BRITISH STANDARD

BS EN
12390-3:2002

# Testing hardened concrete —

## Part 3: Compressive strength of test specimens

The European Standard EN 12390-3:2001 has the status of a British Standard

ICS 91.100.30

# National foreword

This British Standard is the official English language version of EN 12390-3:2001. It will supersede BS 1881-116:1983, which will be withdrawn in 2003 when the full package of the Concrete Standards is available.

The UK participation in its preparation was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/1, Concrete production and testing, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

## Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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This British Standard, having been prepared under the direction of the Building and Civil Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 25 February 2002

## Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 15 and a back cover.

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December 2001

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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 2 September 2001.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**Management Centre: rue de Stassart, 36 B-1050 Brussels**



Ref. No. EN 12390-3:2001 E

# Contents

## Foreword

This European Standard has been prepared by Technical Committee CEN /TC 104, "Concrete", 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 June 2002, and conflicting national standards shall be withdrawn at the latest by December 2003.

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

This standard is based on the draft International Standard ISO 4012 — Concrete — Determination of compressive strength of test specimens.

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 recent laboratory inter-comparison, part-funded by the EC under the Measurement and Testing Programme, contract MATI-CT-94-0043.

A draft for this standard was published in 1996 for CEN enquiry as prEN 12394. It was one of a series of individually numbered test methods for fresh or hardened concrete. For convenience it has now been decided to combine these separate draft standards into three new standards with separate parts for each method, as follows:

— Testing fresh concrete (EN 12350)

— Testing hardened concrete (EN 12390)

— Testing concrete in structures (EN 12504)

The series EN 12390 includes the following parts where the brackets give the numbers under which particular test methods were published for CEN enquiry:

EN 12390 Testing hardened concrete

Part 1: Shape, dimensions and other requirements for specimens and moulds (former prEN 12356:1996)

Part 2: Making and curing specimens for strength tests (former prEN 12379:1996)

Part 3: Compressive strength of test specimens (former prEN 12394:1996)

Part 4: Compressive strength — Specification for testing machines (former prEN 12390:1996)

Part 5: Flexural strength of test specimens (former prEN 12359:1996)

Part 6: Tensile splitting strength of test specimens (former prEN 12362:1996)

Part 7: Density of hardened concrete (former prEN 12363:1996)

Part 8: Depth of penetration of water under pressure (former prEN 12364:1996)

The annexes A and B are normative.

## 1 Scope

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

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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.*

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

Series BS 1881, *Testing concrete*

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

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.

Position the cube specimens 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 0,2 MPa/s ($N/mm^2 \cdot s$) to 1,0 MPa/s ($N/mm^2 \cdot s$). 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.

### 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 megapascals (newtons per square millimetre);

$F$ is the maximum load at failure, in newtons;

$A_c$ 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 according to annex B in $mm^2$.

The compressive strength shall be expressed to the nearest 0,5 MPa ($N/mm^2$).

## 8 Test report

The report shall include:

a) identification of the test specimen;

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

c) surface condition of the specimen at the time of test;

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

e) date of test;

f) maximum load at failure, in kilonewtons;

g) compressive strength of specimen in megapascals (to the nearest 0,5 MPa) or newtons per square millimetre (to the nearest 0,5 $N/mm^2$);

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

i) any deviations from the standard method of testing;

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

The report may include:

k) mass of the specimen;

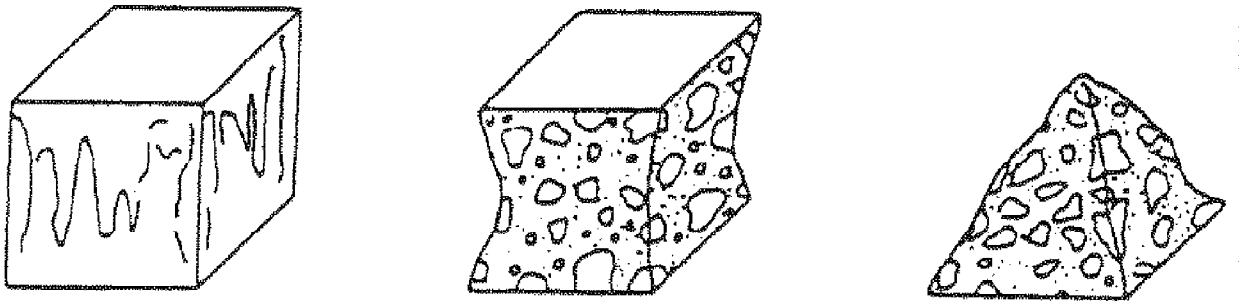
l) apparent density of specimen, to the nearest 10 $kg/m^3$;

m) condition of the specimen on receipt;

n) curing conditions since receipt;

o) time of test (if appropriate);

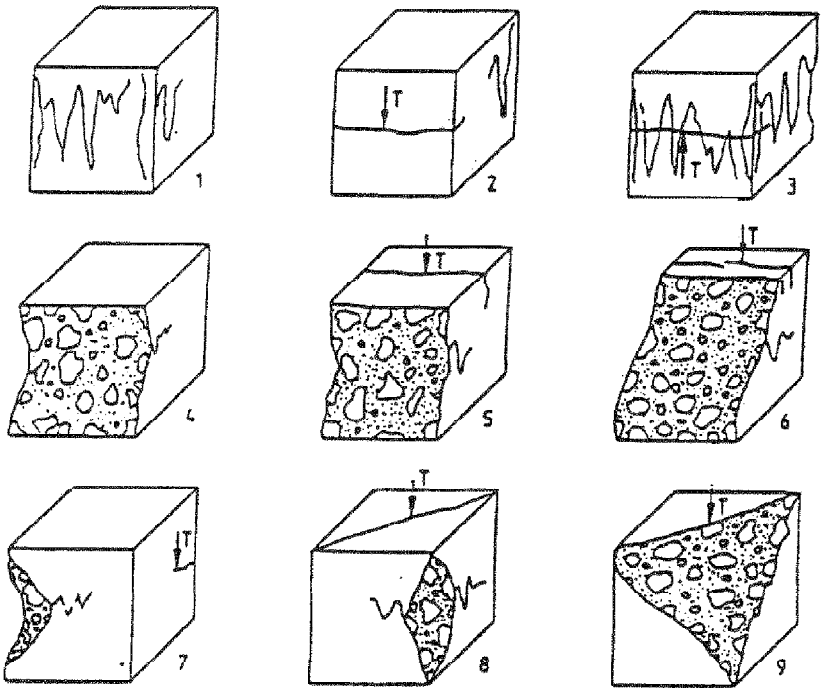
p) age of specimen at time of test.



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**

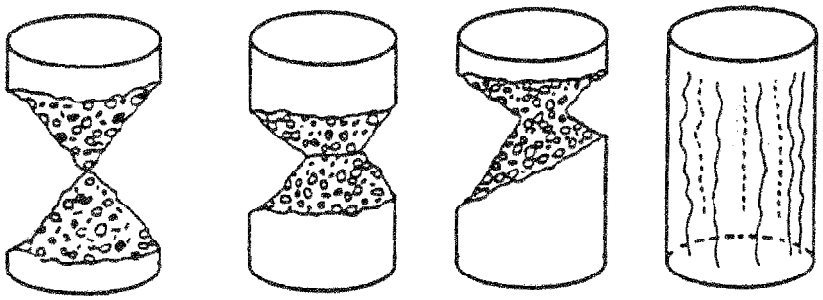


Figure 3 — Satisfactory failure of cylinder specimen

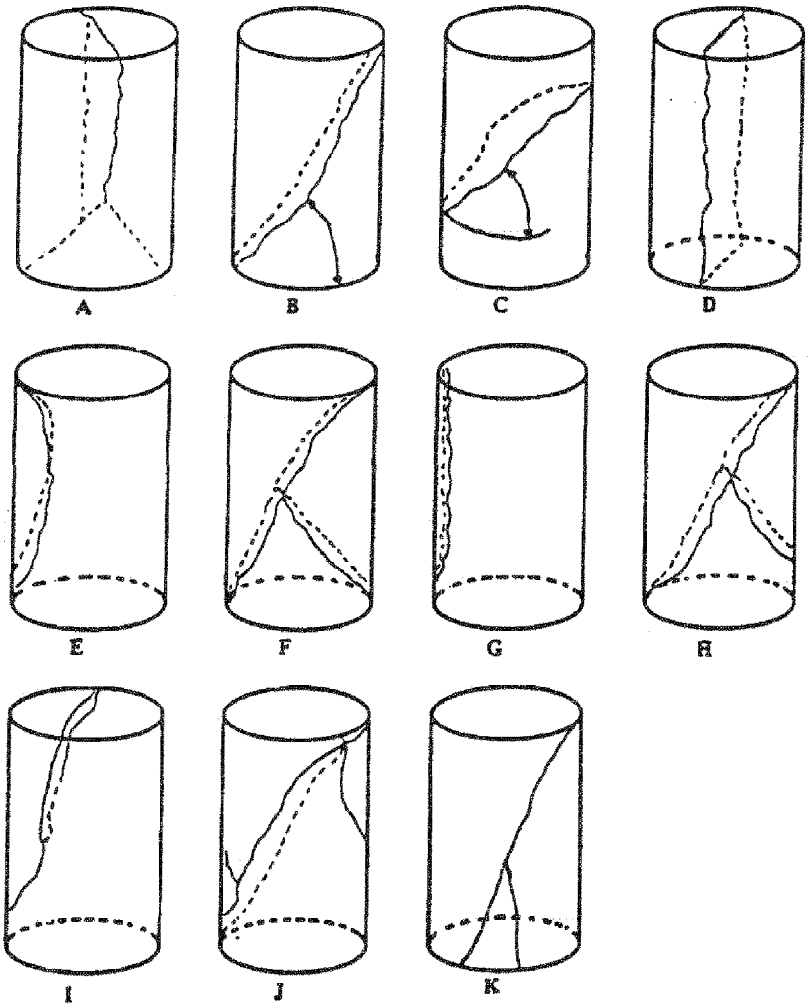



Figure 4 — Some unsatisfactory failures of cylinder specimens

## 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 in the UK as part of an experiment carried out in 1987, in which precision data were obtained for several of the tests described in the series BS 1881. The concretes were made using an ordinary Portland cement, Thames Valley sand, and Thames Valley 10 mm and 20 mm coarse aggregates. Hand compaction was used.

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.

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 on to 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.

— The steel shall have a yield strength of at least 900 MPa ($N/mm^2$).

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

— 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:

— 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;

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

— a mechanical system for locking the sand box against the stops;

— a system to clamp the specimen against the specimen guide;

— 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;

— 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.

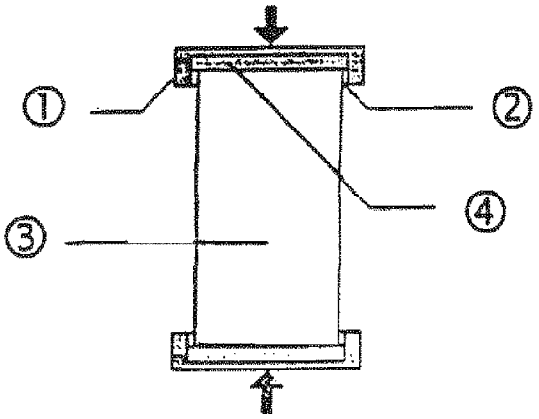
When transporting the specimen, support it by the bottom box.

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.**

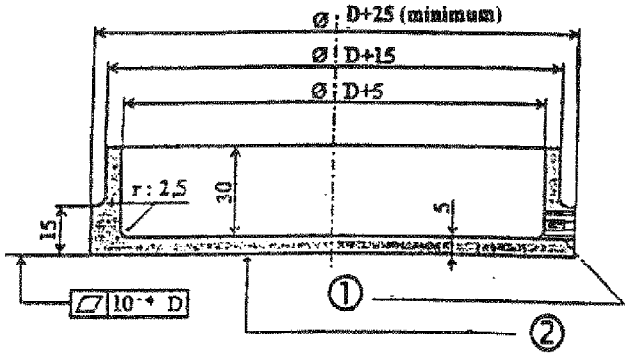
Dimensions in millimetres




**Key**

1 Box
2 Paraffin
3 Specimen
4 Sand

**Figure A.1 — Capping: Sandbox method**




**Key**

1 Opening for form release
2 Surface in contact with plate

**Figure A.2 — Detail of sandbox**

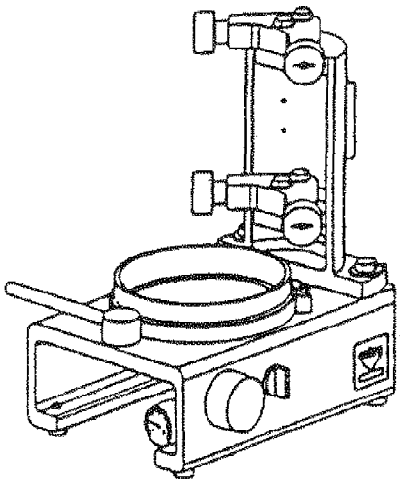


**Figure A.3 — Positioning frame**

# 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

Calipers 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** Three measurements of dimensions are made (see figures B.1 and B.2) in each of the orthogonal directions ($x$, $y$, $z$), to an accuracy of 0,5 % of the dimensions. If any dimension is greater, or less than, 2 % 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 form the six measurements in each direction on the loading faces and expressed to an accuracy of 0,5 % of the dimension.

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

### 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, 2 % 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 0,5 % of the dimension.

**B.3.2.3** The average 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 % of the area.

### 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.

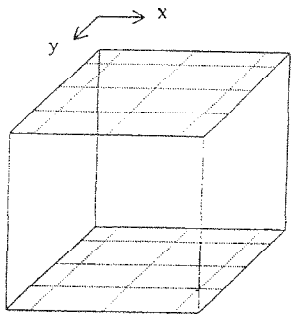



**Figure B.1 — Dotted lines showing measuring positions for the loading faces of cubes**

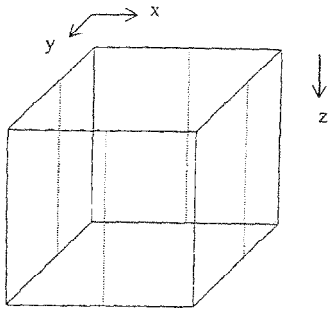



**Figure B.2 — Dotted lines showing measuring positions for the non-loaded faces of cubes**

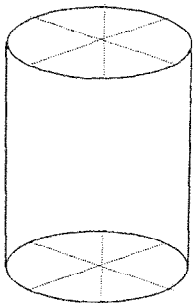


**Figure B.3 — Dotted lines showing the measuring positions for the ends of a cylinder**

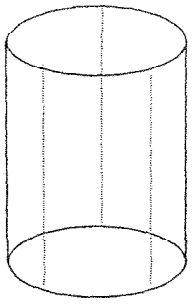


**Figure B.4 — Dotted lines showing the measuring positions for the height of a cylinder**

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