



BSI Standards Publication

## Unbound and hydraulically bound mixtures

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Part 1: Test methods for laboratory reference density and water content - Introduction, general requirements and sampling

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## Unbound and hydraulically bound mixtures - Part 1: Test methods for laboratory reference density and water content - Introduction, general requirements and sampling

Mélanges traités et mélanges non traités aux liants hydrauliques - Partie 1: Méthode d'essai de détermination en laboratoire de la masse volumique de référence et la teneur en eau - Introduction et exigences générales

Ungebundene und hydraulisch gebundene Gemische - Teil 1: Laborprüfverfahren für die Trockendichte und den Wassergehalt - Einführung, allgemeine Anforderungen und Probenahme

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## European foreword

This document (EN 13286-1:2021) has been prepared by Technical Committee CEN/TC 227 “Road Materials”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by May 2022, and conflicting national standards shall be withdrawn at the latest by May 2022.

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

This document supersedes EN 13286-1:2003.

The following changes have been made in comparison with EN 13286-1:2003:

- editorial changes;
- in Table 1, a change to the particle size range for the vibrating hammer test in reflection of the change in EN 13286-4.

This document is one of a series of standards as follows:

- EN 13286-1, Unbound and hydraulically bound mixtures — Part 1: Test methods for laboratory reference density and water content — Introduction, general requirements and sampling
- EN 13286-2, Unbound and hydraulically bound mixtures — Part 2: Test methods for laboratory reference density and water content — Proctor compaction
- EN 13286-3, Unbound and hydraulically bound mixtures — Part 3: Test methods for laboratory reference density and water content — Vibrocompression with controlled parameters
- EN 13286-4, Unbound and hydraulically bound mixtures — Part 4: Test methods for laboratory reference density and water content — Vibrating hammer
- EN 13286-5, Unbound and hydraulically bound mixtures — Part 5: Test methods for laboratory reference density and water content — Vibrating table
- EN 13286-7, Unbound and hydraulically bound mixtures — Part 7: Cyclic load triaxial test for unbound mixtures
- EN 13286-40, Unbound and hydraulically bound mixtures — Part 40: Test method for the determination of the direct tensile strength of hydraulically bound mixtures
- EN 13286-41, Unbound and hydraulically bound mixtures — Part 41: Test methods for the determination of the compressive strength of hydraulically bound mixtures
- EN 13286-42, Unbound and hydraulically bound mixtures — Part 42: Test method for the determination of the indirect tensile strength of hydraulically bound mixtures
- EN 13286-43, Unbound and hydraulically bound mixtures — Part 43: Test method for the determination of the modulus of elasticity of hydraulically bound mixtures



- EN 13286-44, Unbound and hydraulically bound mixtures — Part 44: Test method for the determination of the alpha coefficient of vitrified blastfurnace slag
- EN 13286-45, Unbound and hydraulically bound mixtures — Part 45: Test method for the determination of the workability period of hydraulically bound mixtures
- EN 13286-46, Unbound and hydraulically bound mixtures — Part 46: Test method for the determination of the moisture condition value
- EN 13286-47, Unbound and hydraulically bound mixtures — Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling
- EN 13286-48, Unbound and hydraulically bound mixtures — Part 48: Test method for the determination of the degree of pulverisation
- EN 13286-49, Unbound and hydraulically bound mixtures — Part 49: Test method for the determination of the accelerated swelling of soil treated by lime and/or hydraulic binder
- EN 13286-50, Unbound and hydraulically bound mixtures — Part 50: Method for the manufacture of test specimens of hydraulically bound mixtures using Proctor equipment or vibrating table compaction
- EN 13286-51, Unbound and hydraulically bound mixtures — Part 51: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrating hammer compaction
- EN 13286-52, Unbound and hydraulically bound mixtures — Part 52: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrocompression
- EN 13286-53, Unbound and hydraulically bound mixtures — Part 53: Method for the manufacture of test specimens of hydraulically bound mixtures using axial compression
- CEN/TS 13286-54, Unbound and hydraulically bound mixtures — Part 54: Test method for the determination of frost susceptibility — Resistance to freezing and thawing of hydraulically bound mixtures

Annex A is informative.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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## 1 Scope

This document specifies a number of test methods for the determination of the relationship between the water content and the density of unbound and hydraulically bound mixtures under specified test conditions. The test results provide an estimate of the mixture density that can be achieved and provides a reference parameter for assessing the density of the compacted layer of the mixture.

The test results are used as a basis for specifying requirements for hydraulically bound and unbound mixtures.

The test result also allows a conclusion to be drawn as to the water content at which a mixture can be satisfactorily compacted in order to achieve a given density.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 932-1:1996, *Tests for general properties of aggregates - Part 1: Methods for sampling*

EN 932-2:1999, *Tests for general properties of aggregates - Part 2: Methods for reducing laboratory samples*

EN 932-5, *Tests for general properties of aggregates - Part 5: Common equipment and calibration*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 932-1:1996, EN 932-2:1999 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

### 3.1

#### **laboratory dry density**

maximum dry density that can be determined from the dry density/water content relationship derived using a specified test method

### 3.2

#### **optimum water content**

water content associated with the maximum value of laboratory dry density

### 3.3

#### **aggregate size**

designation of aggregate in terms of lower (d) and upper (D) sieve sizes expressed as d/D

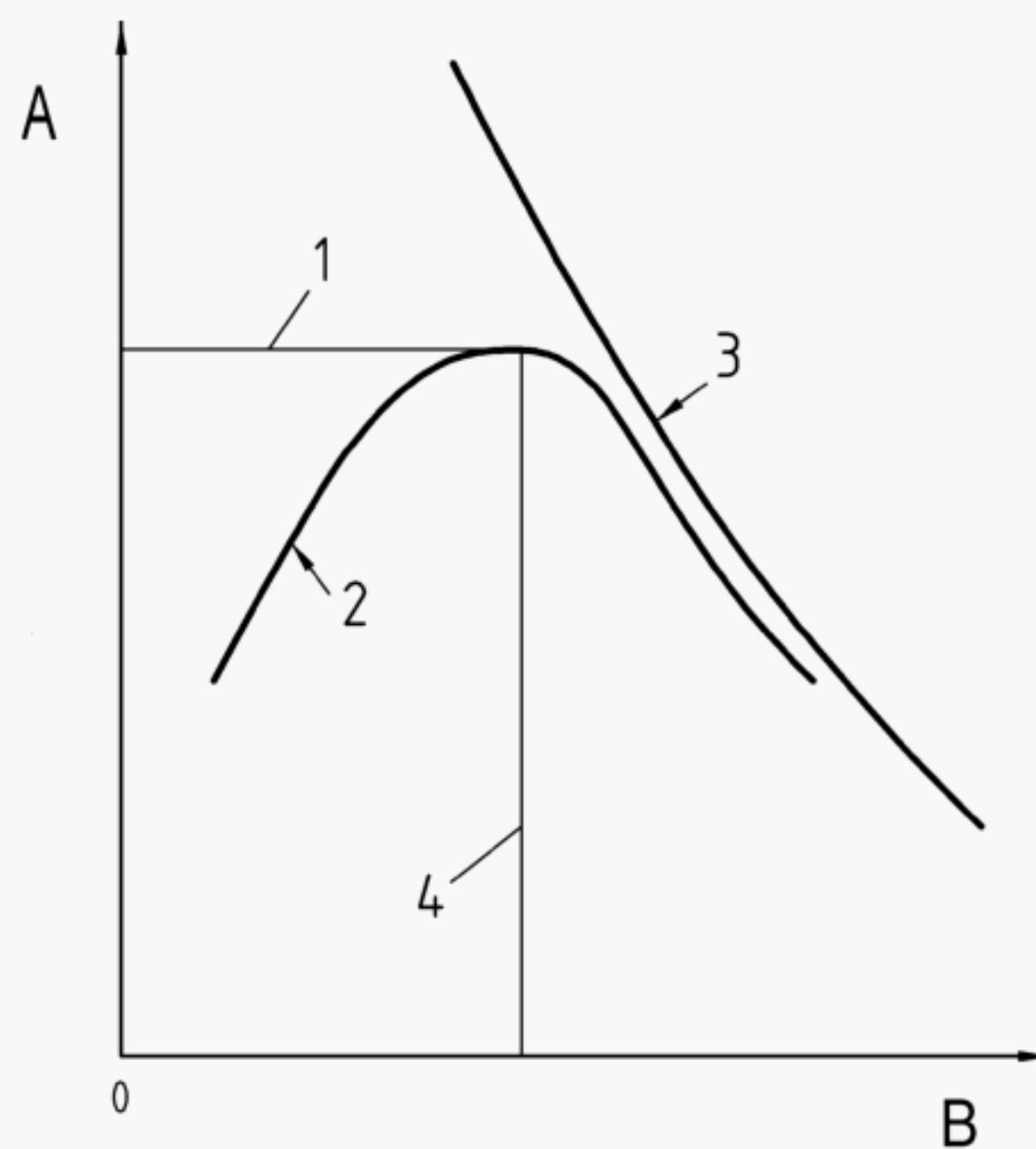
Note 1 to entry: This designation accepts the presence of some particles which will be retained on the upper sieve (oversize) and some which will pass the lower sieve (undersize). The lower sieve size (d) may be zero.

## 4 Principle

### 4.1 Relationship between dry density and water content

The solid particles of unbound and hydraulically bound mixtures are compacted, i.e. packed more closely together, thereby increasing the dry density of the mixture. The dry density which can be achieved depends on the effective compaction work applied and on the amount of water present in the mixture.

For a given degree of compaction work applied to a particular mixture, an optimum water content exists at which the dry density obtained reaches a maximum value. These principles are illustrated in Figure 1.



#### Key

- 1 Maximum value of laboratory dry density
- 2 Compaction curve
- 3 0 % air void line for a given particle density, saturation line
- 4 Optimum water content
- A Dry density, megagrams per cubic metre
- B Water content, per cent

**Figure 1 — Dry density/water content relationship curve**

**NOTE 1** The mixtures which are not free draining will, in most cases, establish a well-defined optimum water content and maximum density. However, for free draining mixtures, the laboratory tests will not, in many cases, produce a well-defined water density relationship. The maximum density obtained will generally be less than that obtained in the finished pavement layer.

**NOTE 2** For free draining mixtures it is possible to draw two curves: one for the relationship between the dry density and the initial water content (before compaction) and another for the relationship between the dry density and the final water content (after compaction). The possible difference between these curves shows the draining capacity of the mixture.



4.2 Choice of test method

The following four test methods are used for compaction:

- EN 13286-2: Proctor compaction;
- EN 13286-3: Vibrocompression with controlled parameters;
- EN 13286-4: Vibrating hammer;
- EN 13286-5: Vibrating table.

Each method applies different levels of compactive effort, and is suitable for different aggregate sizes.

In the Proctor compaction, vibrocompression and vibrating hammer methods the relationship between the dry density and water content of a mixture is determined.

The Proctor compaction method allows a choice between three mould sizes depending upon aggregate size. Three different hammer masses may be used.

In the vibrating table method the water content of the mixture at this maximum dry density is determined,

NOTE The vibrating table method is suitable for mixtures which drain easily.

The range of applicability of each method is given in Table 1.

Table 1 — Choice of test method

Test method			Particle size range	
Proctor compaction	2,5 kg hammer	100 mm mould	maximum size	16 mm
		150 mm mould	75 to 100 percentage passing	31,5 mm
	4,5 kg hammer	100 mm mould	maximum size	16 mm
		150 mm mould	75 to 100 percentage passing	31,5 mm
	15 kg hammer	250 mm mould	75 to 100 percentage passing	63 mm
Vibrocompression with controlled parameters			maximum size	31,5 mm
Vibrating hammer			90 to 100 percentage passing	40 mm
Vibrating table			maximum size	80 mm
			less than 12 percentage passing	0,063 mm

4.3 Determination of water content

Where required the water content is determined by oven drying to constant mass using the procedures set out in EN 1097-5.

The minimum size of the test portion used to determine water content is 0,2 × D kg, where D is the aggregate size of the mixture.

If all of a mixture passes the 1 mm sieve, at least 0,2 kg is used.

NOTE It can be convenient to use all the contents of a mould.

The water content of a compacted specimen is determined as soon as possible after completion of compaction.



**4.4 Sampling and sample reduction**

Sampling and sample reduction are given in EN 932-1 and EN 932-2 with additional requirements given in Annex A.

**5 Apparatus**

All apparatus shall conform to the general requirements of EN 932-5. Where required, specific requirements for the calibration of particular items of apparatus shall be given in an Annex to the relevant part of the EN 13286 series.

**6 Test specimen preparation for other test methods**

The methods described in EN 13286-2 to EN 13286-5 may be used to prepare compacted test specimens for use with other test methods.

## **Annex A** (informative)

### **Sampling and sample reduction**

#### **A.1 General**

This annex describes methods for:

- obtaining samples of unbound and hydraulically bound mixtures after manufacture or at the point of delivery;
- reducing the size of the sample prior to submission to a laboratory;
- reducing the sample submitted to the laboratory to test portion size.

NOTE 1 The methods described are based on manual procedures. Mechanical devices can be used, subject to the criteria for mechanical sampling apparatus set out in EN 932-1.

NOTE 2 Where necessary, the method of dividing the test portion into a number of test specimens is given in the relevant test method.

#### **A.2 Principle**

A bulk sample is obtained that is representative of the average properties of the batch.

NOTE Principles of sampling and sample reduction are given in EN 932-1.

#### **A.3 Bulk sample size and number of increments**

The total size of the bulk sample shall be at least twice the quantity estimated as being required for the tests to be carried out, with a minimum mass of 10 kg. The bulk sample shall consist of at least five increments.

NOTE 1 The use of twice the required quantity allows for repeated tests to resolve anomalous or disputed test results.

NOTE 2 Guidance on the amount of mixture required for each test is given in Table A.1. The values given are based on a loose bulk density of 2,0 Mg/m<sup>3</sup>.



Table A.1 — Guidance on the mass of mixture required for laboratory dry density and water content tests

Test method		Minimum mass [kg]
Part 2: Proctor compaction	100 mm mould or 150 mm mould	15
	150 mm mould	40
	250 mm mould	200
Part 3: Vibrocompression with controlled parameters		10
Part 4: Vibrating hammer		50
Part 5: Vibrating table		45
NOTE For other test methods guidance on the size of the bulk sample is given in EN 932-1.		

A.4 Sampling plan

The sampling plan shall conform to the requirements in EN 932-1.

The sampler should be aware that all mixtures are prone to segregation. Mixtures with a value of upper, D, sieve size greater than 20 mm or which contain aggregates of differing particle densities are particularly liable to segregation.

NOTE The sampling plan can include details of the number of samples to be taken and/or the frequency of sampling. This information can be defined in a system of factory production control.

A.5 Apparatus

All apparatus shall conform to the requirements in EN 932-1.

NOTE The following items are used: Scoop, shovel, sampling tray, riffle box and containers (for transport).

A.6 Sampling procedures

The sampling procedure chosen shall conform to the requirements in EN 932-1.

NOTE 1 The following methods are used:

- sampling from stationary conveyor belts;
- sampling at belt and chute discharge points;
- sampling from stockpiles.

NOTE 2 The outside of a stockpile of a mixture is possibly not representative of the average properties. It can be appropriate to use a loading shovel to take a series of increments to form a secondary stockpile from which a representative sample can be taken.

NOTE 3 If a sample of an uncompacted mixture in a layer is required, the layer is considered as a flat stockpile.

A.7 Sample reduction

If it is necessary to reduce the size of the bulk sample for submission to a laboratory, the methods in EN 932-1 shall be used.

## **A.8 Test portion preparation**

If it is necessary to reduce the size of the laboratory sample to produce one or more test portions, the procedures described in EN 932-2 shall be used.

## **A.9 Marking, packaging and dispatch**

Marking, packaging and dispatch of the samples shall conform to the requirements in EN 932-1.

## **A.10 Sampling report**

The sampling report shall conform to the requirements in EN 932-1.

The sampling report shall refer to this document.

If appropriate, the sampling report may include

- a) ambient temperature and weather conditions;
- b) temperature of the sample.



**Bibliography**

EN 1097-5, *Tests for mechanical and physical properties of aggregates - Part 5: Determination of the water content by drying in a ventilated oven*

EN 13286-2, *Unbound and hydraulically bound mixtures - Part 2: Test methods for laboratory reference density and water content - Proctor compaction*

EN 13286-3, *Unbound and hydraulically bound mixtures - Part 3: Test methods for laboratory reference density and water content - Vibrocompression with controlled parameters*

EN 13286-4, *Unbound and hydraulically bound mixtures - Part 4: Test methods for laboratory reference density and water content - Vibrating hammer*

EN 13286-5, *Unbound and hydraulically bound mixtures - Part 5: Test methods for laboratory reference density and water content - Vibrating table*

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