BRITISH STANDARD

BS EN
12697-10:2002
Incorporating corrigendum no. 1

Bituminous mixtures — Test methods for hot mix asphalt —

Part 10: Compactibility

The European Standard EN 12697-10:2001 has the status of a British Standard

ICS 93.080.20

BSI
British Standards

National foreword

This British Standard was published by BSI. It is the UK implementation of EN 12697-10:2001, incorporating corrigendum February 2007.

The UK participation in its preparation was entrusted by Technical Committee B/510, Road materials, to Subcommittee B/510/1, Coated macadam and hot asphalt.

A list of organizations represented on this subcommittee 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.

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

This British Standard, having been prepared under the direction of the Sector Policy and Strategy Committee for Building and Civil Engineering, was published under the authority of the Standards Policy and Strategy Committee on 28 January 2002

ISBN 0 580 38964 2

Amendments issued since publication

Amd. No.	Date	Comments
17052 Corrigendum No. 1	30 March 2007	Corrections to Clauses **5.2.1** and **6.1.1**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12697-10

November 2001

ICS 93.080.20

Incorporating corrigendum February 2007

English version

Bituminous mixtures — Test methods for hot mix asphalt — Part 10: Compactibility

Mélanges bitumineux — Méthodes d'essai pour mélange hydrocarboné à chaud — Partie 10: Compactabilité

Asphalt — Prüfverfahren für Heißasphalt — Teil 10: Verdichtbarkeit

This European Standard was approved by CEN on 14 October 2001.

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Ref. No. EN 12697-10:2001 E

Contents

Foreword

This European Standard 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of an identical text or by endorsement, at the latest by May 2002, and conflicting national standards shall be withdrawn at the latest by August 2005.

This European Standard 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.*

prEN 12697-2, *Bituminous mixtures — Test methods for hot mix asphalt — Part 2: 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.*

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

prEN 12697-6, *Bituminous mixtures — Test methods for hot mix asphalt — Part 6: Determination of bulk density of bituminous specimen by hydro-static method.*

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

prEN 12697-8, *Bituminous mixtures — Test methods for hot mix asphalt — Part 8: Determination of the air voids content of bituminous materials.*

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

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

prEN 12697-11, *Bituminous mixtures — Test methods for hot mix asphalt — Part 11: Determination of the compatibility between aggregate and bitumen.*

prEN 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.*

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

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

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

prEN 12697-18, *Bituminous mixtures — Test methods for hot mix asphalt — Part 18: Binder drainage from porous asphalt.*

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

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

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

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

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

prEN 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: Dynamic creep test.*

prEN 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.*

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

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

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

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

prEN 12697-33, *Bituminous mixtures — Test methods for hot mix asphalt — Part 33: Specimen preparation, slab compactor.*

prEN 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.*

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

prEN 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.*

The applicability of this European Standard is described in the product standards for bituminous materials.

No existing European Standard is superseded.

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

1 Scope

This European Standard 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 prEN 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.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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

prEN 12697-6, *Bituminous mixtures — Test methods for hot mix asphalt — Part 6: Determination of bulk density of bituminous specimen by hydro-static method.*

prEN 12697-8, *Bituminous mixtures — Test methods for hot mix asphalt — Part 8: Determination of the air voids content of bituminous materials.*

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

prEN 12697-31:2000, *Bituminous mixtures — Test methods for hot mix asphalt — Part 31: Specimen preparation, gyratory compactor.*

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

prEN 13043, *Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas.*

ISO 5725, *Accuracy (trueness and precision) of measurement methods and results*.

3 Terms and definitions

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

3.1
soluble binder
percentage by mass of extractable binder in an anhydrous sample determined by extracting the binder from the sample

NOTE Extraction may be followed by binder recovery.

3.2
insoluble binder content
percentage by mass of binder that adheres to the aggregate particles after extraction

3.3
precision
closeness of agreement between independent test results obtained under stipulated conditions

NOTE 1 Precision depends only on the distribution of random errors and does not relate to the true value or the specified value.

NOTE 2 The measure of precision is usually expressed in terms of imprecision and computed as a standard deviation of the test results. Less precision is indicated by a larger standard deviation.

NOTE 3 "Independent test results" means results obtained in a manner not influenced by any previous result on the same or similar test sample. Quantitative measures of precision depend critically on the stipulated conditions. Repeatability and reproducibility conditions are particular sets of extreme conditions.

3.4
repeatability
precision under repeatability conditions

3.5
repeatability conditions
conditions in which independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time

3.6
repeatability limit
value less than or equal to which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 95 %

NOTE The symbol used for repeatability limit is r.

3.7
reproducibility
precision under reproducibility conditions

3.8
reproducibility conditions
conditions in which test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment

3.9
reproducibility limit
value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of 95 %

NOTE The symbol used for reproducibility limit is R .

3.10
single test result
value obtained by applying the standard test method fully, once to a single specimen may be the mean of two or more observations or the result of a calculation from a set of observations as specified by the standard test method

4 Principle

The bituminous mixture is compacted at a prescribed temperature with varying compaction energies.

One of two methods is used. In the first method two or more specimen are compacted with different amounts of compaction energy and their densities are measured. In the second method one specimen is used and its increase in density is determined after each stage of its compaction from its decrease in thickness.

NOTE For impact compaction, both methods can be used. For gyratory compaction, the second method only is used. For vibratory compaction, the first method only is used.

A graph is drawn of density (or voids content) against compaction energy. When the impact compaction is used, the compaction energy is characterized by the number of blows, when the gyratory compaction is used, by the number of gyrations and when the vibratory compactor is used, by the duration in seconds.

A mathematical equation is derived from the experimental results, the parameters of which equation characterize the compactibility of the bituminous mixture.

5 Apparatus

5.1 Impact compaction

5.1.1 Different specimen for each level of compaction energy, recording increases in density

5.1.1.1 Marshall compactor in accordance with prEN 12697-30.

5.1.2 One specimen for all levels of compaction energy, recording decreases in thickness

5.1.2.1 Marshall compactor in accordance with prEN 12697-30.

5.1.2.2 Measuring device for automatically recording the thickness of the specimen after each blow of compaction with an accuracy of at least 0,1 mm.

5.2 Gyratory compaction

5.2.1 Gyratory compactor in accordance with EN 12697-31.

5.3 Vibratory compaction

5.3.1 Vibratory compactor in accordance with prEN 12697-32.

6 Test procedure

6.1 Impact compaction

6.1.1 Different specimens for each level of compaction energy, recording increases in density

For the determination of a single value of the compactibility, prepare and compact three Marshall specimens in accordance with prEN 12697-30 for each number of blows of compaction. The numbers of blows shall be 5, 15, 25, 35, 50, and 100 to each side of the specimen.

If required, determine the mass of bituminous mixture, to be used in the specimen in order to achieve the specimen thickness in accordance with prEN 12697-30 by a preliminary compaction test.

Determine the bulk density of the compacted specimens in accordance with prEN 12697-6.

6.1.2 One specimen for all levels of compaction energy, recording decreases in thickness

For the determination of a single value of compactibility prepare and compact a Marshall specimen in accordance with prEN 12697-30 using 100 blows of compaction to each side.

If required, determine the mass of bituminous mixture to be used in the specimen in order to achieve the specimen thickness in accordance with prEN 12697-30 by a preliminary compaction test after 100 blows to each side by a preliminary compaction test.

Measure the change in thickness of the specimen after each blow using the specified device. Once the specimen has cooled to room temperature, measure its final thickness with a slide calliper rule with 1/10 mm accuracy at four points uniformly spaced around the periphery. Calculate the thickness of the specimen for each number of blows as the mean of each set of four measurements for the final thickness and after each blow.

6.2 Gyratory compaction

Determine the variation of the density of the bituminous mixture with the number of gyrations in accordance with prEN 12697-31:2000, 7.2. The number of gyrations shall be at least 200.

At least three tests shall be carried out on each mixture. Use the arithmetic mean of the three or more densities for the calculation of the compactibility.

Determine the maximum density of the mixture in accordance with prEN 12697-5 and calculate the void content of the specimens for the various number of gyrations in accordance with prEN 12697-8.

6.3 Vibratory compaction

Prepare the compacted specimens of bituminous mixture in accordance with prEN 12697-32, except that initial compaction shall be achieved for a few seconds of vibration, use the large 146 mm diameter tamping foot.

Prepare duplicate specimens at different levels of compaction with a total compaction time for each side of the specimens of 10 s, 15 s, 20 s, 30 s, 60 s and 120 s. If no density increase occurs after 60 s, limit the total compaction time to 60 s but the number of compacted specimens remain as six.

Determine the bulk density of each specimen in accordance with prEN 12697-6 and record the test result as the average of two determinations for each condition.

Determine the maximum density of mixture in accordance with prEN 12697-5 and the air void content of each compaction levels in accordance with prEN 12697-8.

7 Calculation and expression of results

7.1 Impact compaction

7.1.1 Different specimens for each level of compaction energy, recording increases in density

The variation of the bulk density of the compacted specimens as a function of the compaction energy determined from the following formula:

$$\rho(E_1) = \rho_\infty - (\rho_\infty - \rho_0) \exp\left[\frac{-E_1}{C}\right] \quad (1)$$

where:

$\rho(E_1)$ is the bulk density of specimens compacted at compaction energy, E_1, using an impact compactor, expressed in megagrams per cubic metre (Mg/m^3);

ρ_∞ is the calculated maximum achievable bulk density (impact compaction), expressed in megagrams per cubic metre (Mg/m^3);

ρ_0 is the calculated initial specimen bulk density (impact compaction), expressed in megagrams per cubic metre (Mg/m^3);

E_1 is the compaction energy (impact compactor), expressed with 42 Nm as unit, its numerical value is equal to the number of blows to each side of the specimen;

C is the compaction resistance (impact compaction, method with different specimens for each level of compaction energy), expressed with 42 Nm as unit.

NOTE The relative compaction potential, R, can be defined as a derived value as follows:

$$R = (\rho_\infty - \rho_0)/\rho_\infty$$

Calculate the three parameters of the equation, ρ_0, ρ_∞ and C using the least square method applied to the calculated and experimental densities to obtain the best approximation of the experimental data. For a single test express the compaction resistance, C, to two decimal places.

The compaction resistance, C, of a mixture is the arithmetic mean of three single values, expressed to one decimal place. The three single values shall not differ by more than the permissible variation as shown in Table 1:

Table 1 — Compaction resistance

	Compaction resistance , C, up to 12	Compaction resistance , C, over 12 up to 25	Compaction resistance , C, over 25
Permissible variation	Absolute value 3,18	26,5 % of numerical value	Can not be reliably stated

7.1.2 Same specimen for all levels of compaction energy, recording decreases in thickness

The variation of the reciprocal of the thickness of the compacted specimen as a function of the compaction energy is determined from the formula:

$$\frac{1}{t(E_2)} = \frac{1}{t_\infty} - \left[\frac{1}{t_\infty} - \frac{1}{t_0}\right] \exp\left(\frac{-E_2}{T}\right) \quad (2)$$

where:

$t(E_2)$ is the thickness of the specimen at a compaction energy E_2 using an impact compactor, expressed in millimetres (mm);

t_∞ is the calculated minimum achievable specimen thickness (impact compaction), expressed in millimetres (mm);

t_0 is the calculated initial specimen thickness (impact compaction), expressed in millimeters (mm);

E_2 is the compaction energy (impact compactor), expressed with 21 Nm as unit, its numerical value is equal to the number of blows to the specimen;

T is the compaction resistance (impact compaction, method with the same specimen for all levels of compaction energy), expressed with 21 Nm as unit.

Calculate the three parameters of the equation, t_0, t_∞ and T using the least square method applied to the calculated and experimental reciprocals of the thickness, to obtain the best approximation of the experimental data. For a single test express the compaction resistance, T, to two decimal places.

The compaction resistance, T, of a mixture is the arithmetic mean of three single values, expressed to one decimal place. The three single values shall not differ by more than 20 % from the numerical value of the result.

7.2 Gyratory compaction

The variation of the void content of the compacted specimen as a function of the compaction energy is determined from the following formula:

$$\upsilon(ng) = \upsilon(1) - (K \cdot \ln ng) \quad (3)$$

where:

$\upsilon(ng)$ is the void content for a number of gyration ng, expressed in percent (%);

$\upsilon(1)$ is the calculated void content for one gyration;

K is the compactibility (method using a gyratory compactor);

ng is the number of gyrations.

Calculate the two parameters of the equation, $\upsilon(1)$ and K, for the best possible approximation of the experimental data for a number of gyrations equal or greater than 20, using a linear regression analysis where $\ln ng$ and $\upsilon(ng)$ are the independent and dependent variables respectively. Express the void content, $\upsilon(1)$ to one decimal place and the compactibility, K, to two decimal places.

7.3 Vibratory compaction

The relationship between the void content and compaction energy is determined from the following formula:

$$V(s) = Vs(1) - (k \cdot \log s) \quad (4)$$

where:

$V(s)$ is the difference between air void content at s seconds of vibratory compaction on each side of the specimen and air void content at refusal

(vibratory compaction on each side for 120 s), expressed in percent (%);

$Vs(1)$ is the calculated difference between air void content at 1 s of vibratory compaction on each side of the specimen and void content at refusal, expressed in percent (%);

k is the compactibility (vibratory compactor);

s is the duration of vibratory compaction on each side, expressed in seconds (s).

8 Test report

The test report shall make reference to this European Standard and include the following:

a) the formula of the mixture;

b) the nature and origin of materials;

c) the method of manufacture of the mixture;

d) the compaction method used (impact with different specimens for each level of compaction energy, impact with the same specimen for all levels of compaction energy, gyratory, vibratory);

e) the temperature of compaction, and for the gyratory compaction, the diameter of specimen and the speed of rotation;

f) the value of the two (gyratory compaction and vibratory compaction) or three (impact compaction) parameters which characterize the compactibility;

g) the plot of the experimental results on a graph;

h) any operational details not provided for in this European Standard and anomalies, if any, which might have affected the results.

9 Precision

9.1 Impact compaction

The repeatability and reproducibility of the compaction resistance, C, was determined by a cooperative test using a bituminous mixture prepared in a mixing plant. The results obtained, are shown in Table 2.

Table 2 — Repeatability and reproducibility

	Repeatability	Reproducibility
Mixture with a compaction resistance $C \leq 12$	Absolute value 1,4	Absolute value 3,6
Mixture with a compaction resistance $C > 12$ and ≤ 25	12 % of numerical value of results	30 % of numerical value of result
Mixture with a compaction resistance $C > 25$	Can not be reliably stated	

9.1.1 One specimen for all levels of compaction energy, recording decreases in thickness

The repeatability and reproducibility of the compaction resistance, T, was determined by a cooperative test using a bituminous mixture prepared in a mixing plant. The results obtained, are shown in Table 3.

Table 3 — Repeatability and reproducibility

	Repeatability	Reproducibility
Mixture with a compaction resistance $T \leq 45$	11 % of numerical value of results	22 % of numerical value of results
Mixture with a compaction resistance $T > 45$	Can not be reliably stated	

9.2 Gyratory compaction

A study of the repeatability and reproducibility of K was conducted according to ISO 5725 with 17 laboratories working with the same type of test device, on a laboratory prepared mixture (asphalt concrete for wearing course with D = 10 mm in accordance with prEN 13043).

The average value of K was 3,47. The repeatability was 0,14 and the reproducibility 0,24.

9.3 Vibratory compaction

The determination of compactibility of bituminous mixtures using vibratory compaction is a tentative test procedure and its precision has yet to be established.

Its application is limited to dense graded asphalt concrete binder course and road base mixtures.

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