SLOVENSKI STANDARD
SIST EN 12697-24:2004+A1:2007

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Bitumenske zmesi - Preskusne metode za vroḷ e asfaltne zmesi - 24. del: Odpornost proti utrujanju

Bituminous mixtures - Test methods for hot mix asphalt - Part 24: Resistance to fatigue

Asphalt - Prüfverfahren für Heißasphalt - Teil 24: Beständigkeit gegen Ermüdung

Mélanges bitumineux - Méthodes d'essai pour mélange hydrocarboné a chaud - Partie 24: Résistance a la fatigue

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93.080.20 Materiali za gradnjo cest Road construction materials

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Bituminous mixtures - Test methods for hot mix asphalt - Part 24: Resistance to fatigue

Mélanges bitumineux - Méthodes d'essai pour mélange hydrocarboné à chaud - Partie 24: Résistance à la fatigue

Asphalt - Prüfverfahren für Heißasphalt - Teil 24: Beständigkeit gegen Ermüdung

This European Standard was approved by CEN on 2 March 2004 and includes Amendment 1 approved by CEN on 16 May 2007.

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Foreword

This document (EN 12697-24:2004+A1:2007) 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of an identical text or by endorsement, at the latest by January 2008 and conflicting national standards shall be withdrawn at the latest by January 2008.

This document includes Amendment 1, approved by CEN on 2007-05-16.

This document supersedes EN 12697-24:2004.

The start and finish of text introduced or altered by amendment is indicated in the text by tags !A1) (A1!.

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: 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 bitumen*

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

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: Partial 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*

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 a bituminous specimen*

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

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

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: 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*

prEN 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 deicing 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*

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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, 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 and United Kingdom.

1 Scope

This document specifies the methods for characterising 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.

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.

[A1) EN 12697-6:2003+A1 (A1], *Bituminous mixtures — Test methods for hot mix asphalt — Part 6: Determination of bulk density of bituminous specimen*.

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

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

[A1) EN 12697-33:2003+A1, *Bituminous mixtures — Test methods for hot mix asphalt — Part 33: Specimen prepared by roller compactor.* (A1]

3 Terms, definitions, symbols and abbreviations

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

3.1 General

3.1.1
fatigue
reduction of strength of a material under repeated loading when compared to the strength under a single load

3.1.2
conventional criteria of failure (constant displacement)
number of load applications, $N_{f/50}$, when the complex stiffness modulus has decreased to half its initial value

3.1.3
initial complex stiffness modulus
complex stiffness modulus, $S_{mix,0}$, after 100 load applications

3.1.4
conventional criteria of fatigue (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

3.1.5
fatigue life of a specimen
number of cycles $N_{i,j,k}$ corresponding with the conventional failure criterion at the set of test conditions k (temperature, frequency and loading mode; e.g. constant deflection level, or constant force level, and or any other constant loading condition)

3.2 Two-point bending test on trapezoidal specimens

3.2.1
constant relative to maximum strain
constant that enables the head displacement z of the trapezoidal specimen of dimensions [B, b, e, h], to which a bending strain level ε is applied, to be converted into maximum strain

NOTE K_ε and its relationship with the parameters mentioned above is the following:

$$K_\varepsilon \times z = \varepsilon \tag{1}$$

$$K_\varepsilon = \frac{B^2 \times (B-b)^2}{4b \times h^2 \times \left[(b-B)\times(3B-b) + 2B^2 \times \ln\left(B/b\right)\right]} \tag{2}$$

3.2.2 Symbols

The symbols are as follows, with a strain of 1 microstrain (µstrain) being equal to 10^{-6} by convention:

i is the Index of the specimen for an element test (varies from 1 to n)

h_i is the height, in metres (m)

B_i is the large base, in metres (m)

b_i is the small base, in metres (m)

e_i is the thickness, in metres (m)

v_i is the void content of the specimen i by geometric method, in per cent (%)

$K_{\varepsilon i}$ is the constant, relative to the maximum strain, in inverse metres (m^{-1})

z_i is the amplitude of displacement imposed at the head of specimen i, in metres (m)

ε_i is the maximum relative strain of specimen i corresponding with the displacement imposed at the head

N_i is the conventional fatigue life of specimen i

a is the ordinate of the fatigue line according to the equation $\log(N) = a + (1/b) \log(\varepsilon)$

r_2 is the linear correlation !A1) coefficient (A1! ($\log(N_i)$, $\log(\varepsilon_i)$)

$1/b$ is the slope of the fatigue line

$\overline{\log(\varepsilon)}$ is the average value of $\log(\varepsilon_i)$

$S_{\log(\varepsilon)}$ is the standard deviation of $\log(\varepsilon_i)$

$S_{\log(N)}$ is the standard deviation of $\log(N_i)$

ε_6 is the strain corresponding with 10^6 cycles

s_N is the estimation of the residual standard deviation of the decimal logarithms of fatigue lives

$\Delta\varepsilon_6$ is the quality index of the test

n is the number of specimens

3.3 Two-point bending test on prismatic shaped specimens

3.3.1
average fatigue life of a series of specimens
average from a series of n specimens at the level of tension $\sigma_{j\,max}$ given by equation (3)

$$N_{j\max} = \frac{e}{n} \times \sum_{i=1}^{n} \ln (N_{ij}) \tag{3}$$

where

N_{jmax} is the average number of cycles obtained at the level of tension $\sigma_{j\,max}$;

N_{ij} is the fatigue life of the specimen i at the level of tension $\sigma_{j\,max}$;

J is the number at the level of tension $\sigma_{j\,max}$;

n is the number of specimens at the level of tension $\sigma_{j\,max}$;

l is the thickness, in millimetre (mm).

3.3.2
standard deviation of the fatigue life of a series of specimens
standard deviation of the natural logarithm of the fatigue life obtained at the level of tension $\sigma_{j\,max}$ for n repetitions given by equation (4)

$$S_{jmax} = \frac{1}{(n-1)} \times \sqrt{\sum_{i=1}^{n} \left(\ln(N_{ij}) - \ln(N_{\varepsilon\,j\,max})\right)^2} \quad (4)$$

where

$s_{j\,max}$ is the estimation of the standard deviation;

j is the number of the tension level $\sigma_{j\,max}$;

N_{ij} is the conventional fatigue life at the level of tension $\sigma_{j\,max}$;

$N_{j\,max}$ is the average number of cycles obtained at the level of tension $\sigma_{j\,max}$;

n is the number of specimens at the level of tension $\sigma_{j\,max}$.

3.3.3
constants for consideration of the geometry of specimen
constants that enable the strength of the head P_{ij} of the specimen i of dimensions b_i ,e_i and h_i, to which a bending strength is applied, to be converted to a maximum tension

NOTE $K_{\varepsilon\,i}$, and its relationship with the parameters mentioned above, is as follows:

$$K_{\sigma i} \times P_{ij} = \sigma_{jmax} \quad (5)$$

where

$K_{\sigma i}$ is the constants for consideration of the geometry of specimen at constant strength;

P_{ij} is the amplitude of the strength, with which the head is applied, in Newton (N);

ε_{jmax} is the maximum relative strain of the specimen corresponding with the displacement imposed at the head;

σ_{jmax} the greatest relative tension of the specimen, corresponding to the strength, with which the head is applied.

$$K_{\sigma i} = \frac{6\,h_i}{b_i^2 \times e_i} \quad (6)$$

where

$K_{\sigma i}$ is the constant for consideration of the geometry of specimen at constant strength (factor in accordance to EN 12697-26);

b_i is the base, in millimetre (mm);

h_i is the height, in millimetre (mm);

e_i is the width, in millimetre (mm).

3.3.4 Symbols

The symbols are as follows, with a strain of 1 microstrain (µstrain) being equal to 10^{-6} by convention:

3.3.4.1 Sample *i*

h_I is the height, in millimetres (mm)

b_I is (A) small base or (B) base, in millimetres (mm)

e_I is the thickness, in millimetres (mm)

m_I is the mass, in grams (g)

v_i% is the vacuum achieved by the geometric method as a proportion of atmospheric pressure, in per cent (%)

$K\sigma_i$ is the constant for consideration of the geometry of specimen at constant strength, in inverse millimetres (mm^{-1})

3.3.4.2 Strength at head and greatest tension at specimen *i* at level of tension $\varepsilon_{j\,max}$

P_{ij} is the amplitude of the strength with which the head is applied, in Newtons (N)

$\sigma_{j\,max}$ is the greatest relative tension of the specimen, corresponding to the strength, with which the head is applied

3.3.4.3 Fatigue life of a specimen *i* at the level of tension $\sigma_{j\,max}$

N_{ij} is the fatigue life.

3.3.4.4 Fatigue life relative to sample *i* at the strain level ε_j

N_{ij} is the conventional fatigue life.

3.3.4.5 Fatigue line

p_σ is the slope of fatigue line $\ln(\sigma_{j\,max}) = f(\ln(N_{ij}))$

$\hat{\sigma}_6$ is the tension corresponding with 10^6 cycles, in megapascals (MPa)

$s_{\sigma x/y}$ is the estimation of the residual standard deviation of the natural logarithms of fatigue lives

$\Delta\hat{\sigma}_6$ is the confidence of $\hat{\sigma}_6$ for a probability of 95 %

N is the number of element tests (number of specimens at the level of tension $\sigma_{j\,max}$ times the number of levels) where $N = n*l$

s_N is the estimation of the standard deviation of ln(N_{ij})

3.3.4.6 Fatigue life of a series of n specimens (A) at a strain level ε_{jmax} or (B) at the level of tension $\sigma_{j\,max}$

$N_{\varepsilon jmax}$ is the average number of cycles obtained at the level of tension $\sigma_{j\,max}$

l is the number at the level of tension $\sigma_{j\,max}$

n is the number of specimens at the level of tension $\sigma_{j\,max}$

3.4 Three-point bending test on prismatic shaped specimens

3.4.1 Symbols

The symbols are as follows:

$2A_t$ is the amplitude of the approximate stress function, in megapascals (MPa)

$2A_t$ is the amplitude of the approximate strain function

B is the measuring base of the extensometer, in millimetres (mm)

B_t is the phase angle of the approximate stress function, in radians (rad)

B_ε is the phase angle of the approximate strain function, in radians (rad)

D_c is the displacement at instant t, in microns (µm)

$2D_0$ is the total amplitude of displacement function, in microns (µm)

DDE is the density of dissipated energy, in megapascals (MPa) or megajoules per cubic metre (MJ/m^3)

DE(*total*) is the total density of dissipated energy throughout the whole test, in megajoules per cubic metre (MJ/m^3)

$DDE\ (x)$ is the density of dissipated energy at cycle x, in megajoules per cubic metre (MJ/m^3)

EXT is the instant extensometer signal, in millimetres (mm)

L is the distance between supports, in millimetres (mm)

MD is the dynamic modulus, in megapascals (MPa)

N is the number of cycle at end of test

P is the instant load, in megapascals (MPa)

W is the total density of dissipated energy throughout the whole test, in megajoules per cubic metre (MJ/m^3)

b is the width of specimen, in millimetres (mm)

e is the thickness of specimen, in millimetres (mm)