SLOVENSKI STANDARD
SIST EN 12697-26:2005

01-januar-2005

Bitumenske zmesi ï Preskusne metode za vroļ e asfaltne zmesi ï 26. del: Togost

Bituminous mixtures - Test methods for hot mix asphalt - Part 26: Stiffness

Asphalt - Prüfverfahren für Heißasphalt - Teil 26: Steifigkeit

Mélanges bitumineux - Méthodes d'essai pour mélange hydrocarboné a chaud - Partie 26: Module de rigidité

Ta slovenski standard je istoveten z: EN 12697-26:2004

ICS:

93.080.20	Materiali za gradnjo cest	Road construction materials

SIST EN 12697-26:2005 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12697-26

July 2004

ICS 93.080.20

English version

Bituminous mixtures - Test methods for hot mix asphalt - Part 26: Stiffness

Mélanges bitumineux - Méthodes d'essai pour mélange hydrocarboné à chaud - Partie 26: Rigidité

Asphalt - Prüfverfahren für Heißasphalt - Teil 26: Steifigkeit

This European Standard was approved by CEN on 1 April 2004.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

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

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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 12697-26:2004: E

Contents

page

Foreword

This document (EN 12697-26:2004) 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of an identical text or by endorsement, at the latest by January 2005, and conflicting national standards shall be withdrawn at the latest by August 2005.

This document is one of a series of standards as listed below:

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: Bitumen recovery: Rotary evaporator*

EN 12697-4, *Bituminous mixtures — Test methods for hot mix asphalt — Part 4: Bitumen 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*

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 bitumen*

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

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

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

EN 12697-23, *Bituminous mixtures — Test methods for hot mix asphalt — Part 23: Determination of the indirect tensile strength of bituminous specimens*

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

prEN 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 a bituminous specimen*

EN 12697-30, *Bituminous mixtures — Test methods for hot mix asphalt — Part 30: Specimen preparationby impact compactor*

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

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

prEN 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: 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 pre-coated chippings for HRA*

EN 12697-38, *Bituminous mixtures — Test methods for hot mix asphalt — Part 38: Test equipment and calibration* prEN 12697-39, *Bituminous mixtures — Test methods for hot mix asphalt — Part 39: Binder content by ignition*

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

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

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

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

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

1 Scope

This document specifies the methods for characterising 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.

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.

2 Normative references

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

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

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

EN 12967-31, *Bituminous mixtures — Test methods for hot mix asphalt — Part 31: Specimen preparation by gyratory compactor*.

EN 12967-33, *Bituminous mixtures — Test methods for hot mix asphalt — Part 33: Specimen prepared by roller compactor.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
complex modulus
relationship between stress and strain for a linear visco-elastic material submitted to a sinusoidal load wave form at time, t, where applying a stress $\sigma \times \sin(\omega \times t)$ results in a strain $\varepsilon \times \sin(\omega \times (t - \Phi))$ that has a phase angle, Φ, with respect to the stress

NOTE 1 The amplitude of strain and the phase angle are functions of the frequency, ω, and the test temperature, Θ.

NOTE 2 The stress strain ratio defines the complex modulus E^* as:

$$E^* = |E^*| \times (\cos(\Phi) + i \times \sin(\Phi)) \qquad (1)$$

The complex modulus is characterised by a pair of two components. This pair can be expressed in two ways: the real component E_1 and the imaginary components E_2 :

$$E_1 = |E^*| \times \cos(\Phi) \qquad (2)$$

$$E_2 = |E^*| \times \sin(\Phi) \qquad (3)$$

the absolute value of the complex modulus $|E^*|$ and the phase angle, Φ:

$$|E^*| = \sqrt{E_1^{\,2} + E_2^{\,2}} \qquad (4)$$

$$\Phi = \arctan\left(\frac{E_2}{E_1}\right) \qquad (5)$$

NOTE 3 This second characterisation is more often used in practice. In linear elastic multi-layer calculations for instance the E^* modulus is generally used as input value for Young's modulus.

NOTE 4 For purely elastic materials, the phase angle is zero and then the complex modulus reduces to the Young's modulus. This happens when bituminous materials are at very low temperatures ($\Phi \leq -20$ °C). Then the complex modulus reaches its highest possible value noted E_∞.

3.1.2
stiffness modulus
absolute value of the complex modulus $|E^*|$ or the value of the secant modulus

3.1.3
secant modulus
relationship between stress and strain at the loading time, t, for a material subjected to controlled strain rate loading:

$$E(t) = \frac{\sigma(t)}{\varepsilon(t)} \qquad (6)$$

with stress, $\sigma(t)$, and strain, $\varepsilon(t)$, at time t

NOTE 1 The strain law is:

$$\varepsilon(t) = \alpha_i \times t^n \qquad (7)$$

where α_i and n are constants.

NOTE 2 Several successive tests may be carried out on the same specimen for different values α_i. For linear visco-elastic materials, the secant modulus obtained for different values of α_i at the same temperature depends on the loading time, t, only.

3.2 Symbols

For the purposes of thisdocument, the following symbols apply:

E^* the complex modulus;

E_1 the real component of the complex modulus;

E_2 the imaginary component of the complex modulus;

E_∞ the highest possible value of the complex modulus;

F the loading force, in newtons (N);

h the mean thickness of the specimen, in millimetres (mm);

H the height of a cylindrical specimen, in millimetres (mm);

k the load area factor;

l_0 the length of the measurement area l_0, in millimetres (mm);

L the span length between outer supports in bending tests, in millimetres (mm);

t the loading time, in seconds (s);

S_m the stiffness modulus, in megapascals (MPa);

Θ the test temperature, in degrees celsius (°C);

z the displacement, in millimetres (mm);

ω the test frequency, in hertz (Hz);

Φ the phase angle, in degrees (°);

γ the form factor (a function of specimen size and form);

μ the mass factor (a function of the mass of the specimen and the mass of the movable parts that influence the resultant force by their inertial effects);

ν the Poisson's ratio;

$\varnothing$ the diameter of a cylindrical specimen, in millimetres (mm).

4 Principle

Suitable shaped samples are deformed in their linear range, under repeated loads or controlled strain rate loads. The amplitudes of the stress and strain are measured, together with the phase difference between stress and strain.

5 Sinusoidal loading

5.1 Test methods

5.1.1 General

The following test methods can be adopted by use of the relative form and mass factor (see clause 8). The testing procedures that shall be followed are described in annex A, B, C, D and E. If other test procedures are used to characterise stiffness properties of bituminous mixtures, the equivalence shall first by verified by comparison with one of these procedures and a statement on that equivalence shall be attached to test reports.

NOTE Inter-laboratory tests have shown that the following mentioned bending tests are in good agreement provided that the equipment is carefully calibrated and that some basic guidelines are strictly followed.

5.1.2 Bending tests

The bending test options are:

— 2PB-TR: test applying two point bending to trapezoidal specimens, see annex A;

— 2PB-PR: test applying two point bending to prismatic specimens, see annex A;

— 3PB-PR: test applying three point bending to prismatic specimens, see annex B;

— 4PB-PR: test applying four point bending to prismatic specimens, see annex B.

5.1.3 Indirect tensile test

The indirect tensile test option is:

— IT-CY: test applying indirect tension to cylindrical specimens, see annex C.

5.1.4 Direct uniaxial tests

The direct uniaxial test options are:

— DTC-CY: test applying direct tension-compression to cylindrical specimens, see annex D;

— DT-CY: test applying direct tension to cylindrical specimens, see annex E;

— DT-PR: test applying direct tension to prismatic specimens, see annex E.

5.2 Loading conditions

The amplitude and the frequency of the loading signal shall be controlled by a feedback control, which may be based either on the force or on the displacement.

NOTE The waveform should be harmonic. Any distortion is the sign of an abnormal set up or of a resonance phenomenon that can disturb the measurement.

5.3 Load amplitudes

The amplitude of the load shall be such that no damage can be generated during the time needed to perform the measurements.

NOTE 1 Experience with a number of test methods has shown that for most bituminous mixtures strains should be kept at a level lower than 50 microstrain ($= 50 \times 10^{-6}$ m/m) to prevent fatigue damage.

NOTE 2 It is known that, beyond certain levels of strain, non-linear behaviour (e.g. stress dependency) can be displayed by the material. In such a case, the proportionality between stress and strain is no longer valid and the concept of complex modulus defined above is no longer correct. This limit depends on the material but it also varies with temperature for a given material.

NOTE 3 Special attention should be given in the highest range of temperature. Therefore, it is recommended to perform linearity tests at the highest temperature to be undertaken within the testing programme. This test consists of measuring the complex modulus at a fixed frequency for an increasing range of strains (or stresses) and to determine the value of strain at which the modulus is no longer constant (starts to decrease).

NOTE 4 Attention should be paid to the danger of fatigue damage during testing by minimising the number of cycles or loading time at each applied stress level and/or minimising the number of stress levels. It is recommended to carry out also a reverse scheme of stress levels in order to see if any fatigue damage has occurred (see also NOTE 1).

NOTE 5 The admissible level of deformation is determined for the direct tensile test by a preliminary test at 10 °C, 50 microstrain and loading times 3 s and 300 s.

5.4 Loading frequencies

The range of frequencies is device dependent.

NOTE 1 Most equipment is able to cover a range between 0,1 Hz and 50 Hz. However, it is preferable to make it as wide as possible in order to allow a logarithmic presentation of the isotherms. A typical set of frequencies could be 0,1 Hz, 0,2 Hz, 0,5 Hz, 1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz, 50 Hz and again the starting frequency of 0,1 Hz. This last measurement is to check that the specimen has not been damaged during the loading with various frequencies. If the difference between stiffness of the specimen at the first and last measurements at identical frequency and at the same temperature is greater than 3 %, it can be concluded that the specimen is damaged and, therefore, cannot be used for further testing (e.g. at different temperatures).

NOTE 2 Care should be taken to avoid resonance phenomena especially at high frequencies.

NOTE 3 Care should be taken that the heat is not accumulated in the specimen in an extent that the temperature differs more than ±0,3 °C from the temperature of the climatic chamber. This problem is especially dominant at prolonged measurements and/or higher frequencies.

6 Controlled strain rate loading

6.1 Test method

Uniaxial direct tensile test on cylindrical specimens (DT-CY see annex E) can be adopted.

NOTE The procedure gives comparable test results to sinusoidal loading for loading time less than 1 s, if the moduli at the loading time, t, expresses in seconds, are compared to the complex modulus at a frequency:

$$f = \frac{1}{2\pi \times t} \quad (8)$$

expressed in Hertz (Hz).

6.2 Loading conditions

A controlled rate displacement shall be applied to a specimen in direct tension to provide a constant strain rate with n = 1 so that the strain law is:

$$\varepsilon(t) = \alpha_{\mathrm{i}} \times t \quad (9)$$

6.3 Strain amplitudes

6.3.1 Preliminary test

For direct tensile tests, at least one element test shall be performed in accordance with annex E in order to determine the level of the stiffness of the mixture. The conditions shall be a temperature of 10 °C, strain amplitude of 50 microstrain, loading force F > 200 N and loading times 3 s and 300 s.