modified Darcy's law. The test is carried out at ambient temperature with no correction in the calculation for any change in viscosity of water.

5.4.3 Equivalent British Standard

None.

5.4.4 Implications for UK

BS EN 12697-19 is called up in BS EN 13108-7 for porous asphalt. The introduction of this test will allow porous asphalt mixtures to be designed for permeability in the laboratory. However, experience with the test on cores taken from material of known hydraulic conductivity and on laboratory made samples will be needed before it becomes a useful test.

5.5 Guidance on the use of BS EN 12697-20 – Indentation using cube or Marshall specimen

5.5.1 Scope of BS EN 12697-20

BS EN 12697-20 "describes a test method for determining the depth of indentation of mastic asphalt and [hot] rolled asphalt, when force is applied to them via a cylindrical indentor pin with a circular flat-ended base. This European Standard applies to aggregates of maximum nominal size less or equal to 16 mm."

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5.5.2 Summary of method

Specimens are produced either as Marshall specimens or as moulded test cubes. The specimens are placed in an indentation test apparatus within a water bath. The test apparatus is pre-calibrated using a rubber calibration block.

Two specimens are pre-conditioned at the test temperature of either 40 °C or 22 °C (40 °C for road pavements) for at least one hour and then indentor pins are pushed into them with a force of 25 N for 10 min before the initial reading are taken. The indentor pins are then pushed into the specimen at the test load of 525 N for a set period, the application period depending on the use of the asphalt. The result is the mean indentation from the two specimens.

5.5.3 Equivalent British Standard

BS 5284:1993, Clause **6**.

5.5.4 Principal differences

The two standards are essentially different tests, although measuring the same property. BS 5284 applies a different load (311 N) five times on the same specimen rather than once each on two specimens. BS EN 12697-20 defines the test temperature whilst, for BS 5284, the test temperature is specified in the material standard.

5.5.5 Implications for UK

BS EN 12697-20 is called up in BS EN 13108-6 for mastic asphalt for small aggregate (D = 1.2 mm) when the required indentation is greater than 2.5 mm. The test method in BS EN 12697-20 does not appear to be any better or worse than that in BS 5284. However, its adoption requires a review of the appropriate equivalent values for use in specifications and the purchase of replacement equipment by testing laboratories.

5.6 Guidance on the use of BS EN 12697-21 – Indentation using plate specimen

5.6.1 Scope of BS EN 12697-21

BS EN 12697-21 "describes a test method for measuring the indentation of mastic asphalt when it is penetrated at a given temperature, load and for a fixed time period by a standardized cylindrical indentor pin with a circular flat-ended base. This European Standard applies to mastic asphalt with aggregates of maximum nominal size less or equal to 16 mm."

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5.6.2 Summary of method

Material can be sampled on discharge from a mobile mixer, from site remelting equipment or from laid material. The sampled material is remelted and moulded into slabs (plates). Two specimens are pre-conditioned at the test temperature for at least half an hour and then an indentor-pin is pushed into them with a set force for a set period, with readings made of the penetration after two set periods. The procedure is repeated either three or five times on each of the specimens. The test temperature, test load, area of the surface of the indentor-pin, the number of determinations on a sample and the period to initial and final readings of indentation are set for different uses of mastic asphalt. However, how to select the appropriate set of test conditions from the four listed for particular circumstances is not clearly identified. The result is the mean indentation from the initial to the final reading for the average indentation on the two specimens.

5.6.3 Equivalent British Standard

BS 5284:1993, Clause **6**.

5.6.4 Principal differences

BS 5284 is equivalent to test condition W in BS EN 12697-21 but with a load of 317 N instead of 311 N.

5.6.5 Implications for UK

BS EN 12697-20 is called up in BS EN 13108-6 for mastic asphalt for large aggregate ($D > 1.2$ mm) when the required indentation is greater than 2.5 mm. Test condition W is the preferred option that will mean effectively no change in the test procedure in the United Kingdom.

5.7 Guidance on the use of BS EN 12697-22 – Wheel tracking

5.7.1 Scope of BS EN 12697-22

BS EN 12697-22 “describes test methods for determining the susceptibility of bituminous materials to deform under load. The test is applicable to mixtures with upper sieve size less than or equal to 32 mm. The tests are applicable to specimens that have either been manufactured in a laboratory or cut from a pavement; test specimens are held in a mould with their surface flush with the upper edge of the mould. The susceptibility of bituminous materials to deform is assessed by the rut formed by repeated passes of a loaded wheel at constant temperature. Three alternative types of devices can be used according to this standard: large-size devices, extra large-size devices and small-size devices. With large-size devices and extra large-size devices, the specimens are conditioned in air during testing. With small-size devices, specimens are conditioned in either in air or water. NOTE Large-size devices and extra large-size devices are not suitable for use with cylindrical cores.”

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5.7.2 Summary of method

5.7.2.1 General

There are effectively five methods:

- large size devices with samples conditioned in air;
- extra large size devices with samples conditioned in air;
- small size devices, Procedure A, with samples conditioned in air;
- small size devices, Procedure B, with samples conditioned in air;
- small size devices, Procedure B, with samples conditioned in water.

5.7.2.2 Large size device with samples conditioned in air

Two samples are conditioned by loading with a pneumatic tyre at 600 kPa for 1 000 cycles at a temperature of (20 ± 5) °C. The samples are then raised to the test temperature (which is not defined in the standard) for (14 ± 2) h before the device is run. The deformation is measured at various times including after 1 000, 3 000 and 10 000 cycles at 15 locations and the proportional deformation recorded as the ratio of the mean value from the 15 locations divided by the specimen thickness. Linear regression analysis of the results from both specimens is used to define the relationship between the number of load cycles and the proportional deformation, from which the proportional deformation after a specified number of passes can be calculated.

5.7.2.3 Extra large size device with samples conditioned in air

Two samples are conditioned at the test temperature for (16 ± 2) h. A pneumatic tyred wheel with a load of 10 kN tracks the samples at a frequency of 24 cycles/min. The deformation is measured along three transverse lines initially and after various intervals up to 30 000 cycles. The test finishes when the required number of cycles has been completed or the rut depth has reached 20 mm. The mean rut depth and the proportional rut depth are calculated.

5.7.2.4 Small size device, Procedure A, with samples conditioned in air

Six specimens are conditioned at the test temperature for between four hours (six hours for thicknesses over 60 mm) and 24 h before being tracked for 1 000 cycles under a solid rubber tyre 50 mm wide with a 700 N load. The first five cycles are used for conditioning. The wheel-tracking rate is calculated from the average rate of deformation in μm/cycle over the last third of the test and the proportional deformation is calculated from the average total deformation as a proportion of sample thickness.

5.7.2.5 Small size device, Procedure B, with samples conditioned in air

Two specimens are conditioned at the test temperature for not less than an hour before being tracked for 10 000 cycles under a solid rubber tyre 50 mm wide with a 700 N load. The first five cycles are used for conditioning. The deformation is measured 6 or 7 times in the first hour and every 500 load cycles thereafter. The wheel-tracking rate is calculated as the mean value in mm/10^3 cycles between 5 000 and 10 000 load cycles and the proportional rut depth as for the large size device.

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5.7.2.6 Small size device, Procedure B, with samples conditioned in water

As for the small size device, Procedure B, with samples conditioned in air (**5.7.2.5**) except the samples are held in water during conditioning and testing.

5.7.3 Equivalent British Standard

BS 598-110:1998 (incorporating Amendment 1).

5.7.4 Principal differences

5.7.4.1 Small size equipment test with conditioning in air

The principal differences between the two BS EN 12697-22 procedures for the small size device with samples conditioned in air and BS 598-110 are shown in Table 2.

Table 2 **Principal differences between the two BS EN 12697-22 procedures for the small size device with samples conditioned in air and BS 598-110**

	BS 598-110	**BS EN 12697-22 Procedure A**	**BS EN 12697-22 Procedure B**
No. of replicates:	6	6	2
Conditioning time:	4 h to 16 h	4 h (6 h if thickness > 60 mm) to 24 h	= 1 h
Conditioning passes:	0 cycles	5 cycles	5 cycles
Frequency:	(21.0 ± 0.2) cycles/min	(26.5 ± 1) cycles/min	(26.5 ± 1) cycles/min
Duration:	45 min (= 945 cycles)	1 000 cycles	10 000 cycles
Load:	520 N	700 N	700 N
No. of measurement points:	Single point	Single point	25 points
Measurements:	Rut rate (mm/h) Rut depth (mm)	Rut rate (μm/cycle) Rut depth (mm)	Rut rate (mm/10^3 cycles) Proportional rut depth (%)
Slope measurement length:	Final 15 min (= 315 cycles)	Final 300 cycles	Final 5 000 cycles

5.7.4.2 Comparative studies

Comparative testing has been undertaken with these methods. A European pre-normative study, prior to the changes described above having been made other than the load, compared the small size device to Procedure A with conditioning in air (i.e. the BS 598-110 method with increased load) with the small size device to Procedure B with conditioning in water and the large size device. The small size device in water used a steel wheel which was subsequently excluded because it did not correlate with the results from other two procedures. The results are reproduced in Table 3.

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Table 3 **Rut depths (mm) from pre-normative research on wheel tracking**

Mixture	Temp. °C	BS 598-110 with 700 N load	BS EN 12697-22	
			Small, Proc B in water	Large
HRA 1	50	20.0	10.7	15.5
HRA 2	50	20.2	11.2	13.5
SMA 1	50	11.0	8.0	11.9
SMA 1	60	12.7	11.2	11.9
SMA 2	50	9.5	6.2	11.35
SMA 2	60	11.2	8.1	12.8
AC (N) 1	50	37.6	30.8 A)	52.8
AC (N) 2	50	9.5	9.0	5.5
AC (S) 1	50	5.75	7.5	9.0
AC (S) 1	60	12.75	17.4	30.0 B)
AC (S) 2	60	8.5	9.0	8.3
AC (S) 3	60	20.0 C)	9.75	4.8
AC (SBS)	60	3.5	4.25	8.6 D)
AC (EVA)	60	5.0	3.9	24.6 D)
High Mod	60	5.0	5.25	4.5
AC (Base)	60	3.7	6.2	4.7

A) 5 000 cycles only

B) Extrapolated to 10 000 cycles after test terminated at 3 000 cycles

C) Suspect test result

D) Extrapolated to 10 000 cycles after test terminated at 1 000 cycles

A TRL study on behalf of the HA after the publication of BS EN 1269-22 compared the results from BS 598-110, small size device to Procedure A and small size device to Procedure B with conditioning in air. The results are reproduced in Table 4.

Table 4 **Rut depths (mm) from pre-normative research on wheel tracking**

Mixture	Temp. °C	BS 598-110		BS EN 12697-22				
				Procedure A		Procedure B		
		Rate mm/h	Depth mm	Rate µm/cycle	Depth mm	Rate µm/cycle	Depth mm	Prop. depth %
HRA 1	45	1.00	2.15	1.29	2.25	0.122	13.98	8.0
HRA 2	45	3.05	4.90	2.51	3.14	1.094	13.21	26.4
DBM	60	1.71	4.06	1.99	3.73	0.311	8.60	17.2
SMA	60	1.73	3.01	2.60	4.76	0.146	10.08	20.2

These results indicate that the relationship between the test methods is not independent of the material being tested, but ratios of the appropriate order can be devised.

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5.7.5 Implications for UK

BS EN 12697-22 with small size device to Procedure A is called up in BS EN 13108-4 for hot rolled asphalt whilst BS EN 12697-22 with small size device to Procedure B conditioned in air for asphalt designed for maximum loads < 13 t and with large size devices for asphalt designed for axle loads ⩾ 13 t are called up in BS EN 13108-1 for asphalt concrete and BS EN 13108-5 for stone mastic asphalt. The use of the results from any of these procedures should not present any problems, although the purchase and/or modification of equipment will need to be addressed by test laboratories.

5.8 Guidance on the use of BS EN 12697-24 – Resistance to fatigue

5.8.1 Scope of BS EN 12697-24

BS EN 12697-24 "specifies the methods for characterizing the fatigue of bituminous mixtures by alternative tests, including bending tests and direct and indirect tensile tests. The tests are performed on compacted bituminous material under a sinusoidal loading or other controlled loading, using different types of specimens and supports. The procedure is used to rank bituminous mixtures on the basis of resistance to fatigue, as a guide to relative performance in the pavement, to obtain data for estimating the structural behaviour in the road and to judge test data according to specifications for bituminous mixtures. Because this document does not impose a particular type of testing device, the precise choice of the test conditions depends on the possibilities and the working range of the used device. For the choice of specific test conditions, the requirements of the product standards for bituminous mixtures shall be respected. The applicability of this document is described in the product standards for bituminous mixtures. Results obtained from different test methods are not assured to be comparable."

5.8.2 Summary of method

5.8.2.1 General

The test is to determine the number of load applications before the sample reaches the relevant criterion of failure, where the conventional criteria are:

- constant displacement – when the complex stiffness modulus has decreased to half its initial value;
- constant force – when the displacement of a specimen under constant strength at the head has increased to the double that at the start of the test.

Constant displacement and constant force are inherently different tests.

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There are annexes for five different test methods, although the different methods, for either constant displacement or constant force, are acknowledged to rank materials in different orders. The methods are:

- two-point bending test on trapezoidal shaped specimens;
- two-point bending test on prismatic shaped specimens;
- four-point bending test on prismatic shaped specimens;
- three-point bending test on prismatic shaped specimens;
- indirect tensile test on cylindrical shaped specimens.

5.8.2.2 Two-point bending test on trapezoidal shaped specimens

Specimens are either manufactured in the laboratory as slabs or cut from the road and then kept for at least 12 weeks before being sawn into the required trapezoidal shape. The required thickness and other dimensions of the specimens are dependent on the maximum nominal size of aggregate in the mixture and have tolerances of ±1 mm. The samples are tested between two and eight weeks after cutting.

The longer parallel side of a sample is glued to a grooved metal plate whilst held in a rig to accurately position it and a cap is glued to the other parallel side. The thermostatic chamber and loading equipment are brought to test temperature and the desired head displacement adjusted with a dummy elastic specimen before the test specimen is installed. The test specimen is conditioned to the test temperature before the test starts.

The cap on the shorter parallel side of the specimen is then moved sinusoidally at a constant displacement amplitude. The initial force is defined as the mean of that required between 100 and 500 cycles and the test continues until the failure criterion is reached. The test is repeated on at least six specimens at each of three levels of strain, requiring a minimum of 18 specimens. The fatigue line is then found by linear regression of the natural logarithm of the fatigue life in cycles. The calculated fatigue life is the number of cycles at a strain of 10^6.

5.8.2.3 Two-point bending test on prismatic shaped specimens

The procedure is essentially similar to that for the two-point bending test on trapezoidal shaped specimens except for the different shaped specimen, resulting in different calculation formulae.

5.8.2.4 Four-point bending test on prismatic shaped specimens

Specimens are either manufactured in the laboratory as slabs or cut from the road and then sawn into the required shape. The samples are tested between two and eight weeks after cutting. The sample is mounted with two outer clamps (supports) and two inner clamps (loads). The thermostatic chamber and loading equipment are brought to test temperature and the inner clamps loaded to produce a sinusoidal displacement. The initial force is defined as that required after 100 cycles and the test continues until the failure criterion is reached. The test is repeated on at least six specimens at each of three levels of strain, requiring a minimum of 18 specimens. The fatigue line is then found by linear regression of the natural logarithm of the fatigue life in cycles. The calculated fatigue life is the number of cycles at a strain of 10^6.

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5.8.2.5 Three-point bending test on prismatic shaped specimens

The procedure is essentially similar to that for the four-point bending test on prismatic shaped specimens except for the single point for load application, resulting in different calculation formulae.

5.8.2.6 Indirect tensile test on cylindrical shaped specimens

A cylindrical specimen manufactured in a laboratory or cored from a road layer can be used in this test. The specimen is exposed to repeated compressive loads with a haversine load signal through the vertical diametrical plane. The resulting horizontal deformation of the specimen is measured and an assumed Poisson's ratio used to calculate the tensile strain at the centre of the specimen. The fracture life is determined as the total number of load applications before fracture of the specimen occurs.

5.8.3 Equivalent British Standard

None, although work had started on a British Standard Draft for Development (DD), a draft for which was widely used under the reference DD ABF.

5.8.4 Principal differences

DD ABF is based on the same principle as the indirect tensile test on cylindrical shaped specimens. However, no detailed comparison is made here because the document was never published and, as such, cannot be regarded as an official UK standard.

5.8.5 Implications for UK

The two-point bending test on trapezoidal shaped specimens and the four-point bending test on prismatic shaped specimens from BS EN 12697-24 are called up in BS EN 13108-1 for asphalt concrete as measures of the fundamental property. The choice on the two methods depends on the design approach taken for the pavement in which the asphalt is to be used. It is not anticipated asphalt concrete will be specified using the fundamental approach in the UK at this time, so the implications will occur in the future when understanding of fatigue as a fundamental property is better understood and limits on the property are specified.

5.9 Guidance on the use of BS EN 12697-25 – Cyclic compression

5.9.1 Scope of BS EN 12697-25

BS EN 12697-25 "describes two test methods (A and B) for determining the resistance of bituminous mixtures to permanent deformation.

Test method A describes the method for determining the creep characteristics of bituminous mixtures by means of a uniaxial cyclic compression test with some confinement present. In this test a cylindrical specimen is subjected to a cyclic axial stress. To achieve a certain confinement, the diameter of the loading platen is taken smaller than that of the sample. NOTE Confinement of the sample is necessary to predict realistic rutting behaviour, especially for gap-graded mixes with a large stone fraction.

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Test method B describes the method for determining the creep characteristics of bituminous mixtures by means of the triaxial cyclic compression test. In this test a cylindrical specimen is subjected to a confining stress and a cyclic axial stress. This test is most often used for the purpose of evaluation and development of new types of mixtures.

This European Standard applies to specimens prepared in the laboratory or cored from the road. The maximum size of the aggregates is 32 mm.

5.9.2 Summary of method

5.9.2.1 Triaxial cyclic compression

The test is carried out on at least two specimens that are not tested until at least 14 days after they have been compacted, either in the laboratory or in the road. After sampling and prior to testing, samples are kept within the temperature range 0 °C and 10 °C. The specimens are dried in air to constant mass and the end faces prepared so that a smooth and plain surface is left. The specimens are then conditioned to the test temperature.

A cylindrical test specimen, at the test temperature, is placed between two parallel loading platens. The specimen is subjected to a static confining pressure on which a dynamic axial pressure is superimposed. The static confining pressure can be applied by:

- placing the whole specimen, including the upper and lower platens, in a rubber socket (or foil) that is sealed around the platens by O-rings and the confining pressure is applied by pressurizing the cell by water, oil or air;
- mounting an inner tube of an appropriate sized tyre around the specimen and inflating the tyre; or
- sealing the specimen within a rubber membrane, sealed at each end by O-rings, and forming a partial vacuum by extracting the air through holes in the top face of the lower platen.

The dynamic axial pressure can be a haversinusoidal or block pulse.

The specimens are pre-loaded in order to adjust the self-aligning pressure plates for up to two minutes on the self-aligning platen. The static pre-load is applied again gradually and smoothly for two minutes, after which time the confining pressure is applied. Within 10 s of the confining stress being applied, a cyclic axial load is applied. The specimen is held at a constant temperature whilst being subjected to the static confining pressure and sinusoidal axial stress.

During the test, the height of the specimen is measured at specific time intervals and the deformation from the original height plotted against the number of axial load cycles. The test is ended either when the axial strain is 6% or after 10 000 loading cycles (unless the test needs to be extended in order to be able to determine the creep parameters). The resistance to deformation is computed as the slope during the period when it is constant or at the point of inflection if it never stabilizes.

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5.9.2.2 Uniaxial cyclic compression

The test is carried out on at least five specimens that are not tested until at least a week after they have been compacted. After sampling and prior to testing, the samples are dried in air to constant mass at a temperature of up to 25 °C. The specimens are then conditioned to the test temperature of 40 °C for between four hours and six hours and the ends coated with grease.

A cylindrical specimen with a diameter of 150 mm is placed between two horizontal pressure platens, of which the lower one is fixed. The upper platen has a diameter of 100 mm, chamfered to 96 mm at the interface with the specimen. A pre-load of 10 kPa is applied for 10 min before the cyclic block-pulse axial load of 100 kPa at a frequency of 0.5 Hz is applied. During the test, which ends after 3 600 pulses, there is no confining pressure applied. The axial deformation of the specimen is measured and plotted against the number of load applications, from which the creep at 3 600 pulses and the dynamic creep modulus are computed.

5.9.3 Equivalent British Standard

DD 226:1996.

5.9.4 Principal differences

The principal differences between the two BS EN 12697-25 procedures and DD 226 are shown in Table 5.

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Table 5 **Principal differences between the two BS EN 12697-25 procedures and DD 226**

	DD 226	**BS EN 12697-25 uniaxial**	**BS EN 12697-25 triaxial**
No. of replicates:	1	At least 5	At least 2
Sample diameter:	(100 ± 5) mm, (150 ± 5) mm or (200 ± 5) mm	(148 ± 5) mm	= 50 mm for D = 16 mm; = 75 mm for D > 16 mm
Upper platen diameter:	At least 10% greater than sample	(100 ± 0.5) mm	Greater than sample
Sample thickness:	Between 25 mm and 75 mm	(60 ± 2) mm	= 50 mm for D = 16 mm; = 75 mm for D > 16 mm
Test temperature:	(30 ± 0.5) °C	(40 ± 1.0) °C (typical)	30 °C to 50 °C ± 1.0 °C (50 °C for surface course, 40 °C for base and binder course for BS EN 13108-20)
Pre-load:	10 kPa	(10 ± 1) kPa (typical)	$0.02(2\sigma_{V} + \sigma_{c})$ for haversine pulses or $0.02(\sigma_{B} + \sigma_{c})$ for block pulses
Pre-loading period:	(600 ± 6) s	600 s	120 s
Peak axial stress:	(100 ± 2) kPa	(100 ± 2) kPa (typical)	300 kPa for surface course, 200 kPa for base and binder course for BS EN 13108-20
Pulse shape:	Block pulse	Block pulse	Haversine or block pulse
Confining stress:	0	0	50 kPa to 200 kPa (150 kPa for surface course, 50 kPa for base and binder course for BS EN 13108-20)
Frequency or load application and rest periods:	(1 ± 0.010) s & (1 ± 0.010) s	(1 ± 0.005) s & (1 ± 0.005) s	3 Hz for haversine pulses or 1 s & 1 s for block pulses for BS EN 13108-20
No. of load applications	1 800	3 600	At least 10 000

5.9.5 Implications for UK

The triaxial cyclic compression test from BS EN 12697-25 is called up in BS EN 13108-1 for asphalt concrete as a fundamental measure of the property of resistance to permanent deformation, but it expected that the performance based measure of wheel-tracking will be used in the UK.

The uniaxial cyclic compression test from BS EN 12697-25 is called up in BS EN 13108-6 for mastic asphalt with resistance to indentation. The presence of two other methods to measure the resistance to permanent deformation of different mastic asphalt mixtures, BS EN 12697-20 and BS EN 12697-21, could result in test houses needing three sets of equipment, but it is expected that BS EN 12697-20 will cover most of the mastic asphalt used in the UK.

5.10 Guidance on the use of BS EN 12697-26 – Stiffness

5.10.1 Scope of BS EN 12697-26

BS EN 12697-26 “specifies the methods for characterizing the stiffness of bituminous mixtures by alternative tests, including bending tests and direct and indirect tensile tests. The tests are performed on compacted bituminous material under a sinusoidal loading or other controlled loading, using different types of specimens and supports.

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The procedure is used to rank bituminous mixtures on the basis of stiffness, as a guide to relative performance in the pavement, to obtain data for estimating the structural behaviour in the road and to judge test data according to specifications for bituminous mixtures.

As this standard does not impose a particular type of testing device the precise choice of the test conditions depends on the possibilities and the working range of the used device.

For the choice of specific test conditions, the requirements of the product standards for bituminous mixtures shall be respected.

The applicability of this document is described in the product standards for bituminous mixtures."

5.10.2 Summary of method

5.10.2.1 General

The standard defines the outputs of complex modulus and secant modulus and how to derive them and produce isotherms, a master curve and a Black diagram. General guidance is given on the test conditions, including loading patterns, strain amplitudes, loading frequencies and temperatures but specific advice is dependent on the procedure selected. The accepted test procedures, with methods given for them in annexes, are:

- two-point bending on trapezoidal specimens (Annex A);
- two-point bending on prismatic specimens (Annex A);
- three-point bending on prismatic specimens (Annex B);
- four-point bending on prismatic specimens (Annex B);
- indirect tensile resilient modulus on cylindrical specimens (Annex C);
- direct tension-compression on cylindrical specimens (Annex D);
- direct tension-compression on cylindrical specimens (Annex E); and
- direct tension on cylindrical specimens (Annex E).

All methods are regarded as equivalent, making stiffness a truly fundamental property.

5.10.2.2 Two-point bending of trapezoidal specimens

For two-point bending of trapezoidal specimens, specimens are sawn between two weeks and two months prior to testing. A specimen is glued by its base to a rigid chassis, conditioned at the test temperature for at least four hours and then a sinusoidal deflection is applied to the head of the specimen for between 30 s and two minutes. The deflection is selected to give a strain in the most heavily stressed part of the specimen of less than 50 microstrain, taken to be within the linear range of bituminous materials. On the basis of the applied load, the deflection and the phase lag (measured during the last 10 s of the test), the complex modulus is calculated at not less than four temperatures (separated by not more than 10 °C), starting at the lowest temperature, and at not less than three frequencies at each temperature.

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The test conditions set out in BS EN 13108-20 are a test temperature of 15 °C and a frequency of 10 Hz.

5.10.2.3 Four-point bending on prismatic specimens

For four-point bending on prismatic specimens, specimens are sawn from slabs, which should be between two weeks and two months old, that are taken from the road or manufactured in a laboratory. Four of the specimens from each slab are dried to constant mass and their dimensions measured. Each specimen is subjected to four-point periodic bending with free rotation and translation at each loading and reaction points. The bending is applied in the vertical direction, perpendicular to the axis of the specimen, at the two central supports while the end supports remain fixed. The applied load is sinusoidal to produce a strain amplitude of (50 ± 3) microstrain. During the test, the force needed to deform a specimen is measured as a function of time and the complex stiffness modulus calculated between the 45th and 100th load application; the test result is the mean value for at least two specimens.

The test conditions set out in BS EN 13108-20 are a test temperature of 20 °C and a frequency of 8 Hz.

5.10.2.4 Indirect tensile resilient modulus on cylindrical specimens

For the indirect tensile resilient modulus on cylindrical specimens, a core is trimmed to remove any projections and then cut to form specimen(s) of the appropriate thickness. The specimen, together with a dummy specimen used to monitor the temperature, is conditioned to the test temperature. The specimen is mounted in the test jig on its side with loading platens at the top and bottom of one of the marked diagonals. At least ten conditioning pulses are applied to allow the equipment to adjust the load magnitude and duration to give a horizontal diametral deformation and rise time to achieve a load area factor of 0.60. A further five pulses are applied, the results of which are used to calculate the stiffness modulus. The core is rotated through 90° and the measurement repeated. The test result is the mean of the two measurements provided they do not differ by more than a specific amount.

The test conditions set out in BS EN 13108-20 are a test temperature of 20 °C and a loading time of 124 µs.

5.10.2.5 Direct tension-compression on cylindrical specimens

For the direct tension-compression on cylindrical specimens, a core or a laboratory-prepared cylindrical specimen is stored for between 2 weeks and 2 months. Steel plates are glued to both ends of the specimen; the plates are attached via ball joints and a load cell to a tensile test machine. The specimen is conditioned to the test temperature for at least four hours before being subjected to a sinusoidal strain with an amplitude of not more than 25 microstrain and the complex modulus calculated. Measurements are made at not less than four temperatures (usually 10 °C, 20 °C, 30 °C and 40 °C) and at not less than six frequencies (usually 0.1 Hz, 0.3 Hz, 1.0 Hz, 3.0 Hz, 10 Hz and 20 Hz) at each of the temperatures.

The test conditions set out in BS EN 13108-20 are a test temperature of 15 °C and a frequency of 10 Hz.

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5.10.2.6 Direct tension on cylindrical specimens

For the direct tension on cylindrical specimens, a core or laboratory-prepared cylindrical or prismatic specimen is conditioned at the test temperature for at least four hours (diameter ⩽ 100 mm) or eight hours (diameter > 100 mm). Plates are glued to both ends of the specimen (although this step is not actually given in the Annex) and the plates attached to a tensile test machine. The specimen remains with zero stress for not less than 60 min for temperatures < –5 °C and 30 min for other temperatures. A tensile load is then applied and plotted against the resulting strain. The procedure is repeated on four specimens as one test.

The test conditions set out in BS EN 13108-20 are a test temperature of 15 °C and a loading time of 0.02 s.

5.10.3 Equivalent British Standard

DD 213:1993.

5.10.4 Principal differences

The method for indirect tensile resilient modulus on cylindrical specimens in Annex C of BS EN 12697-26 is based on DD 213. However, the differences are:

- the concept of load area factor is in BS EN 12697-26 but not in DD 213;
- BS EN 12697-26 assumes a Poisson's ratio of 0.35 unless otherwise determined whereas DD 213 assumes that it varies with temperature (although it is 0.35 for the standard test temperature of 20 °C).

5.10.5 Implications for UK

Stiffness from BS EN 12697-25 is called up in BS EN 13108-1 for asphalt concrete and BS EN 13108-4 for hot rolled asphalt to demonstrate conformance with that requirement. BS EN 12697-20 assumes that all methods for determining the stiffness of asphalt mixtures, as given in the separate Annexes, are identical. Therefore, with only minor differences between DD 213 and Annex C of BS EN 12697-26, there should be no problem with implementation.

5.11 Guidance on the use of BS EN 12697-34 – Marshall test

5.11.1 Scope of BS EN 12697-34

BS EN 12697-34 "specifies a test method for determining the stability, flow and the Marshall Quotient values of specimens of bituminous mixtures mixed according to prEN 12697-35 and prepared using the impact compactor method of test EN 12697-30. It is limited to dense graded asphalt concrete and hot rolled asphalt."

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5.11.2 Summary of method

The compacted specimens are demoulded and left for at least four hours but testing is completed within 24 h. The density and height of each specimen is measured and then they are immersed in a water bath at 60 °C for between 40 and 60 min. Each specimen, in turn, is placed on its side between the upper and lower segments of a breaking head on the testing machine and a load is applied at constant strain of 50 mm/min until the load applied has reached a maximum. The mean stability from four specimens is calculated from the maximum load applied and the mean flow from the deformation at maximum load.

5.11.3 Equivalent British Standards

BS 598-107: 2004, Clauses **9** and **10**.

5.11.4 Principal differences

The principal differences are as follows.

- The time of testing is changed from within eight hours in BS 598-107 to 4 h to 24 h in BS EN 12697-34.
- The tolerance on the temperature in BS EN 12697-34 is double that in BS 598-107.
- The tolerance on the rate of strain in BS EN 12697-34 is a third of that in BS 598-107.
- No advice is given in BS EN 12697-34 on the calculation of the design binder content.

5.11.5 Implications for UK

The Marshall test from BS EN 12697-34 is called up in BS EN 13108-1 for asphalt concrete on airfields to demonstrate compliance with resistance to permanent deformation. There are no particular problems with the general content of BS EN 12697-34 except that, if the design procedure for design binder content is still required, it will have to be defined elsewhere.

6 Guidance on test procedures used to support called up test methods

6.1 Guidance on the use of BS EN 12697-23 – Determination of the indirect tensile strength of bituminous specimens

6.1.1 Scope of BS EN 12697-23

BS EN 12697-23 "specifies a test method for determining the (splitting) indirect tensile strength of cylindrical specimens of bituminous materials. NOTE Determination of the water sensitivity of bituminous specimens in accordance with EN 12697-12 is based on determination of the indirect tensile strength in accordance with this test method."

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6.1.2 Summary of method

Specimens can be cores or laboratory prepared cylinders with 100 mm, 150 mm or 160 mm diameters. A test specimen is conditioned at 5 °C for at least four hours before being placed in compression testing machine between loading strips. The specimen is then loaded at a constant strain of 50 mm/min until it breaks. The indirect tensile strength is calculated for each specimen from the peak load and the dimensions of the cylinder; the test result is the mean indirect tensile strength from at least three specimens.

6.1.3 Equivalent British Standard

None.

6.2 Guidance on the use of BS EN 12697-27 – Sampling

6.2.1 Scope of BS EN 12697-27

BS EN 12697-27 "describes test methods for sampling bituminous mixtures for roads and other paved areas to determine their physical properties and composition."

6.2.2 Summary of method

The method specifies the equipment to be used and the procedure to be followed when sampling asphalt materials in the following situations:

- mixed material from a lorry;
- mastic asphalt from a mixer transporter;
- mixed material from around the augers of a paver;
- mixed material from a heap;
- from laid but not rolled material using a sampling tray;
- from laid but rolled material using a trench;
- from laid and compacted material by coring;
- from laid and compacted material by manually breaking out or sawing;
- from the slat conveyor of a continuous process plant; and
- from stockpiles of pre-coated chippings.

The advantages and disadvantages of each method are given.

6.2.3 Equivalent British Standard

BS 598-100:2004.

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6.2.4 Principal differences

The advice on the minimum mass of bulk samples is not given because it was considered to depend on the test to be carried out. All the processes in BS 598-100 are included in BS EN 12697-27 with very similar text except that sampling during discharge from a mixing plant has been made specific for mastic asphalt from a "mixer transporter". Methods for sampling from laid but rolled material using a trench and from laid and compacted material by sawing or manually breaking out have been added to BS EN 12697-27. The nominal size of increments for material with aggregate sizes less than or equal to 16 mm is reduced from 7 kg in BS 598-100 to 3 kg in BS EN 12697-27.

6.3 Guidance on the use of BS EN 12697-28 – Preparation of samples for determining binder content, water content and grading

6.3.1 Scope of BS EN 12697-28

BS EN 12697-28 "describes test methods for preparing test portions for the determination of the binder, water content and grading of samples of bituminous mixtures, when the sample submitted to the laboratory has a mass greater than or equal to four times the test portion."

6.3.2 Summary of method

BS EN 12697-28 sets out how to inspect and store laboratory samples on arrival from site, together with preliminary treatments for:

- situations where binder drainage or the presence of uncoated aggregate may occur with samples taken before compaction; and
- the presence of pre-coated chippings, surface dressings, bond coats, fractured aggregate, multiple courses or free water with samples of compacted material.

The samples are then heated, if they cannot be remixed at room temperature, and reduced to the required mass by either quartering from heaps or by the use of a sample splitter.

6.3.3 Equivalent British Standard

BS 598-101:2004.

6.3.4 Principal differences

The wordings of both standards are very similar. The main differences are that, in BS EN 12697-28:

- a warm laboratory is quantified at (21 ± 3) °C;
- the maximum temperatures for reheating are marginally reduced for mixtures with binders having penetrations less than 55 × 0.1 mm but increased significantly for those with penetrations greater than 200 × 0.1 mm at 25 °C;
- no reheating temperatures are given for tar-bound mixtures because tar-bound materials are not included in the CEN asphalt standards;

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- the maximum mass of mixture required (for which the nominal aggregate sizes are changed to the CEN sizes) is only informative and not normative;
- there is not a separate table of mass; and
- Note 2 to **5.5.1** of BS EN 12697-28 advises against the use of diesel oil for lubricating the sample splitter whereas diesel was in common use with BS 598-101.

6.4 Guidance on the use of BS EN 12697-30 – Specimen preparation by impact compactor

6.4.1 Scope of BS EN 12697-30

BS EN 12697-30 "describes methods of moulding specimens from bituminous mixtures by impact compaction. Such specimens are primarily used to determine bulk density and other technological characteristics, e.g. Marshall Stability and flow according to EN 12697-34. This European Standard applies to bituminous mixtures (both those made up in a laboratory and those resulting from work site sampling), with an upper aggregate size not larger than 22.4 mm."

6.4.2 Summary of method

The compaction takes place with the specimen on an anvil of either steel or wood. The required quantity of asphalt is mixed and kept for not more than three hours at up to 130 °C. It is brought up to the compaction temperature (as given in BS EN 12697-35) and poured loose into a pre-warmed steel mould with an internal diameter of 101.6 mm and covered with a paper disc. The asphalt is compacted by 50 blows of a sliding mass of 4.55 kg falling 460 mm with a steel anvil or 457 mm with a wooden anvil. The mould is then reversed and compacted by a further 50 blows. If further compaction is required, as for refusal density, the process is repeated with a further 50 blows on each face. There are maximum time constraints on each operation. The specimens are then cooled to 40 °C before being demoulded, water-cooling being permitted when quick results are needed.

6.4.3 Equivalent British Standard

BS 598-107:2004, Clause **7**.

6.4.4 Principal differences

The filling of the mould is given in less detail in BS EN 12697-30 than in BS 598-107 and does not positively require cooling in water. BS 598-107 gives the compaction temperature as 92 °C above the softening point of the binder rather than a fixed value depending on binder grade and mixture type.

6.4.5 Implications for UK

Compaction of specimens by impact compactor is one of the methods recognized in BS EN 13108-20. The similarity with BS 598-107 should result in its quick assimilation for preparation of specimens for appropriate test methods.

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6.5 Guidance on the use of BS EN 12697-31 – Specimen preparation by gyratory compactor

See **5.8**.

6.6 Guidance on the use of BS EN 12697-32 – Laboratory compaction of bituminous mixtures by vibratory compactor

6.6.1 Scope of BS EN 12697-32

BS EN 12697-32 "describes a test method for the preparation of bituminous test specimens using a vibratory compaction technique. This European Standard is applicable to loose mixtures and cores and is used to establish a reference density for a bituminous mixture in accordance with the procedures described in EN 12697-9, or the ease of compaction as described in EN 12697-10."

6.6.2 Summary of method

Core specimens are heated until the centre of the sample is at the test temperature. The core or a loose mixture (either plant-mixed or laboratory-prepared) is placed in a 152 mm diameter mould, covered with a paper disc and compacted with a vibratory compactor of which the 102 mm diameter tamping foot has been preheated to above 60 °C. The vibrator is moved in a set pattern around the mould until the total time of compaction is 120 s. The specimen is then levelled with a 146 mm diameter tamping foot.

A spare base plate is clamped to the top of the mould, the specimen inverted and the original base plate removed. The sample is pushed firmly to the bottom of the mould with the 146 mm diameter tamping foot before being compacted for a further 120 s with the 102 mm diameter tamping foot. When completed, the sample is allowed to cool in air for at least two hours before being removed from the mould.

6.6.3 Equivalent British Standard

BS 598-104:2005, Clause **3**.

6.6.4 Principal differences

BS EN 12697-32 includes only the compaction whereas BS 598-104 includes the calculation of percentage refusal density (PRD).

6.6.5 Implications for UK

Compaction of specimens by vibratory compactor is one of the methods recognized in BS EN 13108-20. The similarity with BS 598-104 should result in its quick assimilation for preparation of specimens for appropriate test methods, although there are fewer tests for which vibratory compaction is suitable than for the other methods.

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6.7 Guidance on the use of BS EN 12697-33 – Specimen prepared by roller compactor

6.7.1 Scope of BS EN 12697-33

BS EN 12697-33 "specifies the methods for compacting parallelepipedal specimens (slabs) of bituminous mixtures, to be used directly for subsequent testing, or from which test specimens are cut. For a given mass of bituminous mixture, the specimen can be prepared either under controlled compaction energy, or until a specified volume and therefore bulk density are obtained. This European Standard describes the following methods of compaction:

- pneumatic tyre method;
- steel roller method;
- sliding plates method.

This European Standard is applicable to bituminous mixtures manufactured in the laboratory or in a mixing plant."

6.7.2 Summary of method

The appropriate mass of asphalt is mixed and placed in the mould. The required mass of the mixture is selected to allow for a reduction in volume with compaction. The specimens are then compacted by one of the three pieces of apparatus, although the dimensions of each are only defined in terms of "usual dimensions". After completion, the specimens are allowed to cool to room temperature before being removed from the mould.

In the method using one or two wheels fitted with pneumatic tyres, the number of passes, the tyre pressure and the lateral displacement between passes are defined for "light compaction" and "heavy compaction" with either one or two tyres. Advice on when to use light or heavy compaction is not given. Compaction can be until a specified energy has been applied or until a specified air voids content has been reached.

In the method using a smooth steel roller, the roller is lubricated by a mild soapy solution or the material being compacted is separated from the roller by a thin malleable sheet (or film). Again, compaction can be until a specified energy has been applied or until a specified air voids content has been reached. A vibrating roller can be used, although this option is not mentioned in the scope.

In the method using a kneading action by metal sliding plates (where the sliding plates are mounted vertically and press down on the specimen when a roller passes over them), compaction is until a specified air voids content has been reached.

6.7.3 Equivalent British Standard

None.

6.7.4 Implications for UK

Compaction of specimens by roller compactor is one of the methods recognized in BS EN 13108-20. Furthermore, the availability of a standard method for compaction of slabs will allow the wheel-tracking test to be used as a conformance test as well as a design test.

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6.8 Guidance on the use of BS EN 12697-35 – Laboratory mixing

6.8.1 Scope of BS EN 12697-35

BS EN 12697-35 "describes the laboratory mixing of bituminous materials for manufacture of specimens. The document specifies the reference temperatures for mixing based on the paving grade of the binder."

6.8.2 Summary of method

The bitumen and aggregates are pre-heated to nominal temperatures depending on the binder grade and whether the material is mastic asphalt or not. The aggregate is then weighed into a bowl and any admixtures added and mixed. The prescribed mass of binder is added and the material mechanically mixed for up to three minutes or manually mixed for up to five minutes. The quantity is limited to that sufficient for one sample if it is mixed manually.

6.8.3 Equivalent British Standard

None directly, but BS 598-107:2004, Clause **6** does include a specific procedure for mechanically mixing hot rolled asphalt for the manufacture of "Marshall" specimens.

6.8.4 Implications for UK

BS EN 12697-35 is an additional procedure that will be a requirement for testing laboratories. However, it is assumed that most already have in-house procedures to cover this activity. The proposal should not run counter to present practice, and will help to standardize procedures.

7 Guidance on test methods and procedures not called up in the asphalt standards

7.1 Guidance on the use of BS EN 12697-7 – Determination of the bulk density of bituminous specimens by gamma rays

7.1.1 Scope of BS EN 12697-7

BS EN 12697-7 "specifies a method for measuring the bulk density of pavement materials using a transmission-type gamma radiation test bench. The applicability of this European Standard is described in the product standards for bituminous mixtures. NOTE The safety regulations applicable to the use of gamma rays shall be applied.

This standard is applicable to cylindrical specimens or blocks, prepared in a laboratory or cut from a pavement, for which the thickness and the mass absorption coefficient, which is a function of the chemical composition, are known. The thickness of the specimen traversed by the radiation should be between 30 mm and 300 mm. This method does not apply to materials containing slags, with variable metal content or chemical composition which can affect the absorption of gamma rays."

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7.1.2 Summary of method

If the water content of a specimen is not known, it is dried to constant mass. In all cases, any foreign matter is removed and the dimensions of the specimen are measured. The specimen is placed in the apparatus between collimators in front of the emitter-source unit and remote receiving unit. The apparatus has to be calibrated periodically against a specimen of known density. The test specimen can be either moved in a direction perpendicular to the direction of measurement for continuous measurements or held still for localized measurements. For localized measurements on cylinders, the specimen has to rotate during measurement. The density at each level is then calculated on the basis that the absorption of the gamma rays by bituminous materials follows an exponential law dependent on the density.

7.1.3 Equivalent British Standard

None.

7.2 Guidance on the use of BS EN 12697-10 – Compactibility

7.2.1 Scope of BS EN 12697-10

BS EN 12697-10 "describes three test methods for characterizing the compactibility of a bituminous mix, by the relation between its density or void content and the compaction energy applied to it, using an impact (Marshall) compactor, gyratory compactor, or a vibratory compactor. This European Standard applies to hot bituminous mixtures (both those prepared in laboratory and those resulting sampled from plant produced mixtures), with *D* not larger than 31.5 mm in accordance with EN 13043 for the impact and gyratory compactors, and 40 mm for the vibratory compactor. The results of the test method serve to supplement the results of mixture design."

7.2.2 Summary of method

An asphalt mixture is compacted by either impact, gyratory or vibratory compactor at the prescribed temperature in the compaction method standard. The density is measured after various compaction energies (using the analogues of number of blows for impact compactor, number of gyrations for gyratory compactor and time for vibratory compactor). The specimen height is measured either on the same sample after different compaction energies or on different specimen, each compacted by different compaction energies (the gyratory compactor is only used with the same sample for all levels of compaction energy).

The sample heights are used to calculate the bulk density (impact compactor) or voids content (gyratory compactor and vibratory compactor). Linear regression analysis is carried out on the data pairs of the analogue for compactive energy and the associated density or voids content in order to obtain the constants in the relevant Equation for the type of compactor used.

7.2.3 Equivalent British Standard

None.

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7.3 Guidance on the use of BS EN 12697-13 – Temperature measurement

7.3.1 Scope of BS EN 12697-13

BS EN 12697-13 "describes a test method for measuring the temperature of hot bituminous mixtures after mixing and during storage, transportation and laying. This standard does not include the use of non-contact temperature-measuring devices."

7.3.2 Summary of method

There are separate methods for measuring the temperature of asphalt in a lorry, after being laid and in a heap with a common section on conditioning the probe. Each method requires at least four measurements to be made with the result being their mean. The measurements in a lorry are at a depth of at least 250 mm spaced evenly along each side but not less than 500 mm from any edge. The measurements of laid material are as close as possible to mid-layer depth. The measurements in a heap are at a depth of at least 250 mm spaced evenly around the accessible perimeter and not less than 300 mm from the base.

7.3.3 Equivalent British Standard

BS 598-109:1990, Clause **4**.

7.3.4 Principal differences

Measurement of the temperature of material in a heap is not in the BS 598-109. The minimum number of measurements for laid material has been increased in BS EN 12697-13 from three to four, as for material in a lorry. The recommendation in BS 598-109 for the result to be preferably the mean of six (from a lorry) or five (of laid material) measurements has been removed from BS EN 12697-13.

7.4 Guidance on the use of BS EN 12697-14 – Water content

7.4.1 Scope of BS EN 12697-14

BS EN 12697-14 "describes a test method for the determination of the water content of samples of bituminous mixtures. The test method is suitable for checking conformity to a product specification, where required."

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7.4.2 Summary of method

The laboratory sample is divided into two portions by quartering and one portion retained in a closed container. The other portion is weighed and placed in a well-ventilated oven at 110 °C for one hour before being re-weighed. If the loss in mass is less than 0.1%, no further action is required. Otherwise, the retained portion is transferred to a dry hot extractor pot, possibly in a cylindrical container. Sufficient solvent is added in order to permit refluxing to take place and the apparatus assembled with an adequate flow of cold water and heat to give a steady reflux action. The heating continues until the volume of water in the receiver remains constant for at least five minutes. The volume of water is then measured. The water content is then calculated as a proportion either of the original sample or of the dried portions.

7.4.3 Equivalent British Standard

BS 598-102:2003, Clause **6**.

7.4.4 Principal differences

The solvent to be used is not specified in BS EN 12697-13 where it is limited to trichloroethylene in BS 598-102.

7.5 Guidance on the use of BS EN 12697-15 – Determination of the segregation sensitivity

7.5.1 Scope of BS EN 12697-15

BS EN 12697-15 "specifies a test method for the determination of the mixing quality and the tendency of segregation in composition of hot bituminous mixtures. This test method is considered suitable for design purposes and for client information."

7.5.2 Summary of method

A hot sample of asphalt is placed in a heated conical hopper. The plate at the bottom of the cone is slid away and the mixture falls onto a platform underneath to form a pile. A trap-door in the platform under the centre of the pile is opened and the central, finer portion of the pile flows through the opening. The opening is then expanded further and an intermediate portion of the pile flows through the expanded opening. The binder content and grading of the finer, central portion and of the remaining, coarser portion of the asphalt are determined. The segregation value is the difference between the binder content of the two portions.

7.5.3 Equivalent British Standard

None.

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7.6 Guidance on the use of BS EN 12697-29 – Determination of the dimensions of a bituminous specimen

7.6.1 Scope of BS EN 12697-29

BS EN 12697-29 "specifies a test method for determining the dimensions of cylindrical, rectangular or non-rectangular bituminous test specimens by measurement. The applicability of this European Standard is described in the product standards for bituminous mixtures. The test is applicable to laboratory-made specimens, trimmed by sawing, or specimens from cores cut from the road, trimmed by sawing."

7.6.2 Summary of method

For cylindrical specimens, the height is mean of four measurements made using a calliper gauge (or "approved jig or other device") evenly spaced around the perimeter and 10 mm in from the edge. The diameter is the mean of three pairs of measurements (top, bottom and middle), the pairs being across mutually perpendicular diameters.

For (non-)rectangular specimens, the height, width and depth are each the mean of four measurements evenly spaced around the perimeter. When the dimensions in one or more directions change substantially, the number of readings is increased to allow the volume to be calculated (although no advice is given on determining how many may be appropriate).

7.6.3 Equivalent British Standard

None.

7.7 Guidance on the use of BS EN 12697-36 – Determination of the thickness of a bituminous pavement

7.7.1 Scope of BS EN 12697-36

BS EN 12697-36 "describes two test methods for determining the thickness of a bituminous pavement. The first method describes measurements carried out on one or more cores which have been drilled from the full depth of the slab or road structure (destructive method). The second method electro-magnetic (non-destructive) measurements are used."

7.7.2 Summary of method

For the destructive method, 100 mm or 150 mm diameter full-depth cores are cut from the pavement. Four measurement lines are marked on the side of the core parallel with the axis and evenly spaced around the circumference. Each change in layer is also marked. The depth of each boundary is measured from the surface along each measurement line. The thickness of each layer is the average difference between the depth of the bottom of the layer and that of the top. When the core has been drilled at an angle of more than 5° with the vertical, the measurements is corrected for the slope.

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For the non-destructive method, an antipole consisting of aluminium foil is fixed, prior to laying, at the bottom of the layer to be measured. After it has been overlaid, the thickness of the layer (or layers) is measured by electromagnetic apparatus using the eddy current principle. No metal object must be within one metre of the antipole. The thickness of several layers can be measured with a single antipole if measurements are made after each layer is applied.

7.7.3 Equivalent British Standard

None.

7.8 Guidance on the use of BS EN 12697-37 – Hot sand test for the adhesivity of binder on pre-coated chippings for HRA

7.8.1 Scope of BS EN 12697-37

BS EN 12697-37 “describes a hot sand test method for determining the condition of the binder on coated chippings for use with hot rolled asphalt (HRA) surface course.”

7.8.2 Summary of method

Pre-coated chippings are dried before being placed on trays with 25 mm depth of silica sand at a temperature of 125 °C to 130 °C and then further sand at the same temperature poured over. The chippings and sand are maintained at that temperature for at least 10 min before the tray is removed from the oven, the chippings are sieved out and left to cool. The cool chippings are next placed in a tin with silica grit and shaken, The chippings are re-sieved and weighed to assess the mass of sand, as a proportion of the mass of chippings, adhering to the chippings. The chippings are also assessed for those being less than half covered in sand.

7.8.3 Equivalent British Standard

BS 598-108:2005.

7.8.4 Principal differences

BS EN 12697-37 was based on BS 598-108 and there is only one significant technical difference between them. This difference is that the requirement for the sand and grit to have “rounded particle shape” in BS 598-108 is quantified in BS EN 12697-37 as a flow coefficient of not less than 27 s.

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7.9 Guidance on the use of BS EN 12697-38 – Common equipment and calibration

7.9.1 Scope of BS EN 12697-38

BS EN 12697-38 "specifies general requirements for common test equipment, calibration procedures and reagents for the testing of bituminous materials in the EN 12697 series of standards. NOTE 1 This document makes use by reference of the requirements for common equipment and calibration prepared for aggregates. NOTE 2 Bodies providing accreditation of test equipment may need to consider alternative requirements and/or calibration frequencies in order to cover the possibilities of National Health & safety, regulatory and legislative requirements. Advice is also given on recommendations for laboratory management (Annex …), on the accuracy of measurement (Annex …) and on the rounding of values for reported results (Annex …)."

7.9.2 Summary of method

BS EN 12697-38 gives guidance on the requirements for equipment, including tolerances, and its calibration, including frequency of calibration. The standard also includes the following informative Annexes:

- Annex A – Recommendations for laboratory management;
- Annex B – Accuracy of measurement;
- Annex C – Rounding of values for reported results.

Those items covered in BS EN 932-5, *Tests for general properties of aggregates — Part 5: Common equipment and calibration*, are covered by cross-reference rather than directly. There are informative annexes on recommendations for laboratory management, accuracy of measurement and rounding of values for reported results.

7.9.3 Equivalent British Standard

None, although similar information is provided in UKAS document LAB 21 "Calibration and measurement traceability for construction materials testing equipment".

7.10 Guidance on the use of BS EN 12697-40 – *In situ* drainability

7.10.1 Scope of BS EN 12697-40

BS EN 12697-40 "describes a method to determine the *in situ* relative hydraulic conductivity, at specific locations, of a road surfacing that is designed to be permeable. An estimate of the average value for the surfacing is obtained from the mean value of a number of determinations on each section of road. The test measures the ability to drain water (drainability) achieved *in situ* of a surfacing. As such, it can be used as a compliance check to ensure that a permeable surface course has the required properties when it is laid. The test can also be used subsequently to establish the change of drainage ability with time. For the test to be valid, the surface of the test area must be clean and free from detritus. Measurements can be made when a road is either wet or dry, but not if it is in a frozen state."

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7.10.2 Summary of method

A falling-head radial-flow permeameter is used to determine the time taken for two litres of water under a known head condition to dissipate through an annular area of the surfacing. The reciprocal of the outflow time is used to calculate the relative hydraulic conductivity of the surfacing.

7.10.3 Equivalent British Standard

DD 229:1996.

7.10.4 Principal differences

BS EN 12697-40 is based on the general methodology of DD 229 but the equipment has been radically changed following pre-normative research between TRL and LCPC, in which the larger diameter cylinder, as used in France, and the smaller orifice, as used in the UK were technically superior to either of the existing pieces of equipment. The resulting differences are shown in Table 6.

Table 6 **Differences between DD 229 and BS EN 12697-40**

	DD 229	BS EN 12697-40
Cylinder internal diameter:	63 mm	125 mm
Cylinder height:	1 000 mm	560 mm
Application to road:	Standing board	Standing board or mechanical means
Time measurement:	By eye	By eye or optical sensor

7.11 Guidance on the use of BS EN 12697-42 – Presence of foreign matter

7.11.1 Scope of BS EN 12697-42

BS EN 12697-42 "specifies a visual method of determining the amount and components of coarse foreign matter in reclaimed asphalt. This method does not completely categorize the foreign matter that can occur in asphalt. NOTE 1 For the use of reclaimed asphalt in asphalt mixtures, it is important to know the components in the reclaimed asphalt and to what extent coarse foreign matter is present that can influence the properties of the asphalt mix. NOTE 2 The method is not intended to categorize all foreign materials but rather to ensure that the amount of coarse foreign materials are minimized."

7.11.2 Summary of method

The reclaimed asphalt is visually examined and, if foreign matter is observed, a sample of at least 20 kg is taken and sieved on an 8 mm sieve. The retained portion is divided into two and each portion assessed separately for:

a) material derived from asphalt;

b) the proportion of coarse foreign matter derived from asphalt (cold asphalt produced with cut-back bitumen); and

c) the proportion of coarse foreign matter not derived from asphalt, divided into site materials and other materials.

7.11.3 Equivalent British Standard

None.

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Annex A (informative) British and European standards specifying test methods for asphalt

Existing British Standards specifying test methods for asphalt are listed alongside their equivalent European Standards in Table A.1.

Table A.1 **Comparative list of British Standards and their equivalent European Standards**

British Standards	Title	Equivalent European Standards
BS 598-100	Methods for sampling for analysis	BS EN 12697-27
BS 598-101	Methods for preparatory treatment of samples for analysis	BS EN 12697-28
BS 598-102	Analytical test methods	BS EN 12697-1, BS EN 12697-2, BS EN 12697-14
BS 598-104	Methods of test for the determination of density and compaction	BS EN 12697-6
BS 598-105	Methods of test for the determination of texture depth	BS EN 13036-1
BS 598-107	Methods of test for the determination of the composition of design surface course rolled asphalt	BS EN 12697-30, BS EN 12697-34, BS EN 12697-35
BS 598-108	Methods for determination of the condition of the binder on coated chippings and for measurement of the rate of spread of coated chippings	BS EN 12697-37
BS 598-109	Methods for the assessment of the compaction performance of a roller and recommended procedures for the measurement of the temperature of bituminous mixtures	BS EN 12697-13 (part)
BS 598-110	Methods of test for the determination of wheel-tracking rate and depth	BS EN 12697-22
BS 598-111	Method for determination of resistance to permanent deformation of bituminous mixtures subject to unconfined uniaxial loading	none
BS 598-112	Method for the use of road surface hardness probe	none
BS 5284	Sampling and testing mastic asphalt and pitchmastic used in building	BS EN 12697-20, BS EN 12697-21
BS 2000-105 (withdrawn)	Methods of test for petroleum and its products. Recovery of bituminous binders by dichloromethane extraction	BS EN 12697-4
BS 2000-397	Recovery of bitumen binders. Dichloromethane extraction rotary film evaporator method	BS EN 12697-3
DD 213	Method for determination of the indirect tensile stiffness modulus of bituminous mixtures	BS EN 12697-26
DD 226	Method for determination of resistance to permanent deformation of bituminous mixtures subject to unconfined dynamic loading	BS EN 12697-25
DD 228	Methods for determination of maximum density of bituminous mixtures	BS EN 12697-5
DD 229	Methods for determination of the relative hydraulic conductivity of permeable surfacings	BS EN 12697-40
DD 232	Methods for determination of the maximum binder content of bituminous mixtures without excessive binder drainage	BS EN 12697-18
DD 250	Test method for the analysis of bituminous mixtures by ignition	BS EN 12697-39

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European Standards specifying test methods for asphalt are listed alongside their equivalent British Standards in Table A.2.

Table A.2 **Comparative list of European Standards and their equivalent British Standards**

European Standards	Title	Equivalent British Standards
BS EN 12697-1	Soluble binder content	BS 598-102
BS EN 12697-2	Determination of particle size distribution	BS 598-102
BS EN 12697-3	Binder recovery: rotary evaporator	BS 2000-397
BS EN 12697-4	Binder recovery: fractionating column	BS 2000-105 (withdrawn)
BS EN 12697-5	Determination of maximum density	BS DD 228
BS EN 12697-6	Determination of bulk density of bituminous specimens	BS 598-104
BS EN 12697-7	Determination of bulk density of bituminous specimens by gamma rays	none
BS EN 12697-8	Determination of void characteristics of bituminous specimens	none
BS EN 12697-10	Compactibility	none
BS EN 12697-11	Determination of affinity between aggregate and bitumen	none
BS EN 12697-12	Determination of water sensitivity of bituminous specimens	none
BS EN 12697-13	Temperature measurement	BS 598-109
BS EN 12697-14	Water content	BS 598-102
BS EN 12697-15	Determination of the segregation sensitivity	none
BS EN 12697-16	Abrasion by studded tyres	none
BS EN 12697-17	Particle loss of porous asphalt specimen	none
BS EN 12697-18	Binder drainage	BS DD 232
BS EN 12697-19	Permeability of specimen	none
BS EN 12697-20	Indentation using cube or Marshall specimen	BS 5284
BS EN 12697-21	Indentation using plate specimen	BS 5284
BS EN 12697-22	Wheel tracking	BS 598-110
BS EN 12697-23	Determination of the indirect tensile strength of bituminous specimen	none
BS EN 12697-24	Resistance to fatigue	none
BS EN 12697-25	Cyclic compression	BS DD 226
BS EN 12697-26	Stiffness	DD 213
BS EN 12697-27	Sampling	BS 598-100
BS EN 12697-28	Preparation of samples for determining binder content, water content and grading	BS 598-101
BS EN 12697-29	Determination of the dimensions of a bituminous specimen	none
BS EN 12697-30	Specimen preparation by impact compactor	BS 598-107
BS EN 12697-31	Specimen preparation by gyratory compactor	none
BS EN 12697-32	Laboratory compaction of bituminous mixtures by vibratory compactor	none
BS EN 12697-33	Specimen prepared by roller compactor	none
BS EN 12697-34	Marshall test	BS 598-107
BS EN 12697-35	Laboratory mixing	BS 598-107
BS EN 12697-36	Determination of the thickness of a bituminous pavement	none
BS EN 12697-37	Hot sand test for the adhesivity of binder on precoated chippings for hot rolled asphalt	BS 598-108
BS EN 12697-38	Common equipment and calibration	none
BS EN 12697-39	Binder content by ignition	BS DD 250
BS EN 12697-40	In situ drainability	BS DD 229

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Table A.2 **Comparative list of European Standards and their equivalent British Standards** (*continued*)

European Standards	Title	Equivalent British Standards
BS EN 12697-41	Resistance to de-icing fluids	none
BS EN 12697-42	Analysis for foreign matter	none
BS EN 12697-43	Resistance to fuel	none

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