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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

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Contents

Page

Foreword

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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 Standard supersedes:

ISO 6782:1982(E) — Aggregates for concrete — Determination of bulk density

ISO 6783:1982(E) — Coarse aggregates for concrete — Determination of particle density and water absorption – Hydrostatic balance method

ISO 7033:1987(E) — Fine and coarse aggregates for concrete — Determination of the particle mass-per-volume and water absorption - Pycnometer method

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

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, determination of particle density and water absorption using the hydrostatic balance method and 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*

ISO 20290, *Part xx*[1)] *— Test methods for aggregates — Sampling of normal weight aggregates*

ISO 20290, *Part yy*[(1)] *— Test methods for aggregates — Determination of particle size distribution: Sieving method*

3 Terms and definitions

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 meter (kg/m^3)

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

3.3
oven dry particle 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)

1) The Standard is under preparation.

3.4
saturated surface dry particle 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
the increase in mass of an aggregate sample due to water penetration into the pores of the dry aggregate particles (exclude water adhering to the outside surface of the particles) during a prescribed period of timeIt 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 mm to 1,5 mm.

Table 1 — Minimum capacity of container depending on aggregate size

Upper size of aggregate [mm]	Capacity [l]
4	1
8	2,5
16	5
31,5	10
63	20

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.

4.2.8 Balance, as described in 4.2.2.

4.3 Sampling

The sample shall be taken in accordance with ISO 20290:— part xx(1).

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. 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), ensuring that the aggregate don't fall from more than 50mm from the top of the container. Fill the container above the top and remove the excess aggregates 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, which impedes the progress of the rod and fill in any obvious depressions. When checking aggregate 5mm 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 so 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 the formula:

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

where

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

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

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

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

Table 2 — Accuracy of report result

Bulk Density kg/m³	Accuracy nearest kg/m³
>1,000	10
500-1,000	5
<500	1

4.6 Test report

The test report shall include the following information:

a) a reference to this International Standard;

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

c) maximum size of aggregate;

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

e) dimensions of the container;

f) 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) ^{0}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) ^{0}C 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) complying with the requirements of **ISO 565**. or **ISO 20290** part yy**(1)**.

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 ISO 20290:— part xx(1). 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 millimeters. For lightweight and heavyweight aggregates, the minimum mass of the sample m_{min}, in grams, shall be as given by the formula

$$m_{min} = \frac{d_{max} \times \rho_p}{25}$$

where

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

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

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