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Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption

Prüfverfahren für mechanische und physikalische Eigenschaften von Gesteinskörnungen - Teil 6: Bestimmung der Rohdichte und der Wasseraufnahme

Essais pour déterminer les caractéristiques mécaniques et physiques des granulats - Partie 6 : Détermination de la masse volumique et du coefficient d'absorption d'eau

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Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption

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Prüfverfahren für mechanische und physikalische Eigenschaften von Gesteinskörnungen - Teil 6: Bestimmung der Korndichte und der Wasseraufnahme

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

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European foreword

This document (EN 1097-6:2022) has been prepared by Technical Committee CEN/TC 154 “Aggregates”, the secretariat of which is held by BSI.

This document shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2022, and conflicting national standards shall be withdrawn at the latest by August 2022.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 1097-6:2013.

In comparison with the previous edition, the following technical modifications have been made:

a) Normative references has been extended with EN 1097-5 (used in Annex D). EN 932-1 has been deleted from the clause since sampling is out of the scope, as for other standards;

b) the definitions of laboratory sample and subsample have been added in Clause 3;

c) the glass funnel in 6.4.4 has been deleted since it is part of the pyknometer in 6.5.1. The minimum volume of the pyknometer in 6.5.1 has been changed from 250 ml to 500 ml. New 6.8 and 6.10 have been added and describe special apparatus referenced in new Annexes D and F;

d) Clause 9 has been extended with an illustration of the surface-dry state assessment using the cone test;

e) the possibility to remove air from the pyknometer by applying a vacuum has been added in A.4.3;

f) in Annex B, the test portion mass for single aggregates (B.2.2) and the temperature requirement in B.3 have been clarified. In addition, the time needed for achieving constant mass during suction has been clarified;

g) the Note in C.1 has been revised to say that the method can also be used for aggregate particles passing the 4 mm sieve and retained on the 1 mm sieve. Soaking times for the water absorption determination have been added in C.1. A new paragraph has been added in C.1, saying that for concrete applications the water absorption of coarse lightweight aggregate shall be determined in the as-used moisture state instead of the oven-dry state. In C.4, a Note about using vibrating table as a vibration means has been added. Precision of individual values has been defined in C.5;

h) a new normative Annex D has been designed to determine the particle density and water absorption of fine lightweight aggregates. Consequently, Annex C has been retitled to only apply to coarse lightweight aggregates;

i) the title of Annex E has been shorted. The Note in E.1 has been revised to say that the method can also be used for aggregate particles passing the 2 mm sieve and retained on the 1 mm sieve. Precision of individual values has been defined in E.4;

j) Annex F has been replaced by a new informative annex designed to determine the particle density and water absorption of aggregates passing the 4 mm sieve;

k) the procedure in Annex H has been extended to specify double determination. In addition, the recommended volume which the test portion should occupy to enable the release of entrapped air, has been changed from one third to one half of the pyknometer volume, in consistency with other clauses;

l) all annexes have been reordered to collect the annexes about lightweight aggregates. Annex D Density of water has been moved to Annex G and Annex J List of main changes has been deleted.

Furthermore, the whole standard has been updated according to the current rules and to reflect the changes. The text has been clarified and the Bibliography has been supplemented.

This document forms a part of a series of tests for mechanical and physical properties of aggregates. Test methods for other properties of aggregates are covered by the following European standards:

— EN 932 (all parts), *Tests for general properties of aggregates*

— EN 933 (all parts), *Tests for geometrical properties of aggregates*

— EN 1367 (all parts), *Tests for thermal and weathering properties of aggregates*

— EN 1744 (all parts), *Tests for chemical properties of aggregates*

— EN 13179 (all parts), *Tests for filler aggregate used in bituminous mixtures*

The other parts of EN 1097 include:

— *Part 1: Determination of the resistance to wear (micro-Deval)*

— *Part 2: Methods for the determination of resistance to fragmentation*

— *Part 3: Determination of loose bulk density and voids*

— *Part 4: Determination of the voids of dry compacted filler*

— *Part 5: Determination of the water content by drying in a ventilated oven*

— *Part 7: Determination of the particle density of filler — Pyknometer method*

— *Part 8: Determination of the polished stone value*

— *Part 9: Determination of the resistance to wear by abrasion from studded tyres — Nordic test*

— *Part 10: Determination of water suction height*

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.

According to the CEN-CENELEC Internal Regulations, the national standards organisations 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, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies the reference methods used for type testing and in case of dispute, for the determination of particle density and water absorption of normal weight and lightweight aggregates. Other methods can be used for other purposes, such as factory production control, provided that an appropriate working relationship with the reference method has been established. For convenience, some of these other methods are also described in this document.

The reference methods for normal weight aggregates are:

— a wire basket method for aggregate particles retained on the 31,5 mm sieve (Clause 7, except for railway ballast which uses Annex B);

— a pyknometer method for aggregate particles passing the 31,5 mm sieve and retained on the 4 mm sieve (Clause 8);

— a pyknometer method for aggregate particles passing the 4 mm sieve and retained on the 0,063 mm sieve (Clause 9).

In Clauses 7, 8 and 9, three different particle densities (oven-dried particle density, saturated and surface-dried particle density and apparent particle density) and water absorption are determined after a soaking period of 24 h. In Annex B, the oven-dried particle density is determined after soaking in water to constant mass.

For aggregate particles passing the 31,5 mm sieve and retained on the 4 mm sieve, the wire basket method in Clause 7 can be used as an alternative to the pyknometer method in Clause 8.

NOTE 1 The wire basket method can also be used for single aggregate particles retained on the 63 mm sieve.

NOTE 2 The pyknometer method described in Clause 8 can be used as an alternative for aggregates passing the 4 mm sieve and retained on the 2 mm sieve.

The reference methods for lightweight aggregates are:

— a pyknometer method for aggregate particles passing the 31,5 mm sieve and retained on the 4 mm sieve (Annex C). Three different particle densities (oven-dried; saturated and surface-dried; apparent) and water absorption are determined after pre-drying and a soaking period of 24 h;

— a method, using a Büchner funnel, for aggregate particles passing the 4 mm sieve (Annex D). The three particle densities and water absorption are determined using a vacuum in the range of 50 mbar to 100 mbar for at least five minutes.

Three other methods for normal weight aggregates can be used to determine the pre-dried particle density, as specified in normative Annexes A and H:

— a wire basket method for aggregate particles passing the 63 mm sieve and retained on the 31,5 mm sieve (A.3);

— a pyknometer method for aggregate particles passing the 31,5 mm sieve and retained on the 0,063 mm sieve (A.4);

— a pyknometer method for aggregate particles passing the 31,5 mm sieve, including the 0/0,063 mm size fraction (Annex H).

NOTE 3 If water absorption is less than about 1,5 %, the apparent particle density can be assessed using the pre-dried particle density method as defined in Annex A.

The quick method in normative Annex E can be used in factory production control to determine the apparent particle density of lightweight aggregates.

The method in informative Annex F can be used to determine the particle density and water absorption of aggregate particles passing the 4 mm sieve.

Data on the density of water at various temperatures is specified in normative Annex G.

Guidance on the significance and use of the various density and water absorption parameters is given in informative Annex I.

Precision data are presented in informative Annex J.

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 932-2, *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*

EN 933-2, *Tests for geometrical properties of aggregates — Part 2: Determination of particle size distribution — Test sieves, nominal size of apertures*

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

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
apparent particle density
ρ_a
ratio obtained by dividing the oven-dried mass of an aggregate sample by the volume it occupies in water, including the volume of any internal sealed voids but excluding the volume of water in any water accessible voids

Note 1 to entry: For lightweight aggregates the symbol ρ_{La} is used.

3.2
constant mass
mass determined after successive weighings at least 1 h apart not differing by more than 0,1 %

Note 1 to entry: In many cases, constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven at (110 ± 5) °C. Test laboratories can determine the time necessary to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

3.3
oven-dried particle density
ρ_{rd}
ratio obtained by dividing the oven-dried mass of an aggregate sample by the volume it occupies in water, including the volumes of any internal sealed voids and water accessible voids

Note 1 to entry: For lightweight aggregates, the symbol ρ_{Lrd} is used.

3.4
pre-dried particle density
ρ_{p}
ratio obtained by dividing the pre-dried mass of an aggregate sample by the volume it occupies in water, including the volumes of any internal sealed voids but excluding the volume of water in any water accessible voids

Note 1 to entry: Test conditions in terms of pre-drying of the test sample and the shorter immersion period differ from the ones for apparent particle density.

Note 2 to entry: Pre-dried particle density is a rapid test.

3.5
saturated and surface-dried particle density
ρ_{ssd}
ratio obtained by dividing the sum of the oven-dried mass of an aggregate sample and the mass of water in any water accessible voids by the volume it occupies in water, including the volumes of any internal sealed voids and water accessible voids

Note 1 to entry: For lightweight aggregates, the symbol ρ_{Lssd} is used.

3.6
laboratory sample
sample intended for laboratory testing

3.7
subsample
sample obtained by means of a sample reduction procedure

3.8
test portion
sample used as a whole in a single test

3.9
test specimen
sample used in a single determination when a test method requires more than one determination of a property

3.10
water absorption
mass of absorbed water, expressed as a percentage of the oven-dried mass of the aggregate sample

4 Principle

Particle density is calculated from the ratio of mass to volume. The mass is determined by weighing the test portion in the saturated and surface-dry condition and again in the oven-dry condition. Volume is determined from the mass of the water displaced, either by mass reduction in the wire basket method or by weighings in the pyknometer method.

Due to the influence on the absorption, no artificial heating of the test portion should be applied before testing. However, if such material is used, this fact shall be stated in the test report.

If the aggregate consists of a number of different size fractions, it can be necessary to separate the various fractions before preparing the test portion. The percentage of each size fraction shall be stated in the test report.

5 Materials

5.1 Water, which shall be free from any impurity (e.g. dissolved air or soluble substances) that could significantly affect its density. Dissolved air can be removed by applying a vacuum.

Distilled water which is boiled and cooled before use, or demineralized water, are preferred.

Fresh tap water is also suitable.

6 Apparatus

All apparatus, unless otherwise stated, shall conform to the general requirements of EN 932-5.

6.1 Apparatus for general purposes

6.1.1 Ventilated oven, capable of maintaining a temperature of (110 ± 5) °C.

6.1.2 Balance, accurate to 0,1 % of the mass of the test portion and capable of weighing the wire basket containing the sample while immersed in water.

6.1.3 Water bath, capable of maintaining a temperature of (22 ± 3) °C.

6.1.4 Thermometer, accurate to 0,1 °C.

6.1.5 Test sieves, 0,063 mm, 4 mm, 31,5 mm and 63 mm, with apertures as specified in EN 933-2.

6.1.6 Trays, which can be heated in a ventilated oven without change in mass.

6.1.7 Soft absorbent cloths.

6.1.8 Washing equipment.

6.1.9 Timer.

6.2 Special apparatus for the wire basket method (Clauses 7 and A.3 and Annex B)

6.2.1 Wire basket or perforated container of sufficient capacity for samples according to the clause, and equipped to enable suspension from the balance. The basket or container shall be resistant to corrosion.

6.2.2 Watertight tank, containing water at (22 ± 3) °C, in which the basket may be completely immersed and freely suspended with a minimum clearance of 50 mm between the basket and the sides of the tank.

NOTE A watertight tank can be used instead of the water bath specified in 6.1.3.

6.3 Special apparatus for pyknometer method for aggregate particles passing the 31,5 mm sieve and retained on the 4 mm sieve (Clause 8)

6.3.1 Pyknometer, consisting of a glass flask or other suitable vessel with volume between 1 000 ml and 5 000 ml, constant to 0,5 ml for the duration of the test.

It is recommended that the test portion occupies about half of the pyknometer volume. Two smaller pyknometers can be used instead of one large, by summing the weighings before calculating the density of the aggregate.

NOTE An example of a suitable pyknometer is shown in Figure 1.

6.4 Special apparatus for pyknometer method for aggregate particles passing the 4 mm sieve and retained on the 0,063 mm sieve (Clause 9 and Annex F)

6.4.1 Pyknometer, consisting of a glass flask or other suitable vessel with volume between 500 ml and 2 000 ml, constant to 0,5 ml for the duration of the test.

It is recommended that the test portion occupies about half of the pyknometer volume. Two smaller pyknometers can be used instead of one large, by summing the weighings before calculating the density of the aggregate.

NOTE An example of a suitable pyknometer is shown in Figure 1.

6.4.2 Metal mould, in the form of a frustum of a cone (40 ± 3) mm at the top, (90 ± 3) mm at the bottom and (75 ± 3) mm high. The metal shall have a minimum thickness of 0,8 mm.

6.4.3 Metal tamper, of mass (340 ± 15) g and having a flat circular tamping face of diameter (25 ± 3) mm, for use with the metal mould.

6.4.4 Tray, of non-water absorbing material having a plane bottom of area not less than 0,1 m^2 and an edge of not less than 50 mm in height.

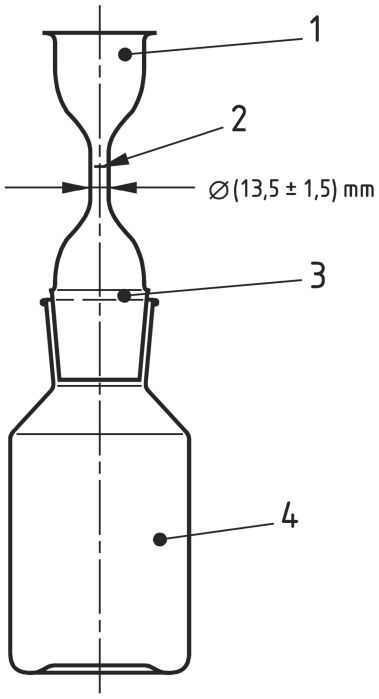
6.4.5 Warm air supply, such as a hair dryer.

6.5 Special apparatus for the pyknometer method for aggregate particles passing the 31,5 mm sieve and retained on the 0,063 mm sieve (A.4)

6.5.1 Pyknometer, consisting of a glass flask with a volume between 500 ml and 5 000 ml, constant to 0,5 ml for the duration of the test, and a corresponding glass funnel.

It is recommended that the test specimen occupies about half of the pyknometer volume.

NOTE An example of a suitable pyknometer is shown in Figure 1.



Key

1 glass funnel
2 mark
3 ground section to fit the wide-neck flat bottom flask
4 wide-neck flat bottom flask

Figure 1 — Example of pyknometer

6.6 Special apparatus for the determination of particle density and water absorption of coarse aggregates saturated to constant mass (Annex B)

6.6.1 Container, of similar capacity to the wire basket specified in 6.2.1 for storage of the sample in water.

6.7 Special apparatus for the determination of particle density and water absorption of coarse lightweight aggregates (Annex C)

6.7.1 Pyknometer, consisting of a glass flask with a volume of 1 000 ml, constant to 0,5 ml for the duration of the test, and a corresponding funnel (Figure 1). If appropriate, the pyknometer shall contain a flexible grid to prevent aggregates from floating.

The size of the funnel shall enable the release of any air bubbles.

It is recommended that the test portion occupies about half of the pyknometer volume.

6.8 Special apparatus for the determination of particle density and water absorption of fine lightweight aggregates (Annex D)

6.8.1 Balance, accurate to 0,1 g.

6.8.2 Glass graduated measuring cylinder, with a measuring volume of 1 000 ml, accurate to 5 ml.