KENYA STANDARD

DKS 2802-12:2019

ICS

Masonry units — Methods of test

Part 12:

Determination of initial shear strength

First Edition, 2019

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Kenya Industrial Research & Development Institute
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Foreword

KENYA STANDARD DKS 2802-12:2019

ICS

This Kenya Standard was prepared by the Clay and Clay Products Technical Committee under the guidance of the Standards Projects Committee and in accordance with the procedures of the Kenya Bureau of Standards.

During the development of this standard, reference was made to the following documents:

BS EN 1052 – 3:2002 Methods of test for masonry - Part 3: Determination of initial shear strength.

Acknowledgement is hereby made for the assistance received from these sources.

Masonry units — Methods of test

Part 12:

Determination of initial shear strength

1. Scope

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

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.

DKS 2802-1, Methods of test for masonry units - Part 1: Determination of compressive strength.

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

DKS 2802 - 8, Methods of test for masonry units - Part 16: Determination of dimensions.

EN 998-2, Specification for mortar for masonry - Part 2: Masonry mortar.

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

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

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

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, definitions and symbols

4.1. Terms and definitions

For the purpose of this Kenyan Standard, the following terms and definitions apply.

4.1.1. masonry

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

4.1.2.shear strength of masonry

strength of masonry subjected to shear forces

4.2. Symbols

A_i is the cross-sectional area of a specimen parallel to the bed joints, in square millimetres (mm^2)

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/mm^2)

f_{pi} is the precompressive stress of an individual sample, in Newton per square millimetres (N/mm^2)

f_{vo} is the mean initial shear strength, in Newton per square millimetres (N/mm^2)

f_{vko} is the characteristic initial shear strength, in Newton per square millimetres (N/mm^2)

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 DKS 2802 -8, in millimetres (mm)

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

l_u is the length of the units according to DKS 2802 -8, 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

5. Materials

5.1. Masonry units

5.1.1. 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 EN 772-10. Record the age of non-autoclaved concrete units at the time of testing the masonry specimens.

5.1.2. Testing

Determine the compressive strength of a sample of masonry units, using the test method given in DKS 2802-1. For non autoclaved concrete units determine the compressive strength at the time of testing th masonry specimens.

5.2. Mortar

The mortar, its mixing procedure and its flow value shall conform with the requirements of EN 998-2, 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 EN 1015-3 and to determine the air content in accordance with EN 1015-7. Use the prism specimens to determine the mean compressive strength at the time of testing the masonry specimens in accordance with EN 1015-11.

6. 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

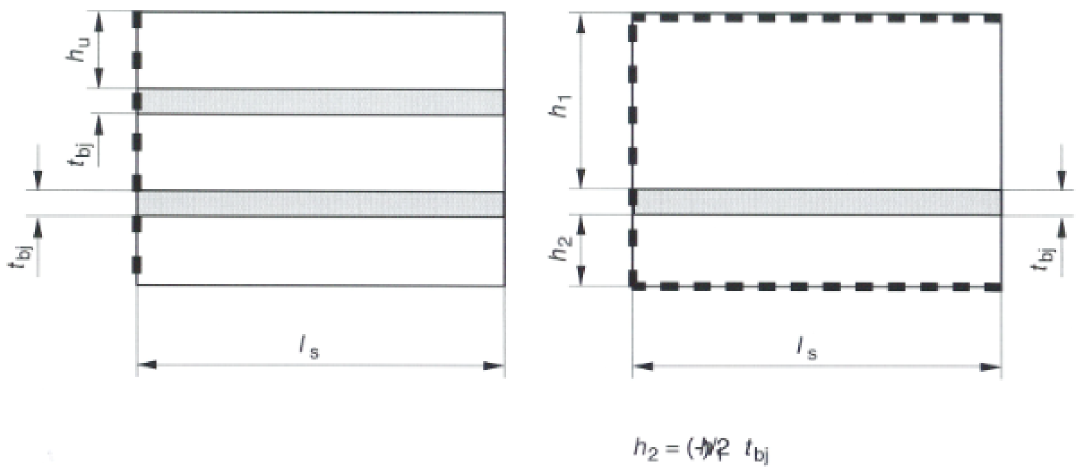
Maximum permissible repeatability of forces as percentage of indicated force	Maximum permissible mean error of forces as percentage of indicated force	Maximum permissible error of zero force as percentage of maximum force of range
2,0± 2,0± 0,4		

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

7. Preparation and curing of specimens

7.1. 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.



A1 Type I   Type II A1

Key

▪▪▪▪▪▪▪▪▪▪ Possible saw cuts

Figure 1 - Dimensions of shear test specimen

A1

Table 2 - Dimensions and type of shear test specimens

Unit length	**Specimen type and dimensions**	
l_u mm	Type according to Figure 1	Dimensions mm
≤ 300	I	$l_s = l_u$
> 300	I	$300 < l_s < 350$
≤ 300	II	$h_1 = 200$ $l_s = l_u$
> 300	II	$h_1 = 200$ $300 < l_s < 350$

A1

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 I 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. 15) In the case of Type I specimens according to Figure 1, the procedure for the second unit shall be repeated for the top unit.

7.2. Curing and conditioning of the specimens

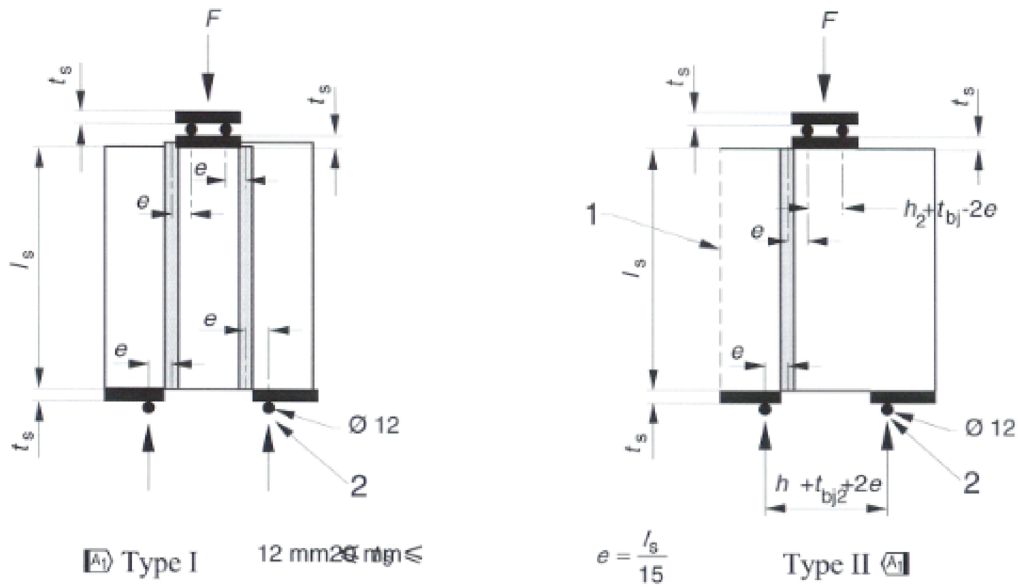
Immediately after building, pre-compress each specimen by an uniformly distributed mass to give a vertical stress between 2,0 x 10^{-3} N/mm^2 and 5,0 x 10^{-3} N/mm^2. Then cure the specimens and maintain them undisturbed until testing. For other than lime based mortars, prevent the test specimens from 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.

8. Procedure

8.1. 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.

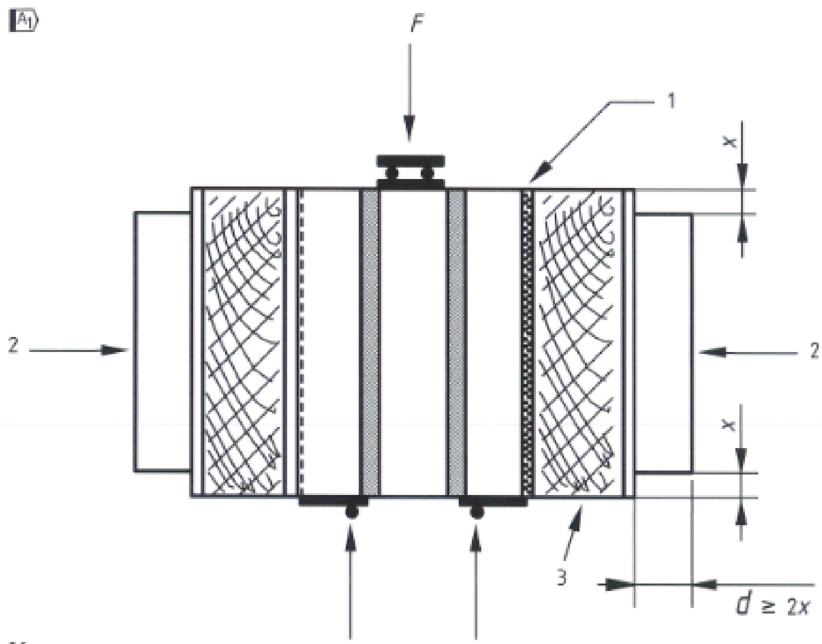


Key

1Saw cut

2Roller, 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

8.2. Loading

8.2.1. Procedure A

Test at least three specimens at each of three precompression loads. For units with compressive strengths greater than 10 N/mm 2, use precompression loads that give approximately 0, 2 N/mm^2, 0,6 N/mm^2 and 1,0 N/mm^2. For units with compressive strength less than 10 N/mm^2 use precompression loads that give approximately 0,1N/mm^2, 0,3 N/mm^{2}and 0,5 N/mm^2. 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, loading beams may be used. These shall have a length equal to the length of the specimen/, and a depth greater than or equal to the length beyond the edge of the plate.

8.2.2. Procedure B

Test at least six specimens at zero precompression.

8.2.3. Loading rate

Increase the shear stress at a rate between 0, 1 N/(mm^2/min) and 0,4 N(mm^2 / min).

8.3. 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).

8.4. 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.

9. 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:

$$f_{voi} = F_{i,max} / 2A_i \quad \text{in N/mm}^2 \ (1)$$

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

where

f_{voi} is the shear strength of an individual sample (N/mm^2);

f_{pi} is the precompressive stress of an individual sample (N/mm^2);

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

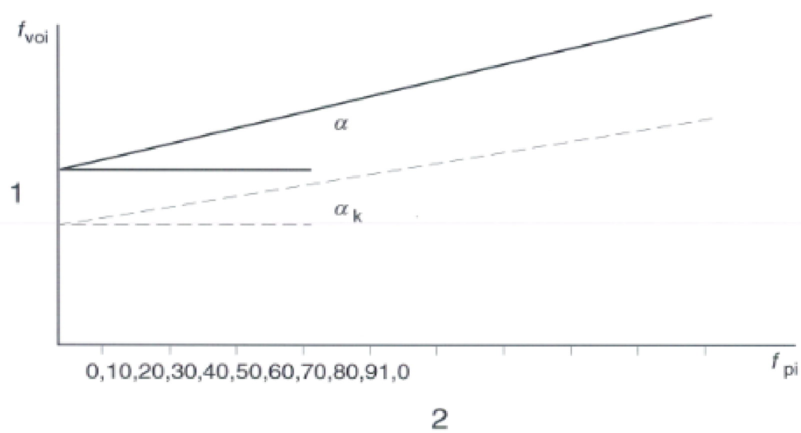
F_{pi} is the precompressive force (N);

A_i is the cross sectional area of a specimen parallel to the bed joints (mm^2). A1

10. Evaluation of results

10.1. 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 $f_{vok} = 0{,}8 f_{v0}$ and the characteristic angle of internal friction from $\tan \alpha_k = 0{,}8 \tan \alpha$.

10.2. Procedure B

10.2.1. 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.

10.2.2. Simple method

The characteristic 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.

10.2.3. Statistical method

Calculate for each individual bond strength f_{vo1}, f_{vo2}....................f_{von} the values of Y1, Y2 ……………Yn

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.

11. Test report

The test report shall contain the following information:

a) the number, title and date of issue of this Kenyan 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 test reports, 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 aerated concrete 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 the nearest 0,01 N/mn1 and the coefficient of variation;

n) mean compressive strength of the mortar in N/mm^2 the nearest 0,01 N/mm^2 and the coefficient 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/mm^2 to 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
(informative)

Annex A

(informative)

Types of failure

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

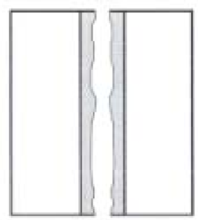


Figure A.2 - Shear failure only in the mortar

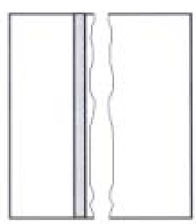


Figure A.3 - Shear failure in the unit

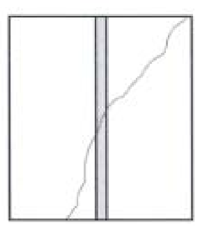


Figure A.4 - Crushing and or splitting failure in the units