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Aggregates for concrete — Test methods for mechanical and physical properties —

Part 1: Determination of bulk density, particle density, particle mass-per-volume and water absorption

PROOF/ÉPREUVE

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 1, *Test methods for concrete*.

This edition of ISO 20290-1, together with ISO 20290-2 and ISO 20290-3, cancels and replaces ISO 6274:1982, ISO 6782:1982, ISO 6783:1982 and ISO 7033:1987, which have been technically revised.

A list of all parts in the ISO 20290 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Aggregates for concrete — Test methods for mechanical and physical properties —

Part 1: Determination of bulk density, particle density, particle mass-per-volume and water absorption

1 Scope

This document describes procedures for determining certain properties of aggregates for use in concrete for the determination of the loose or compacted bulk density, the determination of particle density and water absorption using the hydrostatic balance method and the determination of the particle mass-per-volume and water absorption using the Pycnometer method.

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.

ISO 565, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

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 http://www.electropedia.org/

3.1
bulk density
ratio obtained by dividing the mass of a sample of aggregate filling a specified container by the known volume of the container, expressed in units of mass per unit volume, i.e. kilograms per cubic (1) meter (kg/m^3)

Note 1 to entry: In some countries, the phrases "unit mass", "unit weight" and "density" are used instead.

3.2
particle density
ratio obtained by dividing the mass of a sample of aggregate particles by the volume, including both permeable and impermeable pores within the particles (but not including the voids between the particles)

Note 1 to entry: It is expressed as a mass per unit volume, i.e. kilograms per cubic meter (kg/m^3).

3.3
oven dry density
ratio obtained by dividing the mass of a sample of aggregate particles heated in an oven until reaching a constant mass by the volume including both permeable and impermeable pores within the particles (but not including the voids between the particles)

3.4
saturated surface dry density
ratio obtained by dividing the mass of a sample of aggregate particles and water contained in its permeable voids by the volume including both permeable and impermeable pores within the particles (but not including the voids between the particles)

3.5
water absorption
increase in mass of an aggregate sample due to water penetration into the pores of the dry aggregate particles (to exclude water adhering to the outside surface of the particles) during a prescribed period of time

Note 1 to entry: It is expressed as a percentage of the dry mass.

3.6
constant mass
mass determined after successive weighings at least 1 h apart not differing by more than 0,1 %

4 Determination of bulk density

4.1 Principle

The determination of the loose or compacted bulk density of dry or moist aggregates (normal or lightweight) for concrete is defined by weighing of the aggregate sample using a constant volume container.

4.2 Apparatus and materials

4.2.1 Cylindrical container, with a smooth inside, fitted with handles and with dimensions approximately like those given in Table 1.

The container shall be watertight, corrosion resistant, and sufficiently rigid to retain its dimensions despite rough usage. The top rim shall be smooth, planar to within 0,25 mm and parallel to the base to within 0,5°. The ratio of the height of the container to its diameter shall be within the range 0,5 to 1,5.

Table 1 — Minimum capacity of container depending on aggregate size

Maximum size of aggregate mm	Capacity l
4	1
8	2,5
16	5
31,5	15
63	30
Note Other sizes of aggregates maybe different as valid in the place of use.	

4.2.2 Balance, accurate to 0,2 % of the mass of the material to be weighed.

4.2.3 Tamping rod, made of straight metal with a diameter of 16mm, a length of approximately 600 mm and rounded ends.

4.2.4 Shovel or scoop.

4.2.5 Calibration equipment.

4.2.6 Clear plate, a piece of flat, transparent material larger on all sides than the diameter of the calibrated cylindrical container (4.2.1). It shall be sufficiently rigid to remain planar when placed on the container.

4.2.7 Thermometer, with a range of at least 10 °C to 32 °C and an accuracy of at least 0,5 °C.

4.3 Sampling

The sample shall be taken in accordance with the procedure described in the relevant national standard.

If the test is to be performed on dry aggregates, dry the sample to a constant mass at (105 ± 5) °C in (24 ± 4) h and determine the mass. Repeat this procedure in 24 h increments until the mass changes by less than 0,5 %. and mix thoroughly.

If the test is to be performed on moist aggregates, determine the moisture content as a percentage of the dry mass and state this in the test report.

If the uniformity of a fraction is to be checked, the oversize aggregate (particles that are retained on the upper sieve) and undersize aggregate (particles which pass the lower sieve) shall be removed by sieving.

4.4 Procedure

4.4.1 Calibration of container

Weigh the clear plate and the empty container and then calibrate the container volume by filling it with water at (20 ± 2) °C or at (27 ± 3) °C (in case of tropical environment). Cover it with the clear, flat plate to eliminate air bubbles and excess water, and then dry the sides of the container. Determine the mass of water with an accuracy of 0,1 %. The volume of the container in cubic meters can be determined by dividing the mass of water, in kilograms, by 1,000.

4.4.2 Uncompacted bulk density

Fill the container with the thoroughly mixed aggregate using the shovel or scoop (4.2.4). Ensure that the aggregate particles do not fall from more than 50 mm from the top of the container. Fill it above the top and remove the excess aggregate particles by rolling the tamping rod (4.2.3) across the top of the container remaining in contact with the lip. Remove by hand any aggregate particle, which impedes the progress of the rod and fill in any obvious depressions. When checking aggregate 5 mm or smaller, the surface should be levelled using the tamping rod as a straightedge. Weigh the aggregate and container with an accuracy of 0,1 %.

4.4.3 Compacted bulk density

4.4.3.1 Compaction by rodding

Transfer aggregate to the container according to the procedure described above until it is about one-third full. Level the surface by hand and tamp the layer of aggregate with 10 strokes per 100 cm^2 evenly distributed over the surface. Fill the container to about two-thirds full with more aggregate and tamp as before. For the last layer, fill the container above the top and tamp again as before. When tamping each layer, use an appropriate amount of force so that the previous layer of aggregate or bottom of the

container is not struck, and damage to the aggregate is avoided. Level the surface of the aggregate as described above and weigh the aggregate and container with an accuracy of 0,1 %.

4.4.4 Compaction by other methods

Other methods of compaction such as mechanical vibration or jigging (lifting one side of the container and dropping it from a small height) may be used to compact the aggregate in the container and if used shall be described in detail in the test report.

4.5 Expression of test results

The bulk density, ρ_b, in kilograms per cubic meter, can be calculated with Formula (1):

$$\rho_b = \frac{m_2 - m_1}{V} \quad (1)$$

where

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

m_2 is the mass of the container filled with the aggregate, in kilograms;

V is the volume of the container, in cubic meters.

The results shall be reported with the accuracy as described in Table 2.

Table 2 — Accuracy of report result

Bulk density kg/m³	Accuracy to the nearest kg/m³
>1 000	10
500 to 1 000	5
<500	1

4.6 Test report

The test report shall include the following information:

a) a reference to this document, i.e. ISO 20290-1:—;

b) the identifying details of the sample (mineralogical description, sample location, etc.);

c) the maximum size of aggregate;

d) the moisture content of the sample when tested [relative to saturated-surface-dry (SSD)];

e) the dimensions of the container;

f) the method of compaction (if used);

g) the bulk density.

5 Determination of particle density and water absorption – Hydrostatic balance method

5.1 Principle

The determination of the particle density and water absorption of coarse aggregates, having a nominal size greater than 4 mm, for concrete is defined by measuring the weight difference of the oven-dried and saturated surface dried sample as well as weighing of the aggregate sample in water to define its volume (Archimedes' principle).

5.2 Apparatus and materials

5.2.1 Ventilated oven, thermostatically controlled to maintain a temperature of (105 ± 5) ˚C.

5.2.2 Balance, of adequate capacity (3 kg or more, depending on the sample size) and accurate to within 0,1 % of the mass of the material to be weighed. It shall permit the basket (5.2.3) containing the sample to be suspended and weighed in water.

5.2.3 Wire basket, of mesh, approximately 1 mm to 3 mm or a perforated container (perforations of diameter approximately 1 mm to 3 mm) of convenient size, preferably chromium plated and polished, with wire hangers (not thicker than 1 mm) to allow suspension from the balance.

5.2.4 Water bath, thermostatically controlled to maintain a temperature of (20 ± 5) ˚C or at (27 ± 3) ˚C (in case of tropical environment) in which the wire basket (5.2.3) can be freely suspended.

5.2.5 Two dry soft absorbent cloths, large enough to spread out the aggregate sample in a layer one stone deep.

5.2.6 Closable container, of similar capacity to the basket.

5.2.7 Test sieve (wire cloth or perforated plate), of aperture size 4,0 mm or 4,75 mm or 5,0 mm in accordance with ISO 565.

5.2.8 Water, free from any impurity (for example dissolved air) that can significantly affect its density.

In case of doubt, distilled water, or tap water which has been freshly boiled and cooled to room temperature, may be used.

5.3 Sampling

Sample the aggregate in accordance with the procedure described in the relevant national standard. Prior to testing, thoroughly wash the sample on the 4,0 mm or 4,75 mm or 5,0 mm test sieve (5.2.7), as appropriate, to remove all finer particles, particularly clay, silt and dust, which can be lost during the test and thus affect the results, and drain.

For normal weight aggregates, the minimum mass of the sample, in grams, shall be 100 times the maximum nominal size of the aggregate in millimetres. For lightweight and heavyweight aggregates, the minimum mass of the sample, m_{min}, in grams, shall be as given by Formula (2):

$$m_{min} = \frac{d_{max} \times \rho_p}{25} \quad (2)$$

where

m_{min} is the minimum mass of the sample, in grams;

d_{max} is the maximum nominal size of the aggregate, in millimetres;

ρ_p is the estimated particle density, in kilograms per cubic metre.

5.4 Procedure

Place the prepared test sample in the wire basket (5.2.3), and immerse it in the water bath (5.2.8) maintained at (20 ± 5) °C or at (27 ± 3) °C (in case of tropical environment) in sufficient water (5.2.8), to ensure that there is at least 50 mm of water above the top of the basket.

Immediately after immersion, remove the entrapped air from the sample by reasonable manner. Leave the basket and aggregate completely immersed for a period of (24 ± 4) h. If, for special purposes, immersion periods differing by more than 4 h from that specified, this shall be stated in the test report.

Shake the basket and sample, and weigh them in water at a temperature of (20 ± 5) °C or at (27 ± 3) °C (in case of tropical environment). If it is necessary to transfer the basket to a different tank for weighing, shake them 25 times at least (or remove the entrapped air from the sample by reasonable manner as valid in the place of use) as described above in the new tank before weighing (m_2).

Figure 1 shows an example of the device with wire basket for weighing aggregate in water.

Figure 1 — Wire basket attached to scale for weighing aggregate in water

Remove the basket and aggregate from the water and allow them to drain for a few minutes, then gently empty the aggregate from the basket on to one of the dry cloths, and return the empty baskets to the water. Shake it 25 times at least (or remove the entrapped air from the sample by reasonable manner as valid in the place of use) and weigh it in water (m_3). Alternatively, it is possible to place the basket in the

