BRITISH STANDARD

BS EN 1097-3:1998

Tests for mechanical and physical properties of aggregates —

Part 3: Determination of loose bulk density and voids

The European Standard EN 1097-3:1998 has the status of a British Standard

ICS 91.100.20

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National foreword

This British Standard is the English language version of EN 1097-3:1998. It is included in a package of European Standards declared by CEN/TC 154 and it will supersede clause **6** of BS 812-2:1995 which will be withdrawn on 1999-12-01 if all the European Standards included in the package are available.

The UK participation in its preparation was entrusted by Technical Committee B/502, Aggregates, to Subcommittee B/502/6, Test methods, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 6, an inside back cover and a back cover.

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 September 1998

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1097-3

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Descriptors: Aggregates, tests, mechanical properties, physical properties, determination, density (mass/volume), porosity

English version

Tests for mechanical and physical properties of aggregates — Part 3: Determination of loose bulk density and voids

Essais pour déterminer les caractéristiques mécaniques et physiques des granulats — Partie 3: Méthode pour la détermination de la masse volumique en vrac et de la porosité intergranulaire

Prüfverfahren für mechanische und physikalische Eigenschaften von Gesteinskörnungen — Teil 3: Bestimmung von Schüttolichte und Hohlraumgehalt

This European Standard was approved by CEN on 25 February 1998.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 154, Aggregates, the Secretariat of which is held by BSI.

This European Standard forms part of a series of tests for mechanical and physical properties of aggregates. Test methods for other properties of aggregates will be covered by parts of the following European Standards:

EN 932, *Tests for general properties of aggregates.*

EN 933, *Tests for geometrical properties of aggregates.*

EN 1367, *Tests for thermal and weathering properties of aggregates.*

EN 1744, *Tests for chemical properties of aggregates.*

prEN 13179, *Tests for filler aggregate used in bituminous bound fillers.*

The other parts of EN 1097 will be:

EN 1097-1, *Tests for mechanical and physical properties of aggregates — Part 1: Determination of the resistance to wear (micro-Deval).*

EN 1097-2, *Tests for mechanical and physical properties of aggregates — Part 2: Methods for the determination of resistance to fragmentation.*

prEN 1097-4, *Tests for mechanical and physical properties of aggregates — Part 4: Determination of the voids of dry compacted filler.*

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

prEN 1097-6, *Tests for mechanical and physical properties of aggregates — Part 6: Determination of particle density and water absorption.*

prEN 1097-7, *Tests for mechanical and physical properties of aggregates — Part 7: Determination of the particle density of filler — Pyknometer method.*

prEN 1097-8, *Tests for mechanical and physical properties of aggregates — Part 8: Determination of the polished stone value.*

EN 1097-9, *Tests for mechanical and physical properties of aggregates — Part 9: Method for the determination of the resistance to wear by abrasion from studded tyres: Nordic test.*

prEN 1097-10, *Tests for mechanical and physical properties of aggregates — Part 10: Water suction height.*

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 October 1998, and conflicting national standards shall be withdrawn at the latest by December 1999.

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

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1 Scope

This European Standard specifies the test procedure for the determination of the loose bulk density of dry aggregate and the calculation of the voids.

The test is applicable to natural and artificial aggregates up to a maximum size of 63 mm.

A method for the determination of the apparent (bulk) density of filler in kerosene is given in annex A.

2 Normative references

This European Standard incorporates by dated or by 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.

prEN 932-2, *Tests for general properties of aggregates — Part 2: Methods for reducing laboratory samples.*

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

prEN 1097-6, *Tests for mechanical and physical properties of aggregates — Part 6: Determination of particle density and water absorption.*

ISO 4788:1980, *Laboratory glassware — Graduated measuring cylinders.*

3 Definitions

For the purposes of this standard, the following definitions apply:

3.1

loose bulk density

the quotient obtained when the mass of dry aggregate filling a specified container without compaction is divided by the capacity of that container

3.2

voids

the air-filled spaces between the aggregate particles in the container

3.3

aggregate size

a designation of aggregate in terms of lower (d) and upper (D) sieve sizes

NOTE 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).

3.4

test portion

the sample used as a whole in a single test

3.5

test specimen

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

3.6

constant mass

successive weighings after drying at least 1 h apart not differing by more than 0,1 %

NOTE 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 required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

4 Principle

The dry mass of aggregates filling a specified container is determined by weighing and the corresponding loose bulk density is calculated. The percentage of voids is calculated from the loose bulk density and the particle density.

5 Apparatus

All apparatus shall comply with the general requirements of prEN 932-5.

5.1 *Watertight cylindrical container*, made of corrosion-resistant metal. The ratio of the inside diameter of the container to its internal depth shall be between 0,5 and 0,8. The minimum capacity of the container shall be as specified in Table 1. The container shall be calibrated in accordance with annex B.

It shall be smooth inside, of sufficient rigidity to retain its form under rough usage and preferably fitted with handles. The top rim shall be smooth and plane and parallel to the bottom.

NOTE When testing lightweight aggregates, the mass of the test portion may be much smaller than the mass of the container. In such cases it is permissible for a lighter non-metallic container to be used, provided it is both rigid and watertight.

Table 1 — Minimum capacity of container depending on aggregate size

Upper size of aggregate (D) mm	Capacity l
Up to 4	1,0
Up to 16	5,0
Up to 31,5	10
Up to 63	20

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5.2 *Balance*, of suitable capacity, accurate to 0,1 % of the mass of the test portion. For calibration (see annex B) the balance shall be accurate to 0,1 % of the mass of the water.

5.3 *Scoops*, of convenient size.

5.4 *Straight-edge*, made of steel, not less than 50 mm longer than the external diameter of the container, and rigid enough so as not to deform during the levelling process.

5.5 *Thermometer*, for calibration, capable of measuring the temperature of water at 20 °C to a precision of 0,5 °C.

5.6 *Drying oven.*

5.7 *Glass plate*, for calibration, large enough to cover the container.

6 Preparation of test specimens

Three test specimens shall be obtained in accordance with prEN 932-2. The aggregate shall be dried at (110 ± 5) °C to constant mass. Each test specimen shall be 120 % to 150 % of the mass needed to fill the container.

For lightweight aggregates, where appropriate, allow the test specimens to condition to moisture equilibrium at (23 ± 5) °C and (50 ± 10) % relative humidity after drying at (110 ± 5) °C.

7 Procedure

Weigh the empty, dry and clean container (m_1). Place the container on a horizontal surface and fill it to overflowing using the scoop. Whilst filling the container, minimize segregation by resting the scoop on the top rim. At no time shall the edge of the scoop be more than 50 mm above the rim of the container.

Carefully remove any surplus aggregate from above the top of the container ensuring that the surface spread is even to avoid segregation. Level the surface of the aggregate with the straight-edge, taking care not to compact any part of the upper surface. If this is not feasible, level the surface by hand, taking care to approximate the volume of the aggregates to the capacity of the container as far as possible.

Weigh the filled container and record its mass to 0,1 % (m_2). Three test specimens shall be tested.

8 Calculation and expression of results

The loose bulk density ρ_b is calculated for each test specimen according to the following equation:

$$\rho_b = \frac{m_2 - m_1}{V}$$

where

ρ_b is the loose bulk density, in megagrams per cubic metre;

m_2 is the mass of the container and test specimen, in kilograms;

m_1 is the mass of the empty container, in kilograms;

V is the capacity of the container, in litres.

Report the loose bulk density ρ_b as the mean of the three values rounded to the second decimal place for normal aggregates, and to the third decimal place for lightweight aggregates.

The percentage of voids v is the volumetric proportion of voids in the container. It is calculated according to the following equation:

$$v = \frac{\rho_p - \rho_b}{\rho_p} \times 100$$

where

v is the percentage of voids;

ρ_b is the loose bulk density, in megagrams per cubic metre;

ρ_p is the oven dried or pre-dried particle density, in megagrams per cubic metre, as determined in accordance with prEN 1097-6 using a test portion taken from the same laboratory sample.

NOTE A statement on the precision of the test is given in annex C.

9 Test report

The test report shall make reference to this standard, stating:

a) sample identification, nominal size, and sample description;

b) date of test;

c) loose bulk density (the three values of the test specimens and the mean value);

d) percentage of voids if relevant.

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Annex A (normative)
Method for the determination of the apparent (bulk) density of filler in kerosene

A.1 Principle

A test portion consisting of a fixed mass of filler is dispersed in a volume of kerosene and allowed to settle. The settled volume of the test portion is measured and is used to calculate the apparent (bulk) density.

A.2 Apparatus

A.2.1 *Graduated glass measuring cylinder with stopper*, of 50 ml capacity with a smallest scale division of 1 ml, complying with ISO 4788.

A.2.2 *Balance*, of capacity not less than 100 g, accurate to 0,01 g.

A.2.3 *Ventilated drying oven*, capable of maintaining a temperature of (110 ± 5) °C.

A.2.4 *Desiccator and desiccant.*

A.2.5 *Redistilled kerosene (paraffin oil)*, petroleum distillate with a boiling range between 190 °C and 260 °C.

NOTE The displacement liquid used in the method of testing density of cement, as specified in EN 196-6, is suitable.

A.3 Preparation of test specimens

Reduce the laboratory sample in accordance with the procedures specified in prEN 932-2 to produce a test portion of sufficient mass to give five test specimens.

Dry the test portion of filler at a temperature of (110 ± 5) °C for at least 4 h. Cool to room temperature in the desiccator. Weigh out three test specimens of filler, each with a mass of about 10 g. Record the mass m of each test specimen to the nearest 0,1 g.

A.4 Procedure

Put the first test specimen and about 25 ml of kerosene into a measuring cylinder, then stopper and shake until the filler is completely wetted. Add more kerosene to the cylinder so that the level is about 40 mm from the top. Stopper and shake again.

In order to ensure that the filler is in complete suspension in the kerosene, immediately after the second shaking, invert the cylinder and keep it in an inverted position whilst the air bubble travels the length of the cylinder. Immediately return the cylinder to the upright position and hold it still until the air bubble returns to the top. Repeat this cycle of operations a further four times in rapid succession, then immediately stand the cylinder on a vibration-free surface. If any particles of filler stick to the side of the cylinder above the level of the kerosene, carefully wash them back into the liquid using a small additional quantity of kerosene.

Leave the cylinder undisturbed for at least 6 h before reading and recording the bulk volume of the filler, V, to the nearest millilitre.

Repeat the procedure described above for the second and third test specimens.

A.5 Calculation and expression of results

For each test specimen, calculate the apparent (bulk) density to the nearest 0,01 Mg/m^3 in accordance with the following equation:

$$\text{apparent (bulk) density} = m/V \text{ Mg/m}^3$$

where:

V is the bulk volume as determined in **A.4**, in millilitres;

m is the mass of the test portion, in grams.

Calculate the mean of the three values of apparent (bulk) density, determined using the above equation, to the nearest 0,01 Mg/m^3.

If any of the individual results differ by more than 0,05 Mg/m^3 from the mean value, discard that individual result and determine the apparent (bulk) density of two further test specimens taken from the same test portion.

A.6 Test report

Report the mean value of the three or more results as the apparent (bulk) density of filler in kerosene, to the nearest 0,1 Mg/m^3.

The report shall affirm that the apparent (bulk) density of filler in kerosene was determined in accordance with this European Standard. The test report shall contain at least the following information:

a) sample identification and sample description;

b) the apparent (bulk) density of filler in kerosene.

NOTE A statement on the precision of the test is given in annex C.

Annex B (normative)
Calibration of container

B.1 The capacity of the container shall be calibrated by determining the mass of water required to fill it.

B.2 Firstly, weigh the dry, clean and empty container with the glass plate. Fill with water at (20 ± 2) °C and cover with the glass plate, removing air bubbles and excess water. Dry the outside of the container and weigh it. Determine the net mass of the water to 0,1 %. Obtain the capacity V of the container in litres by expressing the net mass of the water in kilograms.

Annex C (informative)
Precision

C.1 Loose bulk density in the oven dry condition

A precision experiment, using normal weight aggregates, was carried out in 1989 under the auspices of the British Standards Institution to ascertain estimates of repeatability r and reproducibility R_2 for loose bulk density in the oven dry condition. The experiment involved thirteen laboratories and the results are given in Table C.1.

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Table C.1 — Precision estimates of loose bulk density in the oven dry condition

Aggregate type	Repeatability r Mg/m^3	Reproducibility R_2 Mg/m^3
Fine aggregate (limestone fines, sand)	0,032	0,165
Coarse aggregate	0,019	0,079

C.2 Apparent (bulk) density of fillers in kerosene

A precision experiment was carried out in 1984/5 under the auspices of the British Standards Institution. The experiment involved testing two types of ground limestone filler at fifteen laboratories. The results are given in Table C.2.

Table C.2 — Precision estimates of apparent (bulk) density of fillers in kerosene

Filler type	Average density Mg/m^3	Repeatability r Mg/m^3	Reproducibility R_2 Mg/m^3
Carboniferous limestone	0,60	0,03	0,13
Permian limestone	0,93	0,05	0,34

Annex D (informative)
Other conditions of bulk density

It may be useful to determine bulk density in other than the loose condition as specified in this European Standard.

D.1 Compacted dry bulk density

The method of compaction should be indicated when reporting the results.

D.2 Loose bulk density with damp aggregates

The moisture content should be stated when reporting the results.

Annex E (informative)
Bibliography

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ISO 6782:1982, *Aggregates for concrete — Determination of bulk density.*

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