INTERNATIONAL STANDARD

ISO 1920-5

Second edition
2018-06

Testing of concrete —

Part 5: Density and water penetration depth

Essais du béton —

Partie 5: Caractéristiques du béton durci autres que la résistance

Reference number
ISO 1920-5:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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 second edition cancels and replaces the first edition (ISO 1920-5:2004), which has been technically revised. The main changes compared to the previous edition are as follows:

— density of irregular shape specimens can also be determined using this document;

— as-received, saturated or oven-dried specimens (cast in laboratory or cores extracted from sites) can be tested for the determination of water penetration under pressure using this document.

A list of all parts in the ISO 1920 series can be found on the ISO website.

Testing of concrete —

Part 5:
Density and water penetration depth

1 Scope

This document specifies methods for testing the density and depth of water penetration of hardened concrete.

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 1920-3, *Testing of concrete — Part 3: Making and curing test specimens*

3 Terms and definitions

For the purpose 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
density
ratio of the mass of a given quantity of hardened concrete to its volume

Note 1 to entry: The density is expressed in kilograms per cubic metre.

4 Determination of density of hardened concrete

4.1 General

This test method is applicable to lightweight, normal-weight and heavy-weight concrete.

It differentiates between hardened concrete in the following states:

— as-received;

— saturated;

— oven-dried.

The mass and the volume of the specimen of hardened concrete are determined and the density calculated.

4.2 Apparatus

4.2.1 Callipers and **rules**, capable of determining the dimensions of a specimen to within ±0,5 %.

4.2.2 Balance, equipped with a stirrup for weighing the specimen in both air and water to an accuracy of 0,1 % of the mass (see Figure 1).

4.2.3 Water tank, fitted with a device to maintain the water at a constant level and of sufficient size to allow the specimen on the stirrup to be fully immersed to constant depth (see Figure 1).

4.2.4 Ventilated oven, for which the temperature can be maintained at 105 °C ± 5 °C.

4.3 Test specimens

The minimum volume of a specimen shall be 1 l. If the nominal maximum aggregate size exceeds 25 mm, the minimum volume of the specimen, in cubic millimetres, shall be not less than $5D^3$, where D is the nominal maximum size of the coarse aggregate.

Normally, the entire specimen as-received should be used for the determination of the density.

If the shape or size of a specimen is such that it is not possible to use all of it, a smaller specimen, conforming to the requirements given above, may be sawn from the original.

4.4 Procedures

4.4.1 General

4.4.1.1 Calibration of the apparatus

The apparatus used shall be in calibration at time of use. The balance, the device for weighing specimens in water and the oven should be calibrated at least once per year.

4.4.1.2 Determination of mass

This document permits three conditions under which the mass of a specimen can be determined:

a) as-received;

b) water-saturated;

c) oven-dried.

4.4.1.3 Determination of volume

This document permits three methods for determining the volume of the specimen:

a) by water displacement (reference method);

b) by calculation, using actual measurements;

c) for cubes, by calculation, using checked designated dimensions.

4.4.2 Mass of as-received specimen

Weigh the as-received specimen, to an accuracy of 0,1 % of the mass of the specimen.

Record the value, expressed in kilograms, as m_r.

4.4.3 Mass of water-saturated specimen

Immerse the specimen in water at 20 °C ± 2 °C until the mass changes by less than 0,2 % in 24 h. Before each weighing, wipe the surplus water from the surface using a moist cloth.

Specimens of normal-weight concrete cured in water continuously for at least 72 h prior to testing may be assumed to satisfy this requirement.

Record the value, expressed in kilograms, of saturated mass as m_s.

NOTE In hot climate locations, the conditions can be different. In this case, alternative temperature of 27 °C ± 2 °C can be included.

4.4.4 Mass of oven-dried specimen

Dry the specimen in a ventilated oven at 105 °C ± 5 °C until the mass changes by less than 0,2 % in 24 h.

Before each weighing, cool the specimen to near room temperature in a dry airtight vessel or desiccator.

Record the value, expressed in kilograms, of the oven-dried mass as m_o.

4.4.5 Volume obtained by water displacement

4.4.5.1 General

This method is suitable for specimens of all shapes and is the only method suitable for specimens of irregular shape.

The specimen shall be in a saturated condition.

This method is not suitable for specimens of no-fines concrete, concrete made with lightweight aggregate that floats in water, concrete with large pores, or specimens the moisture content of which is not to be altered. However, if an impermeable layer is applied to the specimen, this method may be used.

4.4.5.2 Mass in water

Allow the hydrostatic device of the balance to reach equilibrium. Ensure that the empty stirrup hanging from the balance is completely immersed in the water tank and that the stirrup is not touching the bottom of the tank.

Record the depth of the immersion of the stirrup and the apparent mass, in kilograms, of the stirrup as m_{st}.

Place the specimen in the stirrup and fully immerse in water to the same depth as the empty stirrup.

Take care to avoid trapping air bubbles on the sides of the sample and on the stirrup.

Weigh the completely immersed specimen and stirrup. Record (m_{st} + m_w), the apparent mass, in kilograms.

4.4.5.3 Mass in air

Remove the specimen from the stirrup, and wipe the surplus water from the surfaces using a damp cloth. Weigh the specimen on the balance.

Record the mass, in kilograms, of the specimen in air as m_a.

4.4.5.4 Calculation of volume

Calculate the volume of the specimen using Formula (1):

$$V = \frac{m_a - \left[\left(m_{st} + m_w\right) - m_{st}\right]}{\rho_w} \quad (1)$$

where

V is the volume, in cubic metres, of the specimen;

m_a is the mass, in kilograms, of the specimen in air;

m_{st} is the apparent mass, in kilograms, of the immersed stirrup;

m_w is the apparent mass, in kilograms, of the immersed specimen;

ρ_w is the density of water, in kilograms per cubic metre, at 20 °C, taken as 998 kg/m^3.

NOTE 1 In hot climate locations, conditions can be different. In this case, the density of water can be specified at 27 °C, and the value can be taken accordingly as 997 kg/m^3.

NOTE 2 For irregular shape specimens, a volume measurement by water displacement can be applied by means of an appropriate calibrated vessel.

4.4.6 Volume, using actual measurements

Only undamaged, prismatic, or cylindrical specimens shall be used for the calculation of volume.

Where there is no documentation to show that a specimen has been cast in a calibrated mould, each dimension shall be measured in accordance with ISO 1920-3.

The average of the actual measurements taken and recorded for each dimension shall be used to calculate the volume, V, in cubic metres, of the specimen, rounded to four significant figures.

4.4.7 Volume, using checked designated dimensions

Only undamaged, prismatic, or cylindrical specimens shall be used for the calculation of volume.

Where specimens have documentation to show that they have been made in calibrated moulds (see ISO 1920-3), it shall be necessary only to check that each dimension is within ±0,5 % of the designated size.

The volume, V, of the specimen shall be calculated from the designated dimensions, and expressed in cubic metres, rounded to four significant figures.

NOTE Undamaged specimens are free of any cracks or segregation traces.

4.4.8 Test result

Calculate the density using the value determined for the mass of specimen and its volume, using Formula (2):

$$D = \frac{m}{V} \quad (2)$$

where

D is the density, in kilograms per cubic metre, related to the condition of the specimen and the method of determining the volume;

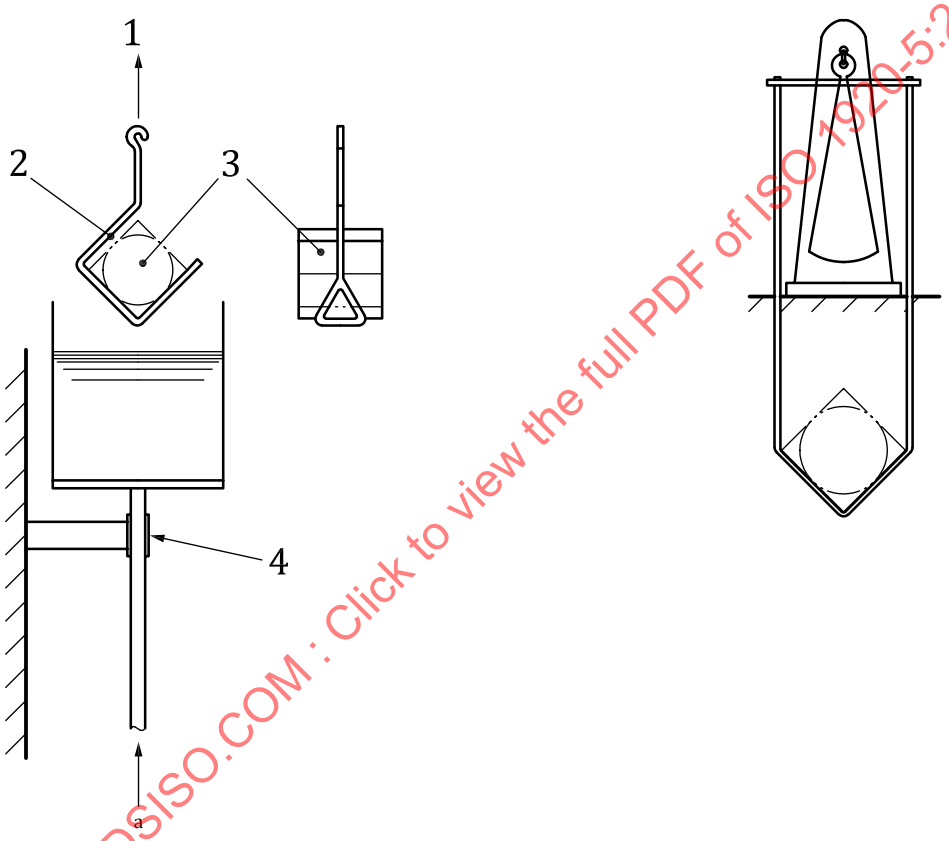
m is the mass, in kilograms, of the specimen in its condition at the time of test;

V is the volume, in cubic metres, determined by the particular method.

Report the condition of the specimen at the time of test (see 4.4.1.2) and the method used for determining the volume of the specimen (see 4.4.1.3).

Express the result of the density determination to the nearest 10 kg/m^3.

NOTE Refer to Annex A with regard to the precision for the method of determination of the density.



a) Stirrup suspended beneath the balance mechanism

b) Alternate form of stirrup suspended above the balance mechanism

Key

1 balance
2 stirrup
3 concrete specimen
4 guide
a Water tank is moved vertically.

Figure 1 — Typical stirrup arrangement for the determination of the volume of concrete specimens by water displacement

5 Determination of water penetration under pressure

5.1 Principle

The method determines the depth of penetration of water under pressure in hardened concrete that has been water-cured, as-received, saturated or oven dried (cast in laboratory or cores extracted from sites).

Water is applied under pressure to the surface of hardened concrete. The specimen is then split and the depth of penetration of the water front is recorded and measured.

5.2 Apparatus

5.2.1 Testing equipment, which shall consist of any equipment in which the test specimen, of given dimensions, is placed in such a manner that the water pressure can act on the test area and the continuously pressure applied displayed.

An example of a test arrangement is shown in Figure 2.

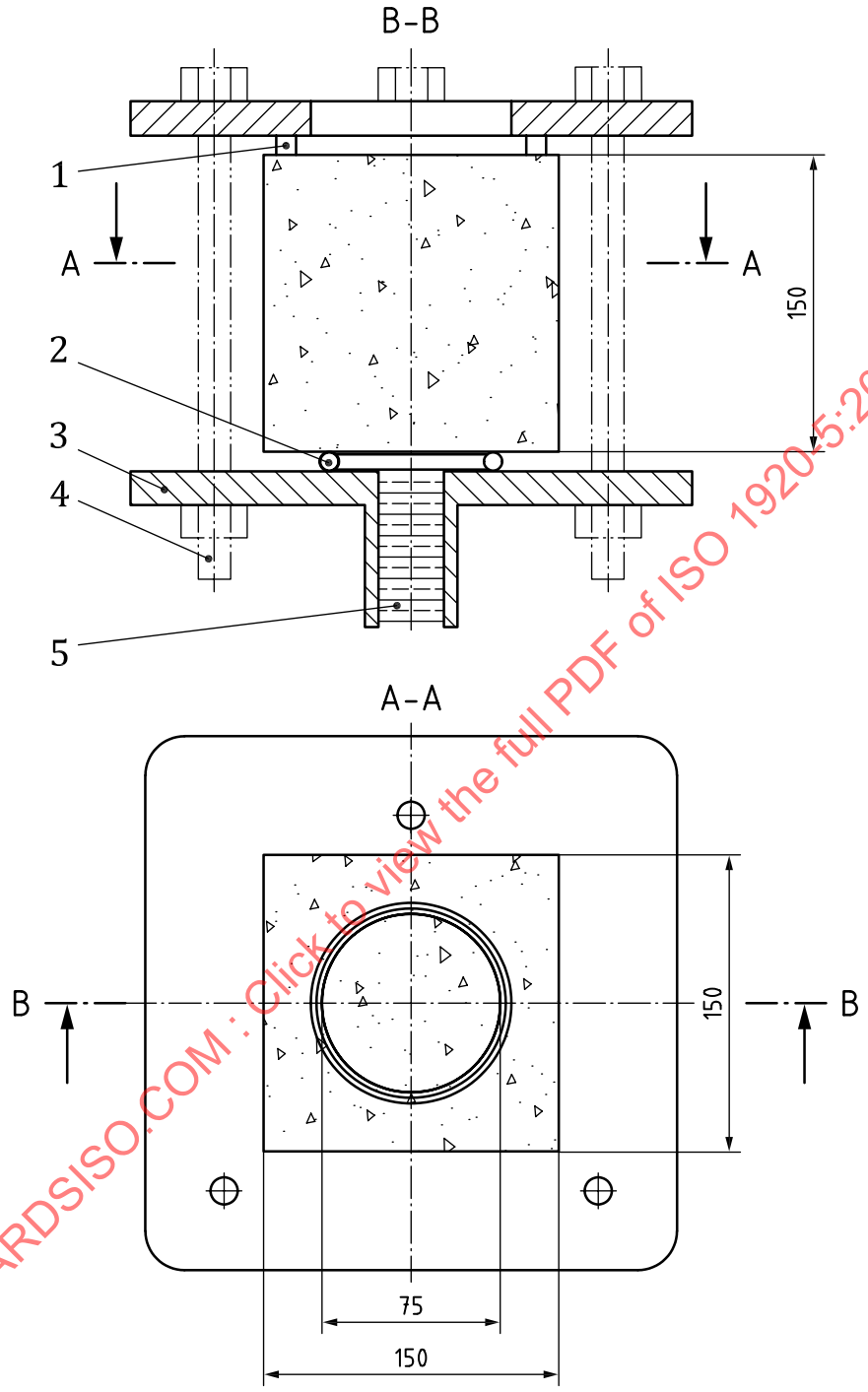
It is preferable that the apparatus allow the other faces of the test specimen to be observed.

The water pressure may be applied to the surface of the test specimen either from the bottom or the top.

A suitable seal, made of rubber or other similar material, shall be used to provide the necessary sealing.

The dimension of the test area shall be approximately half of the length of the edge or diameter of the test surface.

Dimensions in millimetres



Key

1 packing piece
2 sealing ring
3 screwed on plate
4 screw-threaded rod
5 water under pressure

Figure 2 — Example of test arrangement

5.2.2 Wire brush. A hand tool consisting of bristles made of wire, most often steel wire, and a handle.

5.3 Test specimen

The undamaged specimen shall be cubic, cylindrical or prismatic of edge length, or diameter not less than 150 mm. Cored and sawn specimens may also be used.

The ratio of the height to the length of the edge (or height-to-diameter) shall be greater than or equal to 0,5, but the height shall be not less than 100 mm.

Whilst specimen dimensions should generally be in accordance with ISO 1920-3, the tolerances are unimportant for this test.

NOTE Undamaged specimens are free of any cracks or segregation traces.

5.4 Procedure

5.4.1 Preparation and conditioning of the test specimen

The test can be conducted on:

— saturated specimen;

— oven dried specimen; or

— as-received samples (cores cut from existing structures).

The saturated test specimen shall be water-cured for 28 days in accordance with ISO 1920-3. Laboratory dry the saturated specimen in max RH of 50 % for at least 14 days. In case of saturated concrete specimen, the specimen with no readily available surface water should be used as a test specimen.

In case of oven dried concrete specimen, the specimen should be pre-condition for 3 days in an environmental chamber under a controlled temperature and RH of 50 °C and 80 %, respectively followed by 10 days storage in sealed container at 23 °C ± 2 °C (27 °C ± 2 °C for tropical countries).

Start the test when the specimens are at least 28 days old. Immediately after the specimen is demoulded, roughen the surface with a wire brush to remove the loose layer of cement paste if any on the test surface, so that the specimen is exposed to water pressure. In case of as-received samples extracted from existing structures, cut surface roughened with sand blasting may be used.

5.4.2 Application of water pressure

The water used shall be potable tap water.

Place the specimen in the apparatus and apply a water pressure of 500 kPa ± 50 kPa for the duration of 72 h ± 2 h.

Do not apply the water pressure to a trowelled surface of a specimen.

During the test, periodically observe the appearance of the surfaces of the test specimen not exposed to the water pressure to note the presence of water. If leakage is observed, then record the fact and consider the validity of the result.

5.4.3 Examination of specimen

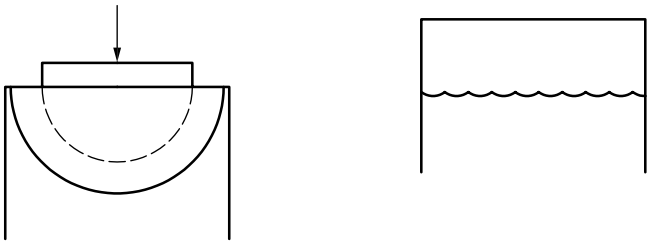
After the pressure has been applied for 72 h ± 2 h, remove the specimen from the apparatus. Wipe the face on which the water pressure was applied to remove excess of water.

Immediately split the specimen in half, perpendicular to the face on which the water pressure was applied. When splitting the specimen, and during the examination, place the face of the specimen exposed to the water pressure on the bottom.

As soon as the split face has dried to such an extent that the water penetration front can be clearly seen, mark the water front on the specimen.

The water front should be compared with the acceptable water penetration fronts (see Figure 3).

If the water front is acceptable, measure the maximum depth of penetration under the test area and record it to the nearest millimetre.



a) Acceptable **b) Unacceptable**

Figure 3 — Water fronts

5.5 Test result

The maximum depth of penetration, expressed to the nearest millimetre, is the test result.

6 Test report

6.1 General

The test report (refer to Annex B) shall include, in addition to the requirements for each test method, the following:

a) identification of the test specimen;

b) location of the test site;

c) time/date of receipt of the specimen;

d) any deviation from the standard test methods;

e) declaration by the person technically responsible for the test that it was carried out in accordance with this document (ISO 1920-5), except as noted in 6 d).

6.2 Test report for density

In addition to the requirements in 6.1, the test report for density shall include the following:

— description of the specimen (e.g. 100 mm cube, 150 mm diameter core);

— condition of specimen at time of test (as-received/saturated/oven-dried);

— time/date of determination of mass and volume;

— mass of specimen;

— method of determination of volume (checked designated size/measured size/water displacement);

— volume of specimen;

— calculated density of specimen.

6.3 Test report for water penetration depth

In addition to the requirements in 6.1, the test report for water penetration depth shall include the following:

— type of specimen (water cured saturated, oven dried or as-received;

— shape and size of the test specimen;

— date of start of the test;

— direction of application of water pressure (on top or bottom of the specimen perpendicular to or parallel to the direction of casting);

— any deviation of the water penetration front from the acceptable ones;

— maximum depth of penetration, in mm;

— any leakage and consideration of the validity of the result (if appropriate);

— the penetration front curve;

— the age of the specimen when tested.

Annex A
(informative)

Precision for the method of determination of the density

Precision data are given in Table A.1. These apply to density measurements in the range 2 300 kg/m^3 to 2 400 kg/m^3 made on cubes of concrete taken from the same sample and under the conditions that each test result is obtained from a single determination of the saturated density of a single cube. They indicate the variability that occurs when sampling, making and curing the cubes (in accordance with ISO 1920-3), as well as in the measurement of their densities.

Table A.1 — Precision data for measurements of the saturated density of hardened concrete

Test method	Repeatability conditions		Reproducibility conditions	
	S_r kg/m^3	r kg/m^3	s_R kg/m^3	R kg/m^3
By calculation:				
100 mm cubes	13,9	39	20,5	57
150 mm cubes	9,9	28	20,5	57
By water displacement:				
100 mm cubes	6,5	18	12,8	36
150 mm cubes	6,4	18	10,6	30

NOTE 1 The difference between two test results from the same sample by one operator using the same apparatus within the shortest feasible time interval exceeds the repeatability value, r, on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 2 Test results on the same sample obtained within the shortest feasible time interval by two operators each using their own apparatus differ by the reproducibility value, R, on average not more than once in 20 cases in the normal and correct operation of the method.

NOTE 3 For further information on precision, and for definitions of the statistical terms used in connection with precision, see ISO 5725 (all parts).

Annex B
(informative)

Example of test reports

B.1 Example of test report of the density of hardened concrete

Client	**Test organization**
	Accreditation test report ref.

Test location

Sample

Specimen identification:
Date and time received:
Description of specimen:
Abnormalities:
Details of specimen preparation:
Date/time of determination of mass and volume:

Determination of mass

Condition of specimen at time of test: as-received/saturated/oven-dried:
Mass of specimen (kg)(m_a, m_s or m_o): kg

Determination of volume

Method of determination of volume: checked designated size/actual (measured) size/displacement<?>

Checked designated size[1)]

Reference to mould calibration
Confirmation measurements × × mm

Actual measurements[1)]

Confirmation measured: × × mm
Volume of specimen: m^3