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2η Έκδοση

ΕΛΛΗΝΙΚΟ ΠΡΟΤΥΠΟ
HELLENIC STANDARD

ΕΛΟΤ

Δοκιμές σκληρυμένου σκυροδέματος - Μέρος 3: Αντοχή σε θλίψη δοκιμίων

Testing hardened concrete - Part 3: Compressive strength of test specimens

Κλάση Τιμολόγησης: **8**

ΕΛΟΤ ΕΝ 12390.03 Ε2

Εθνικός Πρόλογος

Αυτό είναι το Φύλλο Επικύρωσης του εγκεκριμένου Ευρωπαϊκού Προτύπου

EN 12390-3 : 2009

ως Ελληνικού Προτύπου. Το πρότυπο αυτό διατίθεται στην Αγγλική, ή Γαλλική ή Γερμανική γλώσσα από τον Ελληνικό Οργανισμό Τυποποίησης Α.Ε. Αυτό το Ελληνικό Πρότυπο αντικαθιστά το ΕΛΟΤ ΕΝ 12390.03:2002.

National Foreword

This Endorsement Sheet ratifies the approval of European Standard

EN 12390-3 : 2009

as a Hellenic Standard. This standard is available in English, French or German from the Hellenic Organization for Standardization S.A. This Hellenic Standard replaces ELOT EN 12390.03:2002.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12390-3

February 2009

ICS 91.100.30

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English Version

Testing hardened concrete - Part 3: Compressive strength of test specimens

Essais pour béton durci - Partie 3: Résistance à la compression des éprouvettes

Prüfung von Festbeton - Teil 3: Druckfestigkeit von Probekörpern

This European Standard was approved by CEN on 27 December 2008.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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Foreword

This document (EN 12390-3:2009) has been prepared by Technical Committee CEN/TC 104 "Concrete and related products", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2009, and conflicting national standards shall be withdrawn at the latest by August 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12390-3:2001.

It is recognised good practice to include measurement of density prior to the determination of compressive strength.

The methods for adjusting the ends of test specimens, given in Annex A, have been validated in a laboratory inter-comparison, part-funded by the EC under the Measurement and Testing Programme; contract MATI-CT-94-0043.

This standard is one of a series concerned with testing concrete.

The series EN 12390 includes the following parts:

EN 12390 Testing hardened concrete –

Part 1: Shape, dimensions and other requirements for specimens and moulds;

Part 2: Making and curing specimens for strength tests;

Part 3: Compressive strength of test specimens;

Part 4: Compressive strength - Specification for testing machines;

Part 5: Flexural strength of test specimens;

Part 6: Tensile splitting strength of test specimens;

Part 7: Density of hardened concrete;

Part 8: Depth of penetration of water under pressure.

The following amendments have been made to the 2001-12 edition of this standard:

— editorial revision

— the compressive strength to be expressed to the nearest 0,1 MPA (N/mm²) instead of 0,5 MPa (N/mm²)

— the loading rate has been changed from between 0,2 MPa/s and 1,0 MPa/s to 0,6 ± 0,2 MPa/s

— the allowable tolerance for specimens which do not meet the tolerance given in EN 12390-1 for designated size has been increased

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies a method for the determination of the compressive strength of test specimens of hardened concrete.

2 Normative references

The following referenced documents are indispensable 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.

EN 197-1, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

EN 12350-1, *Testing fresh concrete — Part 1: Sampling*

EN 12390-1, *Testing hardened concrete - Part 1: Shape, dimensions and other requirements for specimens and moulds*

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

EN 12390-4, *Testing hardened concrete — Part 4: Compressive strength — Specification for testing machines*

EN 12504-1, *Testing concrete in structures — Part 1: Cored specimens — Taking, examining and testing in compression*

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

3 Principle

Specimens are loaded to failure in a compression testing machine conforming to EN 12390-4. The maximum load sustained by the specimen is recorded and the compressive strength of the concrete is calculated.

4 Apparatus

Compression testing machine, conforming to EN 12390-4.

5 Test specimens

5.1 Requirement

The test specimen shall be a cube, cylinder or core meeting the requirements of EN 12350-1, EN 12390-1, EN 12390-2, or EN 12504-1. If the dimension of the test specimen does not conform to the tolerances for designated size in EN 12390-1, it can be tested in accordance with the procedure given in Annex B.

NOTE Damaged specimens or specimens which are badly honeycombed should not be tested.

5.2 Adjustment of test specimens

Where the dimensions or shapes of test specimens do not conform to the requirements given in EN 12390-1 because they exceed the respective tolerances, they shall be rejected, adjusted or tested in accordance with Annex B.

One of the methods given in Annex A shall be used to adjust specimens.

6 Procedure

6.1 Specimen preparation and positioning

Wipe all testing machine bearing surfaces clean and remove any loose grit or other extraneous material 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 (see EN 12390-4) between the specimen and the platens of the testing machine.

Wipe the excess moisture from the surface of the specimen before placing in the testing machine.

Position the cube specimens so that the load is applied perpendicularly to the direction of casting.

Centre the specimen with respect to the lower platen to an accuracy of 1 % of the designated size of cubic, or designated diameter of cylindrical specimens.

If auxiliary platens are used, align them with the top and bottom face of the specimen.

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

6.2 Loading

Select a constant rate of loading within the range 0,6 ± 0,2 MPa/s (N/mm²·s). After the application of the initial load, which does not exceed approximately 30% of the failure load, apply the load to the specimen without shock and increase continuously at the selected constant rate ± 10 %, until no greater load can be sustained.

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

Record the maximum load indicated in kN.

NOTE Further guidance on loading rates for high and low strength concrete e.g. above 80 MPa and below 20 MPa cube strengths, may be given in national Annex NA

6.3 Assessment of type of failure

Examples of the failure of specimen showing that the tests have proceeded satisfactorily are given in Figure 1 for cubes and in Figure 3 for cylinders.

Examples for unsatisfactory failure of specimens are shown in Figure 2 for cubes and in Figure 4 for cylinders.

If failure is unsatisfactory this shall be recorded with reference to the pattern letter according to Figure 2 or 4 closest to that observed.

NOTE Unsatisfactory failures can be caused by:

insufficient attention to testing procedures, especially positioning of the specimen;

a fault with the testing machine.

For cylindrical specimens, failure of the capping before the concrete is an unsatisfactory failure.

7 Expression of results

The compressive strength is given by the equation:

$$f_c = \frac{F}{A_c}$$

where

f_c is the compressive strength, in MPa (N/mm²);

F is the maximum load at failure, in N;

A_c is the cross-sectional area of the specimen on which the compressive force acts, calculated from the designated size of the specimen (see EN 12390-1) or from measurements on the specimen if tested according to Annex B, in mm².

The compressive strength shall be expressed to the nearest 0,1 MPa (N/mm²).

8 Test report

The report shall include:

a) identification of the test specimen;

b) designated dimensions of the specimen or if tested in accordance with Annex B, actual dimensions;

c) details of adjustment by grinding/capping (if appropriate);

d) date of test;

e) maximum load at failure, in kN;

f) compressive strength of specimen, to the nearest 0,1 MPa (N/mm²);

g) unsatisfactory failure (if appropriate) and if unsatisfactory the closest type;

h) any deviations from the standard method of testing;

i) a declaration from the person technically responsible for the test that it was carried out in accordance with this document, except as detailed in item h).

The report may include:

j) mass of the specimen;

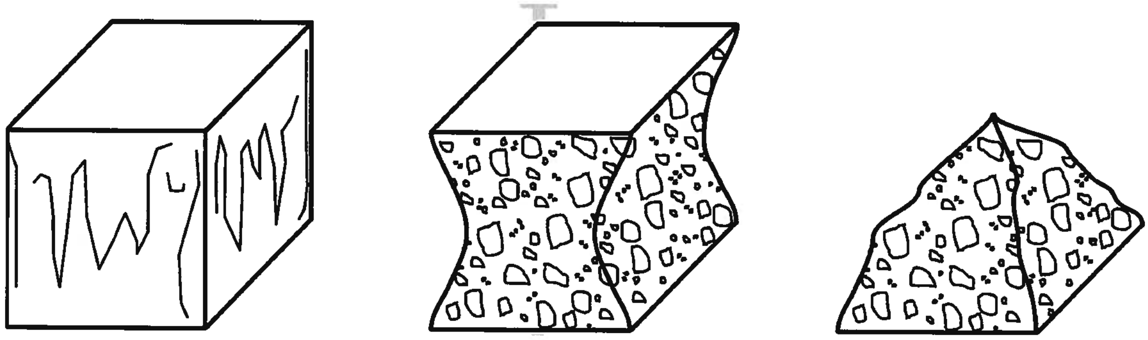
k) apparent density of specimen, to the nearest 10 kg/m³;

l) condition of the specimen on receipt;

m) curing conditions since receipt;

n) time of test (if appropriate);

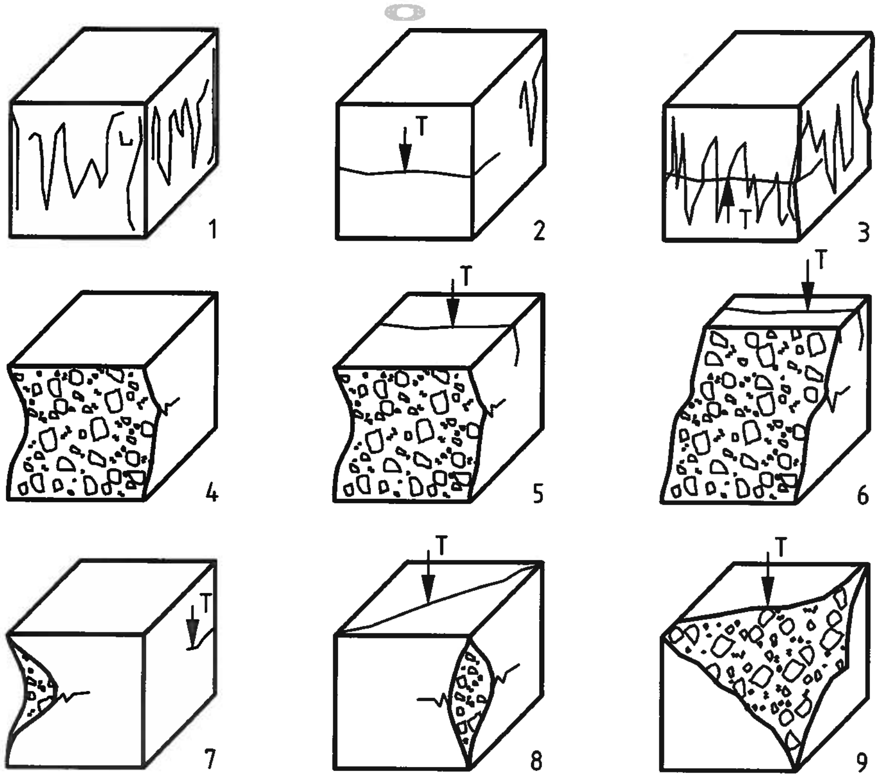
o) age of specimen at time of test (if known).



Explosive failure

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

Figure 1 — Satisfactory failures of cube specimens



NOTE T = tensile crack

Figure 2 — Some unsatisfactory failures of cube specimens

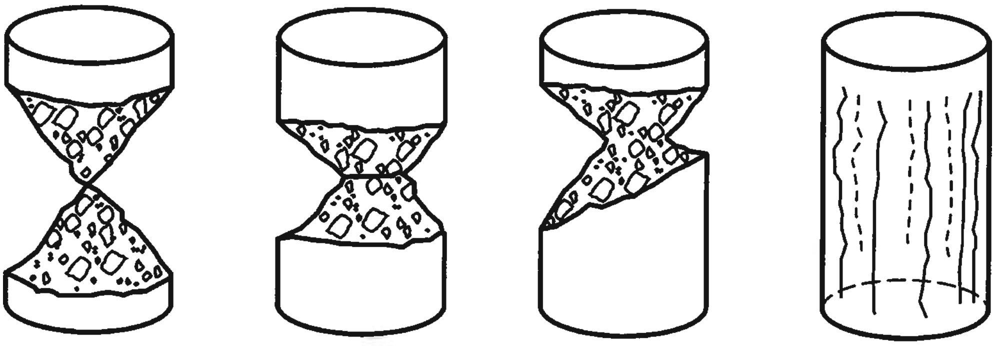


Figure 3 — Satisfactory failure of cylinder specimen

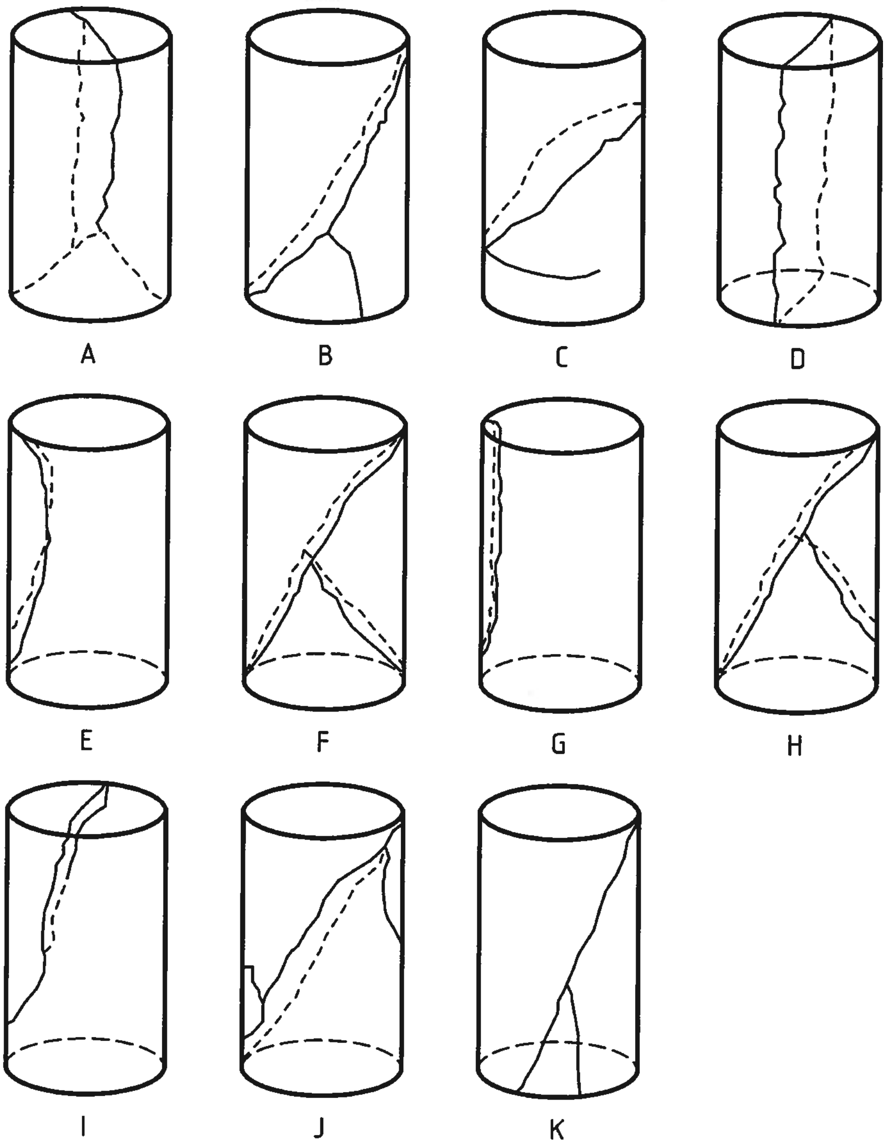


Figure 4 — Some unsatisfactory failures of cylinder specimens

9 Precision

Table 1 — Precision data for measurements of the compressive strength of hardened concrete, expressed as percentages of the mean of the two cube strengths whose difference is to be compared with repeatability (*r*) or reproducibility (*R*).

Test method	Repeatability conditions		Reproducibility conditions	
	s_r %	*r* %	s_R %	*R* %
100 mm cubes	3,2	9,0	5,4	15,1
150 mm cubes	3,2	9,0	4,7	13,2

NOTE 1 The precision data were determined as part of an experiment carried out in 1987 in which precision data were obtained for several of the tests described in BS 1881. The experiment involved 16 operators. The concretes were made using an ordinary Portland cement, Thames Valley sand, and Thames Valley 10 mm and 20 mm coarse aggregates.

NOTE 2 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.

NOTE 3 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.

NOTE 4 For further information on precision, and for definitions of the statistical terms used in connection with precision, see ISO 5725-1.

Table 2 — Precision data for measurements of the compressive strength of hardened concrete, expressed as percentages of the mean of the three cylinder strengths whose differences are to be compared with repeatability (*r*) or reproducibility (*R*).

Test method	Repeatability conditions		Reproducibility conditions	
	s_r %	*r* %	s_R %	*R* %
Cylinder (160 mm diameter, 320 mm height)	2,9	8,0	3,1	11,7

NOTE 1 The precision data were determined in France as part of a Round Robin Test carried out in 1992. They are based on the results obtained by 89 laboratories which had participated in the test.

NOTE 2 The concretes were made using CPA55 cement (CEMI), Seine river sand and 20 mm aggregate. The average value was 38,87 MPa.

NOTE 3 The precision data only includes the procedure of testing for compressive strength.

Annex A (normative)

Adjustment of test specimens

A.1 General

When it is necessary to reduce the size of a specimen, it shall be ground or sawn.

The intended load-bearing surfaces shall be prepared by grinding or by capping. (See Table A.1).

Table A.1 — Restrictions on methods of adjustment

Method	Restriction based on (anticipated) measured strength
Grinding	unlimited
Calcium aluminate cement mortar	up to approximately 50 MPa (N/mm^2)
Sulfur mixture	up to approximately 50 MPa (N/mm^2)
Sandbox	unlimited

In cases of dispute, grinding shall be the reference method.

NOTE Other methods of adjustment may be used if they are validated against grinding.

A.2 Grinding

Remove specimens cured in water from the water for grinding for not more than 1 h at a time and re-immerse in water for at least 1 h before further grinding or testing.

A.3 Capping (using calcium aluminate cement)

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

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

The capping material should consist of a mortar composed of three parts by mass of calcium aluminate cement to one part by mass of fine sand (most of which passes a 300 µm ISO 3310-1 woven wire sieve).

Other cements conforming to EN 197-1 may be used provided that, at the time of test, the mortar has a strength at least equal to the strength of the concrete.

Place the specimen with one end on a horizontal metal plate. Rigidly clamp a steel collar of correct dimensions and having a machined upper edge 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.

Fill the capping material into the collar until it is the form of a convex surface above the edge of the collar. Press a glass capping plate, coated with a thin film of mould oil down onto the capping material with a rotary motion until it makes complete contact with the edge of the collar.

Immediately place the specimen with collar and plate in position in moist air of ≥ 95 % RH and at a temperature of (20 ± 5)°C. Remove the plate and collar when the mortar is hard enough to resist handling damage.

NOTE At the time of test, the capping should be at least as strong as the concrete specimen.

A.4 Capping: Sulfur mixture method

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

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

Proprietary sulfur capping mixtures are usually suitable. Alternatively, the capping material may consist of a mixture composed of equal parts by mass of sulfur and fine siliceous sand (most of which passes a 250 μm woven wire sieve and is retained on a 125 μm woven wire sieve conforming to ISO 3310-1). A small proportion, up to 2 %, of carbon black may be added.

Heat the mixture to the temperature recommended by the supplier or to a temperature where, whilst stirring continuously, the required consistency is reached.

The mixture is stirred continuously to ensure its homogeneity and to avoid sediment forming at the bottom of the melting pot.

NOTE 1 If capping operations have to be carried out repeatedly, it is advisable to use two thermostatically controlled melting pots.

NOTE 2 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.

CAUTION A fume extraction system should 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.

Lower one end of the specimen, held vertically, into a pool of molten sulfur mixture on a horizontal plate/mould. Allow the mixture to harden, before repeating the procedure for the other end. Use a capping frame which will ensure that both capped surfaces are parallel and mineral oil as a release agent for plates/moulds.

NOTE 3 It may be necessary to trim surplus capping material from the edges of the specimen.

Check the specimen to ensure that the capping material has adhered to both ends of the specimen. If a capping layer sounds hollow, remove it and then repeat the capping operation.

Allow 30 min to elapse since the last capping operation before carrying out a compression test on the test specimen.

A.5 Capping: Sandbox method: Use of sand boxes for capping cylindrical specimens

A.5.1 Preparation

This method is shown in Figure A.1.

Before capping, ensure that the surface of the specimen to be capped is clean and that all fine loose particles have been removed.

The sand used shall be fine siliceous sand, most of which passes a 250 µm woven wire sieve and is retained on a 125 µm woven wire sieve conforming to ISO 3310-1.

A.5.2 Apparatus

A.5.2.1 Steel boxes, conforming to the shape and dimensions set out in Figure A.2.

1) The steel shall have a yield strength of at least 900 MPa (N/mm²).

2) The tolerance on the dimensions is 0,1 mm.

3) Each box shall be provided with an opening to receive a line from an air compressor, and the opening shall be provided with a means of blanking it off during placing and testing.

A.5.2.2 Positioning frame, (Figure A.3) consisting of:

1) a guidance device capable of ensuring that the tolerance on the perpendicularity of the side of the specimen and the contact surface of the box in the frame is 0,5 mm, and capable of ensuring that the tolerance on the coaxiality of each box and the specimen is 0,5 mm;

2) two box centring stops, integral with the horizontal plane of the frame;

3) a mechanical system for locking the sand box against the stops;

4) a system to clamp the specimen against the specimen guide;

5) a 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;

6) an assembly, isolated so as not to transmit the vibration to the support and capable of ensuring the correct relative positioning between the specimen and the two boxes.

A.5.2.3 Compressed air-blower, for releasing the boxes

A.5.2.4 Flask, for containing the paraffin wax

A.5.2.5 Hotplate, thermostatically controlled to melt the paraffin wax at a temperature of(110 ± 10) °C.

A.5.2.6 Calibrating container, to calibrate a volume of sand corresponding to a height of (10 ± 2) mm in the sand box.

A.5.2.7 Paraffin wax, with a setting point of (60 ± 10)°C.

A.5.3 Procedure

Place the positioning frame on a horizontal working surface. Position one of the sand boxes on the frame and lock in position. Pour the required volume of sand, without spreading it, in the centre of the box. After wiping the bearing surfaces, place the specimen on the pile of sand and clamped in position.

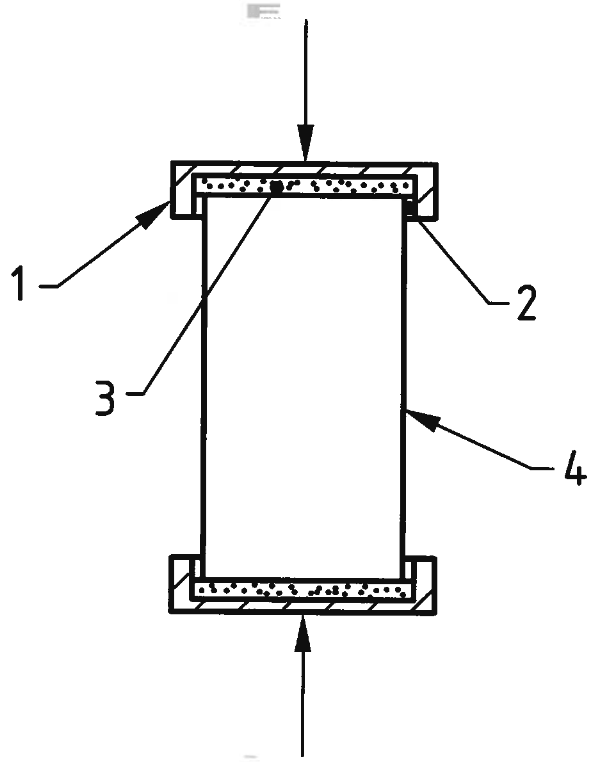
Run the vibrator for (20 ± 5) s, making sure that the guide rollers bear correctly against the specimen.

Pour the paraffin wax up to the rim of the box and allow to set. Un-clamp the specimen and turn it over on the working surface. Repeat the operations for the second box.

When transporting the specimen, support it by the bottom box.

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

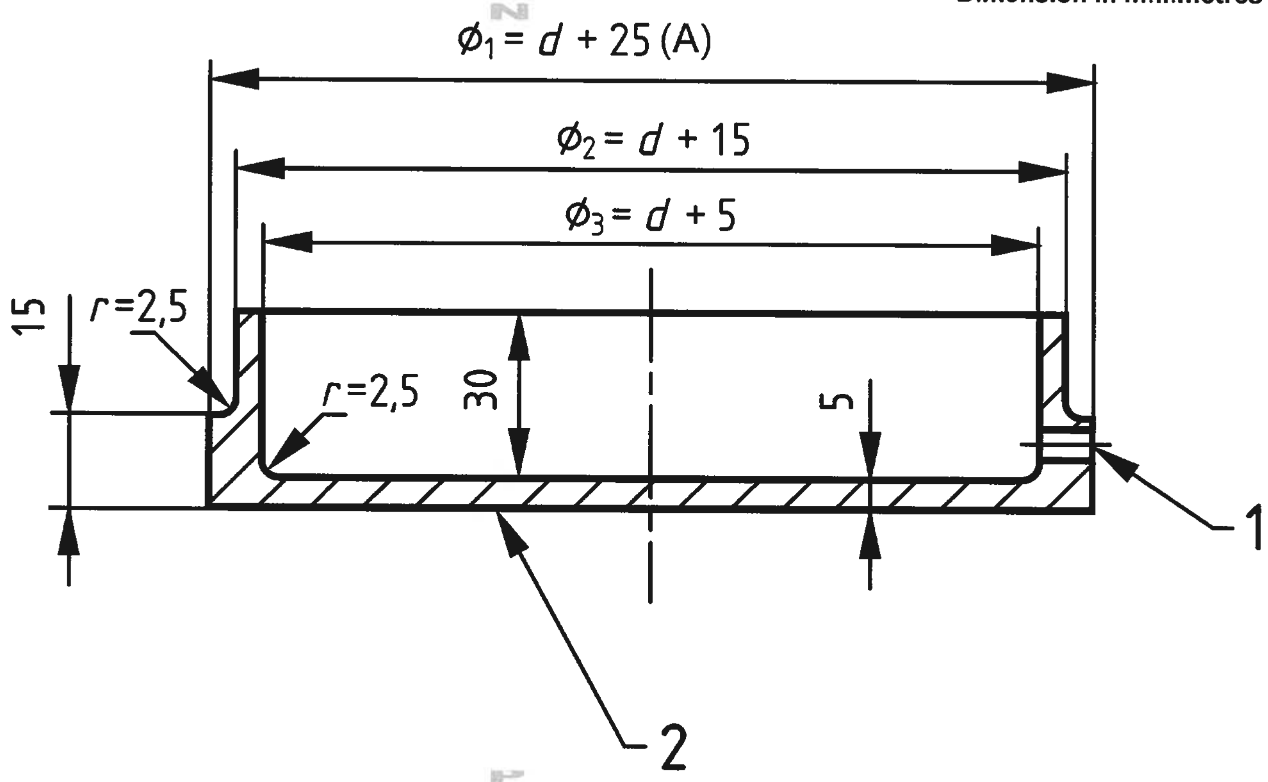
CAUTION It is recommended that a cover with an ovoid hole is made and placed on a gravel-filled hopper. With the box upside down, the rim of the box should be placed on the edge of the opening, using one hand to hold the box whilst the other manipulates the blower. The ovoid shape of the hole must be 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 Sand
4 Specimen

Figure A.1 — Capping: Sandbox method

Dimension in millimetres



Key

1 Opening for form release
2 Surface in contact with plate (flatness of 0,001d)
A minimum
d designated diameter of specimen

Figure A.2 — Detail of sandbox

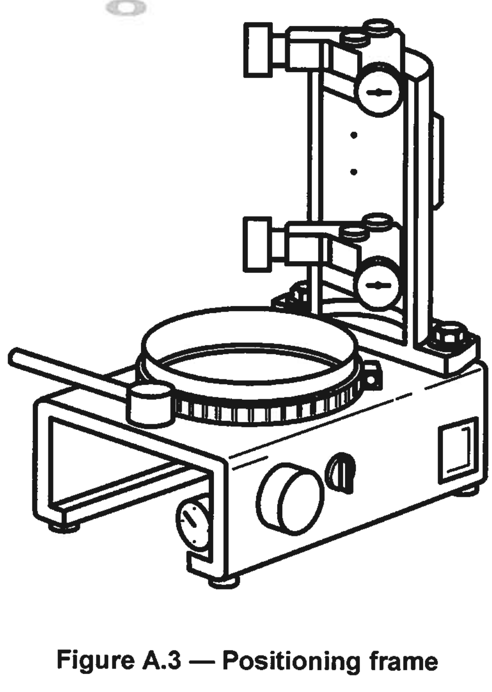


Figure A.3 — Positioning frame

Annex B
(normative)

Procedure for testing specimens with dimensions which are outside the tolerances of the designated sizes of EN 12390-1

B.1 Principle

Before testing for compressive strength, the dimensions of the specimen are measured in several positions and the mean values calculated. The cross-sectional area of the loading faces are calculated. The specimen is tested in accordance with Clause 6, except that there are additional requirements regarding the testing machine platens, auxiliary or spacing blocks.

B.2 Apparatus

Callipers or rules: capable of measuring the dimensions of specimens to an accuracy of 0,5 % of the dimension.

B.3 Procedure

B.3.1 Cubes

B.3.1.1 Measurements of dimensions are made in each of the orthogonal directions (x, y, z), at the lines indicated in figures B.1 and B.2, to an accuracy of 0,5 % of the dimensions. If any dimension is greater, or less than, 3 % from the designated size, then the specimen is rejected or adjusted (Annex A).

B.3.1.2 The mean values (x_m, y_m) are calculated from the six measurements in each direction on the loading faces and expressed to the nearest 1 mm of the dimension.

B.3.1.3 The area of the cube loading face, $A_c = x_m \cdot y_m$, is calculated and expressed to the nearest 1 mm².

B.3.2 Cylinders or cores

B.3.2.1 Three measurements of diameter, to an accuracy of 0,5 % of the dimension, are made at each end of the cylinder or core, at positions approximately 60° to each other (see Figure B.3) The height of the cylinder or core is measured, to an accuracy of 0,5 % of the dimension, at three positions approximately 120° to each other (see Figure B.4). If any dimension is greater, or less than, 3 % from the designated size, then the specimen is rejected or adjusted (Annex A).

B.3.2.2 The average diameter, d_m, of the loading faces of the cylinder or core is calculated from the six measurements and expressed to the nearest 1 mm of the dimension.

B.3.2.3 The area of the loading face of the cylinder or core, $A_c = \Pi \cdot d_m{}^2/4$, is calculated and expressed to the nearest 1 mm².

B.3.3 Testing for compressive strength

Specimens are tested as in Clause 6 except that the dimensions of the testing machine platens, auxiliary platens or spacing blocks shall be greater than, or equal to, the dimensions of the faces of the specimens in contact with them.

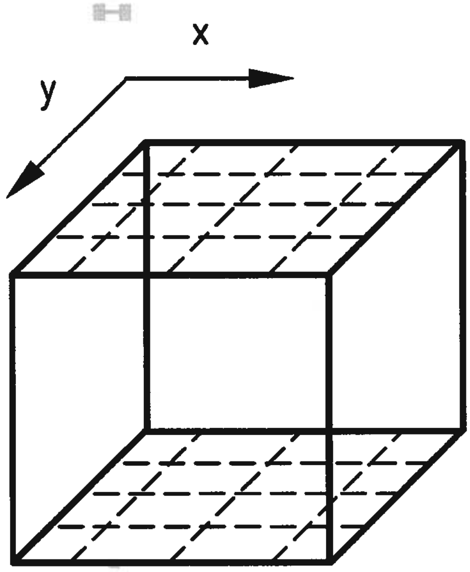


Figure B.1 — Dotted lines showing measuring positions for the loading faces of cubes

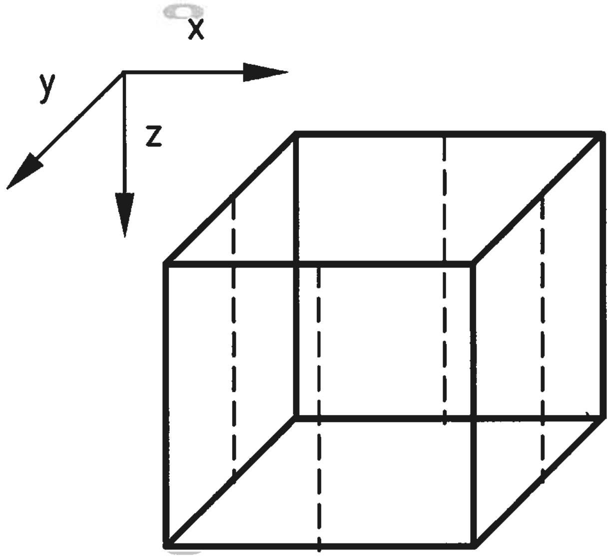


Figure B.2 — Dotted lines showing measuring positions for the non-loaded faces of cubes

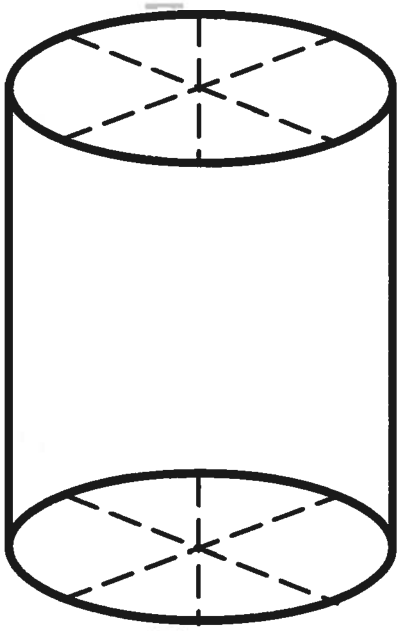


Figure B.3 — Dotted lines showing the measuring positions for the ends of a cylinder

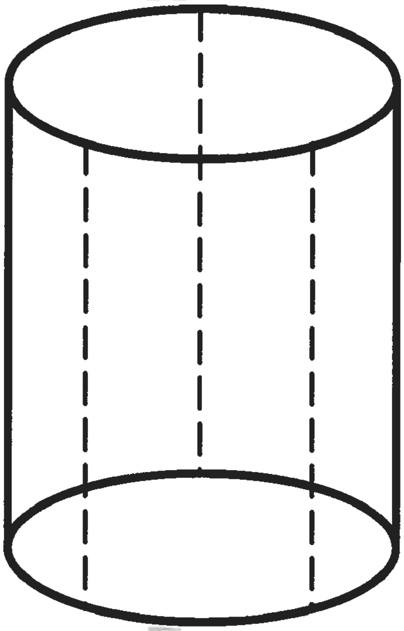


Figure B.4 — Dotted lines showing the measuring positions for the height of a cylinder

Bibliography

[1] ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

[2] Series BS 1881, *Testing concrete*