BS EN 12697-45:2012

BSI Standards Publication

Bituminous mixtures — Test methods for hot mix asphalt

Part 45: Saturation Ageing Tensile Stiffness (SATS) conditioning test

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 12697-45:2012.

The UK participation in its preparation was entrusted to Technical Committee B/510/1, Asphalt products.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

ISBN 978 0 580 75915 4

ICS 93.080.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2012.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12697-45

April 2012

ICS 93.080.20

English Version

Bituminous mixtures - Test methods for hot mix asphalt - Part 45: Saturation Ageing Tensile Stiffness (SATS) conditioning test

Mélanges bitumineux - Méthodes d'essai pour mélange hydrocarboné à chaud - Partie 45 : Essai de module en traction après saturation conditionnée (SATS)

Asphalt - Prüfverfahren für Heißasphalt - Teil 45: Alterungsprüfung an gesättigten Asphalt-Probekörpern (SATS-Prüfung)

This European Standard was approved by CEN on 23 March 2012.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 12697-45:2012: E

Contents

Page

Foreword

This document (EN 12697-45:2012) has been prepared by Technical Committee CEN/TC 227 “Road materials”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2012, and conflicting national standards shall be withdrawn at the latest by October 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document is one of a series of standards for bituminous mixtures which includes the following:

EN 12697-1, *Bituminous mixtures — Test methods for hot mix asphalt — Part 1: Soluble binder content*

EN 12697-2, *Bituminous mixtures — Test methods for hot mix asphalt — Part 2: Determination of particle size distribution*

EN 12697-3, *Bituminous mixtures — Test methods for hot mix asphalt — Part 3: Binder recovery: Rotary evaporator*

EN 12697-4, *Bituminous mixtures — Test methods for hot mix asphalt — Part 4: Binder recovery: Fractionating column*

EN 12697-5, *Bituminous mixtures — Test methods for hot mix asphalt — Part 5: Determination of the maximum density*

EN 12697-6, *Bituminous mixtures — Test methods for hot mix asphalt — Part 6: Determination of bulk density of bituminous specimens*

EN 12697-7, *Bituminous mixtures — Test methods for hot mix asphalt — Part 7: Determination of bulk density of bituminous specimens by gamma rays*

EN 12697-8, *Bituminous mixtures — Test methods for hot mix asphalt — Part 8: Determination of void characteristics of bituminous specimens*

EN 12697-9, *Bituminous mixtures — Test methods for hot mix asphalt — Part 9: Determination of the reference density*

EN 12697-10, *Bituminous mixtures — Test methods for hot mix asphalt — Part 10: Compactibility*

EN 12697-11, *Bituminous mixtures — Test methods for hot mix asphalt — Part 11: Determination of the affinity between aggregate and binders*

EN 12697-12, *Bituminous mixtures — Test methods for hot mix asphalt — Part 12: Determination of the water sensitivity of specimen*

EN 12697-13, *Bituminous mixtures — Test methods for hot mix asphalt — Part 13: Temperature measurement*

EN 12697-14, *Bituminous mixtures — Test methods for hot mix asphalt — Part 14: Water content*

EN 12697-15, *Bituminous mixtures — Test methods for hot mix asphalt — Part 15: Determination of the segregation sensitivity*

EN 12697-16, *Bituminous mixtures — Test methods for hot mix asphalt — Part 16: Abrasion by studded tyres*

EN 12697-17, *Bituminous mixtures — Test methods for hot mix asphalt — Part 17: Particle loss of porous asphalt specimen*

EN 12697-18, *Bituminous mixtures — Test methods for hot mix asphalt — Part 18: Binder drainage*

EN 12697-19, *Bituminous mixtures — Test methods for hot mix asphalt — Part 19: Permeability of specimen*

EN 12697-20, *Bituminous mixtures — Test methods for hot mix asphalt — Part 20: Indentation using cube or Marshall specimen*

EN 12697-21, *Bituminous mixtures — Test methods for hot mix asphalt — Part 21: Indentation using plate specimen*

EN 12697-22, *Bituminous mixtures — Test methods for hot mix asphalt — Part 22: Wheel tracking test*

EN 12697-23, *Bituminous mixtures — Test methods for hot mix asphalt — Part 23: Indirect tensile test*

EN 12697-24, *Bituminous mixtures — Test methods for hot mix asphalt — Part 24: Resistance to fatigue*

EN 12697-25, *Bituminous mixtures — Test methods for hot mix asphalt — Part 25: Cyclic compression test*

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

EN 12697-27, *Bituminous mixtures — Test methods for hot mix asphalt — Part 27: Sampling*

EN 12697-28, *Bituminous mixtures — Test methods for hot mix asphalt — Part 28: Preparation of samples for determining binder content, water content and grading*

EN 12697-29, *Bituminous mixtures — Test methods for hot mix asphalt — Part 29: Determination of the dimensions of bituminous specimen*

EN 12697-30, *Bituminous mixtures — Test methods for hot mix asphalt — Part 30: Preparation of specimen by impact compactor*

EN 12697-31, *Bituminous mixtures — Test methods for hot mix asphalt — Part 31: Specimen preparation, gyratory compactor*

EN 12697-32, *Bituminous mixtures — Test methods for hot mix asphalt — Part 32: Laboratory compaction of bituminous mixtures by vibratory compactor*

EN 12697-33, *Bituminous mixtures — Test methods for hot mix asphalt — Part 33: Specimen prepared by roller compactor*

EN 12697-34, *Bituminous mixtures — Test methods for hot mix asphalt — Part 34: Marshall test*

EN 12697-35, *Bituminous mixtures — Test methods for hot mix asphalt — Part 35: Laboratory mixing*

EN 12697-36, *Bituminous mixtures — Test methods for hot mix asphalt — Part 36: Method for the determination of the thickness of a bituminous pavement*

EN 12697-37, *Bituminous mixtures — Test methods for hot mix asphalt — Part 37: Hot sand test for the adhesivity of binder on precoated chippings for HRA*

EN 12697-38, *Bituminous mixtures — Test methods for hot mix asphalt — Part 38: Common equipment and calibration*

EN 12697-39, *Bituminous mixtures — Test methods for hot mix asphalt — Part 39: Binder content by ignition*

EN 12697-40, *Bituminous mixtures — Test methods for hot mix asphalt — Part 40: In situ drainability*

EN 12697-41, *Bituminous mixtures — Test methods for hot mix asphalt — Part 41: Resistance to de-icing fluids*

EN 12697-42, *Bituminous mixtures — Test methods for hot mix asphalt — Part 42: Amount of coarse foreign matters in reclaimed asphalt*

EN 12697-43, *Bituminous mixtures — Test methods for hot mix asphalt — Part 43: Resistance to fuel*

EN 12697-44, *Bituminous mixtures — Test methods for hot mix asphalt — Part 44: Crack propagation by semi-circular bending test*

EN 12697-45, *Bituminous mixtures — Test methods for hot mix asphalt — Part 45: Saturation Ageing Tensile Stiffness (SATS) conditioning test*

EN 12697-46, *Bituminous mixtures — Test methods for hot mix asphalt — Part 46: Low temperature cracking and properties by uniaxial tension tests*

EN 12697-47, *Bituminous mixtures — Test methods for hot mix asphalt — Part 47: Determination of the ash content of natural asphalts*

prEN 12697-48[1)], *Bituminous mixtures — Test methods for hot mix asphalt — Part 48: Inter-layer bond strength*

prEN 12697-49, *Bituminous mixtures — Test methods for hot mix asphalt — Part 49: Skid resistance of asphalt in the laboratory*

prEN 12697-50[1)], *Bituminous mixtures — Test methods for hot mix asphalt — Part 50: Scuffing resistance of surface course asphalt*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1) In preparation.

1 Scope

This European Standard specifies a test method to assess the durability of adhesion in base and binder course asphalt mixtures. The Saturation Ageing Tensile Stiffness (SATS) conditioning regime is used to age the specimens in the presence of water. A comparative test for assessing their performance before and after conditioning is also conducted. The applicability of this test method is limited to bituminous specimens with consistent air voids contents and hard binder, in particular, to asphalt concrete mixtures with a binder content between 3,5 % and 5,5 %, air voids contents between 6 % and 10 % and 10/20 pen hard paving grade bitumen. The test is intended to be used as a screening test for the assessment of a combination of aggregate, filler and additives with respect to the retained adhesion properties after simulated ageing in a moist atmosphere for lean/stiff base and binder course mixtures.

NOTE Alternative conditions for mixtures with binders other than 10/20 hard grade bitumen or other situations not covered by this European Standard are being developed.

2 Normative references

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

EN 12697-5:2009, *Bituminous mixtures — Test methods for hot mix asphalt — Part 5: Determination of the maximum density*

EN 12697-6:2012, *Bituminous mixtures — Test methods for hot mix asphalt — Part 6: Determination of bulk density of bituminous specimens*

EN 12697-8, *Bituminous mixtures — Test methods for hot mix asphalt — Part 8: Determination of void characteristics of bituminous specimens*

EN 12697-26:2012, *Bituminous mixtures — Test methods for hot mix asphalt — Part 26: Stiffness*

EN 12697-30, *Bituminous mixtures — Test methods for hot mix asphalt — Part 30: Preparation of specimen by impact compactor*

EN 12697-31, *Bituminous mixtures — Test methods for hot mix asphalt — Part 31: Specimen preparation by gyratory compactor*

EN 12697-33, *Bituminous mixtures — Test methods for hot mix asphalt — Part 33: Specimen prepared by roller compactor*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12697-5:2009, EN 12637-6:2012 and the following apply.

3.1
saturation before conditioning
saturation of the mixture, determined as the calculated proportion of air voids filled with water after partial vacuum saturation, prior to conditioning by storage under increased pressure and elevated temperature, in percent

3.2
unconditioned stiffness
stiffness modulus of the mixture as determined in accordance with EN 12697-26:2012, Annex C, prior to conditioning by storage under increased pressure and elevated temperature

Note 1 to entry: Alternative comparative tests can be used but should be recorded in the results.

3.3
conditioned stiffness
stiffness modulus of the mixture as determined in accordance with EN 12697-26:2012, Annex C, after conditioning by storage under increased pressure and elevated temperature

3.4
stiffness ratio
ratio of the conditioned stiffness to the unconditioned stiffness

3.5
saturation after conditioning
saturation of the mixture, determined as the calculated proportion of air voids filled with water after conditioning by storage under increased pressure and elevated temperature, in percent

4 Principle

Nominally identical test specimens are subjected to moisture saturation by a vacuum system. They are then transferred into a pressurised vessel partially filled with water where they are subjected to a conditioning procedure by storage at 85 °C temperature and 2,1 MPa pressure for 65 h. The ratios of the stiffness, measured by indirect tension on cylindrical specimens, before and after conditioning by storage under increased pressure and elevated temperature on the individual specimens situated above the water are averaged to determine the sensitivity of the material to ageing and moisture. The whole process is referred to as the Saturation Ageing Tensile Stiffness (SATS) conditioning test. The average ratio is the SATS durability index of the mixture components when the comparative test is the indirect tensile stiffness modulus.

NOTE Tests other than stiffness by indirect tension on cylindrical specimens can be used as the comparative test.

5 Apparatus

5.1 Sample manufacture

5.1.1 Asphalt mixer

5.1.2 Coring equipment

5.1.3 Saw for cutting asphalt

5.2 Conditioning regime

5.2.1 Vacuum desiccator and **vacuum pump**, including manometer or calibrated vacuum gauge in accordance with EN 12697-5.

5.2.2 Balance with a capacity greater than the mass of a sample that is accurate to 0,1 g.

5.2.3 Pressure/temperature vessel designed to operate at (2,1 ± 0,1) MPa between 80 °C and 115 °C and which shall be made from stainless steel, having internal dimensions adequate to contain the specimen tray (see 5.2.7) and an integral temperature control system that is capable of:

a) bringing the loaded pressurised vessel to the desired conditioning temperature ± 0,5 °C, as recorded by a suitable thermometer inside the vessel, within 2 h;

b) maintaining the temperature at all points within the vessel at the ageing temperature ± 0,5 °C.

SAFETY PRECAUTIONS — The pressure ageing vessel operates at high temperatures and high pressures. All safety guidelines issued by equipment manufacturers shall be adhered to.

5.2.4 Pressure controlling devices

5.2.4.1 Pressure release valve, which prevents pressure in the vessel from exceeding 2,5 MPa during the ageing procedure.

5.2.4.2 Pressure regulator, capable of controlling the pressure within the vessel to ± 0,1 MPa and with a capacity sufficient to reduce the pressure from the source of compressed air so that the pressure within the vessel is maintained at the operating pressure of (2,1 ± 0,1) MPa.

5.2.4.3 Slow release bleed valve, which allows the pressure in the vessel at the completion of the test to be reduced from the 2,1 MPa operating pressure, to atmospheric pressure within 20 min to 30 min.

5.2.4.4 Pressure gauge, capable of measuring the pressure within the vessel to within 0,3 MPa during the test. The pressure gauge shall be calibrated to an accuracy of ± 0,1 MPa at appropriate intervals.

5.2.4.5 Porous disc, 5 mm thick by 100 mm diameter, with a permeability substantially greater than that of the asphalt and the capability withstand the maximum vertical pressure likely to be imposed. The discs shall be checked before each use to ensure that they are not clogged by particles. They shall be boiled for at least 10 min in distilled water before use and kept immersed in de-aerated water until required.

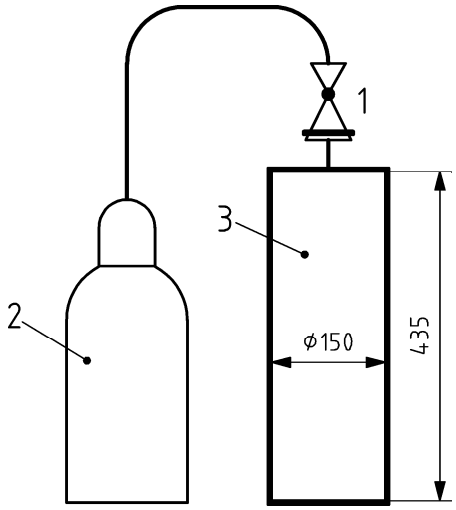
5.2.5 Thermometer, accurate to 0,1 °C, for measuring the temperature inside the pressure vessel.

NOTE A resistance thermal detector (RTD) has been found to be suitable.

5.2.6 Temperature recording device, data acquisition system capable of recording the temperature throughout the test to 0,1 °C.

NOTE The current method of monitoring temperature is via a computerised log of time and temperature. It is assumed the temperature recorded is that which is to be found within every point within the ageing vessel.

Dimensions in millimetres



Key
1 pressure regulator
2 compressed air cylinder
3 pressure vessel

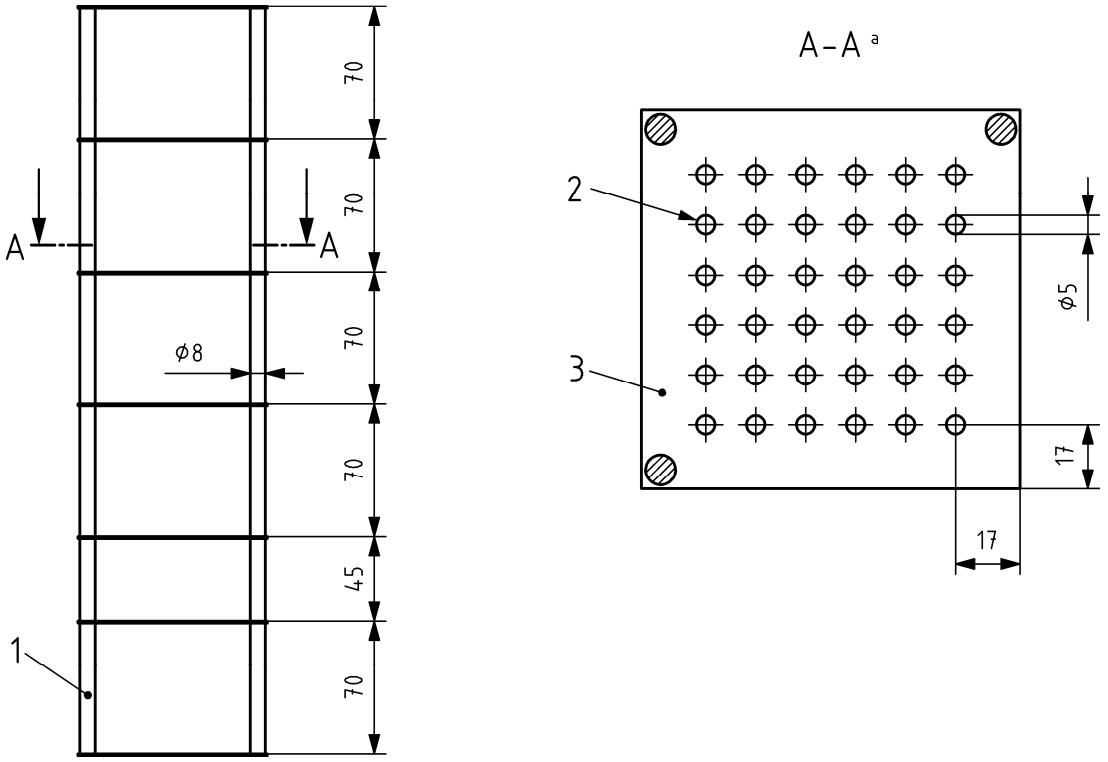
Figure 1 — Schematic diagram and dimensions of typical pressure vessel

5.2.7 Specimen tray, having the form and dimensions specified in Figure 2, to accommodate five test specimens for a full test. The tray shall sit in the pressure vessel on top of a porous disc, as shown in Figure 3.

NOTE 1 The form and dimensions of the pressure vessel and specimen tray shown in Figures 1 and 2 have been found to be practicable in the SATS test when used with different aggregate types. Other forms of pressure vessel and specimen tray may also be suitable, but have not yet been specifically investigated. However, early work carried out in a standard binder pressure ageing vessel in EN 14769 yielded similar results to those generated using the apparatus described in this European Standard.

NOTE 2 The fifth sample is placed so that, unlike the other samples, it is submerged during the test. As such, it is not included in the averaging to produce the overall result. However, the ratio for this sample can be used to provide additional information on the properties of the mixture.

Dimensions in millimetres

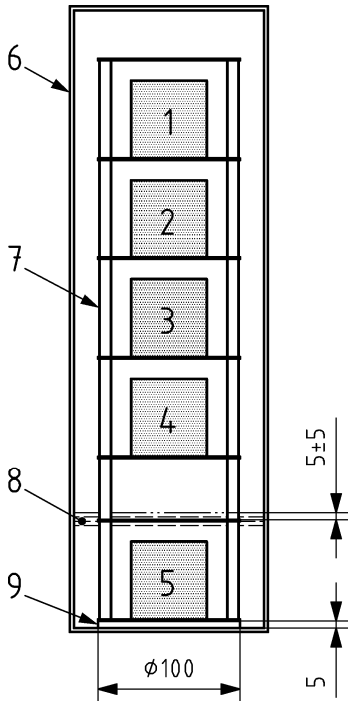


Key
1 8 mm diameter stainless steel pillars
2 5 mm diameter holes, evenly spaced ($6 \times 6 = 36$ holes)
3 100 mm to 105 mm square by 2 mm thick stainless steel plate
[a] enlarged sectional view

Figure 2 — Schematic diagram and dimensions of typical specimen tray

NOTE If the specimens have a diameter greater than 100 mm, then the dimensions of the square plate should also be at least equal to diameter of the specimens in order to avoid any overhang.

Dimensions in millimetres



Key
1 to 5 asphalt specimens
6 pressure vessel
7 specimen tray
8 partially filled with water to (5 ± 5) mm above the 5th tray
9 porous disk

Figure 3 — Schematic diagram of the specimen configuration in the pressure vessel

5.3 Comparative test

Steel load frame and associated equipment in accordance with EN 12697-26:2012, Annex C.

NOTE If the comparative test is not the IT-CY stiffness test, other equipment may be required.

6 Solvent and other materials

6.1 Distilled water (or water of equivalent purity), freshly de-aired and cooled.

6.2 Self-adhesive aluminium foil capable of adhering to and covering the specimen with an impervious coating.

6.3 Absorbent paper towelling.

7 Sample preparation

7.1 Test specimens shall be cylinders of (100 ± 5) mm diameter and (60 ± 5) mm thickness. Specimens shall be cored from a slab manufactured using a laboratory roller compactor in accordance with EN 12697-33. The specimens shall be compacted to have to an air voids content of (8 ± 2) %.

Alternatively, samples may be taken from the site or manufactured using an impact compactor in accordance with EN 12697-30 or using a gyratory compactor in accordance with EN 12697-31.

NOTE 1 However, it can be difficult to achieve homogenous distribution of air voids and the samples should be cored, even from a cylindrical specimen, in order to have cut faces. The method of compaction should then be included in the test report.

NOTE 2 The lower limit on the air voids content is set in order to have a reasonable probability that the air voids will be interconnected so that the pressure in the conditioning phase will apply throughout the specimen. Having set one limit, the upper limit is imposed to ensure comparable samples.

NOTE 3 If specimens are manufactured to the correct dimension by gyratory or impact compactor without cut faces, this fact should be clearly included in the test report.

7.2 The slab shall be approximately 100 mm thick and shall be produced using the recipe for the bituminous mixture to be tested.

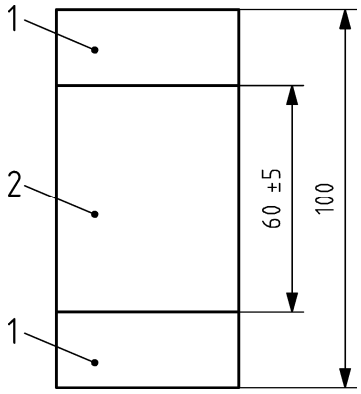
NOTE The binder grade, but not the binder source, has been found to be a significant parameter. The control on the grade is imposed to ensure comparable results between different aggregate skeletons. If the test is used for a mixture with a binder other than 10/20 paving grade, a standard 10/20 paving grade binder to EN 13924 should be substituted.

7.3 The cores shall be cut from the slabs and sawn to the correct length, removing approximately equal amounts from each end of the core (see Figure 4). Five specimens with similar densities shall be used for a full test.

NOTE 1 It can be useful to prepare more than five specimens because some of them may have to be rejected after the air voids content (see 8.3) saturation (see 8.7) determinations.

NOTE 2 The SATS test involves specimens cored from a slab manufactured using a laboratory roller compactor. Specimens for testing may also be cored from an in-service pavement in accordance with EN 12697-27, but research data on the performance of such specimens in the SATS test is currently unavailable.

Dimensions in millimetres



Key
1 sections of core to be discarded from sample
2 section of core forming the sample

Figure 4 — Schematic diagram of the specimen cut from core

8 Conditioning procedure

8.1 The maximum density of the bituminous mixture under test shall be determined in accordance with EN 12697-5:2009, Procedure A.

8.2 The bulk density of each compacted specimen shall be determined in accordance with EN 12697-6:2012, Procedure C. Remove any sealing material after the test.

NOTE Wax is not considered entirely suitable as the sealing material for Procedure C because it is practically impossible to remove from the specimens that will be subjected to subsequent mechanical testing. Self-adhesive aluminium foil, as defined in 6.2, has been successfully used in a number of laboratories for over 10 years, and is easy to remove. However, for laboratory prepared specimens with a rough surface texture, the foil may cause observation of texture voids as internal specimen voids, which may cause an under-estimation of the specimen density and an over-estimation of the air voids level of the specimen. Yet the risk of this inaccuracy of estimation is considered to be relatively small in the case of SATS test specimens, which are normally cored from a laboratory manufactured slab and then trimmed (sawn) to the specified thickness.

8.3 The air voids content of each specimen shall be calculated in accordance with EN 12697-8. Any specimen whose calculated air voids are outside the range $(8 \pm 2)\ \%$ shall be rejected and replaced with further samples of suitable void content.

8.4 The IT-CY stiffness test (or another comparative test) is undertaken on the unconditioned (initial) specimens and the results designated CTR_{U}.

NOTE If an alternative comparative test is used that is destructive, such as the indirect tensile strength test, an extra set of samples is needed for the unconditioned results.

8.5 Determine the dry mass of each specimen using the balance and designate this as M_{d}.

8.6 The specimens shall be partially saturated by placing them in the vacuum desiccator and covering them with distilled water at (20 ± 1) °C. After sealing the apparatus, a vacuum shall be applied so that a residual pressure of between 40 kPa and 70 kPa is reached in the vacuum desiccator within 60 s. The residual pressure of between 40 kPa and 70 kPa shall be maintained for (30 ± 2) min.

8.7 Remove each specimen from the vacuum desiccator and remove any water on its surface using the absorbent paper towelling. Determine its wet mass and designate this as M_{w}. The proportion saturation (S) shall be determined in accordance with 10.2. Any specimens whose calculated saturation is $\geq 80\ \%$ shall be rejected and replaced with a core with a saturation of less than 80 %.

8.8 Partly fill the pressure vessel with water. The water level shall be between the 4$^{\mathrm{th}}$ and 5$^{\mathrm{th}}$ specimen after loading the samples, as shown in Figure 3. Only freshly distilled water shall be used (i.e. do not re-use water). The vessel and water shall be controlled to the target temperature of 85 °C for at least 2 h before the conditioning procedure commences.

NOTE Preheating to a lower temperature, such as 75 °C, has proven to be suitable for preventing overheating due to the pressure build-up.

8.9 The specimens shall be placed into the vessel, using the specimen tray. The specimen tray shall be centrally placed in the chamber of the vessel so that the specimen trays are as close to horizontal as practicable. The cover shall be closed and the pressure gradually increased from atmospheric pressure to 2,1 MPa and the temperature raised to 85 °C over a period of 20 min. The conditioning procedure shall then be performed at $(2{,}1 \pm 0{,}1)$ MPa pressure and at a temperature of (85 ± 1) °C for (65 ± 1) h.

8.10 After the test period of 65 h has elapsed, adjust the target temperature to 30 °C. Leave the vessel for approximately a further 24 h to cool to the adjusted temperature of 30 °C. Do not release the pressure.

NOTE The 24 h cooling period is applied to minimise pressure-related damage during the depressurising process. It has been found that the reduced target temperature (30 °C) can be achieved well within 24 h using the apparatus described in this test method. The pressure needs to be carefully maintained during this cooling process because the reducing temperature will reduce the vessel pressure accordingly. This maintenance can be achieved by careful adjustment of the pressure input controlling valve to just below the target pressure (2,1 MPa); any gradual loss of pressure will then be automatically compensated for by the gradual input of pressure from the compressed air cylinder.

8.11 When the pressure vessel display temperature has reduced to 30 °C (i.e. after the 24 h cooling period), the heater shall be turned off and the pressure shall be slowly released from the vessel. The pressure release mechanism shall be adjusted so that the pressure returns to atmospheric pressure over a period of 20 min to 30 min (linear reduction). The cover shall then be opened and all the specimens extracted, on the tray, from the vessel.

NOTE A slow release of pressure is required at the end of the SATS conditioning procedure in order to minimise damage to the specimens as a result of sudden changes.

8.12 Each specimen shall be surface dried using the absorbent paper towelling, and its wet mass measured within 3 min of removing the specimens from the pressure vessel. Designate this mass as M_{w2}. The saturation after the conditioning procedure (S_a) shall be calculated in accordance with 10.3.

NOTE 3 min has been found to be a practical time period to complete the surface drying and weighing of all five specimens after removal from the pressure vessel. Any reduction in this time period (below 3 min) should help to improve the precision of the test.

8.13 The specimens shall be observed for any visual cracks and unusual appearances (e.g. colour of binder or aggregates). Record any comments as appropriate.

8.14 The comparative tests shall be undertaken on the conditioned (final) specimens within 8 h after turning off the heater on the pressure vessel and the results designated CTR_C.

9 Comparative test procedure

9.1 The comparative test shall be the IT-CY stiffness modulus at $(20 \pm 0{,}5)$ °C in accordance with EN 12697-26:2012, Annex C, except that the sample size shall be 100 mm diameter for all grain sizes.

9.2 Alternatively, other tests can be used as the comparative test, provided the test method is included in the test report.

10 Calculation

10.1 Bulk density and air voids content

10.1.1 Calculate the bulk density of each specimen in accordance with EN 12697-6:2012, Procedure C. The specimen bulk density shall be expressed in megagrams per cubic metre (Mg/m^3) to 0,001 Mg/m^3.

10.1.2 The air voids content of each specimen shall be calculated in accordance with EN 12697-8. The calculated air voids shall be expressed in per cent (%) to 0,1 %.

10.2 Saturation before conditioning

10.2.1 Calculate the saturation before conditioning as follows:

$$S = 100 \times \frac{M_w - M_d}{M_d \times \left(\frac{1}{G_{mb}} - \frac{1}{G_{mm}} \right)} \quad (1)$$

where

S is the proportion saturation before conditioning, in percent (%);

M_d is the mass of dry specimen, in grams (g);

M_w is the mass of wet specimen, in grams (g);

G_{mb} is the dry bulk density, in megagrams per cubic metre (Mg/m^3);

G_{mm} is the maximum density, in megagrams per cubic metre (Mg/m^3).

10.2.2 The saturation before conditioning shall be expressed to 1 %.

10.3 Saturation after conditioning

10.3.1 Calculate the saturation after conditioning as follows:

$$S_a = 100 \times \frac{M_{w2} - M_d}{M_d \times \left(\frac{1}{G_{mb}} - \frac{1}{G_{mm}} \right)} \quad (2)$$

where

S_a is the proportion saturation after conditioning, in percent (%);

M_d is the mass of dry specimen, in grams (g);

M_{w2} is the mass of wet specimen after conditioning, in grams (g);

G_{mb} is the dry bulk density, in megagrams per cubic metre (Mg/m^3);

G_{mm} is the maximum density, in megagrams per cubic metre (Mg/m^3).

10.3.2 The saturation after conditioning shall be expressed to 1 %.

10.4 Stiffness ratio

10.4.1 If the comparative test is not IT-CY stiffness, the ratio of the relevant comparative test results shall be used. The alternative test shall be given in the result sheet.

10.4.2 Calculate the stiffness ratio for each specimen using the following formula:

$$CTR_R = 100 \times \frac{CTR_C}{CTR_U} \quad (3)$$

where

CTR_R is the stiffness ratio;

CTR_C is the conditioned stiffness;

CTR_U is the unconditioned stiffness.

10.4.3 The stiffness ratio shall be expressed in percent (%) to 1 %.

10.4.4 The mixture SATS ratio shall be the average of the ratio of comparative test results for the four individual specimens above the water. When the comparative test is the IT-CY stiffness modulus, the mixture SATS ratio shall be defined as the mixture SATS durability index.

NOTE With a destructive comparative test, the mixture SATS ratio is the ratio of mean results before and after conditioning rather than the mean of the ratios of individual samples before and after conditioning.

11 Test report

The test report shall include the following information:

a) name and address of the testing laboratory;

b) reference to this European Standard;

c) a unique serial number for the test report;

d) name of the client;

e) description and an identification of the sample, and the date of receipt;

f) comparative test used (if not IT-CY stiffness test);

g) maximum density of the mixture tested, to 0,001 Mg/m³;

h) for each specimen tested:

— dry bulk density (G_{mb}), to 0,001 Mg/m^3;

— air voids content (V_v), to 0,1 %;

— proportion saturation (S) before conditioning, to 1 %;

— proportion saturation after conditioning, (S_a), to 1 %;

— unconditioned stiffness (CTR_U) (to 100 MPa);

— conditioned stiffness (CTR_C) (to 100 MPa);

— stiffness ratio (CTR_R), to 1 %;

— any cracks or unusual appearance;

If the comparative test is not IT-CY stiffness, the ratio of the relevant comparative test results shall be used.

i) the Mixture SATS Durability Index;

Alternatively, the Mixture SATS Ratio shall be reported if the comparative test is not IT-CY stiffness.

j) if required, the stiffness ratio of the individual specimens tested shall also be plotted against the corresponding saturation value after conditioning. The graph shall have linear axes for stiffness ratio (y axis) and saturation after conditioning (x axis). The scales of the graph shall cover a range of stiffness ratio of at least 0 to 1,0 and of proportional saturation after conditioning of 0 % to 100 %;

k) date and time of the test;

l) signature of the person accepting technical responsibility for the test report;

m) that the test has been carried out according to the method specified by this European Standard.

12 Precision

Data have not yet been compiled that are suitable for use in developing precision statements for this test with bituminous mixtures.

Bibliography

[1] EN 12697-27, *Bituminous mixtures — Test methods for hot mix asphalt — Part 27: Sampling*

[2] EN 13924, *Bitumen and bituminous binders — Specification for hard paving grade bitumen*

[3] EN 14769, *Bitumen and bituminous binders — Accelerated long-term ageing conditioning by a Pressure Ageing Vessel (PAV)*

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™