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BSI Standards Publication

Methods of test for ancillary components for masonry

Part 14: Determination of the initial shear strength between the prefabricated part of a composite lintel and the masonry above it

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Méthodes d'essai des composants accessoires de maçonnerie - Partie 14: Détermination de la résistance initiale au cisaillement entre la partie préfabriquée d'un linteau composite et de la maçonnerie placée au-dessus

Prüfverfahren für Ergänzungsbauteile für Mauerwerk - Teil 14: Bestimmung der Anfangsscherfestigkeit des Verbunds zwischen dem vorgefertigten Teil eines teilweise vorgefertigten, bauseits ergänzten Sturzes und dem über dem Sturz befindlichen Mauerwerk

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 846-14:2012) 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of an identical text or by endorsement, at the latest by March 2013, and conflicting national standards shall be withdrawn at the latest by March 2013.

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1 Scope

This European Standard specifies a method for determining the in plane initial shear strength of the horizontal bed joint between the prefabricated part of a composite lintel and the masonry above it, 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.

The method corresponds with the method described in EN 1052-3:2003+A1:2006. Guidance is given where the method deviates from EN 1052-3. Therefore, each section of EN 1052-3 is repeated given the necessary changes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 772-1, *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*

EN 772-16, *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 the horizontal bed joint between the prefabricated part of a composite lintel and the masonry above it is derived from the strength of small 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 European 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 gross cross-sectional area of a specimen parallel to the bed joints, in mm^2
E	distance between centre lines of the mortar bed and the loading roller, in mm
f_{v0i}	is the shear strength of an individual sample, in N/mm^2
f_{pi}	is the precompressive stress of an individual sample, in N/mm^2
f_{v0}	is the mean initial shear strength, in N/mm^2
$f_{vk0,cl}$	is the characteristic initial shear strength, in N/mm^2
F	is the representation of the force applied to the specimen, in N
$F_{i,max}$	is the maximum shear load, in N
F_{pi}	is the precompressive force, in N
h_1 and h_2	are the heights of cut units, in mm
h_u	is the height of the units according to EN 772-16, in mm
h_{ppcl}	is the height of the part of the prefabricated composite lintel according to EN 772-16, in mm
k	is a function of n given in Table 3
l_s	is the length of specimen, in mm
l_u	is the length of the units according to EN 772-16, in mm
n	is the number of samples
s	is the standard deviation of the n log values
t_{bj}	is the thickness of the bed joint, in mm
t_s	is the thickness of the steel loading plates, in mm
Y	is $\log_{10}$ of the initial shear strength, f_{v0}
Y_c	is the characteristic value of the $\log_{10}$ of the individual samples
Y_i	is $\log_{10}$ of the shear strength of the individual samples
Y_{mean}	is the mean of the $\log_{10}$ of the shear strength of the individual samples

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 EN 772-1. For non-autoclaved concrete units determine the compressive strength at the time of testing the 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.

5.3 Prefabricated part of the composite lintel — Conditioning of the prefabricated part of the composite lintels

The conditioning of the lintel shall be as specified after cutting.

Record the method of conditioning the prefabricated part of the composite lintels prior to laying.

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

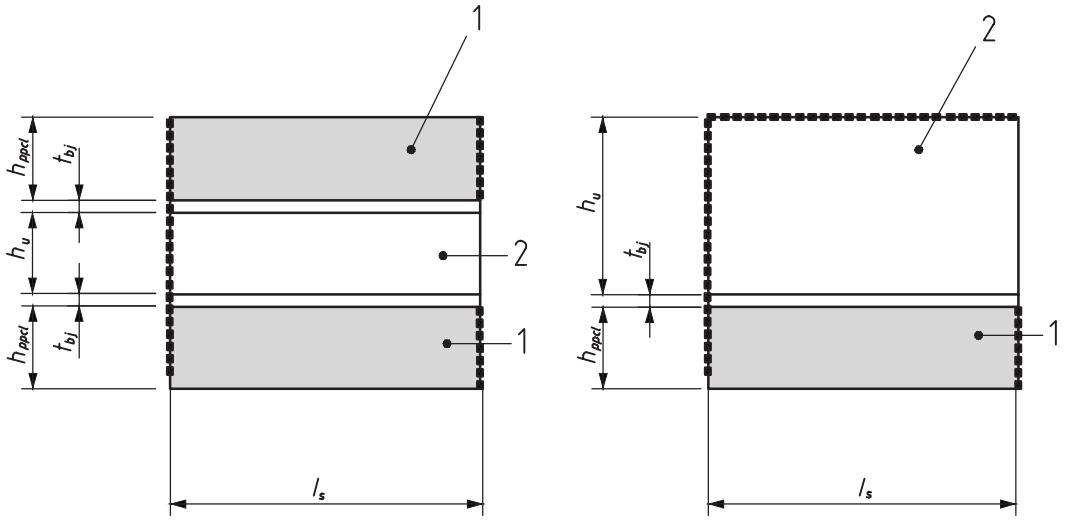
Maximum permissible repeatability of forces as percentage of indicated force	Maximum permissible mean error of forces as percentage of indicated force	Maximum permissible error of zero force as percentage of maximum force of range
2,0	± 2,0	± 0,4

6.1 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 specimen

Prepare specimens, according Table 2 and Figure 1. If h_U < 200 mm, type I specimens shall be used. The top and bottom parts consist of two pieces of the prefabricated part of the composite lintels with the intended upper bed face towards the respective mortar joints. The middle part of the specimen consists out of a masonry unit. If the upper bed face of the piece of the prefabricated part of the composite lintel is not obvious or declared then the top and bottom part shall have the same orientation. If h_U > 200 mm, type II specimens may be used. The bottom parts consist of a piece of the prefabricated part of the composite lintels with the intended upper bed face towards the mortar joints. 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. The length l_s of the piece of the prefabricated part of the composite lintel shall correspond with the length of the masonry unit $l_u \leq 300$ mm.



Type I **Type II**

Key

1 Piece of prefabricated part of composite lintel

2 Masonry unit

▪▪▪▪▪▪▪▪▪▪▪▪

Possible saw cuts

Figure 1 — Dimensions of shear test specimens

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	$h_u \geq 200$ $l_s = l_u$
> 300	II	$h_u \geq 200$ $300 < l_s < 350$

Record the method of conditioning the prefabricated part of the composite lintels prior to laying. 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 piece of the prefabricated part of the composite lintel shall be laid on a clean level surface. The masonry 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. The procedure for the masonry unit shall be repeated for the top piece of the prefabricated part of the composite lintel. The intended bonding faces of the pieces of the prefabricated part of the composite lintel shall be in contact with the mortar (the faces that are normally visible shall stay visible).

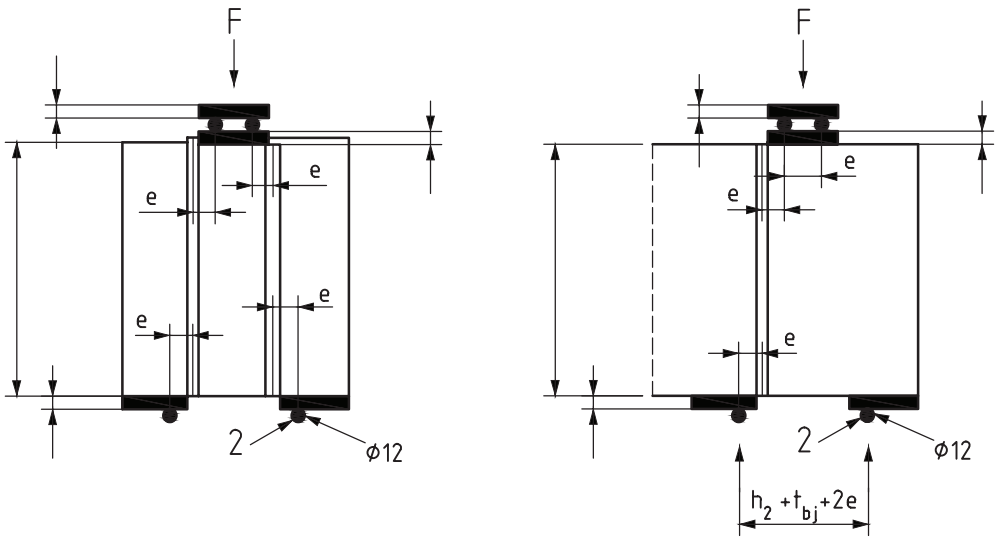
7.2 Curing and conditioning of the specimens

Immediately after building, pre-compress each specimen by an uniformly distributed mass to give a vertical stress between $2{,}0\ \text{N/mm}^2 \times 10^{-3}\ \text{N/mm}^2$ and $5{,}0\ \text{N/mm}^2 \times 10^{-3}\ \text{N/mm}^2$. 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 days ± 1, 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.

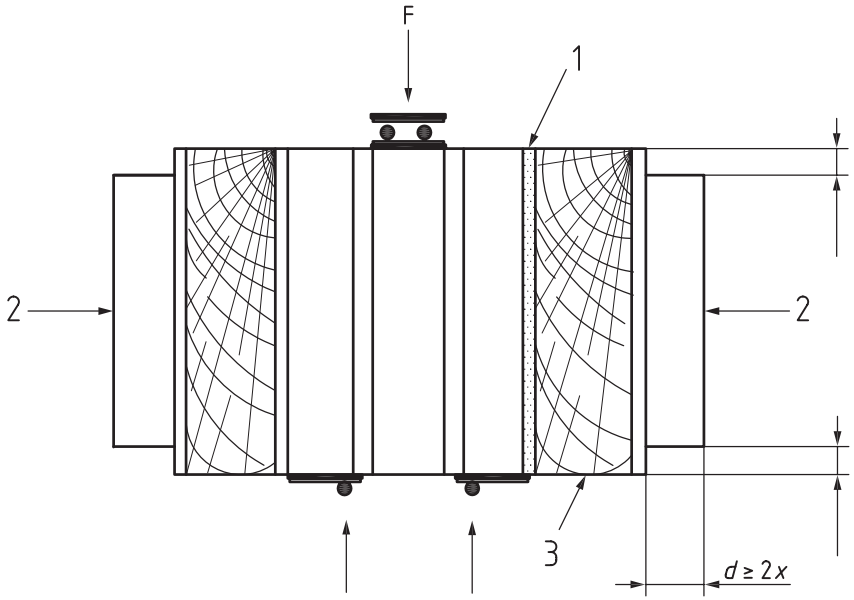


Key

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

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 0,1 N/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 precompression 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 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 A_i 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:

$$f_{v0i} = F_{i,max}/2A_i \text{ in N/mm}^2 \quad (1)$$

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

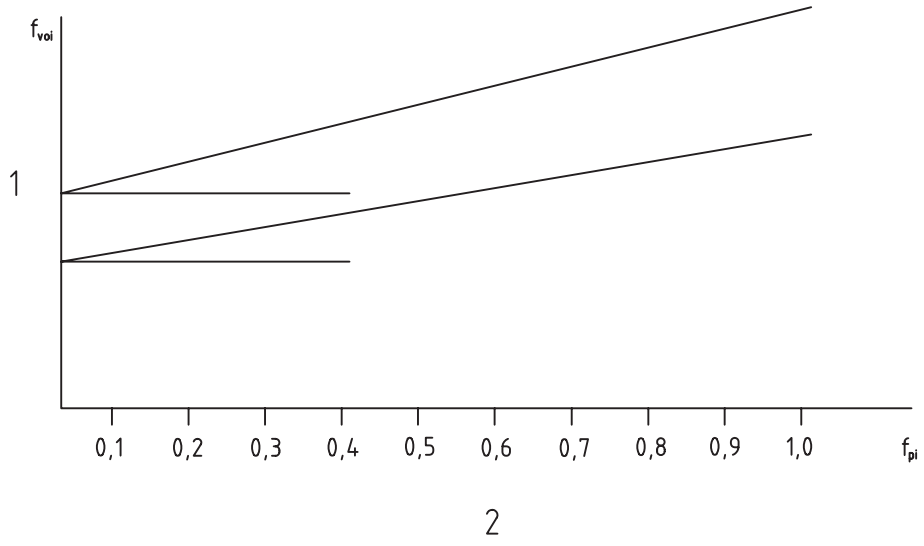
where

f_{v0i} 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).

10 Evaluation of results

10.1 Procedure A

Plot a graph of the individual shear strength f_{v0i} 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_{v0} at zero normal stress to the nearest 0,01 N/mm^2. Obtain this from the intercept of the line with the vertical axis.



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_{v0k} where $f_{v0k} = 0{,}8 f_{v0}$.

10.2 Procedure B

10.2.1 General

Calculate the mean initial shear strength f_{v0} 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_{v0k}, shall be calculated as:

$$f_{v0k} = 0{,}8 \times f_{v0}$$

or f_{v0k} 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 $f_{v01}, f_{v02,} f_{v0n}$ the values of Y_1, $Y_{2,}$ Y_n

where

$Y_i = \log_{10} f_{v0i}$ and calculate $Y_{mean} = \dfrac{\sum Y_i}{n}$

where $i = 1……..n.$

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

where

s is the standard deviation of the n log values

Y_i is $\log_{10}$ of the shear strength of the individual samples

Y_{mean} is the mean of the $\log_{10}$ of the shear strength of the individual samples

Y_c is the characteristic value of the $\log_{10}$ of the individual samples

k is a function of n given in Table 3

n is the number of samples

Y is $\log_{10}$ of the initial shear strength, f_{v0}.

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_{vk0} = anti $\log_{10}$ (Yc) 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 European 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 to the nearest 0,01 N/mm^2 and the coefficient of variation;

n) mean compressive strength of the mortar in N/mm^2 to 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) remarks, if any.

Annex A
(informative)

Types of failure

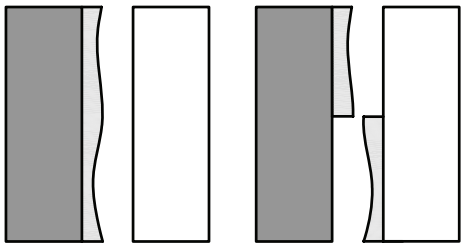


Figure A.1 — Shear failure in the lintel/mortar bond area either on one or divided between two unit faces

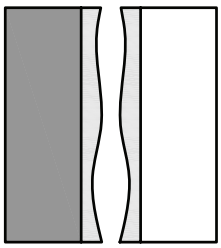


Figure A.2 — Shear failure only in the mortar

Failure mode A1 and A2 are restricted to the joint between the pieces of the prefabricated part of the composite lintel and the masonry unit. If a failure occurs within the possible joint between the masonry units another type of adhesive shall be used.

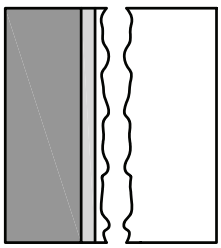


Figure A.3 — Shear failure in the unit

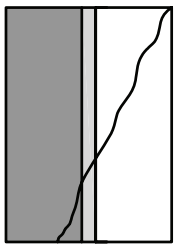


Figure A.4 — Crushing and or splitting failure in the units

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[1] EN 845-2, *Specification for ancillary components for masonry — Part 2: Lintels*

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