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Masonry units test methods — Determination of initial shear strength

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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.

DRS538 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 1052-3:2002: Methods of test for masonry — Part 3: Determination of initial shear 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.

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Africeramics Ltd

Consultants Engineers Group (CEG) Ltd

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Methods for testing masonry — Determination of initial shear strength

1 Scope

This Draft Rwanda Standard specifies a method for determining the in plane initial shear strength of horizontal bed joints in masonry using a specimen tested in shear.

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 editioncited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DRS 536Methods of test for masonry units — Determination of dimensions

RS 108, Mortar for masonry — Specification.

3 Principle

The initial shear strength of masonry is derived from the strength of small masonry specimens tested to destruction. The specimens are tested in shear under four-point load.

Four different failure modes are considered to give valid results.

Two procedures, A and B are included. Procedure A involves testing specimens at different precompressions and the initial shear strength is defined by a linear regression curve to zero prestress. Procedure B involves testing specimens at zero precompression and determining a characteristic initial shear strength from a simple or a statistical consideration of the results."

4 Terms and definitions

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

4.1.

masonry

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

4.2

shear strength of masonry

strength of masonry subjected to shear forces

5 Symbols (and abbreviated terms)

A_i is the cross-sectional area of a specimen parallel to the bed joints, in square millimetres (mm2)

e distance between centre lines of the mortar bed and the loading roller, in millimetres (mm)

f_{voi} is the shear strength of an individual sample, in Newton per square millimetres (N/mm2)

fpi is the precompressive stress of an individual sample, in Newton per square millimetres (N/mm2)

f_{vo} is the mean initial shear strength, in Newton per square millimetres (N/mm2)

f_{vko} is the characteristic initial shear strength, in Newton per square millimetres (N/mm2)

F is the representation of the force applied to the specimen, in Newton (N)

$F_{i,max}$ is the maximum shear load, in Newton (N)

F_{pi} is the precompressive force, in Newton (N)

h_1 and h_2 are the heights of cut units, in millimetres (mm)

h_u is the height of the units according to DRS 536 , in millimetres (mm)

l_s is the length of specimen, in millimetres (mm)

l_u is the length of the units according to DRS 536 , in millimetres (mm)

t_{bj} is the thickness of the bed joint, in millimetres in millimetres (mm)

t_s is the thickness of the steel loading plates, in millimetres (mm)

α is the angle of internal friction, in degrees

α_k is the characteristic angle of internal friction, in degrees

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 masonry units prior to laying. Measure the moisture content by mass of autoclaved aerated concrete and calcium silicate units in accordance with Annex B of DRS 539 . 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 test method given in Annex A of DRS 539.

For non-autoclaved concrete units determine the compressive strength at the time of testing the masonry specimens.

6.2 Mortar

The mortar, its mixing procedure and its flow value shall conform with the requirements ofRS 108-, unless otherwise specified, and these shall be reported in the test report.

Take representative samples of fresh mortar from the mason's board to make mortar prism specimens, to determine the flow value in accordance with Annex C of DRS 539 and to determine the air content in accordance withAnnex D of DRS 5397. Use the prism specimens to determine the mean compressive strength at the time of testing the masonry specimens in accordance with Annex E of DRS 539.

7 Apparatus

The testing machines used to apply the shear loads and precompression shall comply with the requirements given in Table 1.

The testing machine to apply the shear loads 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.

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

Apparatus capable of measuring the cross-sectional area of the specimens to an accuracy of 1 %.

8 Preparation and curing of specimens

8.1 Preparation of masonry specimens

Prepare type I specimens according to Table 2 and Figure 1. If h_u> 200 mm, type II specimens may be used. Where for practical purposes it is necessary to cut units, ensure that the faces of the unit to be mortared are representative of the unit as a whole.

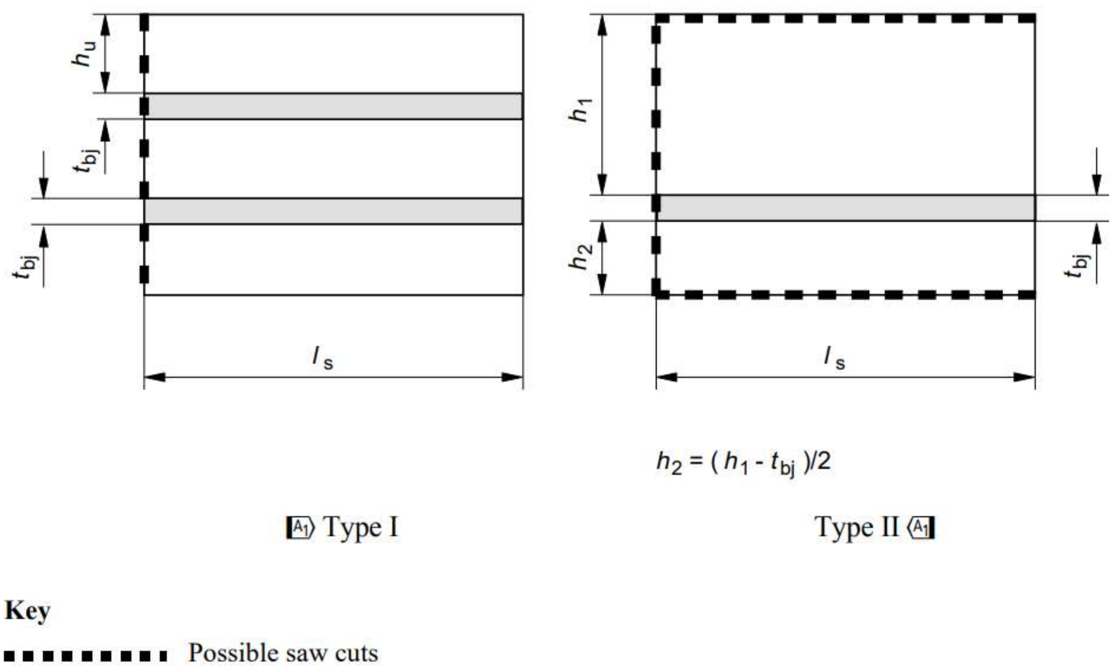


Figure 1 - Dimensions of shear test specimen

Table 2 - Dimensions and type of shear test specimens

Unit length	Specimen type and dimensions	
lu mm	Type according to Figure 1	Dimensions mm

$\leq$ 300	I	$l_s = l_u$
> 300	I	$300 < l_s < 350$
$\leq$ 300	II	$h_1 = 200$ $l_s = l_u$
> 300	II	$h_1 = 200$ $300 < l_s < 350$

Build the specimens within 30 min after completion of the conditioning of the units. Use mortar mixed not more than 1 h beforehand unless it is designed to be used over a more prolonged period.

The bearing surfaces of the masonry units shall be wiped clean of any adherent dust. The lower unit shall be laid on a clean level surface. The next unit shall be laid so that a final mortar joint thickness of 8 mm to 15 mm, representative of masonry with conventional mortar joints, or of 1 mm to 3 mm, representative of masonry with thin layer mortar joints, is attained. The masonry unit shall be checked for linear alignment and level using a set-square and spirit level. Excess mortar shall then be struck off with a trowel. In the case of Type I specimens according to Figure 1, the procedure for the second unit shall be repeated for the top unit.

8.2 Curing and conditioning of the specimens

Immediately after building, pre-compress each specimen by an uniformly distributed mass to give a vertical stress between 2,0 × 10-3 N/mm2 and 5,0 × 10-3 N/mm2

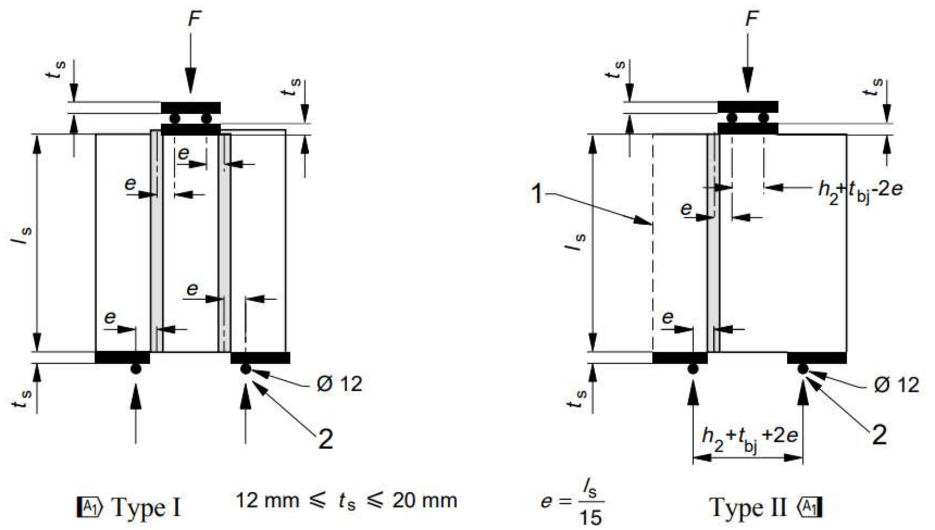
Then cure the specimens and maintain them undisturbed until testing. For other than lime based mortars, prevent the test specimens from drying out during the curing period by close covering with polyethylene sheet, and maintain the specimens undisturbed until testing, unless otherwise specified. Test each specimen at an age of 28 d ± 1 d, unless otherwise specified for lime based mortars, and determine the compressive strength of the mortar at the same age following EN 1015-11.

9 Procedure

9.1 Placing the specimens in the testing machine

Support the end units of each specimen in the test apparatus in accordance with Figure 2. For this, use pieces of steel at least 12 mm thick, with an appropriate capping, if necessary, to ensure good contact. The diameter of the roller bearings shall be 12 mm with a length of at least the width of the unit.

Apply the load through a ball hinge placed in the centre of the top central steel plate.

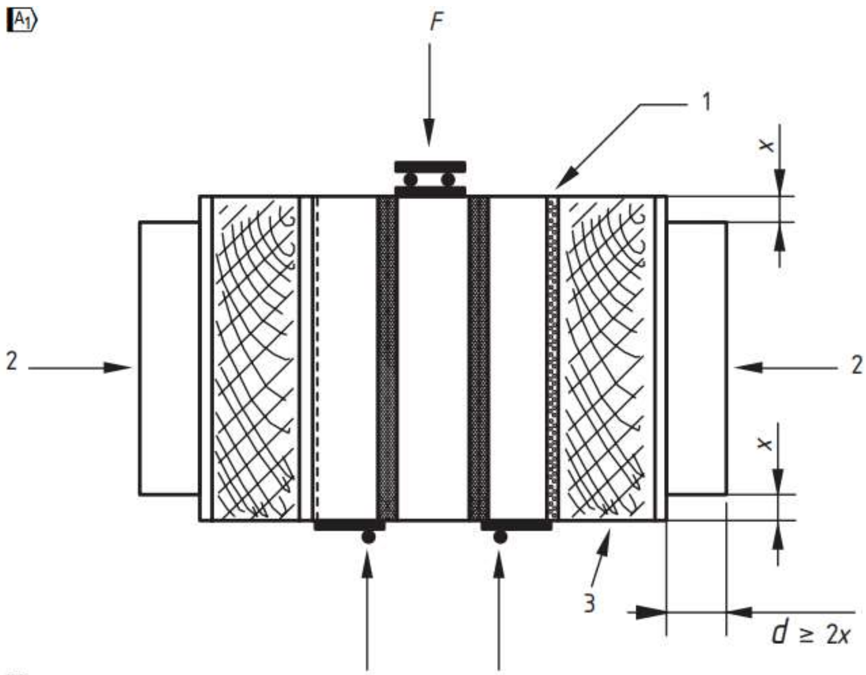


Key

1 Saw cut

2 Roller, fixed or positively located

Figure 2 - Loading of shear test specimen



Key

1 Strawboard/softboard/gypsum plaster

2 Precompression

3 Loading beam

d depth of loading beam

x length by which the loading beam extends beyond the end of the platen

Figure 3 - Precompression load

9.2 Loading

9.2.1 Procedure A

Test at least three specimens at each of three precompression loads. For units with compressive strengthsgreater than 10 N/mm^{2}use precompression loads that give approximately 0.2 N/mm^2 0.6 N/mm^2 and1.0 N/mm^2 For units with compressive strength less than 10 N/mm^{2}use precompression loads that giveapproximately 0.1 N/mm2, 0.3 N/mm2 and 0.5 N/mm2. The precompression load shall be kept within ± 2 %of the initial value. The pre-compression shall be applied according to Figure 3.

The stiffness of the loading beams that are used for the precompression, shall be sufficient to ensure an equally distributed stress. If the platens of the machine are shorter than the length of the specimen l_u, loading beams may be used. These shall have a length equal to the length of the specimen l_u and a depth greater thanor equal to the length beyond the edge of the plate.

9.2.2 Procedure B

Test at least six specimens at zero precompression.

9.2.3 Loading rate

Increase the shear stress at a rate between 0,1 N/(mm2/min) and 0,4 N/(mm2/min)

9.3 Measurements and observations

Record the following:

— the age of non-autoclaved concrete units

— the cross-sectional area Ai of the specimens parallel to the shear force with an accuracy of 1 %

— the maximum load $F_{i,max}$

— the precompression load F_{pi} for procedure A

— the type of failure (see annex A).

9.4 Replications

If failure is by:

— shear failure in the unit parallel with the bed joint (see Figure A.3) or;

— crushing or splitting of the units (see Figure A.4), then;

either

— further specimens may be tested until shear failures of the types shown in Figure A.1 or Figure A.2 have been achieved for each precompression level (Procedure A) or six times (Procedure B) or alternatively;

— the result may be used as a lower bound to the shear strength for each precompression level.

Lower bound results should not be used in the evaluation of results in clause 10. If necessary, an alternative precompression may be needed for Procedure A so that sufficient failures are achieved.

10 Calculations

For each specimen calculate the shear strength and for Procedure A" the precompression stress to the nearest 0,01 N/mm^{2}using the following equations:

$$f_{voi} = F_{i,max} / 2A_i \qquad \text{in N/mm}^2$$

$$f_{pi} = F_{pi} / A_i \qquad \text{in N/mm}^2$$

F_{voi} is the shear strength of an individual sample (N/mm2);

f_{pi} is the precompressive stress of an individual sample (N/mm2);

$F_{i,\, max}$ is the maximum shear force (N);

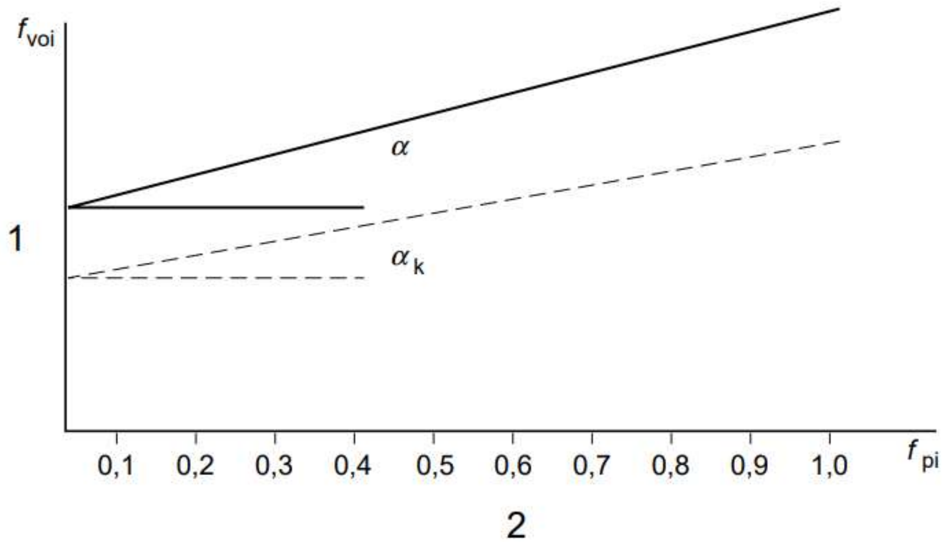
F_{pi} is the precompressive force (N);

A_i is the cross-sectional area of a specimen parallel to the bed joints (mm^2)."

11 Evaluation of results

11.1 Procedure A

Plot a graph of the individual shear strength f_{voi} against the normal compressive stress f_{pi} as shown in Figure 4. Plot the line determined from a linear regression of the points. Record the mean initial shear strength f_{vo} at zero normal stress to the nearest 0,01 N/mm^2. Obtain this from the intercept of the line with the vertical axis. Record also the angle of internal friction to the nearest degree, from the slope of the line.



Key

1 Shear strength (N/mm^2)

2 Precompressive stress (N/mm^2)

Figure 4 - Shear strength and angle of internal friction

The characteristic value of the initial shear strength is f_{vok} where f_{vok} = 0,8f_{vo} and the characteristic angle of internal friction from tan $α_k$ = 0,8 tan α.

11.2 Procedure B

11.2.1 General

Calculate the mean initial shear strength f_{vo} to the nearest 0,01 N/mm^2.

The characteristic initial shear strength may be calculated using 10.2.2 or 10.2.3.

11.2.2 Simple method

Thecharacteristic shear strength, f_{vok}, shall be calculated as:

$f_{vok} = 0,8 \times f_{vo}$

or f_{vok} shall be taken as the lowest individual result whichever is the lower, and shall be given to the nearest 0,01 N/mm^2.

11.2.3 Statistical method

Calculate for each individual bond strength f_{vo1}, f_{vo2} ………. f_{von} the values of Y_1, Y_2 ………Y_n

where

$Y_i = \log_{10} f_{voi}$ and calculate $Y_{mean} = \dfrac{\Sigma Y_i}{n}$

where $i = 1 \ldots \ldots n$.

Calculate $Y_c = Y_{mean} - (k \times s)$

Where:

s is the standard deviation of the n log values;

k is a function of *n* given in Table 3;

n is the number of individual values (normally 6);

Y is $\log_{10}$ of the initial shear strength, f_{vo}.

Calculate the characteristic initial shear to the nearest 0,01 N/mm^2

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

n	k
6	2,18
7	2,08
8	2,01
9	1,96
10	1,92
11	1,89
12	1,89
20	1,77

Take the characteristic initial shear strength to be f_{vko} = anti $\log_{10}$ (Y_c) N/mm^2 to the nearest 0.01 N/mm^2.

NOTE The characteristic value derived is based upon a 95 % confidence level.

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) the Test Procedure used, A or B;"

d) date of building and number of" specimens;

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

f) date of testing the specimens;

g) description of the specimens including dimensions;

h) descriptions of the masonry units and the mortar, preferably consisting of the appropriate testreports, securely attached, or of extracts taken from these reports;

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

j) type of mortar and the mixing procedure of the mortar;

k) the method of conditioning the units prior to the time of laying and for autoclaved aeratedconcrete and calcium silicate units the moisture content by mass;

l) maximum load reached by the test specimens;

m) mean compressive strength of the masonry units in N/mm^2 to the nearest 0,01 N/mm^2 and thecoefficient of variation;

n) mean compressive strength of the mortar in N/mm^2 to the nearest 0,01 N/mm^2 and thecoefficient of variation;

o) individual values for the shear strength and for Procedure A precompression stress for each specimen in $N/mm^2$to the nearest 0,01 $N/mm^2$and the description of the failure mechanism of each specimen and whether any lower bound values have been recorded;

p) mean and characteristic initial shear strength in N/mm2to the nearest 0,01 N/mm^2 and in the case of Procedure B whether the simple or statistical method has been used;"

q) if Procedure A is used the angle of internal friction and characteristic angle of internal friction;

r) remarks, if any.

Annex A
(normative)

Types of Failure

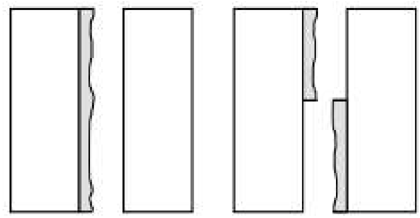


Figure A.1 - Shear failure in the unit/mortar bond area either on one or divided between two unit faces

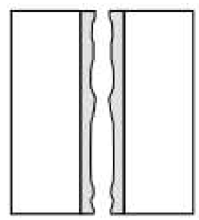


Figure A.2 - Shear failure only in the mortar

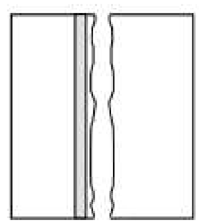


Figure A.3 - Shear failure in the unit

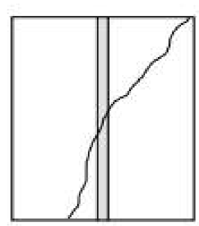


Figure A.4 - Crushing and or splitting failure in the units

Bibliography

[1] EN 772-20, Methods of test for masonry units - Part 20: Determination of flatness of faces of aggregate concrete, manufactured stone and natural stone masonry units.

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