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Contents

Page

Foreword ... v

1 Scope ... 1

2 Normative references ... 1

3 Principle ... 1

4 Terms and definitions ... 1

5 Symbols (and abbreviated terms) ... 1
5.1 Definitions ... 1
5.2 Symbols ... 1

6 Materials ... 2
6.1 Masonry units ... 2
6.1.1 Conditioning of the units ... 2
6.1.2 Testing ... 2
6.2 Mortar ... 3

7 Apparatus ... 3

8 Preparation of specimens ... 3
8.1 Masonry specimens ... 3
8.2 Construction and curing of the specimens ... 4

9 Procedure ... 4
9.1 Placing the specimens in the testing equipment ... 4
9.2 Loading ... 4
9.3 Measurements and observations ... 6
9.4 Replications ... 7

10 Calculations ... 7

11 Evaluation of results ... 7

12 Test report ... 8

Annex A (normative) Determine the compressive strength of a sample of masonry units ... 10
A.1 Procedures ... 10
A.1.1 Placing specimen in the testing machine ... 10
A.1.2 Loading ... 10
A.2 Calculation and expression of results ... 11
A.3 Evaluation of the results ... 11

Annex B (normative) Determination of moisture content of calcium silicate and autoclaved aerated concrete units ... 12
B.1 Principle ... 12
B.2 Symbols ... 12
B.3 Apparatus ... 12
B.4 Preparation of specimens ... 12
B.5 Test procedure ... 12
B.6 Calculation and expression of results ... 12
B.7 Evaluation of results ... 13

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Annex C (normative) Determination of consistence of fresh mortar (by flow table) ... 14
C.1 Principle ... 14
C.2 Apparatus ... 14
C.3 Sampling, preparation and storage of test samples ... 14
C.4 Procedure ... 15
C.5 Calculation and expression of results ... 15

Annex D (normative) Determination of air content of fresh mortar ... 16
D.1 Principle ... 16
D.2 Symbols ... 16
D.3 Apparatus ... 16
D.3.1 5.1 Apparatus for Method A — Pressure method ... 16
D.3.2 Apparatus for Method B — Alcohol method ... 16
D.3.3 Materials for method B — Alcohol method ... 17
D.4 Sampling, preparation and storage of test samples ... 17
D.5 Method A — Pressure method ... 17
D.5.1 Applicability ... 17
D.5.2 Operational principle ... 17
D.5.3 Procedure ... 18
D.5.4 Calculation and expression of results ... 18
D.6 Method B — Alcohol method ... 18
D.6.1 General ... 18
D.6.2 Procedure ... 18
D.6.3 Calculation and expression of results ... 19

Annex E (normative) Determination of flexural and compressive strength of hardened mortar ... 20
E.1 Principle ... 20
E.2 Definitions and symbols ... 20
E.2.1 Definitions ... 20
E.2.2 Symbols ... 20
E.3 Apparatus ... 20
E.4 Sampling ... 21
E.5 Preparation and storage of test specimens ... 21
E.5.1 General ... 21
E.5.2 Preparation ... 22
E.5.3 Storage and curing conditions ... 23
E.6 Determination of flexural strength ... 23
E.6.1 Apparatus ... 23
E.6.2 Procedure ... 24
E.6.3 Calculation and expression of results ... 25
E.7 Determination of compressive strength ... 25
E.7.1 Apparatus ... 25
E.7.2 Procedure ... 26
E.7.3 Calculation and expression of results ... 26

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Foreword

Rwanda Standardsarepreparedby Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS539 was prepared by Technical Committee RSB/TC 9, *Civil engineering and Building materials.*

In the preparation of this standard, reference was made to the following standard:

BS EN 1052-2:1999 Methods of test for masonry — Part 2: Determination of flexural strength

The assistance derived from the above source is hereby acknowledged with thanks.

Committee membership

The following organizations were represented on the Technical Committee on *Civil engineering and Building materials*(RSB/TC 9) in the preparation of this standard.

A+Construction Group Ltd

Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

D&D Resources Ltd

Dutureheza Ltd

Enabel Rwanda

Greenpack Africa Ltd

Integrated Polytechnic Regional Centre (IPRC) - Musanze

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Method of test for masonry — Determination of flexural strength

1 Scope

This Draft Rwanda Standard specifies a method for determining the flexural strength of small masonry specimens for the two principal axes of loading. 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

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

There are no normative references.

3 Principle

The flexural strength of masonry is derived from the strength of small specimens tested to destruction under four-point loading. The maximum load achieved is recorded. The characteristic value, calculated from the maximum stresses achieved by the samples is considered to be the flexural strength of the masonry

4 Terms and definitions

For the purposes of this standard, the terms and definitions given in DRS 546 apply.

5 Symbols (and abbreviated terms)

5.1 Definitions

4.1.1 Masonry. An assemblage of masonry units laid in a specified pattern and jointed together with mortar.

4.1.2 Flexural strength of masonry. The strength of masonry in pure bending assuming a linear stressdistribution of internal stresses.

5.2 Symbols

b is the height or width of a masonry specimen perpendicular to the direction of span, (mm)

$F_{i, max}$ is the maximum load applied to an individual masonry specimen, (N)

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f_{xi} is the flexural strength of an individual masonry specimen, (N/mm2) fmean is the mean flexural strengthof the masonry specimens, (N/mm2) fxk is the characteristic flexural strength of masonry, (N/mm2)

h_u is the height of masonry unit, (mm)

k is the numerical factor

l_s is the length of a masonry specimen in the direction of span, (mm)

l_u is the length of masonry unit, (mm)

l_1 is the spacing of the outer bearings, (mm)

l_2 is the spacing of the inner bearings, (mm)

n is the number of specimens

s is the standard deviation of the log values

t_u is the width of masonry unit, (mm)

6 Materials

6.1 Masonry units

6.1.1 Conditioning of the units

The conditioning of masonry units shall be as specified:

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

6.1.2 Testing

Determine the compressive strength of a sample of masonry units, using the method given in Annex A . For non-autoclaved concrete units determine the compressive strength at the time of testing the masonry specimens.

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6.2 Mortar

Take representative samples of fresh mortar from the mason's board to make mortar prisms, to determine the flow value in accordance with Annex C , and to determine the air content in accordance with Annex D . Use the prism specimens to determine the mean compressive strength at the time of testing of the masonry specimens.

7 Apparatus

A testing machine complying with the requirements given in table 1, and accommodating variations of plane. The testing machine shall have adequate capacity but the scale used shall be such that the ultimate load on the specimen exceeds one fifth of the full-scale reading. The machine shall be provided with a load pacer or equivalent means to enable the load to be applied at the rate specified.

The bearings shall be designed to ensure that contact is provided over the full width of the masonry, for example by using a hollow rubber bolster of at least 7 mm wall thickness and a 10 mm bore containing an 8 mm diameter steel rod.

Table1:Requirementsfortestingmachines

Maximum permissible repeatabilityofforcesas percentage of indicated force	Maximum permissible meanerrorofforcesas percentageofindicated force	Maximum permissible error of zero force as percentageofmaximum force of range
2,0	±2,0	±0,4

8 Preparation of specimens

8.1 Masonry specimens

For each of the two principal axes of loading use at least five specimens according to figure 1 having the sizes given in table 2. The size of the masonry specimens shall be chosen so that the distance between the inner and outer bearings shall be not less than the thickness of the masonry specimen. The thickness of the specimen shall be equal to tu unless otherwise specified.

Table2:Specimensizesfortestingtheflexuralstrengthofmasonry

Direction	h_u (mm)	b (mm)	Additional conditions
Flexuralstrengthforaplaneof failure parallel to the bed joints	any	≥400and ≥1,5l_u	minimum2bedjointswithin l_2
Flexural strength for a plane of failure perpendicular to the bed joints	≤250	≥240and ≥3h_u	minimum 1 head joint every course within l_2

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	>250	≥1000	minimum1bedjointandminimum 1headjointeverycoursewithin l_2

8.2 Construction and curing of the specimens

Build the specimens within 30 min after completion of the conditioning of the units, using mortar mixed not more than one hour beforehand unless the mortar is designed to be used over a more prolonged period. Construct the specimens to the bond specified. Do not allow the work to be interrupted before completion.

Immediately after building, pre-compress each specimen using a uniformly distributed mass to give a vertical stress between 25 · 10-3 N/mm2 and 5.0 · 10-3 N/mm2; then cure the specimens, and maintain them undisturbed until testing. For other than lime-based mortar prevent the test specimens from drying out during the curing period by close covering with polyethylene sheet , andmaintain the specimens undisturbed until testing unless otherwise specified. Test each specimen at an age of 28 days ± 1 day, unless otherwise specified, and determine the compressive strength of the mortar at the same age, following EN 1015-11. For lime-based mortars an alternative curing regime and period may be necessary and this should be specified.

9 Procedure

9.1 Placing the specimens in the testing equipment

Test the masonry specimen in the vertical attitude under four-point loading (see figure 1). The distance between the outer bearings and the end of the specimen shall be greater than or equal to 50 mm. The distance between the inner bearings may be varied to suit the format of the masonry but shall be 04 to 0,6 times the spacing of the outer bearings. The inner bearings shall be located so that they are, as far as practicable, midway between the nearest mortar joints which are parallel to the bearings.

Ensure that the base of each masonry specimen is free from frictional restraint, for example by setting it on two layers of polytetrafluoroethylene with grease between them or on ball, needle or roller bearings.

9.2 Loading

Increase the flexural stress at a rate between 003 N/mm2/min and 03 N/mm2/min.

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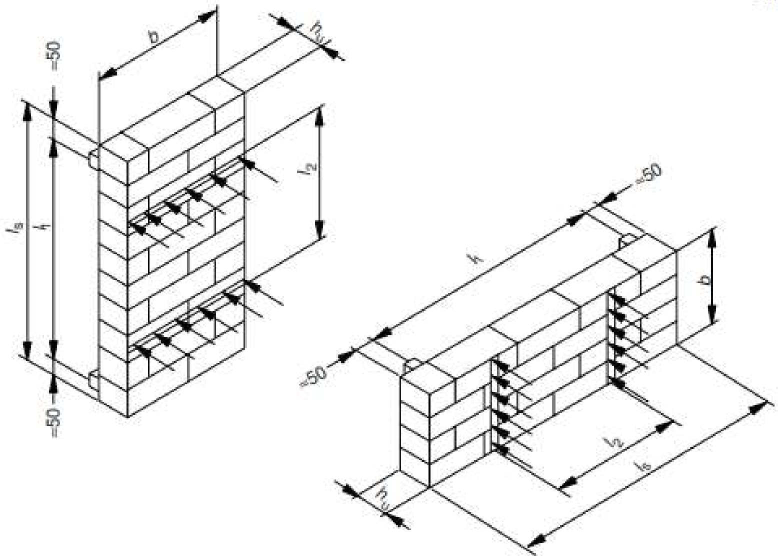
Dimensions in millimetres



a)

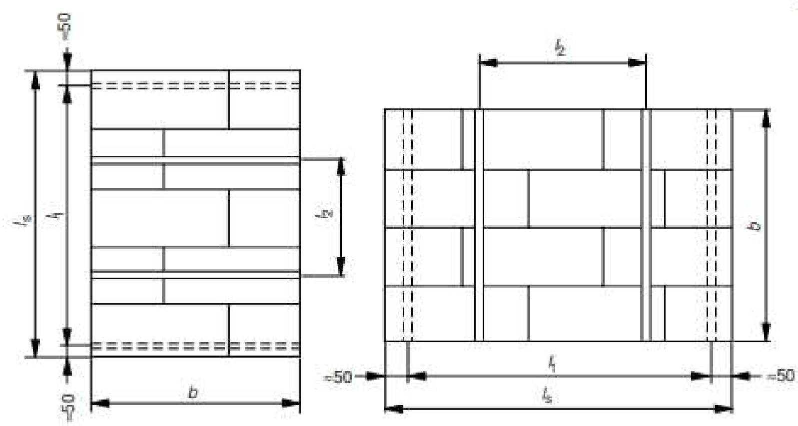
$b \approx 2l_u$ and $b \geq 400$ mm and $h_u \leq 250$ mm and more than two bed joints in l_2

Flexural strength for a plane of failure parallel to the bed joints

$b \approx 4h_u$ and $b \geq 240$ mm and $h_u \leq 250$ mm and a minimum of one head joint in l_2

Flexural strength for a plane of failure perpendicular to the bed joints

Dimensions in millimetres



b)

$b \approx 1{,}5l_u$ and $b \geq 400$ mm and $h_u \leq 250$ mm and two bed joints in l_2

Flexural strength for a plane of failure parallel to the bed joints

$b \approx 4h_u$ and $b \geq 240$ mm and $h_u \leq 250$ mm and a minimum of one head joint in l_2

Flexural strength for a plane of failure perpendicular to the bed joints

Figure 1 : Typical examples of masonry test specimens meeting the requirements of table 2

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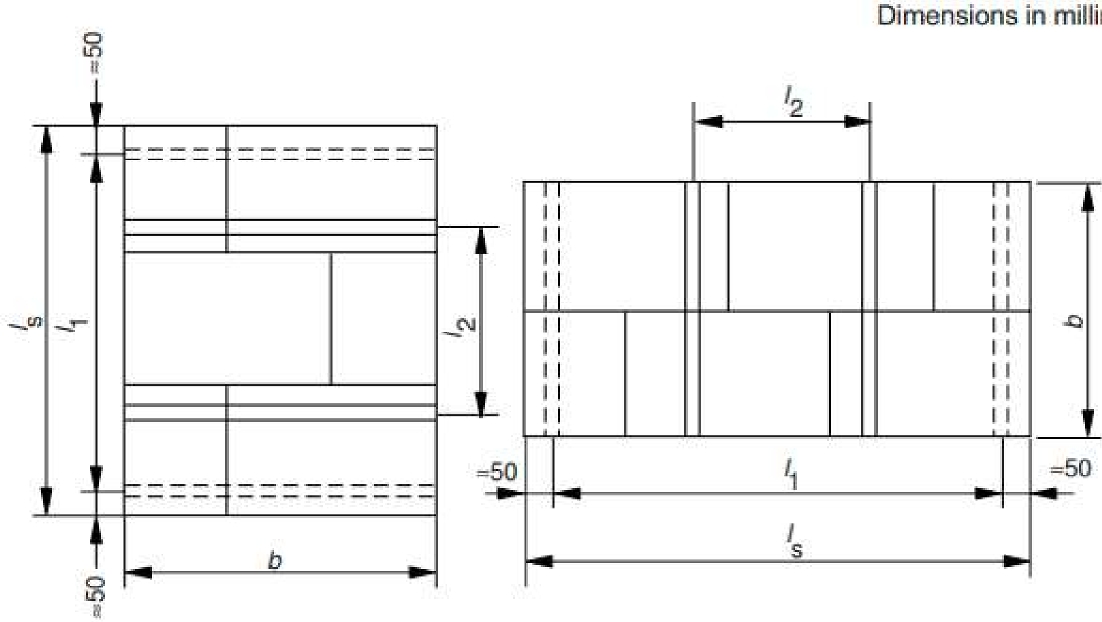
Dimensions in millimetres



$b \approx 1{,}5 l_u$ and $b \geq 400$ mm and two bed joints in l_2

Flexural strength for a plane of failure parallel to the bed joints

$b \geq 1000$ mm and $h > 250$ mm and one head joint and one bed joint in l_2

Flexural strength for a plane of failure perpendicular to the bed joints

Figure 1 (concluded) : Typical examples of masonry test specimens meeting the requirements of table 2

9.3 Measurements and observations

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Record the following:

- age of non-autoclaved concrete units,
- the dimensions of the cross section of the specimen parallel to the bearings, to the nearest 1 mm,
- the spacing of the outer and of the inner bearings, in mm,
- the maximum load $F_{i,max}$ to the nearest 10 N. Discard any result where failure does not occur between the inner bearings,
- the length of time from the start of loading until the maximum load is achieved,
- crack patterns.

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9.4 Replications

If less than five results are obtained in which failure occurs between the inner bearings, further tests shall be carried out until five valid results are obtained.

10 Calculations

Calculate the flexural strength of each specimen, to the nearest 0,01 N/mm^2, using the following formula :

$$f_{xi} = \frac{3F_{i,max}(l_1 - l_2)}{2btu^2} \text{N/mm}^2$$

Calculate the mean flexural strength (f_{mean}) to the nearest 0,01 N/mm^2.

11 Evaluation of results

Calculate the characteristic flexural strength to the nearest 0.01 N/mm^2 from a) or b)

a) $f_{xk} = f_{mean}/1{,}5$ for five specimens

b) f_{x1}, f_{x2} f_{x3}, ... f_{xn} for more than 5 specimens

calculate the values y_1, y_2, y_3, ... y_n, from $y_n = \log_{10} f_{xn}$, and y_{mean} from $y_{mean} = \sum y_n / n$.

Then $y_c = y_{mean} - k.s$,

where

s is the standard deviation for the n log values

k is a function of n, given in table 3

n is the number of individual specimens

Table 3 : Relationship between *n* and *k*

n	*k*
6	2,18
7	2,08
8	2,01
9	1,96
10	1,92

Take the characteristic flexural strength to be:

$f_{xk} = anti\log_{10}(y_c)$ N/mm^2 to the nearest 0,01 /mm^2.

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12 Test report

The test report shall contain the following information:

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

b) name of the testing laboratory;

c) number of specimens tested in each direction;

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, bonding pattern and spacing of the bearings;

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 load 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 001 N/mm2

n) and the coefficient of variation;

o) mean compressive strength of the mortar in N/mm2 to the nearest 001 N/mm2 and the coefficient of variation, at 28 days ± 1 day;

p) individual values for the flexural strengths, of the masonry specimens in N/mm^2 to the nearest 001 N/mm^2, with notes on any unusual form of failure ;

q) mean and characteristic flexural strength of masonry in N/mm^2 to the nearest 001 N/mm^2;

r) statistical treatment of the results where relevant;

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s) crack patterns;

t) remarks, if any.

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Annex A
(normative)

Determine the compressive strength of a sample of masonry units

A.1 Procedures

A.1.1 Placing specimen in the testing machine

Wipe the bearing surfaces of the testing machine (6.1) clean and remove any loose grit from the bed faces of the specimen. Align the specimen carefully with the centre of the ball-seated platen so that a uniform seating is obtained. Units with a single frog shall be placed with the frog uppermost. Units with a frog in both bed faces shall be placed with the larger frog uppermost.

Do not use any packing material except for units intended to be face-shell bedded or strip-bedded and which have been prepared by grinding. In such cases position four stiff steel strips (6.3), the same width as the face-shells and 50 mm longer, two at the top and two at the bottom, overlapping equally at each end.

A.1.2 Loading

Initially, use any convenient rate of loading but, when about half the expected maximum load has been applied, adjust the rate so that the maximum load is reached in not less than approximately 1 min. **Table 2** is given as a guide to choosing appropriate loading rates.

Record the maximum load achieved.

Table 3 — Loading rate

Table 2: Loading rate

Expected compressive strength (N/mm^2)	Loading rate ($(N/mm^2)/s$)
< 10	0,05
11 to 20	0,15
21 to 40	0,3
41 to 80	0,6
>80	1,0

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NOTE: With some specimens, the applied load may fluctuate several times before maximum failure load is reached. This will be indicated by a reduction in load as the specimen yields followed by an increase to a new maximum as loading is continued. This temporary reduction may occur several times before the specimen finally fails.

A.2 Calculation and expression of results

Calculate the strength of each specimen by dividing the maximum load achieved by its loaded area, which is the gross area for units intended to be laid on a full bed of mortar, to be face-shell or strip-bedded and those containing frogs not intended to be filled in practice, or in accordance with **7.4.2** in other cases, and express it to the nearest 0,1 N/mm^2.

A.3 Evaluation of the results

Calculate the compressive strength as the mean value of the strength of the individual specimens to the nearest 0,1 N/mm^2.

Calculate the coefficient of variation of the sample.

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Annex B
(normative)

Determination of moisture content of calcium silicate and autoclaved aerated concrete units

B.1 Principle

After drying to constant mass, the moisture content is calculated as the ratio of the loss of mass during drying to the mass after drying.

B.2 Symbols

w_s is the moisture content, in percentage by mass;

$m_{o,s}$ is the mass of specimen before drying, in grams;

$m_{dry,s}$ is the mass of specimen after drying, in grams.

B.3 Apparatus

5.1 Ventilated oven, capable of maintaining a temperature of (105 ± 5) 8C.

5.2 Weighing instrument, capable of weighing specimens to an accuracy of at least 0,1 % of their mass.

B.4 Preparation of specimens

Take a representative sample of no fewer than six units. For units with lengths $ 500 mm and/or heights $ 300 mm, take no fewer than six representative portions cut from at least three units.

B.5 Test procedure

Before drying, weigh the test specimens (mo,s). Dry the test specimens at a temperature of (105 ± 5) 8C, to constant mass. Constant mass is reached if, during the drying process, in two subsequent weighings with a 24 h interval, the loss in mass between the two determinations is less than 0,2 % of the total mass.

After drying to constant mass, weigh the specimens (mdry,s).

B.6 Calculation and expression of results

Calculate the moisture content (ws) of the specimen from the ratio of the loss in mass during drying to the dry mass, expressed as a percentage to the nearest 0,5 %:

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$$w_s = \frac{m_{o,s} - m_{dry,s}}{m_{dry,s}} \times 100$$

B.7 Evaluation of results

Calculate the mean value of the moisture content of the specimens to the nearest 1 %

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Annex C
(normative)

Determination of consistence of fresh mortar (by flow table)

C.1 Principle

The flow value is measured by the mean diameter of a test sample of the fresh mortar which has been placed on a defined flow table disc by means of a defined mould, and given a number of vertical impacts by raising the flow table and allowing it to fall freely through a given height.

C.2 Apparatus

4.1 A flow table, as described in Annex A, consisting of the following main parts:

— stand;

— rigid table plate and disc;

— horizontal shaft and lifting cam;

— lifting spindle.

4.2 A truncated conical mould, made of stainless steel or brass, 60 mm ± 0.5 mm in height and with internal diameter of 100 mm ± 0.5 mm at the bottom and 70 mm ± 0.5 mm at the top. The inside surface and the edges of the mould are smooth. The planes containing the top and bottom edges are at right angles to its axis. The minimum thickness of the mould wall is 2.0 mm.

4.3 A tamper, consisting of a rigid, non-absorptive rod of circular cross-section, approximately 40 mm in diameter and approximately 200 mm long. The tamping face is flat and at right angles to the length of the tamper. The mass of the tamper is 0. 250 kg±0.015 kg.

4.4 Calipers, capable of measuring diameters up to 300 mm with an accuracy of 1 mm.

4.5 Trowel.

4.6 Palette knife.

C.3 Sampling, preparation and storage of test samples

The fresh mortar for this test shall have a minimum volume of 1.5 l and shall be obtained by reduction of the bulk test sample using a sample divider or by quartering. Ready to use mortars (factory-made wet mortars which are retarded), and pre-batched air-lime/sand wet mortars when not gauged with hydraulic binders, shall be tested within their specified workable life. Mortars that are made from dry constituents and water shall be mixedunless otherwise specified.

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The length of the mixing period shall be measured from the moment all the constituents are introduced into the mixer.

Before testing, the batch shall be gently stirred by hand using a trowel or palette knife in 5 – 10 seconds to counteract any false setting etc., but without any additional mixing of the batch.

Any deviation from the mixing procedure shall be noted.

Two test samples shall be tested.

C.4 Procedure

Before each test, wipe the disc and the inner surface and edges of the mould clean with a damp cloth and let it dry. If the table has not been used within the last 24 h, operate it for ten revolutions before use.

Place the mould centrally on the disc of the flow table and introduce the mortar in two layers, each layer being compacted by at least 10 short strokes of the tamper to ensure uniform filling of the mould.

During filling, hold the mould firmly on the disc, using one hand.

Skim off the excess mortar with a palette knife and wipe the free area of disc clean and dry, being especially careful to remove any water from around the bottom edge of the mould. After approximately 15 s, slowly raise the mould vertically and spread out the mortar on the disc by jolting the flow table 15 times at a constant frequency of approximately one per second.

Measure the diameter of the mortar in two directions at right angles to one another using calipers. State the results in mm to the nearest mm.

C.5 Calculation and expression of results

Calculate the mean value of the two measurements. This mean value is the flow value for the test sample. If the individual flow values from the two test samples deviate from their mean value by less than 10 %, use this mean value as the flow value of the mortar. If the two individual flow values deviate from their mean value by more than 10 %, repeat the test using further mortar from the reduced bulk test sampleand if the results deviate from the mean value by less than 10 % use the mean value from the repeat test as the flow value of the mortar. If the results differ by more than 10 % consider the measurements unsatisfactory and take fresh test samples from the bulk test sample or laboratory prepared mortar and repeat the test.

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Annex D
(normative)

Determination of air content of fresh mortar

D.1 Principle

A volume of mortar is placed into a specified measuring vessel. Water is introduced on top of the mortar surface, and by means of applied air-pressure or the use of an alcohol-water mix water is forced into the mortar displacing air from within any pores. The water level falls and reflects the volume of air displaced from the mortar.

D.2 Symbols

*L*air content of mortar (%);

$V_{m,i}$initial volume of mortar (ml);

$V_{m,f}$final volume of mortar plus alcohol (ml).

D.3 Apparatus

D.3.1 5.1 Apparatus for Method A — Pressure method

D.1.1 Sample container and cover assembly, comprising a metal bowl (sample container) with a capacity of approximately 1 litre, fitted with a metal cover assembly to which is attached a sealed air chamber (pressure chamber). A pressure gauge for measurement of the applied air pressure is connected to it.

D.1.2 Tamper, consisting of a rigid, non-absorptive rod of circular cross-section, approximately 40 mm in diameter and approximately 200 mm long. The tamping face is flat and at right angles to the length of the tamper. The mass of the tamper is 0.250 kg ± 0.015 kg.

D.1.3 Trowel.

D.1.4 Palette knife.

D.3.2 Apparatus for Method B — Alcohol method

D.2.1 Graduated measuring cylinder, with a capacityof 500 ml and approximately 50 mm in diameter.

D.2.2 Rubber bung, fitting the measuring cylinder.

D.2.3 Funnel, fitting the measuring cylinder.

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D.2.4 Trowel.

D.3.3 Materials for method B — Alcohol method

Mixture of ethyl alcohol, 60 % by volume, and water,40 % by volume.

D.4 Sampling, preparation and storage oftest samples

The fresh mortar for this test shall have a minimumvolume of 1.5 1 or at least 1.5 times the quantity neededto perform the test, whichever is the greater, and shalleither be obtained by reduction of the bulk test sampleusing a sample divider or by quarteringor by preparation from dry constituents and water inthe laboratory. The flow value of the mortar in the bulktest sample shall be determined and reported.

Laboratory mixed samples shall be brought to a definedflow value before testing.

Ready to use mortars (factory-made wet mortars whichare retarded), and pre-batched air-lime/sand wetmortars when not gauged with hydraulic binders, shallbe tested within their specified workable life.

The length of mixing period shall be measured fromthe moment all the constituents are introduced into themixer.

Before testing, the batch shall be gently stirred by handusing a trowel or palette knife in 5 to 10 s to counteract any false setting etc., butwithout any additional mixing of the batch.

Any deviation from the mixing procedure shall be noted.

Two test samples shall be tested.

D.5 Method A — Pressure method

D.5.1 Applicability

This method shall only be used for mortars withdeclared air contents of less than 20 %.

D.5.2 Operational principle

A specified pressure is applied in the closed apparatus bymeans of a hand pump or compressed air line through avalve connection at the top of the apparatus. The coverassembly is fitted with air valves, air bleedervalves, and valves for bleeding off water or throughwhich water may be introduced as necessary for theparticular meter design. The cover has machined smoothinterior surfaces contoured to provide an air space abovethe top level of the sample container.

1) This information is contained in the certificate of sampling.

The operational principle of this meter consists ofequalizing a known volume of air at a known pressurein a sealed air chamber with the unknown volume ofair in the mortar sample container, the two chambersbeing

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connected through an air valve. The lowered airpressure in the air chamber reflects the air content ofthe mortar sample and is read from the dial on thepressure gauge, which is calibrated in terms ofpercentage of air for the observed pressure at whichequalization takes place.

D.5.3 Procedure

Fill the bowl completely with mortar in fourapproximately equal layers, each layer beingcompacted by 10 short strokes with the tamper (5.1.2),evenly distributed to give a flat mortar surface.

Using the palette knife skim off the excess mortar,leaving the mortar surface plane and level with the topedge of the bowl.

Wipe the outside of the bowl clean and dry and clampthe cover securely in place on the bowl.

Close the main air valve between the air chamber andthe sample container (see annex A). Fill the air spaceunder the cover and above the mortar with waterthrough valve A, keeping valve B open until all the airabove the mortar surface is expelled.

Pump air into the sealed air chamber until a stabilized pressure is reached equal to that determined in the calibration test (see annex A). Close both valves A and B and open the valve between the air chamber and the sample container. When equilibrium is reached read the air content from the calibrated pressure gauge or from a calibration curve. Record this value to the nearest 0.1 %.

D.5.4 Calculation and expression of results

Calculate the air content as the mean value from the two individual values of each mortar test sample rounded to the nearest 0.5 %. If the two individual values deviate more than 10 % from their mean value, repeat the test with two additional test samples taken from the reduced bulk test sample, in which case use the individual and mean values of the two additional samples.

D.6 Method B — Alcohol method

D.6.1 General

This method shall only be used for mortars with declared air contents of 20 % or more.

D.6.2 Procedure

Fill the measuring cylinder (5.2.1) with approximately 200 ml of mortar using the funnel (5.2.3), taking care to avoid creating voids in the mortar. Tap the measuring cylinder to level the mortar surface and record the mortar volume, V_m,i, to the nearest ml. Pour the mixture of alcohol and water carefully into the measuring cylinder up to the 500 ml mark.

Seal the measuring cylinder with the rubber bung and invert 20 times to obtain a complete dispersion of the mortar in the alcohol-water mixture. Let the mixture settle for 5 min and read the resulting surface level, V_m,f, to the nearest ml. Repeat this process until two consecutive readings do not differ by more than 1 ml.

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D.6.3 Calculation and expression of results

Calculate the air content, L, of each mortar sample from the following formula to the nearest 0.1 %.

$$L = \frac{(500 - V_{m,f})}{V_{m,i}} \times 100\,\%$$

Calculate the mean value of the two measurements tothe nearest 0.5 %. If the two individual air contentvalues deviate from their mean value by less than 10 %,use the mean value as the air content of the mortar. Ifthe two individual values deviate from their meanvalue by more than 10 %, repeat the test using furthermortar from the reduced bulk test sample(see clause 6) and if the results deviate from theirmean value by less than 10 % use the mean value fromthe repeat test as the air content of the mortar. If theresults differ by more than 10 % consider themeasurements unsatisfactory and take fresh testsamples from the bulk test sample or laboratoryprepared mortar and repeat the test.

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Annex E
(normative)

Determination of flexural and compressive strength of hardened mortar

E.1 Principle

The flexural strength of mortar is determined by three point loading of hardened moulded mortar prism specimens to failure. The compressive strength of the mortar is determined on the two parts resulting from the flexural strength test. Where the flexural strength is not required, the parts for compressive strength testing can be produced from the prisms in any way which does not lead to these parts being damaged.

E.2 Definitions and symbols

E.2.1 Definitions

air-lime[1)]

limes mainly consisting of calcium oxide or hydroxide which slowly harden in air by reacting with atmospheric carbon dioxide. Generally, they do not harden under water as they have no hydraulic properties

E.2.2 Symbols

F is the maximum load applied to the specimen, in Newtons (N).

l is the distance between the axes of the support rollers, in millimetres (mm).

b is the width of specimen in millimetres (mm).

d is the depth of the specimen in millimetres (mm).

E.3 Apparatus

E.3.1 Metal moulds, consisting of an open frame of removable walls forming three compartments whenassembled (see Figure 1 for typical design and annex A for a detailed description).

E.3.2 A tamper, consisting of a rigid, non-absorptive rod of square cross-section, each side of which is 12 mm ± 1 mm. The tamping face is flat and at right angles to the length of the tamper. The mass of the tamper is 50 g ± 1 g.

E.3.3 Storage chambers, capable of maintaining a temperature of 20 8C ± 2 8C and a relative humidity of 95 % ± 5 % or 65 % ± 5 %.

E3.4 A clamp, enabling the assembled mould frame to be kept together at right angles.

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E.3.5 White cotton gauze, four sheets each with a size of approximately 150 mm 3 175 mm.

E.3.6 Absorbent filter paper, with a specific mass of 200 g/m2 ± 20 g/m2 and water absorption capacity of 160 g/m2 ± 20 g/m2; twelve sheets each with a size of approximately 150 mm ± 175 mm.

E.3.7 Polyethylene bags, capable of containing the steel moulds.

E.3.8 Two glass plates, of sufficient area to cover the steel mould.

E.3.9 A palette knife.

E.3.10 A grid, with webs of triangular section providing point contact support for storing and curing the specimens.

E.3.11 A trowel.

E.4 Sampling

The fresh mortar for this test shall have a minimum volume of 1.5 1 or at least 1.5 times the quantity needed to perform the test, whichever is the greater, and shall be obtained either by reduction of the bulk test sample using a sample divider or by quartering, or by preparation from dry constituents and water in the laboratory. The flow value of the mortar in the bulk test sample shall be determined in accordance with Annex C and reported.

Laboratory mixed samples shall before testing be brought to a defined flow value.Ready to use mortars (factory-made wet mortars whichare retarded), and pre-batched air-lime/sand wetmortars when not gauged with hydraulic binders, shallbe tested within their specified workable life.

The length of mixing period shall be measured fromthe moment all constituents are introduced into themixer.

Before testing, the batch shall be gently stirred by handusing a trowel or palette knife in 5 s to 10 s tocounteract any false setting etc., but without anyadditional mixing of the batch.

Any deviation from the mixing procedure shall benoted.

E.5 Preparation and storage of testspecimens

E.5.1 General

The test specimens shall be prisms160 mm 3 40 mm 3 40 mm. Three specimens shall beprovided. For the compressive strength test, break theprisms into two halves to provide six half prisms.

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E.5.2 Preparation

E.5.2.1 General

Prepare mortars based on hydraulic binders (retardedor not retarded), and air-lime/cement mortars withmass of air-lime not exceeding 50 % of the total bindermass, in accordance with E 5.2.2.

Prepare mortars based on air-lime, and air-lime/cementmortars with cement mass not exceeding 50 % of thetotal binder mass, in accordance with E.5.2.3.

Preparation and storage conditions are given inTable 4.

Prepare three specimens for testing at an age of28 days, or more if retarding agents are incorporated inthe mortar, unless otherwise specified.

Clean the moulds and lubricate the internal faces ofthe assembled moulds with a thin layer of mineral oilto prevent adhesion of the mortar.

E.5.2.2 Mortars with hydraulic binders, andair-lime/cement mortars with mass of air-lime notexceeding 50 % of the total binder mass

Fill the mould with mortar in two approximately equallayers, each layer being compacted by 25 strokes of thetamper.

Skim off the excess mortar with a palette knife, leavingthe mortar surface plane and level with the top of themould. Then store the mould as described in E 5.3.

E.5.2.3 Mortars based on air-lime, andair-lime/cement mortars with cement mass notexceeding 50 % of the total binder mass

Place the assembled mould frame, clamped together atright angles, on a glass plate on which two layers ofdry white cotton gauze have been placed. Fill themould with mortar in two approximately equal layers,each layer being compacted by 25 strokes of thetamper.

Skim off the excess mortar with a palette knife leavingthe mortar surface plane and level with the top of themould.

Place two layers of white cotton gauze tightly on themortar surface. Place six layers of absorbent filterpaper on top of the gauze.

Cover the absorbent filter paper with a glass plate andturn the mould upside down keeping the glass plates atthe bottom and top firmly attached to the mould.

Carefully remove the glass plate from the top of theinverted mould, place six layers of absorbent filterpaper on the exposed gauze and re-cover with theglass plate on top.

Re-invert the mould back to its upright position andplace it on a fixed table and load with mass ofapproximately 5 kg.

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After 3 h remove the load and the glass plate. Discardthe absorbent filter paper and the gauze on top of themould, and re-cover with the glass plate on top. Invertthe mould, keeping the glass plates at the bottom andthe top firmly attached to the mould. Remove the glassplate from the top of the inverted mould and discardthe absorbent filter paper and the gauze. Then storethe mould as described in E.5.3.

E.5.3 Storage and curing conditions

Place the mould in a humidity chamber or in sealedpolyethylene bags. Then after the period given in

Table 1 remove the specimens from the mould andsubsequently store them on the grid with triangularsection webs under the conditions also described inTable 4.

Table 4 — Preparation and conditions of storing specimens

Table 1 — Preparation and conditions of storing specimens

Type of mortar	Preparation	Storage time at a temperature of 20 °C ± 2 °C in days		
		Relative humidity		
		95 % ± 5 % or in polyethylene bag		65 % ± 5 %
		in the mould	with the mould removed	with the mould removed
Air-lime mortars	**7.2.3**	5	2	21
Air-lime/cement mortars with cement mass not exceeding 50 % of the total binder mass	**7.2.3**	5	2	21
Cement and air-lime/cement mortars with mass of air-lime not exceeding 50 % of the total binder mass	**7.2.2**	2	5	21
Mortars with other hydraulic binders	**7.2.2**	2	5	21
Retarded mortars	**7.2.2**	5	2	21

E.6 Determination of flexural strength

E.6.1 Apparatus

A testing machine, capable of applying the load at a rate specified in E 6.2. The machine shall comply with the requirements in Table 2. The machine shall have two steel supporting rollers of length between 45 mm and 50 mm and 10 mm ± 0.5 mm diameter, spaced 100.0 mm ± 0.5 mm apart, and a third steel roller of the same length and diameter located centrally between the support rollers (Figure 2). The three vertical planes through the axes of the three rollers shall be parallel and remain parallel, equidistant normal to the direction of the prism under test. One of the supporting rollers and the loading roller shall be capable of tilting slightly to allow a uniform distribution of the load over the width of the prism without subjecting it to any torsional stresses.

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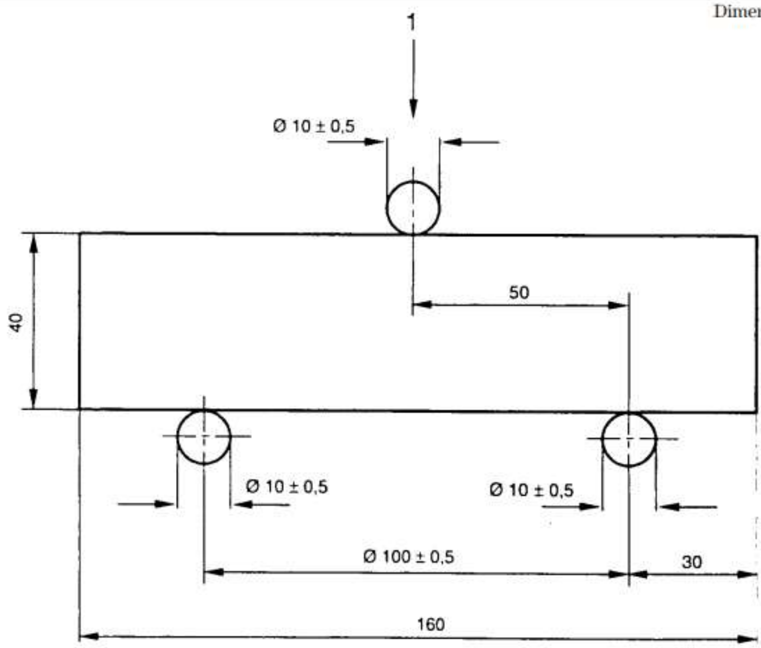
Dimensions in millimetres



Key

1 Load

Figure 1 — Flexural strength test

Figure 2 — Flexural strength test

Table 5 — Requirements for testing machine

Table 2 — Requirements for testing machines

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

E.6.2 Procedure

E.6.2.1 Preparation

Test the specimen at 28 days after casting, or more if retarding agents are incorporated in the mortar, unless otherwise specified, and immediately after removing from the storage atmosphere. Wipe the bearing surfaces

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of the roller and the sides of specimen with a clean cloth to remove any loose grit or other material. Place the specimen with one of its faces (which has been cast against the steel of the mould) on the supporting rollers.

E.6.2.2 Loading

Apply the load without shock at a uniform rate in the range 10 N/s to 50 N/s so that failure occurs within a period of 30 s to 90 s. NOTE A loading rate at the lower end of the permitted range may need to be used for the lower strength mortars. Record the maximum load applied, in N. Return the broken specimen to the storage chamber and keep it there if required, for compressive strength measurements.

E.6.3 Calculation and expression of results

Calculate the flexural strength, f, in N/mm using the following equation:

$$f = 1{,}5\,\frac{Fl}{bd^2}$$

b and *d* (see 4.2) may be taken as the internal moulddimensions.

Record the flexural strength of each specimen to thenearest 0.05 N/mm2. Calculate the mean to the nearest0.1 N/mm2.

Record age of test specimen and age at demoulding.

E.7 Determination of compressive strength

E.7.1 Apparatus

a) *A testing machine*, capable of applying the load at a rate specified in E 7.2.2. The machine shall comply with the requirements in Table 2. The upper machine platen shall be able to align freely as contact is made with the specimen, but the platens shall be restrained from tilting with respect to one another during loading.

b) Two bearing plates, made of tungsten carbide or of steel of surface hardness at least 600 HV Vickers hardness value in accordance with ISO 6507-1.

The plates shall be 40.0 mm long340,0 mm ± 0.1 mm wide and 10 mm thick. The dimensional tolerance for the width shall be based on the average of four symmetrically placed measurements. The flatness tolerance for the contact faces shall be 0.01 mm.

c) Compression jig, used to facilitate the location of the bearing plates. The base plate of the jig shall be of hardened and tempered tool steel and the faces shall have a flatness tolerance of 0.01 mm. A device to provide positive centring on the lower platen of the testing machine shall be provided. Hardened and tempered silver steel pillars shall be symmetrically placed about the centring device so that the gap in one direction is the nominal width of the prism plus 0.3 mm and in the other direction is the nominal width of the prism plus 0.8 mm. The top face of the base plate shall be marked with an arrow in the direction of the greater distance between the pillars to indicate the direction of the long axis of the bearing plates.

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E.7.2 Procedure

E.7.2.1 Preparation

Test the specimen at 28 days after casting, or more if retarding agents are incorporated in the mortar, unless otherwise specified, and immediately on removing from the storage atmosphere or after the flexural strength test. Remove any loose grit or other material from the sides of the specimen as cast. Wipe the bearing surface of the testing machine, and the bearing plates and jig, with a clean cloth and place the specimen in the machine in such a manner that the load is applied to one of its faces (which has been cast against the steel of the mould) Arrange the prism so that the cast end is 16 mm ± 0.1 mm from the nearer edge of the platens or bearing plates. Discard any specimens that do not provide a cube of solid material between the top and bottom platens or bearing plates. Carefully align the specimen so that the load is being applied to the whole width of the faces in contact with the platens. When using the bearing plates and jig, place one bearing plate on the upper surface of the jig with its long axis parallel to the indicating arrow, ensuring that it makes close contact over the whole surface. Place the specimen in the jig, between the pillars, with its long axis perpendicular to the arrow and place the other bearing plate on top of the specimen parallel to the lower bearing plate. Carefully centre the compression jig assembly on the lower platen of the test machine.

E.7.2.2 Loading

E.7.3 Calculation and expression of results

Calculate the strength as the maximum load carried by the specimen divided by its cross-sectional area.

Record the strength of each specimen to the nearest 0.05 N/mm2. Calculate the mean to the nearest 0.1 N/mm2.

Record the age of specimens and the age at demoulding.

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