INTERNATIONAL STANDARD

ISO 1920-4

First edition
2005-07-15

Testing of concrete —

Part 4: Strength of hardened concrete

Essais du béton —

Partie 4: Résistance du béton durci

Reference number
ISO 1920-4:2005(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 1920-4 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 1, *Test methods for concrete*.

This first edition of ISO 1920-4:2005 cancels and replaces the first editions of ISO 4012:1978, ISO 4013:1978 and ISO 4108:1980, which have been technically revised.

ISO 1920 consists of the following parts, under the general title *Testing of concrete*:

— *Part 1: Sampling of fresh concrete*

— *Part 2: Properties of fresh concrete* [1)]

— *Part 3: Making and curing test specimens*

— *Part 4: Strength of hardened concrete*

— *Part 5: Properties of hardened concrete other than strength*

— *Part 6: Sampling, preparing and testing of concrete cores*

— *Part 7: Non-destructive tests on hardened concrete*

The following parts are under preparation:

— *Part 8: Determination of drying shrinkage of concrete*

— *Part 9: Determination of creep of concrete*

This series of Draft International standards was based on existing and draft ISO standards and on draft CEN standards dealing with testing concrete.

1) To be published.

Testing of concrete —

Part 4:
Strength of hardened concrete

1 Scope

This part of ISO 1920 specifies procedures for testing the strength of hardened concrete.

2 Normative references

The following referenced documents are essential for the application 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 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 679, *Methods of testing cement — Determination of strength*

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

ISO 2781, *Rubber, vulcanized — Determination of density*

ISO 3310-1, *Test Sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 4662, *Rubber — Determination of rebound resilience of vulcanizates*

EN 316:1999, *Wood Fiberboards — Definition, Classification and Symbols*

EN 12390-4:2000, *Testing Hardened Concrete — Part 4: Compressive Strength — Specification for Testing Machines*

3 Determination of compressive strength

3.1 Test specimens

The test specimen shall be a cube or a cylinder meeting the requirements of ISO 1920-3 or cores meeting the requirements of ISO 1920-6.

Damaged specimens shall not be tested.

Specimens that are badly honeycombed shall not be regarded as being representative of the quality of concrete supplied. In general, standard cube and cylinder specimens should not be tested if they are badly honeycombed as this is an indication of poor specimen making. When such specimens are tested, the test report shall include the fact that the specimen was honeycombed.

Where the designated size, l_1 or l_2, of the cross-section is outside the tolerances, the specimens may be used for testing by using the actual dimensions; see 3.4.

Where the dimensions or shape of a test specimen exceed the respective tolerances given in ISO 1920-3, the specimen shall be rejected or adjusted (if feasible) by one or more of the following methods:

— uneven surfaces levelled by grinding or by capping;

— the deviation of angles corrected by cutting and/or grinding.

The procedures given in Annex B shall be used to adjust the specimen.

Adjustment by grinding shall be the reference method.

3.2 Apparatus

The test shall be carried out using a compression-testing machine conforming to EN 12390-4 or to a national standard valid in the place of testing. The test machine shall be in calibration at the time of test. The calibration shall be carried out at least once per year.

3.3 Procedure

3.3.1 Preparation and positioning of specimens

For specimens stored in water, excess moisture shall be wiped from the surface of the specimen before placing in the testing machine.

The time between the extraction of the specimen from the humidity chamber or the water tank until the test shall be as short as possible and not more than 3 h. During the time the specimen is outside the humidity chamber or water tank, it shall be protected from drying, e.g. by covering with wet burlap.

All testing-machine bearing surfaces shall be wiped clean and any loose grit or other extraneous material removed from the surfaces of the specimen that will be in contact with the platens.

Do not use packing, other than auxiliary platens or spacing blocks, between the specimen and the platens of the testing machine.

Cube specimens shall be compressed perpendicularly to the direction of casting.

The specimen shall be centred on the lower platen to an accuracy of 1 % of the designated size of cubic, or diameter of cylindrical specimens.

Where physical means of ensuring centring are provided on the testing machine and they are in calibration, these shall be deemed to satisfy the requirements for accuracy of centring.

If auxiliary platens are used, the top auxiliary platen shall be aligned with the top of the specimen.

With two-column testing machines, cubic specimens should be placed with the trowelled surface facing a column.

3.3.2 Loading

The load shall be applied without shock and shall be increased continuously at a constant rate until no greater load can be sustained. Select a rate of stress not less than 0,15 MPa/s and not greater than 1,0 MPa/s.

When using manually controlled testing machines, any tendency for the selected rate of loading to decrease as specimen failure is approached shall be corrected by appropriate adjustment of the controls.

When using automatically controlled testing machines, the rate of loading whilst testing concrete specimens in compression shall be periodically checked to ensure that the rate is constant.

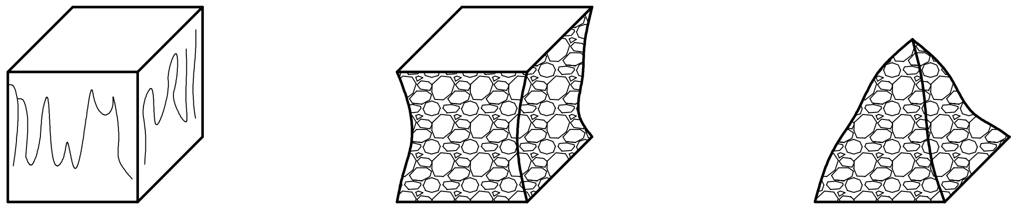
The maximum load indicated shall be recorded.

3.3.3 Assessment of type of failure

For cubic specimens, if the failure is satisfactory (see Figure 1), this fact shall be recorded. If the failure pattern is unsatisfactory, this fact shall be recorded and the type of failure recorded using the pattern number in Figure 2 closest to that observed.

For cylindrical specimens, if the failure is satisfactory (see Figure 3), this fact shall be recorded. If the failure pattern is unsatisfactory, this fact shall be recorded and the type of failure recorded using the pattern letter in Figure 4 closest to that observed.

NOTE Unsatisfactory failures can be caused by insufficient attention to the detailed procedures for making, capping and testing specimens or by a machine fault.

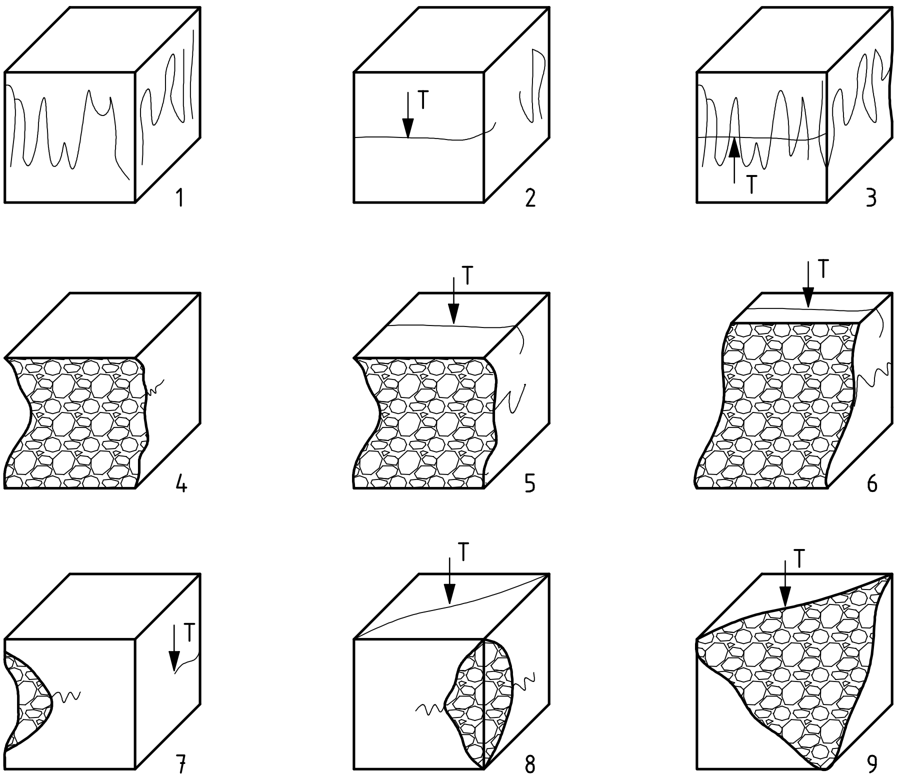


a) b) c)

NOTE 1 All four exposed faces are cracked approximately equally, generally with little damage to faces in contact with the platens.

NOTE 2 Figure 1 c) demonstrates explosive failure.

Figure 1 — Satisfactory failures of cube specimens



Key

T indicates a tensile crack

Figure 2 — Some unsatisfactory failures due to unequal cracking of the exposed faces of cube specimens

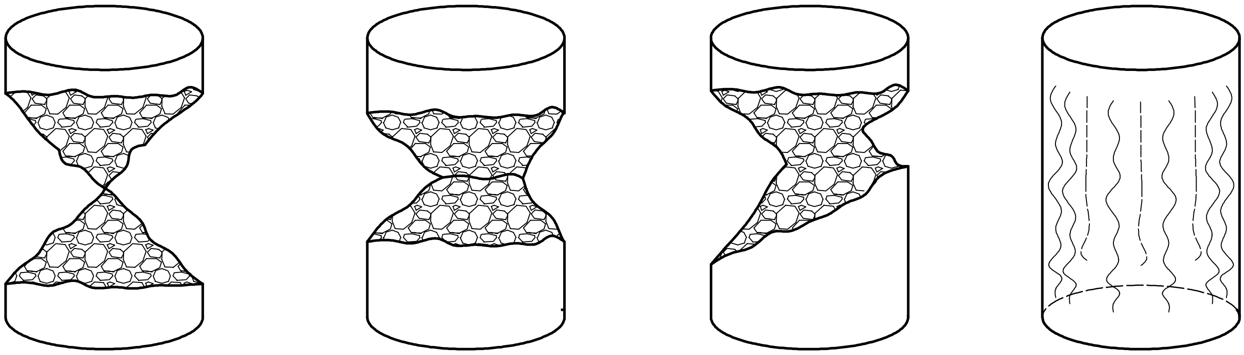


Figure 3 — Satisfactory failure of cylinder specimen

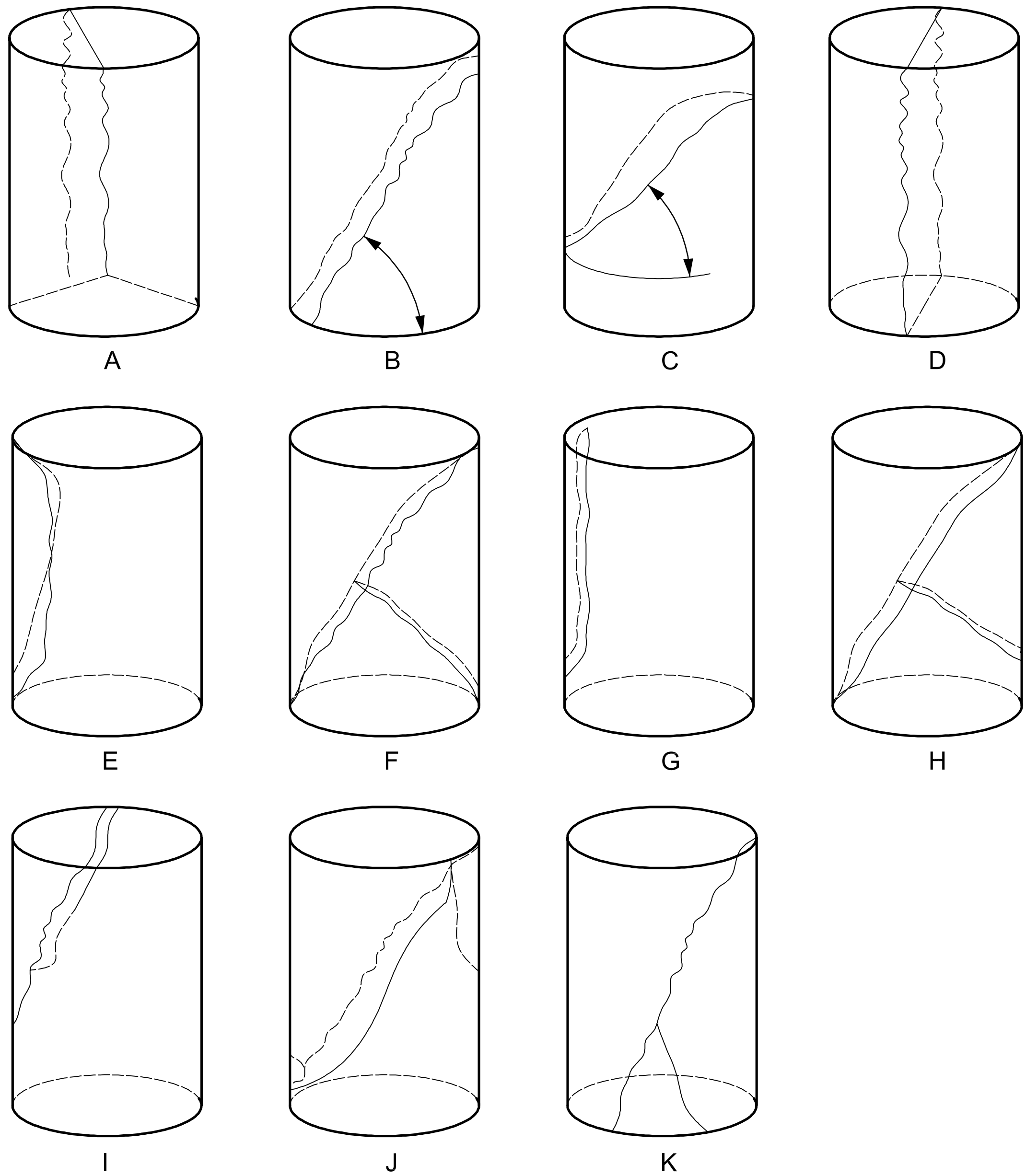


Figure 4 — Some unsatisfactory failures of cylinder specimens

3.4 Test results

The compressive strength is given by the equation:

$$f_c = \frac{F}{A_c} \quad (1)$$

where

f_c is the compressive strength, expressed in megapascals;

F is the maximum load, expressed in newtons

A_c is the cross-sectional area, expressed in square millimetres, of the specimen on which the compressive force acts.

If the actual dimensions of the test specimen are within ± 0,5 % of the designated size, the strength may be calculated on the basis of the designated size. If the actual dimensions are outside this tolerance, the strength calculation shall be based on the actual dimensions of the test specimen, determined in accordance with ISO 1920-3.

The compressive strength shall be expressed to the nearest 0,5 MPa.

3.5 Test report

In addition to the requirements in Clause 6, the test report shall include the following:

— type of specimen: cube, cylinder or core;

— method of adjustment, if relevant;

— compressive strength of specimen (to the nearest 0,5 MPa);

— type of failure (satisfactory or unsatisfactory, and, if unsatisfactory, the nearest type).

4 Determination of flexural strength

4.1 Test specimens

The test specimen shall be a prism conforming to ISO 1920-3.

Sawn specimens of nominal width, l, of 100 mm or 150 mm with a square cross-section and overall length of between $4l$ and $5l$ may also be tested to this part of ISO 1920. The ratio of l to the maximum size of aggregate shall be not less than four, except for specimens with a nominal width of 150 mm and a maximum size of aggregate of 40 mm, which may also be tested.

The direction of casting shall be identified on the specimen.

4.2 Apparatus

4.2.1 Testing machine

The test shall be carried out using a testing machine conforming to EN 12390-4:2000, 4.2 and 4.3, or to a national standard valid in the place of testing.

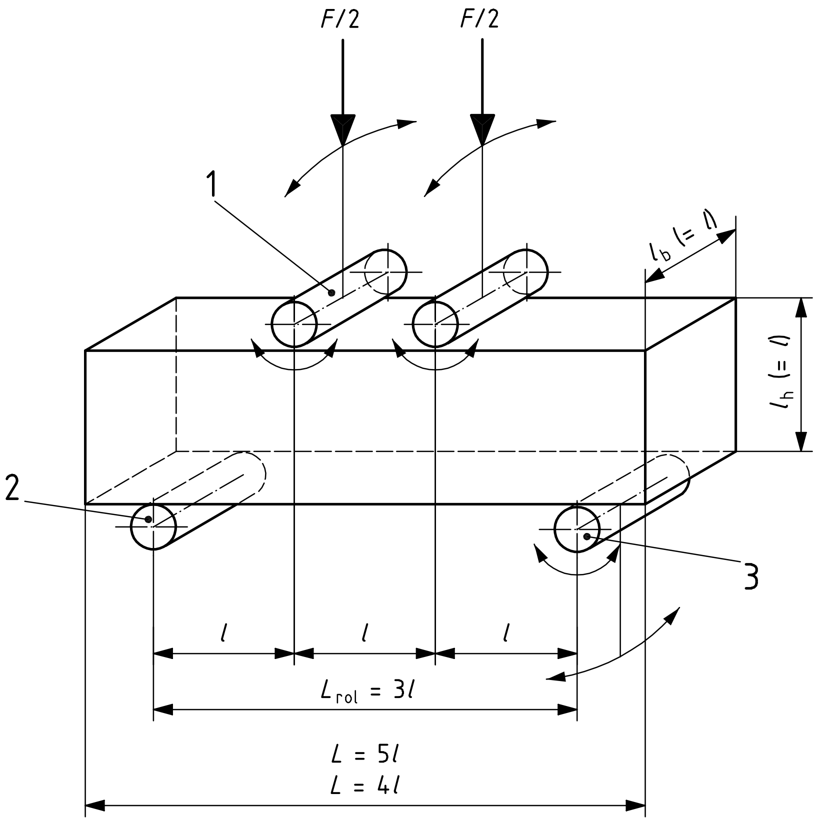
4.2.2 Force application

The device for applying loads shall consist of two upper rollers and two lower rollers (see Figure 5).

All rollers shall be manufactured from steel and shall have a circular cross-section with a diameter between 20 mm and 40 mm and shall be at least 10 mm longer than the width of the test specimen.

Each roller, except one of the lower ones, shall be capable of rotating around its axis and of being inclined in a plane normal to the longitudinal axis of the test specimen.

The distance, L_{rol}, between the lower (outer) rollers (i.e. the span) shall be equal to $3l$, where l is the width of the specimen. The distance between the upper (inner) rollers shall be equal to l. The inner rollers shall be equally spaced between the outer rollers as shown in Figure 5. All rollers shall be adjusted in the positions illustrated in Figure 5 to an accuracy of ± 2 mm.



Key

1 loading roller (capable of rotation and of being inclined)

2 supporting roller

3 supporting roller (capable of rotation and of being inclined)

Figure 5 — Arrangement for loading a test specimen (two-point loading)

4.3 Procedures

4.3.1 Preparation and positioning of specimens

The specimen shall be examined and any abnormalities shall be reported.

For specimens stored in water, excess moisture shall be wiped from the surface of the specimen before placing in the testing machine.

The time between the extraction of the specimen from the humidity chamber or the water tank until the test shall be as short as possible and not more than 3 h. During the time the specimen is outside the humidity chamber or water tank, it shall be protected from drying, e.g. by covering with wet burlap.

All testing-machine bearing surfaces shall be wiped clean and any loose grit or other extraneous material removed from the surfaces of the specimen that will be in contact with the rollers.

The test specimen shall be placed in the machine, correctly centred with the longitudinal axis of the specimen at right angles to the longitudinal axis of the upper and lower rollers.

The reference direction of loading shall be perpendicular to the direction of casting of the specimen.

The test result may be affected by the direction of loading with respect to the direction of casting.

4.3.2 Loading

Do not apply the load until all loading and supporting rollers are resting evenly against the test specimen.

The load shall be applied without shock and shall be increased continuously at a constant rate until no greater load can be sustained. Select a constant rate of stress of not less than 0,04 MPa/sec and not greater than 0,06 MPa/sec.

NOTE The required loading rate on the testing machine is given by Equation (2):

$$F_R = \frac{s \times l_b \times l_h^2}{l_{rol}} \qquad (2)$$

where

F_R is the required loading rate, expressed in newtons per second;

s is stress rate, expressed in megapascals per second;

l_b, l_h are the lateral dimensions (breadth and height), expressed in millimetres, of the specimen;

l_{rol} is the spacing, expressed in millimetres, of the lower rollers.

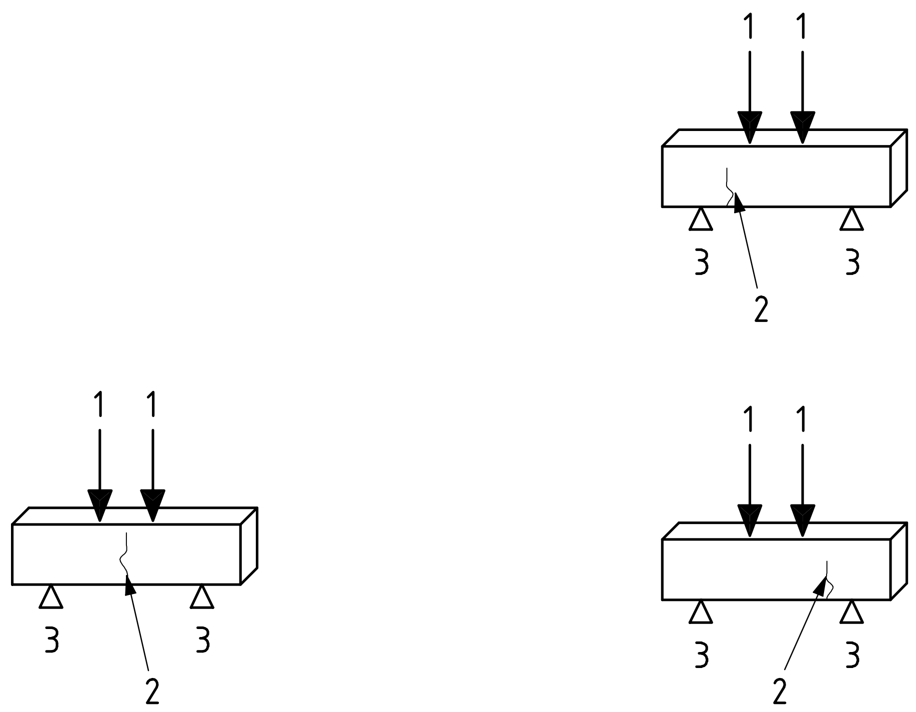
When using manually controlled testing machines, any tendency for the selected rate of loading to decrease, as specimen failure is approached, shall be corrected by appropriate adjustment of the controls.

When using automatically controlled testing machines, the rate of loading shall be periodically checked to ensure that the rate is constant.

The maximum load indicated shall be recorded.

4.3.3 Assessment of type of fracture

The fractured specimen shall be examined and the appearance of the concrete and type of fracture shall be recorded (see Figure 6).



a) **Satisfactory failure**

b) **Unsatisfactory failure**

Key

1 loading points

2 fracture

3 supporting roller

Figure 6 — Types of fracture

A fracture outside the loading rollers (see Figure 6) shall be reported as unsatisfactory.

4.4 Test results

The flexural strength is given by Equation (3):

$$f_{cf} = \frac{F \times l_{rol}}{l_b \times l_h^2} \tag{3}$$

where

f_{cf} is the flexural strength, expressed in megapascals;

F is the maximum load, expressed in newtons;

l_b, l_h are the lateral dimensions (breadth and height), expressed in millimetres, of the specimen;

l_{rol} is the spacing, expressed in millimetres, of the lower rollers.

The flexural strength shall be expressed to the nearest 0,1 MPa.

4.5 Test report

In addition to the requirements in Clause 6, the test report shall include the following:

— method of loading: two point/centre point;

— flexural strength of specimen (to the nearest 0,1 MPa).

5 Determination of tensile splitting strength

5.1 Specimens

The specimen shall be a cube, cylinder or prism meeting the requirements of ISO 1920-3.

Damaged or badly honeycombed specimens shall not be tested.

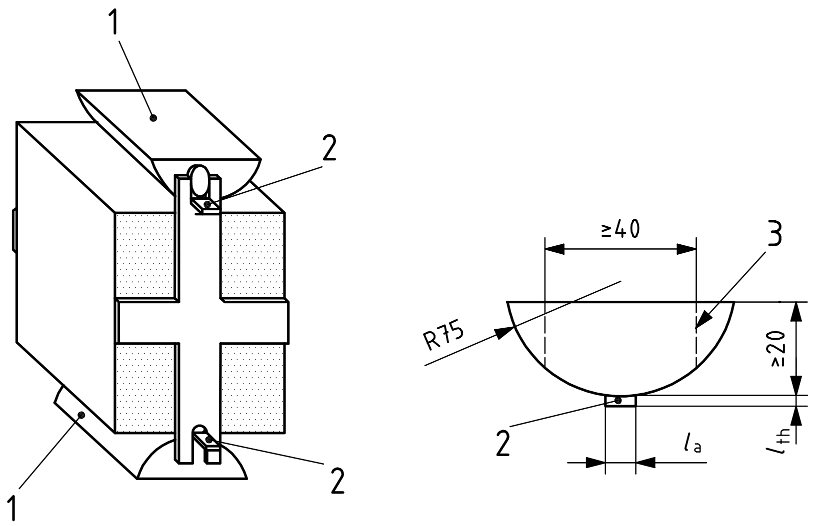
5.2 Apparatus

5.2.1 Testing machine

The test shall be carried out using a machine conforming to EN 12390-4:2000, 4.2 and 4.3, or to a national standard valid in the place of testing.

Curved steel loading pieces may be used in place of conventional plane platens when tests are carried out on cubical or prismatic specimens (see Figure 7).

Dimensions in millimetres



Key

1 steel loading piece

2 hardboard packing

3 location where segment may be trimmed

Figure 7 — Curved loading piece

The machine shall be in calibration at the time of test.

5.2.2 Jig

A jig may be used for positioning the specimen and the packing strips (optional). The jig shall not restrict the deformation of the specimen during the test.

A suitable jig for cylindrical specimens is shown in Figure 8.

5.2.3 Packing strips

Packing strips shall be of hardboard conforming to EN 316 or to a relevant standard valid in the place of use, with a density > 900 kg/m^3 and their use shall be the reference method.

NOTE Results obtained with and without packing strips are not comparable.

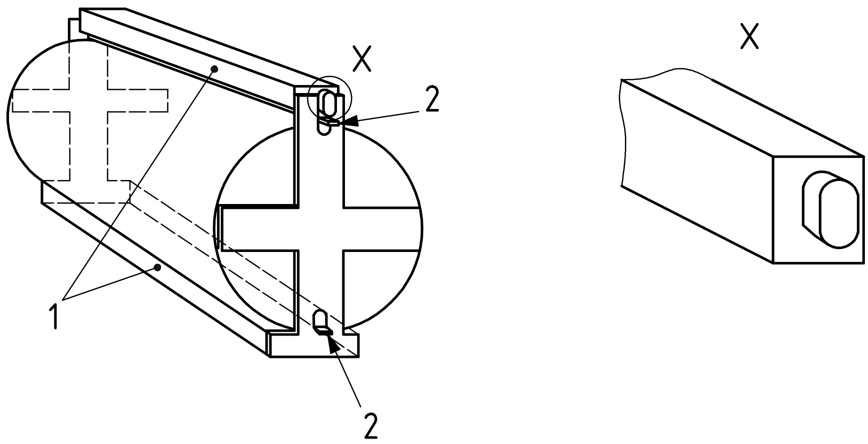
Hardboard packing strips shall be used only once.

Packing strips shall have the following dimensions:

— width, l_a = 10 mm ± 1mm;

— thickness, l_{th} = 4 mm ± 1mm;

— length, l_{lc} greater than the length of the line of contact of the test specimen.



Key

1 steel loading piece strips

2 hardboard packing

Figure 8 — Jig for testing cylindrical specimens

5.3 Procedure

5.3.1 Preparation of the specimen

5.3.1.1 Marking

The direction of casting shall be identified on the specimen.

For cylindrical specimens, two lines shall be marked along which the load is to be applied. Unless a centring jig is used, these lines shall be opposite to each other in an axial plane.

For cubic and prismatic specimens, the lines shall be marked on the moulded faces so that the fracture plane will cross the trowelled face, or the upper face as cast (see Figure 9).

The extremities of the two lines shall be connected over each end of the specimen, so as to define clearly the plane of loading.

5.3.1.2 Cleaning

For specimens stored in water, any excess moisture shall be wiped from the surface of the specimen before placing in the testing machine.

The bearing surfaces of the jig, packing strips, loading pieces and platens shall be wiped clean and any loose grit or other extraneous material removed from the surface of the specimen that will be in contact with the packing strips.

5.3.2 Specimen positioning

The test specimen shall be placed centrally in the testing machine, optionally using a jig. Packing strips and loading pieces, if required, shall be carefully positioned along the top and bottom of the plane of loading of the specimen.

With cylindrical specimens, care shall be taken to ensure that the upper platen is parallel with the lower platen during loading.

5.3.3 Loading

Ensure that cylindrical specimens remain centred when the load is first applied, either by means of a jig or by temporary supports.

The load shall be applied without shock and shall be increased continuously at a constant rate until no greater load can be sustained. The rate of stress increase(s) shall be not less than 0,04 MPa/s and not greater than 0,06 MPa/s.

NOTE The required loading rate on the testing machine is given by Equation (4):

$$F_{\mathrm{R}} = \frac{s \times \pi \times L \times l}{2} \quad (4)$$

where

F_{R} is the rate of increase of load, expressed in newtons per second;

L is the length, expressed in millimetres, of the specimen;

l is the designated dimension, expressed in millimetres, of the specimen;

s is the increase, expressed in megapascals per second, in rate of stress.

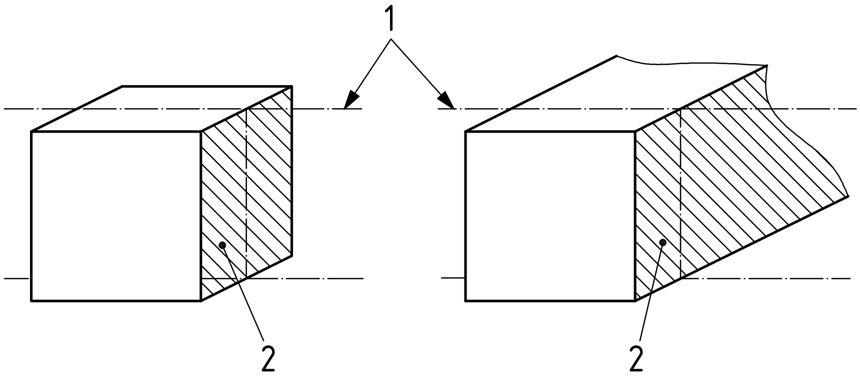
When using manually controlled testing machines, any tendency for the selected rate of loading to decrease, as specimen failure is approached shall be corrected by appropriate adjustment of the controls.

When using automatically controlled testing machines, the rate of loading shall be periodically checked to ensure that the rate is constant.

The maximum load indicated shall be recorded.

5.3.4 Examination of specimen

The fractured specimen shall be examined and the appearance of the concrete and type of fracture, if unusual, shall be recorded (see Figure 9). An example of unusual type of fracture is when the plane of fracture is not vertical.



Key

1 plane of loading

2 trowelled surface

Figure 9 — Plane of loading

5.4 Test results

The tensile splitting strength is given by Equation (5):

$$f_{\text{ct}} = \frac{2F}{\pi \times L \times l} \qquad (5)$$

where

f_{ct} is the tensile splitting strength, expressed in megapascals;

F is the maximum load, expressed in newtons;

L is the length, expressed in millimetres, of the line of contact with the specimen;

l is the designated cross-sectional dimension, expressed in millimetres.

For deviations from the standard method with respect of the dimensions of the specimen, the strength calculation may be based on the actual dimensions of the test specimen.

The tensile splitting strength shall be expressed to the nearest 0,05 MPa.

5.5 Test report

In addition to the requirements in Clause 6, the test report shall include the following:

— description of loading pieces (if appropriate)

— tensile splitting strength of specimen (to the nearest 0,05 MPa).

6 Test report

In addition to the requirements for each test method, the report shall include the following:

a) identification of the test specimen;

b) location of performance of test;

c) time and date of test;

d) dimensions of the specimen (actual or checked designated);

e) mass of specimen and apparent density (optional);

f) checks on shape and flatness of specimen, including cross-sectional area, expressed in millimetres (if appropriate);

g) details of adjustment by grinding (if appropriate);

h) condition of specimen at receipt for storage (if appropriate);

i) surface moisture condition of specimen at time of test (saturated/moist);

j) age of specimen at time of test (if known);

k) maximum load, expressed in kilonewtons, at fracture;

l) appearance of the concrete (if unusual);

m) location of fracture (if appropriate);

n) appearance of fracture surface (if unusual);

o) deviations from the standard method of testing;

p) a declaration from the person technically responsible for the test that the testing was carried out in accordance with ISO 1920-4 except as noted in 6 o).

Annex A
(normative)

Precision data for measurements of compressive strength

Tables A.1 and A.2 give the precision data.

Table A.1 — Precision data [a] for measurements of the compressive strength of hardened concrete

Sample shape and size mm	Repeatability conditions [b]		Reproducibility conditions [c]	
	s_r %	r %	s_R %	R %
cube, 100	3,2	9,0	5,4	15,1
cube, 150	3,2	9,0	4,7	13,2

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

[a] The precision data includes the procedures of sampling, specimen making, curing and testing of compression strength. Values are expressed as percentages of the mean of the two cube strengths whose difference is to be compared with r or R.

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

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

Table A.2 — Precision data [a] for measurements of the compressive strength of hardened concrete

Sample shape and size mm	Repeatability conditions		Reproducibility conditions	
	s_r %	r %	s_R %	R %
cylinder, 150 (diameter) by 300 (height)	2,9	8,0	3,1	11,7

NOTE The precision data only includes the procedure of testing for compressive strength.

[a] Values are expressed as percentages of the mean of the three cylinder strengths whose difference is to be compared with r or R.

Annex B
(normative)

Adjustment of test specimens for the compressive strength test

B.1 General

When it is necessary to adjust the size of the specimen, it shall be ground or sawn perpendicular to its longitudinal axis.

The intended load-bearing surfaces shall be prepared by grinding or by capping to improve the contact with the loading machine.

Cutting and grinding shall be carried out in such a way that structural changes of the test specimen are avoided.

Various capping materials and the maximum compressive strength that are suitable are shown in Table B.1.

Table B.1 — Restrictions on methods of adjustment

Method	Restriction based on (anticipated) measured strength MPa
Grinding	unlimited
Calcium aluminate cement mortar [a]	up to 50
Calcium aluminate cement paste	up to 60
Sulfur mixture	up to 50
High-strength sulfur mixture	up to 100
Sandbox	up to 100
Elastomeric pad	up to 80

[a] Other cements may be used provided that, at the time of test, the mortar has a strength at least equal to the anticipated strength of the concrete.

B.2 Grinding

Specimens cured in water shall be removed from the water for grinding for not more than 1 h at a time and re-immersed in water for at least 1 h before further grinding or testing.

The ends of the specimen shall be ground to the tolerances set out in ISO 1920-3

B.3 Capping — Calcium aluminate cement mortar or cement paste method

B.3.1 General

These methods shall be used only for capping cylindrical concrete test specimens.

Before capping, ensure that the surface of the specimen is in a wet condition, is clean and all loose particles removed.

The caps shall be as thin as possible and shall not, on average, be greater than 5 mm thick: small local deviations are permissible.

B.3.2 Capping with calcium aluminate cement mortar

The capping material shall consist of a mortar containing three parts by mass of calcium aluminate cement to one part by mass of fine sand in a saturated surface dry condition (most of which passes a 300 µm ISO 3310 woven wire sieve).

The water-to-cement ratio shall not exceed 0,35.

The soaked specimen shall be placed with one end on a horizontal metal plate. A steel collar of correct dimensions and having a machined upper edge shall be rigidly clamped to the upper end of the specimen to be capped in such a way that the upper edge is horizontal and just extends beyond the highest part of the concrete surface.

The capping material shall be filled into the collar until it is the form of a convex surface above the edge of the collar. The glass capping plate, coated with a thin film of mould oil shall be pressed down on to the capping material with a rotary motion until it makes complete contact with the edge of the collar.

The specimen with collar and plate in position, shall immediately be placed in moist air of at least 90 % relative humidity and at a temperature of 20 °C ± 5 °C. The plate and collar shall be removed when the mortar is hard enough to resist handling damage.

B.3.3 Capping with calcium aluminate cement paste

In the case of capping using cement paste conducted immediately after casting a specimen, the mould is filled with concrete leaving a height of less than 5 mm at the top and then the cement paste is placed into the mould until it forms a convex surface above the edge of the mould. The specimen left in the mould is placed for curing in the same condition as specified above.

B.4 Capping — Sulfur mixture method

B.4.1 General

Before capping, ensure that the surface of the specimen is in a dry condition, is clean and all loose particles removed.

The caps shall be as thin as possible and should not, on average, be greater than 5 mm thick. Small local deviations are permissible.

B.4.2 Capping material

Sulfur mixtures shall be of normal strength or of high strength, as described below.

a) Normal strength: The capping material shall comprise equal mass fractions of sulpfur and fine siliceous sand (most of which passes a 250 µm woven wire sieve conforming to ISO 3310-1 and is retained on a 125 µm woven wire sieve). A small proportion, up to 2 %, of carbon black may be added.

b) High strength: The capping material shall consist of a blend of sulfur and suitable additions passing a 0,5 mm sieve. The strength of the mixture tested in accordance with B.5 shall be as follows:

 — flexure strength: at least 65 MPa;

 — compressive strength: at least the estimated compressive strength of the concrete.

B.4.3 Procedure

Lower one end of the specimen, which is held vertically, into a pool of molten sulfur mixture on a horizontal plate/mould. Allow specimen to harden before repeating the procedure for the other end. Use a capping frame that will ensure that both capped surfaces are parallel. Mineral oil shall be used as a release agent for plates/moulds. Where necessary, trim surplus capping material from the edges of the specimen.

NOTE 1 Stir the mixture continuously to ensure its homogeneity and to avoid sediment forming at the bottom of the melting pot.

NOTE 2 If capping operations are carried out repeatedly, it is advisable to use two thermostatically controlled melting pots.

The level of the mixture in the melting pot should never be allowed to fall too low, as there will be an increased risk of the production of sulfur vapour, which could ignite.

WARNING — A fume extraction system shall be operating during the whole melting process to ensure full extraction of the sulfur vapour, which is heavier than air. Care should be taken to ensure that the temperature of the mixture is maintained within the specified range to reduce the risk of pollution.

The specimen shall be checked to ensure that the capping material has adhered to both ends of the specimen. If a capping layer sounds hollow, it shall be removed and the capping operation repeated.

The cap shall not fail or fracture before the concrete fails when the specimen is tested.

The compression test on the test specimen shall not be carried out until at least 30 min have elapsed since the last capping operation.

B.5 Capping — Material test for high strength sulfur mixture

B.5.1 Principle

B.5 defines the procedures to be carried out to check the conformity of the capping material used for the high-strength sulphur mixture method.

B.5.2 Apparatus

B.5.2.1 **Prism mould**, with dimensions of 40 mm × 40 mm × 160 mm, complete with a filling frame.

B.5.2.2 **Melting pot**, with a thermostat to control the temperature of the mixture to 130 °C ± 10 °C.

B.5.2.3 **Ladle**, with a capacity of at least 1/3 l.

B.5.2.4 **Saw**, capable of cutting the capping material when it is dry.

B.5.2.5 **Compression testing machine**, capable of testing mortar prisms for flexural and compressive strength in accordance with ISO 679 (a new edition of which is in preparation). Until the publication of this International Standard, the compression-testing machine shall conform to the provisions at the place of testing.

B.5.3 Procedures

The sulfur mixture shall be heated in the melting pot to 130 °C ± 10 °C, stirring with the ladle to make the mixture homogenous.

The filling frame shall be fitted to the mould and both shall be lightly oiled using a normal mould-release oil.

The liquid sulfur mixture shall be poured into the mould, overfilling each part in turn using the filling frame to produce three specimens.

Thirty minutes after casting the last specimen, the filling frame shall be removed and the three specimens demoulded. They shall then be left at ambient temperature for a further 30 min.

Approximately 1 h after casting, each test specimen shall be sawn to remove the excess height and to produce three specimens with dimensions of 40 mm ± 1 mm × 40 mm ± 1 mm × 160 mm ± 1 mm. The actual dimensions shall be measured and recorded.

Approximately 2 h after casting, the specimens shall be tested for flexural and compressive strength.

B.5.4 Test result

The compressive and the flexural strength of each specimen shall be determined using the actual dimensions recorded, not the nominal dimensions. The test procedures are as described in ISO 679.

The compressive strength of the sulphur mixture shall be taken as the mean of the results of the tests on the three specimens.

B.6 Capping — Sandbox method — Use of sandboxes for capping cylindrical specimens

B.6.1 Principle

This method, the principles of which are shown in Figure B.1, shall be used for capping cylindrical concrete test specimens if the expected compressive strength of the specimen is likely to be in a range up to 100 MPa.

Before capping, the surface of the specimen to be capped shall be clean and all fine loose particles removed.

The sand used shall be fine siliceous sand, most of which passes a 250 µm woven wire sieve that conforms to ISO 3310.

B.6.2 Apparatus

B.6.2.1 Steel boxes, conforming to the shape and dimensions in accordance with Figure B.2 and the following list.

— The steel shall have a yield strength of at least 900 MPa.

— The tolerance on the dimensions shall be ± 0,1 mm.

— Each box shall be provided with an opening to receive a line from a compressor.

— The opening shall be provided with a means of blanking it off during placing and testing.

B.6.2.2 Positioning frame, consisting of the following:

— guidance device capable of ensuring that the tolerance on the perpendicularity of the side(s) [generatrix] of the specimen and the contact surface of the box in the frame, shall be 0,5 mm and ensuring that the tolerance on the coaxiality of each box and the specimen is 0,5 mm;

— two box-centring stops, integral with the horizontal plane of the frame;

— mechanical system for locking the sandbox against the stops;

- system to clamp the specimen against the specimen guide;
- vibrator mounted under the horizontal plane of the frame and integral with it, intended to ensure the homogeneous distribution and compaction of the sand in the boxes;
- assembly, which shall be isolated so as not to transmit the vibration to the support, capable of ensuring the correct relative positioning between the specimen and the two boxes.

B.6.2.3 **Compressed-air blower**, consisting of an air blower used for releasing the boxes.

B.6.2.4 **Flask**, used for containing the paraffin wax.

B.6.2.5 **Hotplate**, thermostatically controlled to melt the paraffin wax at a temperature of 110 °C ± 10 °C.

B.6.2.6 **Calibrating container**, used to calibrate a volume of sand corresponding to a height of 10 mm ± 2 mm in the sandbox.

B.6.2.7 **Paraffin wax**, with a setting point of 60 °C ± 10 °C.

B.6.3 Procedure

The positioning frame shall be installed on a horizontal working surface.

One of the sand boxes shall be positioned on the frame and locked in position.

The required volume of sand shall be poured, without spreading it, in the centre of the box.

After wiping the bearing surfaces, the specimen shall be placed on the pile of sand and clamped in position.

The vibrator shall be run for 20 s ± 5 s, making sure that the guide rollers bear correctly against the specimen.

The paraffin wax shall be poured up to the rim of the box and allowed to set.

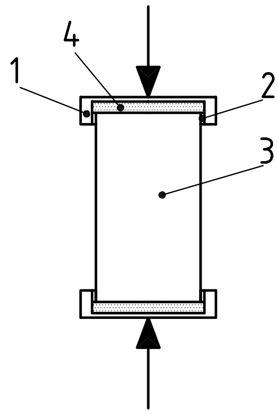
The specimen shall be unclamped and turned over on the working surface.

The operations shall be repeated for the second box.

The specimen, when it is being transported, shall be supported by the bottom box.

After completion of the compression test, the two boxes shall be separated from the debris of the specimen by blowing air through the opening provided for the purpose.

CAUTION — It is recommended that a cover with an ovoid hole is made and placed on a gravel-filled hopper. With the box upside down, the rim of the box should be placed on the edge of the opening, using one hand to hold the box whilst the other manipulates the blower. The ovoid shape of the hole shall be of sufficient size to allow the correct positioning of the rim of the box, on the rare occasions when the specimen fails to break completely and the two boxes remain at either end of the specimen. The arrangement of the holes shall be such as to limit the amount of dust generated.



Key

1 box

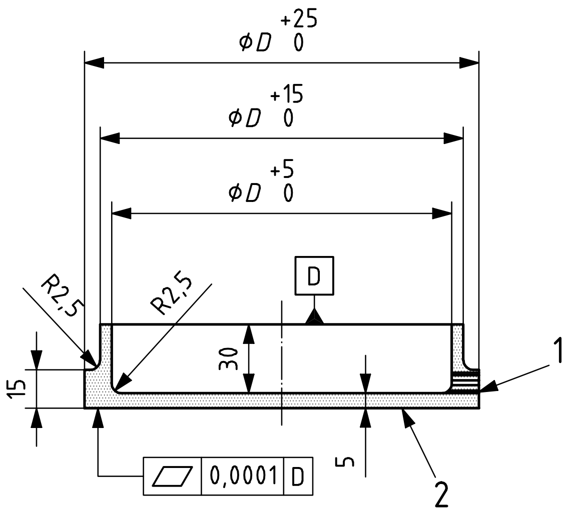
2 paraffin

3 specimen

4 sand

Figure B.1 — Diagram of principle

Dimension in millimetres



Key

1 opening for form release

2 surface in contact with the plate

D cylinder diameter

Figure B.2 — Geometrical shape of the boxes

B.7 Capping — Elastomeric pads (unbonded caps)

B.7.1 General

A capping system using elastomeric pads with steel caps may be used for capping cylindrical concrete specimens having a diameter of up to 150 mm and an estimated compressive strength not greater than 80 MPa. This capping method may also be used for cut cored specimens having maximum irregularities of end surfaces of up to 3 mm.

NOTE 1 The steel caps that cover the top and/or bottom ends of concrete specimens restrain the horizontal deformation of the elastomeric pads that are inserted in the caps during compression testing.

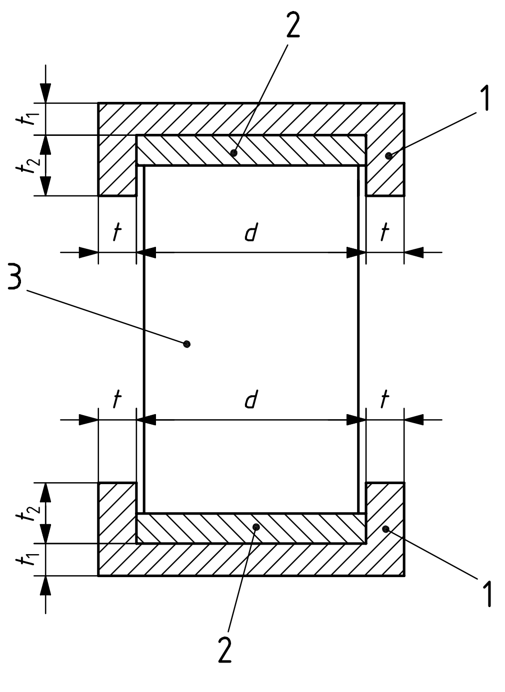
The elastomeric pads shall be of chloroprene or polyurethane.

NOTE 2 They are used to correct the irregularities of the unmoulded surfaces or cutting surfaces of concrete specimens to allow the uniform distribution of the applied load.

B.7.2 Apparatus

B.7.2.1 Steel caps, that shall be made of hardened C45 or 105WCr1 steel with the flatness of surfaces in contact with the compression-testing machine being within 0,02 mm.

The shapes and dimensions of steel caps shall be as shown in Figure B.3 and Table B.2.



Key

1 steel cap

2 elastomeric pad

3 concrete specimen

Figure B.3 — Steel cap

Table B.2 — Dimensions of steel caps

Dimensions in millimetres

Specimen size φ	Inside diameter d	Outside thickness t	Outside thickness t_1	Depth t_2
100 × 200	102,0 ± 0,1	18 ± 2	11 ± 2	25 ± 1
125 × 250	127,0 ± 0,1			
150 × 300	152,0 ± 0,1			

B.7.2.2 Elastomeric pads

Elastomeric pads shall be hot-formed, with an outside diameter smaller than the inside diameter of the steel caps by 0,1 mm and a thickness of 10 mm ± 2 mm. The qualities of elastomeric pads shall be in accordance with Table B.3.

Table B.3 — Qualities of elastomeric pads

Quality	Material	
	Chloroprene	Polyurethane
Hardness [a]	A/65/5 to A/70/5	
Impact resilience [a] (%)	53 ± 3	60 ± 3
Density (g/cm^2)	1,40 ± 0,03	1,30 ± 0,03

[a] The hardness and impact resilience are values measured using Shore "A" durometer in accordance with ISO 48 and a test apparatus having a Lupke pendulum in accordance with ISO 4662, respectively. The density values are those measured in accordance with ISO 2781.

B.7.2.3 Shore "A" durometer, which shall conform to ISO 48.

B.7.3 Hardness of elastomeric pads

B.7.3.1 Measuring method

Measure the hardness of elastomeric pads as follows :

a) Insert an elastomeric pad in a steel cap. Select three measuring points on the pad at about 20 mm from the circumference of the pad towards the centre. The three points should be spaced uniformly around the circumference of the pad.

b) Hold the durometer in a vertical position at a measuring point and apply the presser foot to the elastomeric pad so that the indentor is perpendicular to the pad.

c) Press the durometer onto the pad and take a reading of the pointer after 5 s. The force to press the durometer should be about 8 N to 10 N.

NOTE 1 The use of a load regulator using an oil damper provides stable hardness measurements for elastomeric pads.

d) Calculate the arithmetic mean of the three measurements and round off to two integers.

Note 2 The value calculated in B.7.3.1 d) is taken as the measurement of the hardness of the elastomeric pad.

Calculate the hardness at 20 °C using this measurement and the temperature of the pad using Equation (B.1):

$$K_{20} = 1{,}08T^{0{,}03}K_i^{0{,}96} \tag{B.1}$$

where

K_{20} is the hardness of elastomeric pad at 20 °C;

T is the temperature, expressed in degrees Celsius, of elastomeric pad at the time of hardness measurement;

K_i is the durometer reading.

Hardness measurements of elastomeric pads vary depending on the temperature. When the temperature of the elastomeric pad cannot be directly measured and it may be deemed the same as the room temperature.

B.7.3.2 Verification of pad life

The hardness of the elastomeric pads shall be checked before use and after every 150 uses.

The pad shall be replaced when the measured hardness is lower than the initial hardness by more than 2 units.

B.7.4 Capping method

B.7.4.1 Preparation

When using a new elastomeric pad, insert it in the steel cap as shown in Figure B.3 and apply a load of approximately 150 kN two to three times to expel air from between the steel cap and the pad.

Dummy specimens should be used to insert a new elastomeric pad in the steel cap.

B.7.4.2 Procedure

Cover the concrete specimen with the steel cap containing an elastomeric pad so that the surface of the top and/or bottom end of the specimen comes in contact with the pad. Two caps shall be used for a specimen with two rough end surfaces. Adjust the position of the steel cap to avoid contact between the curved surface of the specimen and the inside of the cap.

Annex C
(informative)

Examples of test reports

C.1 Example of compressive strength test report

Client

Test organisation

Accreditation certificate ref

Test Location

Test Item

Sample declaration number: Date and time received:
Concrete mix reference number (or mix details):
Condition of sample: on receipt:
at time of test:
abnormalities:
temperature: (if required)
Details of test preparation, including method of adjustment:

Test and Test results

Specimen number:
Specimen description:
Mass: (Optional)
Condition when weighed: As received/saturated
Dimensions: nominal/measured:
Density: (Optional)
Condition at time of test: Dry/wet
Age:
Max. load at failure:

Compressive strength:			N/mm^2	
Appearance of concrete:	normal			
Type of failure:	satisfactory		unsatisfactory	

Any deviations from the standard:
Except as detailed above this test was carried out in accordance with ISO 1920-4.

Technical Responsibility

Responsible person: Name: Position:

Signature:

Test report identification

Test report No.: Date issued:

C.2 Example of test report of flexural strength

Client

Test organisation

Accreditation certificate ref

Test Location

Test Item

Sample declaration number: Date and time received:

Concrete mix reference number (or mix details):

Condition of sample: on receipt:

at time of test:

abnormalities:

temperature: (if required)

Details of specimen preparation, including method of adjustment:

Details of specimen storage/curing:

Test and Test results

Specimen number:

Specimen description:

Method of loading: two-point/centre-point

Dimensions: designated/actual

Moisture condition at time of test:

Age:

Max. load at failure:

Fractural strength: N/mm^2

Location of fracture:

Appearance of fractured surface:

Any deviations from the standard:

Except as detailed above this test was carried out in accordance with ISO 1920-4.

Technical Responsibility

Responsible person: Name: Position:

Signature:

Test report identification

Test report No.: Date issued:

C.3 Example of test report of tensile splitting strength

Client

Test organisation

Accreditation test report ref

Test Location

Test Item

Sample declaration number:

Date and time received:

Concrete mix reference number (or mix details):

Condition of sample:

on receipt:

at time of test:

abnormalities:

temperature: (if required)

Details of specimen preparation, including method of adjustment

Details of specimen storage/curing:

Test and Test results

Specimen number:

Specimen description:

Dimensions:

designated/measured

Density: (Optional)

Surface moisture condition at time of test:

Age of specimen (if known):

Description of loading pieces:

Max. load at failure:

Tensile splitting strength: MPa

Location of fracture

Appearance of fractured surface:

Any deviations from the standard:

Except as detailed above this test was carried out in accordance with ISO 1920-4.

Technical Responsibility

Responsible person:

Name:

Position:

Signature:

Test report identification

Test report No.:

Date issued:

ICS 91.100.30

Price based on 27 pages