BRITISH STANDARD

BS EN
12504-1:2009

Testing concrete in structures

Part 1: Cored specimens — Taking, examining and testing in compression

ICS 91.100.30

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 12504-1:2009. It supersedes BS EN 12504-1:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/517/1, Concrete production and testing.

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

Guidance on the use of BS EN 12504-1:2009 is included in National Annex NA (informative).

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Essais pour béton dans les structures - Partie 1: Carottes - Prélèvement, examen et essais en compression

Prüfung von Beton in Bauwerken - Teil 1: Bohrkernproben - Herstellung, Untersuchung und Prüfung der Druckfestigkeit

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Foreword

This document (EN 12504-1:2009) 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of an identical text or by endorsement, at the latest by August 2009, and conflicting national standards shall be withdrawn at the latest by August 2009.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 12504-1:2000.

It is recognized good practice to include measurement of density prior to the determination of compressive strength, as a check on compaction of the concrete.

In drafting the standard consideration has been given to the results of the research programme, part funded by the EC under the Measurement and Testing Programme, contract MAT1-CT94-0043.

The standard includes simple guidance on the process of taking cores, but does not consider a sampling plan. It also provides procedures for visual examination and compressive strength testing, but not the interpretation of the results.

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

This series EN 12504 includes the following parts:

EN 12504 Testing concrete in structures

Part 1: Cored specimens - Taking, examining and testing in compression;

Part 2: Non-destructive testing - Determination of rebound number;

Part 3: Determination of pull-out force;

Part 4: Determination of ultrasonic pulse velocity.

The following amendments have been made to the 2000-03 edition of this standard:

— editorial revision

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

— 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 taking cores from hardened concrete, their examination, preparation for testing and determination of compressive strength.

NOTE 1 This European Standard does not give guidance on the decision to drill cores or on the locations for drilling.

NOTE 2 This European Standard does not provide procedures for interpreting the core strength results.

NOTE 3 For the assessment of in-situ compressive strength in structures and precast concrete components EN 13791 may be used.

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

EN 12390-3:2009, *Testing hardened concrete - Part 3: Compressive strength of test specimens*

EN 12390-4:2000, *Testing hardened concrete - Part 4: Compressive strength - Specification for testing machines*

EN 12390-7, *Testing hardened concrete - Part 7: Density of hardened concrete*

3 Principle

Cores extracted using a core drill are carefully examined, prepared by grinding or capping and tested in compression using standard procedures.

4 Apparatus

4.1 Core drill, equipment capable of extracting cores from the hardened concrete to the dimensions set out in 5.4 to the tolerances set out in 7.3

4.2 Compression testing machine, conforming to EN 12390-4 and related to the size of specimens and their expected failure load

NOTE Concrete compression testing machines conforming to EN 12390-4 may need to be adapted to test cores. (see the Foreword of EN 12390-4:2000).

4.3 Balance or scale, capable of determining the mass of the core, as tested, to an accuracy of 0,1 % of the mass

4.4 Callipers and/or rules, capable of measuring the dimensions of the core and the steel reinforcement to an accuracy of 1 %.

4.5 Gauge, capable of establishing that the relevant flatness of the specimen is within the requirements of 7.3.a)

4.6 Squares and gauges (or other means), capable of establishing that the perpendicularity and straightness of specimens are within the requirements of 7.3.b) and 7.3.c)

5 Taking cores

5.1 General

The ratio of the maximum aggregate size in the concrete to the diameter of the core has a significant influence on the measured strength when it approaches values greater than about 1:3.

It is essential that full consideration is given to the aims of the testing and the interpretation of the data, before deciding to drill cores.

NOTE Informative Annex A provides information on the effect of aggregate size and core diameter on the strength of core specimens.

5.2 Location

Consider any structural implications resulting from taking a core prior to drilling.

NOTE Cores should preferably be taken at points away from joints or edges of the concrete element and where there is little or no reinforcement.

5.3 Drilling

Unless otherwise specified, drill the cores perpendicular to the surface in such a manner as not to damage the cores. Keep the drill rigidly positioned during coring.

5.4 Length of cores

In deciding the length of cores to be taken for strength testing, take into account:

a) the diameter of the core;

b) the possible method of adjustment;

c) whether comparison is to be made with cube strength or cylinder strength.

5.5 Marking and identification

Immediately after drilling, clearly and indelibly mark each core. Record its location and orientation within the element from which it has been drilled. If a core is subsequently cut to produce a number of specimens, mark each specimen to indicate its position and orientation within the original core.

5.6 Reinforcement

Drilling through reinforcement shall be avoided wherever possible. Ensure that cores for determination of compressive strength do not contain any reinforcing bars in, or close to, the direction of the longitudinal axis.

If transverse reinforcement is encountered, record its diameter and position in mm.

6 Examination

6.1 Visual inspection

Carry out a visual examination of the cored specimen to identify any abnormalities.

If required, an estimation of the cores' voidage shall be made by reference to standard documentation or by comparison to a reference concrete of known voidage.

6.2 Measurements

Measurements shall be as follows:

a) core diameter dm shall be measured to within 1 %, from pairs of measurements taken at right angles, at the half and quarter points of the length of the core.

b) core length, the maximum and minimum lengths shall be measured to 1 % as received and the length after completion of the end preparation, in accordance with Clause 7.

c) reinforcement, the diameter [size] of any reinforcement shall be measured and the position, measuring from the centre of the exposed bar to the end(s) and/or axis of the core, both as received and after end preparation. Measurement shall be to the nearest mm.

If it is required to determine the density of the core, this shall be determined in accordance with the procedures given in EN 12390-7 prior to capping the ends of the core.

NOTE All measurements should be recorded.

7 Preparation of cores

7.1 General

Prepare the ends of cores for compression tests in accordance with Annex A of EN 12390-3:2009.

7.2 Length diameter/ratios

The preferred length diameter/ratios are:

a) 2,0 if the strength result is to be compared to cylinder strength;

b) 1,0 if the strength result is to be compared to cube strength.

7.3 Tolerances

Prepare the specimen to within the following tolerances:

a) for flatness, the tolerance for the end surfaces prepared by grinding or capping, using high alumina cement or sulphur, shall conform to EN 12390-1.

b) for perpendicularity, the tolerance for the prepared ends, with respect to the side, shall comply with EN 12390-1.

c) for straightness, the tolerance on the generating line of the core shall be 3 % of the average core diameter.

NOTE If other smaller diameter cores are tested then the tolerances above should be considered with regard to their adequacy and narrowed if necessary: for example, reduced in proportion to the actual specimen diameter to l00 mm.

8 Compression test

8.1 Storage

Record the storage condition(s) of the specimen.

If it is required to test the specimen in a saturated condition, soak in water at (20 ± 2) °C for at least 48 h before testing.

8.2 Testing

Carry out the testing in accordance with EN 12390-3 using a compression testing machine conforming to EN 12390-4. (see the Note to 4.2).

Do not test cores with cracked, hollow, or loose caps.

Remove any loose sand or other material on the surface of the specimen.

If the specimen is to be tested whilst it is still wet, remove any surface water.

Record the surface moisture condition (wet/dry) of the specimen at the time of test.

9 Expression of results

Determine the compressive strength of each specimen by dividing the maximum load by the cross-sectional area, calculated from the average diameter and express the result to the nearest 0,1 MPa (N/mm^2).

10 Test report

The report shall include:

a) description and identification of the test specimen;

b) estimated maximum size of aggregate;

c) date of coring;

d) visual inspection, noting any abnormalities identified;

e) reinforcement (when appropriate): diameter, in mm, position(s) in mm;

f) method used for the preparation of specimen(cutting, grinding, or capping);

g) length and diameter of the core as received;

h) length/diameter ratio of prepared specimen;

i) surface moisture condition at time of test;

j) date of performance of test;

k) core compressive strength, to nearest 0,1 MPa (N/mm^2);

l) any deviations from the standard method of examination or compression testing;

m) a declaration by the person responsible for the examination and testing that these were carried out in accordance with the standard except as detailed in item l).

The report may include:

n) mass of the specimen, in kg;

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

p) condition of the specimen on receipt;

q) curing conditions since receipt;

r) time of test (if appropriate);

s) age of specimen at time of test;

t) other relevant information e.g. voidage.

11 Precision

No estimate of repeatability or reproducibility is given with this test, but it is likely to be inferior to that for standard cast specimens.

Annex A
(informative)

The effect of aggregate size and core diameter on core specimen strength

Experiments, where cores of 25 mm, 50 mm and 100 mm diameters containing aggregates of maximum sizes 20 mm and 40 mm were tested showed that:

a) for 20 mm aggregate:
   100 mm diameter cores were approximately 7 % stronger than 50mm diameter cores; 50 mm diameter cores were approximately 20 % stronger than 25mm diameter cores;

b) 40 mm aggregate:
   100 mm diameter cores were approximately 17 % stronger than 50 mm diameter cores; 50 mm diameter cores were approximately 19 % stronger than 25 mm diameter cores.

NOTE The above data is based on the results of the research programme, part funded by the EC under the Measurement and Testing Programme, contract MAT1-CT94-0043.

Bibliography

[1] EN 13791: 2007, Assessment of in-situ compressive strength in structures and precast concrete components

National Annex NA (informative)
Guidance on the use of BS EN 12504-1

NA.1 General

Prior to taking core specimens from a structure it is important that both the aims of the investigation and the way in which the data is to be interpreted are established. Guidance on the interpretation of these test data is given in BS EN 13791 and BS 6089[1].

The results of any tests carried out on the core specimens will give an in-situ compressive strength of the concrete that, for assessment purposes, needs to be converted into an equivalent in-situ cube or cylinder strength. The formulae provided in this National Annex NA give suitable correction factors for transverse reinforcement and core dimensions. These specific corrections need to be applied if the objective of the investigation is to determine the in-situ compressive strength expressed as either an in-situ cube or cylinder strength.

The core result, even after being corrected for transverse reinforcement, core dimensions or excess voidage, will not be comparable with the cube strength of the concrete supplied to the construction works by the concrete supplier; even when the specimen was sampled in accordance with BS EN 12350-1, made in accordance with BS EN 12390-2 or tested in accordance with BS EN 12390-3.

If an estimate of the characteristic compressive strength of standard test specimens as used in the original structural design is needed, further corrections not covered in this National Annex NA have to be applied, and consultation with BS EN 13791 and BS 6089 is needed. The assessment of core specimen test data is not an alternative to conformity testing in accordance with BS EN 206-1.

NA.2 Precision
NA.2.1 General

BS EN 12504-1 gives no information on the repeatability or reproducibility of the compression test, and instead refers us to BS EN 12390-3 for this. The process of capping the cores is also contained in BS EN 12390-3, which gives four different methods; grinding, calcium aluminate cement capping, sulfur mixture capping, and the sandbox method. The calcium aluminate and sulfur mixture methods are restricted to concretes where the core strength is not expected to exceed 50 MP (N/mm^2). For cores greater than this value, test results are likely to be unpredictable. There is little experience of the sandbox method within the UK. Grinding is considered to be the most reliable method for all concretes.

NA.2.2 Repeatability of in-situ strength from cores results
NA.2.2.1 Capped by grinding

Analysis of 528 sets of 4 cores[2], which were all prepared by grinding in the same laboratory, indicates the standard deviation achieved was 1.9 MPa (N/mm^2) or 5.2 % of the mean (coefficient of variation). Therefore, the repeatability is ~14 % (95 % confidence limits). In comparison with the standard deviation and repeatability of normally cured cylinders of 2.9 % and 8.0 % respectively, as given in BS EN 12390-3, this suggests cores capped using grinding to be at least twice as variable.

NOTE Information on the repeatability or reproducibility of the other capping methods is not available.

NA.3 Correction factors to derive the in-situ cube or cylinder strength

The following formulae give corrections for core dimensions and the presence of transverse reinforcement to give the in-situ cube or cylinder strength. These specific corrections need to be applied if the objective of the investigation is to determine the in-situ compressive strength. If the limitations on core location given in BS 6089 are applied, an adjustment for the direction of drilling is not appropriate.

[1] Currently at the public comment stage
[2] The Concrete Society, (2004), *In situ concrete strength. An investigation into the relationship between core strength and standard cube strength*, The Concrete Society, Camberley, UK

In order to express the in-situ compressive strength as in-situ cube or cylinder strength, adjustments are applied for the length/diameter ratio (λ). It is essential that the following equation is used for this factor. The correction factors (K_{is}) are valid for cores with a λ value of between 1.0 and 1.2 for in-situ cube strength determination and between 1.6 and 2.4 for in-situ cylinder strength determination.

Correction factors (K_{is}) for the core dimensions are given by:

$$K_{is,\,cube} = \frac{2.5}{1.5 + 1/\lambda} \qquad [NA.1]$$

$$K_{is,\,cyl} = \frac{2.0}{1.5 + 1/\lambda} \qquad [NA.2]$$

λ = length/diameter ratio of the core.

Cores containing reinforcing bars should be avoided wherever possible by the use of cover meters when deciding where to cut the cores. It is essential that corrections for the influence of transverse reinforcing bars are made using the following formulae:

Correction factor for a single bar:

$$K_s = 1.0 + 1.5\left(\frac{\varphi_r \times}{\varphi_c \times}\right) \qquad [NA.3]$$

Where

φ_r = diameter of the bar
φ_c = diameter of the core
h = distance of axis of bar from the nearer end of core
L = length of core

Correction factor for multiple bars:

$$K_s = 1.0 + 1.5\left(\frac{\sum(\varphi_r \times h)}{\varphi_c \times L}\right) \qquad [NA.4]$$

NOTE For two bars which are no further apart at their closest point than the diameters of the larger bar, only the bar corresponding to the higher value of (φr x h) needs to be included

The corrected in-situ cube or cylinder strength ($f_{is\ corr,\ cube\ or\ cyl}$) is calculated by applying the corrections given above to the actual core strength.

$$f_{is\ corr,\ cube\ or\ cyl} = K_{is,cube\ or\ cyl} \times K_s \times \text{actual core strength} \qquad [NA.5]$$

This value may be used for assessing the structural integrity and no further corrections are required. When reporting the core strength, both the actual test result and corrected value should be reported.

NA.4 Corrections for excess voidage

NA.4.1 Estimating excess voidage

Although it is not the purpose of BS EN 12504-1, an estimate for excess voidage of the fully compacted in-situ core strength may be necessary. Fully compacted concrete, for example, in a well made standard test specimen, will always have some entrapped air, typically ~0.5 %. In an actual structure, the compaction is such that there is likely to be some excess voids over that found in a test specimen made from the concrete supplied to that structure. This excess voidage will have reduced the measured core strength of the concrete relative to a normal test specimen. An estimate of the excess voidage can be made by comparing the core sample against photographs and/or by calculations based on concrete density.

NA.4.2 A method of estimating excess voidage by visual means

The excess voidage of the core may be estimated by comparing the number and size of the voids exposed on the drilled surface of the air-dry core with those displayed in Figure NA.1(a) to (e). These are 125 x 80 mm actual-size photographs of the surface of the cores having known actual voidages, and hence inferable excess voidages, as shown in Table NA.1.

Table NA.1 — Excess voidage associated with Figure NA.1(a) to (e)

Figure	Excess Voidage (%)
NA.1(a)	0
NA.1(b)	0.5
NA.1(c)	1.5
NA.1(d)	3
NA.1(e)	13

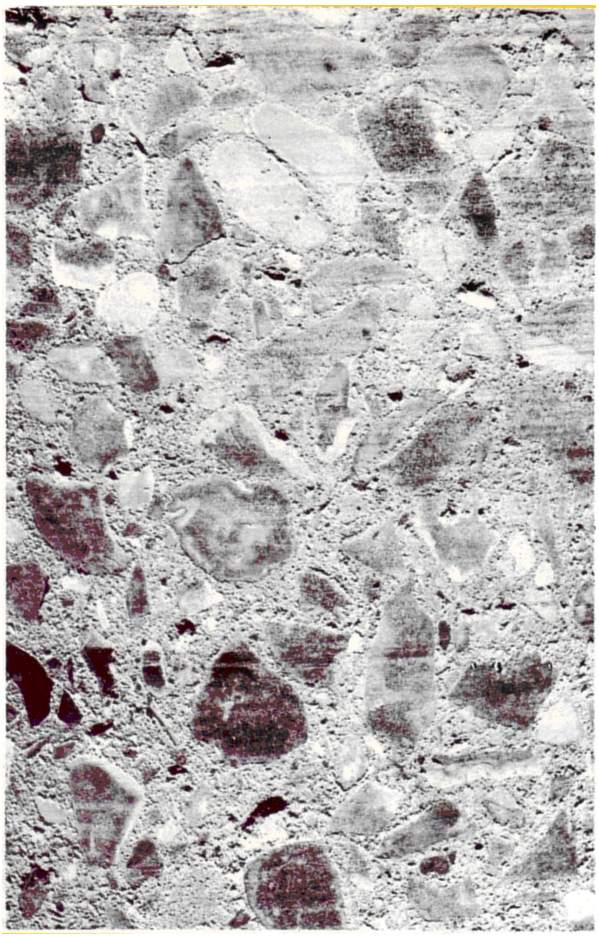
The comparison of the surface voids of a given core with those shown in Figure NA.1(a) to (e) should always be made by two observers in order to avoid extremes of subjective bias. Care should be taken to ensure that the voids are viewed in strong light angled to highlight them with shadows (as in Figure NA.1(a) to (e)). The recommended procedure for the comparison is as follows:

a) cut a 125 x 80 mm rectangular aperture in a piece of thin card;
b) place the card on the core with elastic bands;
c) assess the excess voidage of the area of core in view by comparing it with Table NA.1 and record the assessment;
d) move the card to another area and repeat the assessment until the cylindrical face of the core has been surveyed representatively;
e) average the individual assessments and record the result to the nearest multiple of 0.5 %.

NOTE 1 Where the relative frequencies of small and large voids on the test core differ from those shown in Table NA.1, estimation of the excess voidage may be facilitated by remembering that a void of a given diameter (or linear dimension) is equal in volume to eight voids having only half that diameter (or linear dimension).

NOTE 2 Where a photographic record of the air-dry core is required, the centre of the photo¬graph should include the 125 x 80 mm area that has an estimated excess voidage nearest to the average for the whole core. The lighting should also be such that a photograph comparable in quality to Figure NA.1 is obtained, and the photograph should be reproduced to actual-size.

NOTE 3 It should be noted that when counting the voids, the number and size of the voids are to be expressed as 'per 100,000 mm^2 of cut face', which is ten times the area of each individual area surveyed by using the method described in this subclause (**NA.4.2**).

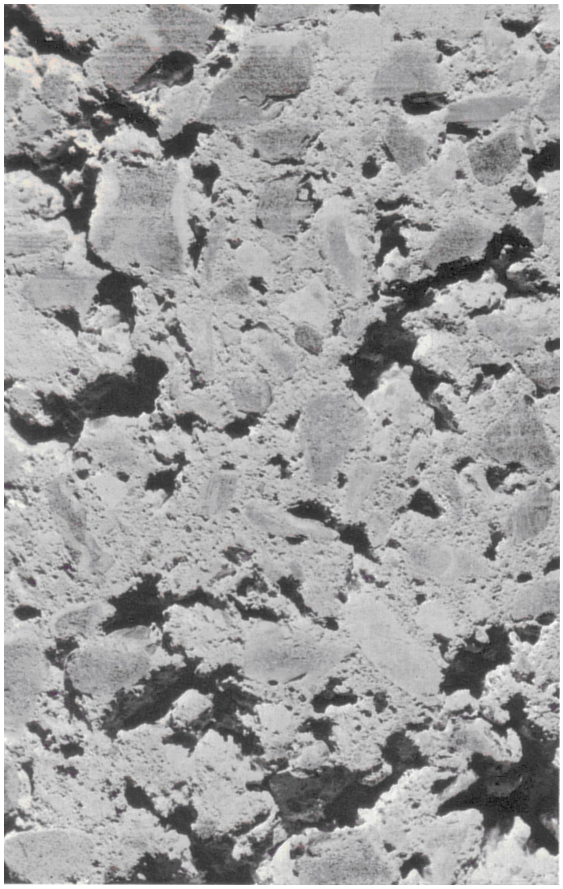


(a) Excess voidage = 0

(b) Excess voidage = 0.5 %

(c) Excess voidage = 1.5 %

(d) Excess voidage = 3 %



(e) Excess voidage = 13 %

Figure NA.1(a) to (e) — Actual-size photographs of cores of different voidages, masked (in each case) to give a standard area of 125 mm x 80 mm

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*(*Complementary guidance to that given in BS EN 13791*)*
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BS EN 12350-1, *Testing fresh concrete — Sampling*
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The Concrete Society, (2004), *In situ concrete strength. An investigation into the relationship between core strength and standard cube strength,* The Concrete Society, Camberley, UK

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