BRITISH STANDARD

BS EN
1052-1:1999

Methods of test for masonry —

Part 1: Determination of compressive strength

The European Standard EN 1052-1:1998 has the status of a British Standard

ICS 91.080.30

National foreword

This British Standard is the English language version of EN 1052-1:1998. It is intended that it will partially supersede BS 5628, *Code of practice for use of masonry*, BS 5628-1:1992, *Structural use of unreinforced masonry*, the equivalent masonry test method of which will be withdrawn on 30 September 2000 if all of the European Standards included in the proposed package of standards, upon which EN 1052-1 is reliant, are available.

The UK participation in its preparation was entrusted by Technical Committee B/519, Masonry and associated testing, to Subcommittee B/519/4, Tests, 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.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 8, an inside back cover and a back cover.

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English version

Methods of test for masonry — Part 1: Determination of compressive strength

Méthodes d'essai de la maçonnerie — Partie 1: Détermination de la résistance à la compression

Prüfverfahren für Mauerwerk — Teil 1: Bestimmung der Druckfestigkeit

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 1052-1:1998 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 125, Masonry, the Secretariat of which is held by BSI.

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 March 1999, and conflicting national standards shall be withdrawn at the latest by September 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports the essential requirements of the EU Construction Products Directive (89/106/EEC) and includes the performance requirements referred to in the Eurocode for masonry structures.

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.

Contents

1 Scope

This European Standard specifies a method for determining the compressive strength of masonry. Guidance is given on the preparation of the specimens, the conditioning required before testing, the testing machine, the method of test, the method of calculation and the contents of the test report.

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.

prEN 772-1, *Methods of test for masonry units — Part 1: Determination of compressive strength.*

prEN 772-10, *Methods of test for masonry units — Part 10: Determination of moisture content of calcium silicate and autoclaved aerated concrete masonry units.*

prEN 998-2, *Specification for mortar for masonry — Part 2: Masonry mortar.*

prEN 1015-3, *Methods of test for mortar for masonry — Part 3: Determination of consistence of fresh mortar (by flow table).*

prEN 1015-7, *Methods of test for mortar for masonry — Part 7: Determination of air content of fresh mortar.*

prEN 1015-11, *Methods of test for mortar for masonry — Part 11: Determination of flexural and compressive strength of hardened mortar.*

3 Principle

The compressive strength of masonry perpendicular to the bed joints is derived from the strength of small masonry specimens, tested to destruction. The materials, construction and bonding pattern should correspond to those used in practice.

The specimens are loaded uniformly in compression. The maximum load ($F_{\max}$) achieved is recorded. The characteristic compressive strength of the masonry is derived from the strengths of the individual specimens.

If the units, or the mortar, do not achieve the exact strengths specified, then it is permissible to adjust the measured values in accordance with annex A within the specified range. Any such adjustment should be clearly indicated in the test report.

4 Definitions and symbols

4.1 Definitions

For the purpose of this standard the following definitions apply.

4.1.1

masonry

an assemblage of masonry units laid in a specified bonding pattern and jointed together with mortar

4.1.2

compressive strength of masonry

the strength of masonry in compression without the effects of loading restraint, slenderness or eccentricity of loading

4.2 Symbols

A_i	is the loaded cross-section of an individual masonry specimen, (mm^2)
E	is the mean modulus of elasticity, (N/mm^2)
E_i	is the modulus of elasticity of an individual masonry specimen, (N/mm^2)
$F_{i,\max}$	is the maximum load reached on an individual masonry specimen, (N)
f	is the mean compressive strength of the masonry, (N/mm^2)
f_i	is the compressive strength of an individual masonry specimen, (N/mm^2)
$f_{i,\min}$	is the smallest compressive strength of an individual masonry specimen, (N/mm^2)
f_{id}	is the adjusted individual masonry compressive strength, (N/mm^2)
$f_{id,\min}$	is the smallest adjusted compressive strength of an individual masonry specimen, (N/mm^2)
f_k	is the characteristic compressive strength of the masonry, (N/mm^2)
f_b	is the mean compressive strength of masonry units at the time of the masonry test, (N/mm^2)
f_{bd}	is the specified mean compressive strength of the masonry units, (N/mm^2)
f_d	is the mean adjusted compressive strength of the masonry, (N/mm^2)
f_m	is the mean compressive strength of the mortar at time of the masonry test, (N/mm^2)
f_{md}	is the specified mean compressive strength of the mortar, (N/mm^2)
h_s	is the height of the specimen, (mm)
h_u	is the height of the masonry unit, (mm)
l_s	is the length of the specimen, (mm)
l_u	is the length of the masonry unit, (mm)
t_s	is the thickness of the specimen, (mm)
t_u	is the width of the masonry unit, (mm)
ε_i	is the mean strain in an individual masonry specimen at one third of the maximum strength achieved.

5 Material

5.1 Masonry units

5.1.1 *Sampling*

All of the masonry units for individual tests and for making the masonry specimens shall be taken from the same consignment.

5.1.2 *Conditioning of the units*

The conditioning of masonry units shall be as specified:

Record the method of conditioning the units prior to laying. Record the age of non-autoclaved concrete units at the time of testing the masonry specimens. Measure the moisture content by mass of autoclaved aerated concrete and calcium silicate masonry units in accordance with prEN 772-10.

5.1.3 *Testing*

Determine the compressive strength of a sample of masonry units, using the method given in prEN 772-1.

NOTE Where the strength of the masonry units will change with time, the compressive strength test should be carried out on the same day as the masonry test.

5.2 Mortar

The mortar, its mixing procedure and its flow value shall conform with the requirements of prEN 998-2, unless otherwise specified, and these shall be reported in the test report.

Take samples of mortar from the mason's board to make mortar specimens and determine the flow value of fresh mortar in accordance with prEN 1015-3, the air-content of the fresh mortar in accordance with prEN 1015-7 and the compressive strength of mortar in accordance with prEN 1015-11 at the time of testing the masonry specimens.

6 Apparatus

A testing machine that will apply load to a specimen such that displacements are uniform across the loaded surfaces. If the platens of the testing machine are shorter than the specimen to be tested, loading beams having a length greater than the length of the specimen and a depth greater than or equal to the length beyond the edge of the platens shall be used. The testing machine shall be fitted with a self-locking ball-seating.

Table 1 — Requirements for testing machines

Maximum permissible repeatability of forces as percentage of indicated force %	Maximum permissible mean error of forces as percentage of indicated force %	Maximum permissible error of zero force as percentage of maximum force of range %
2,0	±2,0	±0,4

7 Preparation of specimens

7.1 Masonry specimens

Use at least three specimens having the sizes given in Table 2 and Figure 1.

If the expected height of the specimen in accordance with Table 2 is greater than 1 000 mm, it is allowable to reduce the dimensions of the specimen (except for those made with units having perforations perpendicular to the direction of loading) by cutting the units used to make the bottom and the top courses provided that.

a) $l_s \geq 400$ mm and $l_s \geq l_u$.

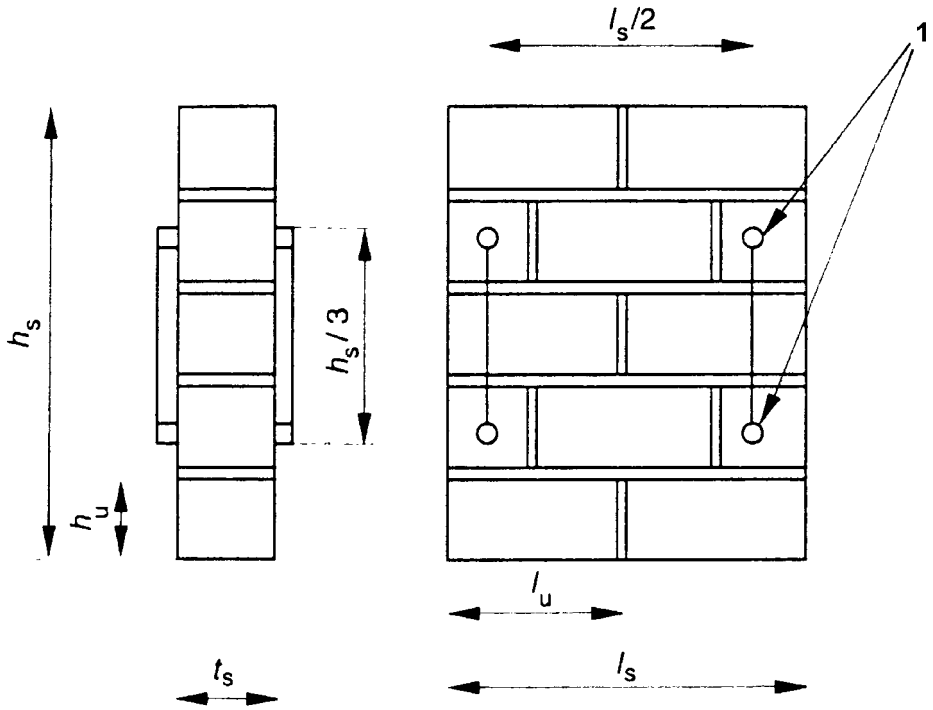
b) The specimens include at least one head joint in the central course centrally placed.

c) The height of the cut portions of the units in the top and bottom courses is not less than the thickness of the specimen (t_s).

d) The original faces of the units shall be used for mortar joints.

Table 2 — Small specimen sizes for testing the compressive strength of masonry

Face size of unit		Masonry specimen size			
		Length	Height		Thickness
l_u (mm)	h_u (mm)	l_s	h_s		t_s
≤ 300	≤ 150	≥ ($2 \times l_u$)	≥ $5h_u$	≥ 3 t_s and ≤ $15t_s$ and ≥ l_s	≥ t_u
	> 150		≥ $3h_u$		
> 300	≤ 150	≥ ($1{,}5 \times l_u$)	≥ $5h_u$		
	> 150		≥ $3h_u$		



1 Displacement measurements

Figure 1 — Masonry specimen

7.2 Construction and curing of the specimens

Build the specimens on a flat horizontal surface. Take appropriate steps to prevent the test specimens from drying out during the first three days after construction e.g. by covering them with polyethylene sheets, after which time leave them uncovered in a laboratory environment.

Ensure that the load distribution faces of the specimens are flat and parallel to one another and at right angles to the main axis of the specimen. This may be achieved for example by using steel plates, at the top and the bottom of the specimen, which have been milled flat on the machine side together, if necessary, with a thin compensating layer of a suitable material e.g. gypsum plaster or an appropriate mortar. If each plate is not applied at the same time as the specimen is built, e.g. when the specimen is put into the testing machine, the mortar used for this purpose shall achieve at least the same strength as the mortar in the masonry at the time the masonry is tested.

Test the specimens at an age at which the mortar compressive strength falls within the range of values given in column 3 of Table 3. Determine the compressive strength of the mortar in accordance with prEN 1015-11 at the age at which the specimens are tested.

Alternatively if the masonry specimens are to be tested at a set time, e.g. 28 days, the strength of the mortar shall be determined at that age of testing.

8 Procedure

8.1 Placing the specimens in the testing machine

Place the specimen centrally in the testing machine. Ensure that both the top and bottom of the specimen are in full contact with the testing machine, if necessary using a thin compensating layer.

8.2 Loading

Apply the load uniformly to the top and bottom of the specimen. Increase the load steadily so that failure is reached after 15 min to 30 min from the commencement of loading.

NOTE The loading rate required in order that failure occurs in the recommended time depends on the strength of the masonry concerned. The time taken to fail the first specimen tested will be a guide as to the required rate. As a guide, rates will vary from about 0,15 N/(mm^2·min) for low strength units to 1,25 N/(mm^2·min) for high strength units.

Table 3 — Permissible ranges of mortar strength within which masonry may be tested

Mortar class	Specified compressive strength (f_{md}) N/mm^2	Mean compressive strength at time of testing (f_m) N/mm^2
M1	1,0	$1,0 \leq f_m < 2,5$
M2,5	2,5	$2,5 \leq f_m < 5,0$
M5	5,0	$5,0 \leq f_m < 7,5$
M7,5	7,5	$7,5 \leq f_m < 10,0$
M10	10,0	$10,0 \leq f_m < 12,5$
M12,5	12,5	$12,5 \leq f_m < 15,0$
M15	15,0	$15,0 \leq f_m < 20,0$
M20	20,0	$20,0 \leq f_m < 30,0$
M30	30,0	$30,0 \leq f_m < 40,0$

If the modulus of elasticity is to be determined, proceed as follows: the masonry specimens shall be fitted with measuring devices as shown in Figure 1 in order to measure the change in height. Apply the compressive force in at least 3 equal steps until half the probable maximum force is attained. After each step, the compressive force shall be kept constant for 2 min ± 1 min in order to determine the changes in height. After completion of the measurements of the last step, increase the compressive force at a constant rate until failure. If measuring devices are available that can measure the displacement whilst applying the force continuously, select the constant loading or displacement rate so that the maximum force is attained after 15 min to 30 min.

8.3 Measurements

Record the following:

— the dimensions of the loaded cross-section of the specimen with an accuracy of ±1 mm;

— the maximum load $F_{i,\max}$ in Newtons to the nearest 1 kN;

— the load at which visible cracks occur;

— the length of time from the start of loading until the maximum load is achieved.

If the modulus of elasticity is to be determined, displacement measurements with an accuracy on the strains of $\pm 25 \times 10^{-6}$ shall be taken at the four measuring points shown in Figure 1 up to about 50 per cent of the maximum load.

9 Calculations

9.1 Expression of strength results

Calculate the compressive strength of each masonry specimen to the nearest 0,1 N/mm^2, using the following formula:

$$f_i = \frac{F_{i,\max}}{A_i} \qquad \text{N/mm}^2 \qquad (1)$$

9.2 Expression of modulus of elasticity results

Calculate the modulus of elasticity E_i as a secant modulus from the mean of the strains of all four measuring positions occurring at a stress equal to one third of the maximum stress achieved

$$E_i = \frac{F_{i,\max}}{3 \times \varepsilon_i \times A_i} \qquad \text{N/mm}^2 \qquad (2)$$

10 Evaluation of results

10.1 Mean compressive strength

Calculate the mean compressive strength (f) of the masonry specimens to the nearest 0,1 N/mm^2. Where the compressive strength of the masonry units and of the mortar at the time of testing deviate from the specified values the test results shall be converted in accordance with annex A.

10.2 Characteristic compressive strength

Calculate the characteristic compressive strength of masonry, to the nearest 0,1 N/mm^2, from a) or b), whichever is the greater:

a) $f_k = f/1,2$ or $f_k = f_{i,\min}$ N/mm^2 (3)
whichever is the smaller;
or using adjusted values as calculated from annex A
$f_k = f_d/1,2$ or $f_k = f_{id,\min}$ N/mm^2 (4)
whichever is the smaller.

b) When there are five specimens or more calculate the 5 % fractile value based on a confidence level of 95 %.

10.3 Mean modulus of elasticity

When required, calculate the mean modulus of elasticity E to the nearest 100 N/mm^2.

11 Test report

The test report shall contain the following information:

a) the number, title and date of issue of this European Standard;

b) name of the testing laboratory;

c) number of specimens;

d) date of building the specimens;

e) curing conditions (time, temperature, humidity);

f) date of testing the specimens;

g) description of the specimens, including dimensions, number of courses, loaded cross-sectional area, bonding pattern of the specimen in the testing machine;

h) description of the masonry units and the mortar (to include also details of the mortar mixing procedure, flow value, air content and compressive strength), preferably consisting of the appropriate test reports, or of extracts taken from these reports;

i) age of non-autoclaved concrete units at the time of testing the masonry;

j) moisture content by mass of autoclaved aerated concrete and calcium silicate units or, for other types of unit, the method of conditioning prior to the time of laying;

k) maximum loads reached by the test specimens;

l) the length of time from the start of loading until the maximum load is achieved;

m) mean compressive strength of the masonry units in N/mm^2 to the nearest 0,1 N/mm^2 and the coefficient of variation;

n) mean compressive strength of the mortar in N/mm^2 to the nearest 0,1 N/mm^2 and the coefficient of variation, at the time of testing the masonry;

o) individual values of the compressive strength of the masonry specimens in N/mm^2 to the nearest 0,1 N/mm^2;

p) mean and characteristic compressive strength of the masonry in N/mm^2 to the nearest 0,1 N/mm^2;

q) statistical treatment of the results where relevant;

r) adjusted values of mean and characteristic strength of masonry (if appropriate);

s) stress in N/mm^2 at which the first visible crack occurred;

t) mean and individual values for the modulus of elasticity in N/mm^2 (where specified) to the nearest 100 N/mm^2;

u) remarks, if any.

Annex A (normative)

Adjustment of mean compressive strength

If the compressive strength of the masonry units, and/or the mortar, at the time of masonry testing deviate from the specified strengths of the masonry units (f_{bd}) or mortar (f_{md}), then the masonry compressive strength determined from the testing shall be converted to the equivalent masonry strength relevant to the specified unit and mortar strengths using the following equation:

$$f_{id} = f_{\mathrm{i}} \times \left(\frac{f_{bd}}{f_b}\right)^{0,65} \times \left(\frac{f_{md}}{f_m}\right)^{0,25}$$

Calculate f_d as the mean of the individual values f_{id}.

Conversion of compressive strength values for units shall only be carried out when the tested mean strength of the units is within $\pm 25\,\%$ of the specified strength and the mortar strength falls within the range given in Table 3 and the mortar is of the general purpose type.

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