BS EN 16758:2016

BSI Standards Publication

Curtain walling — Determination of the strength of sheared connections — Test method and requirements

bsi.

National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/538/6, Curtain walling.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2016

ISBN 978 0 580 86564 0

ICS 91.060.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2016.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16758

June 2016

ICS 91.060.10

English Version

Curtain walling - Determination of the strength of sheared connections - Test method and requirements

Façades rideaux - Détermination de la résistance des assemblages - Méthode d'essai et exigences

Vorhangfassaden - Festlegung der Beanspruchbarkeit von auf Abscheren beanspruchten Verbindungen - Prüfverfahren und Anforderungen

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Ref. No. EN 16758:2016 E

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European foreword

This document (EN 16758:2016) has been prepared by Technical Committee CEN/TC 33 “Doors, windows, shutters, building hardware and curtain walling”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by December 2016, and conflicting national standards shall be withdrawn at the latest by December 2016.

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1 Scope

This European Standard specifies test methods for the determination of bearing capacity (ultimate limit state and serviceability limit state), of connections between curtain walling framing members for which it cannot be calculated in accordance with current codes or conventional calculations based upon the strength of the materials.

Mechanical performances of the curtain walling connections are already assessed in accordance with the provisions described in EN 13830. Additional information with respect to mechanical performance of the connections and direct applications can be determined with this standard.

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 13119, *Curtain walling - Terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13119 and the following apply.

3.1
connection
set of components designed to transfer loads between framing members (e.g. cleat, screw)

4 Symbols

For the purposes of this document, the following symbols apply.

$F_{h,des}$	design horizontal load
$F_{v,des}$	design vertical load
F_{u5}	the characteristic force giving 75 % confidence that 95 % of the test results will be higher than this value
s	the standard deviation of the series under consideration
γ_u	partial factor for the connection applicable to rupture
$\tau_{\alpha\beta}$	statistical eccentricity of 5 % with 75 % confidence

5 Method of evaluation

5.1 General

Connections are subjected to permanent loads as well as to variable loads. The measurement of the deformation is recorded at the application of the force. The support shall restraint vertical and horizontal movements.

5.2 Samples

The samples shall be representative of the connection methods between the framing members of the curtain walling.

Based on the type of curtain walling (e.g. stick construction, unitized system etc) different types of connection between the framing members should be tested, depending to the design of the connection,

Figures from 1 to 3 are examples of typical test configurations, but different configurations may be used.

Figures from 4 to 7 are examples of typical test configurations incorporating actual glass supports.

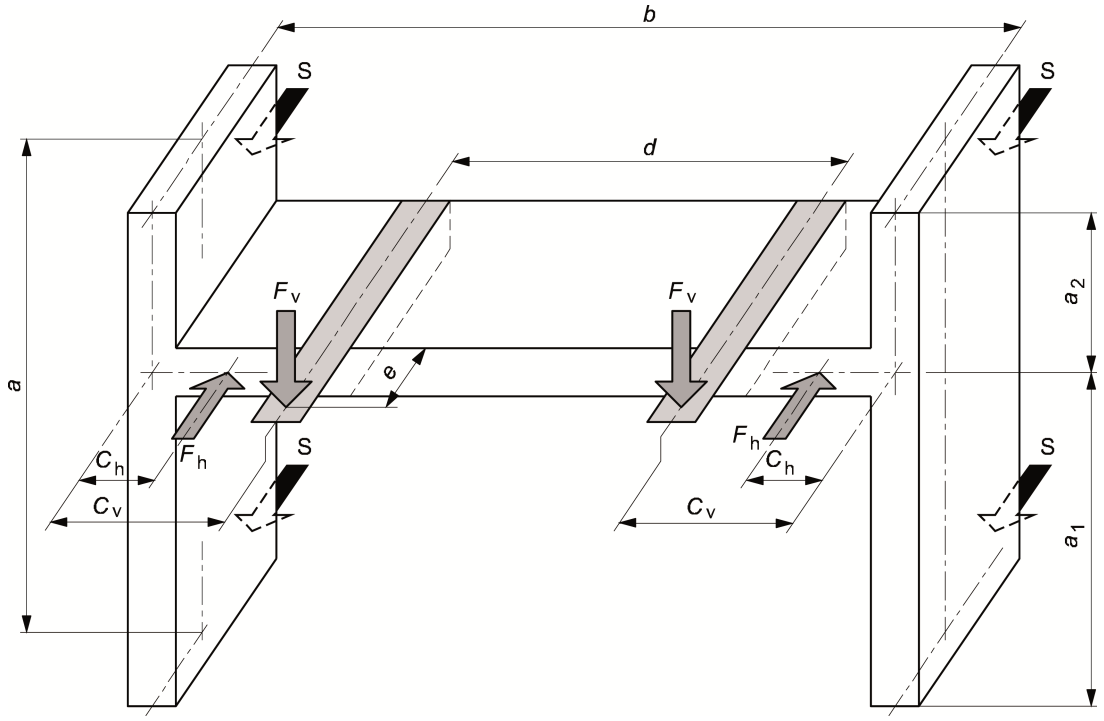


Figure 1 — Schematic T-connection and loading points (any connection method can be chosen)

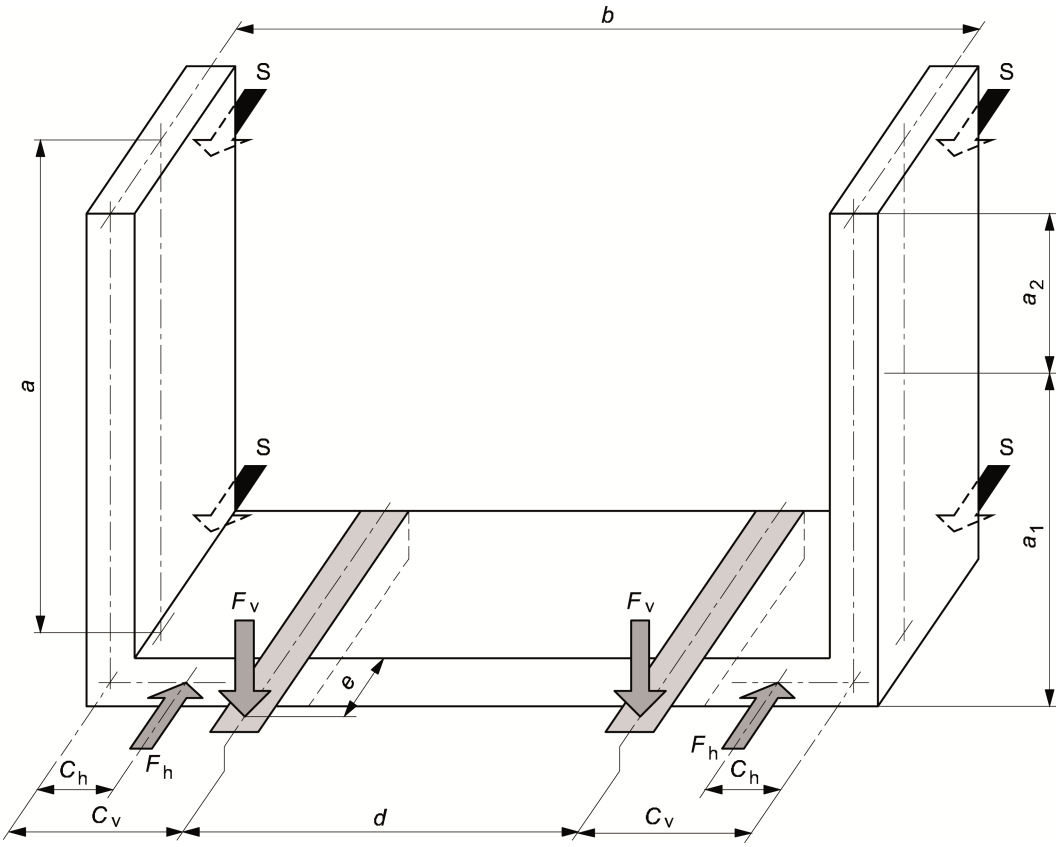


Figure 2 — Schematic L-connection and loading points (any connection method can be chosen)

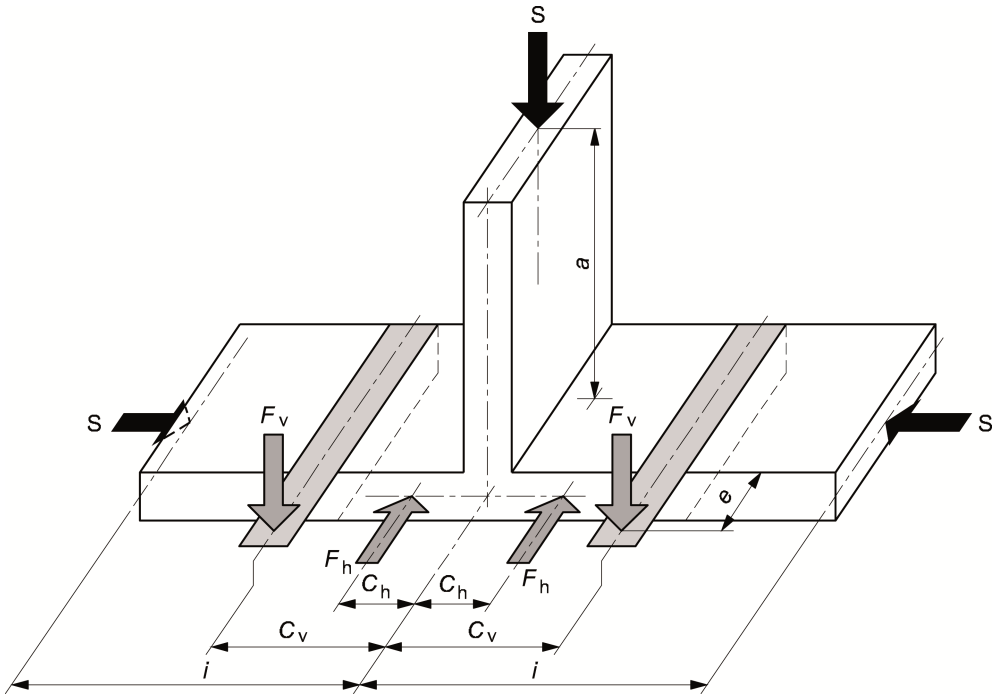


Figure 3 — Axial resistance (any connection method can be chosen)

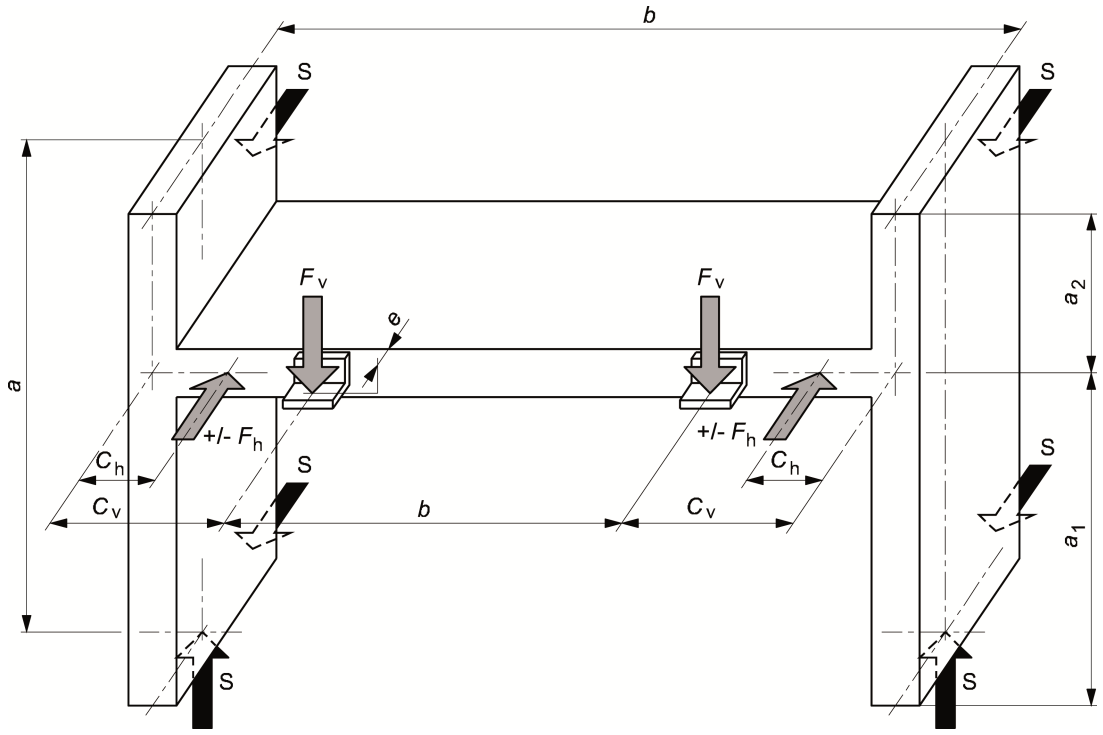


Figure 4 — Schematic T- connection and loading points

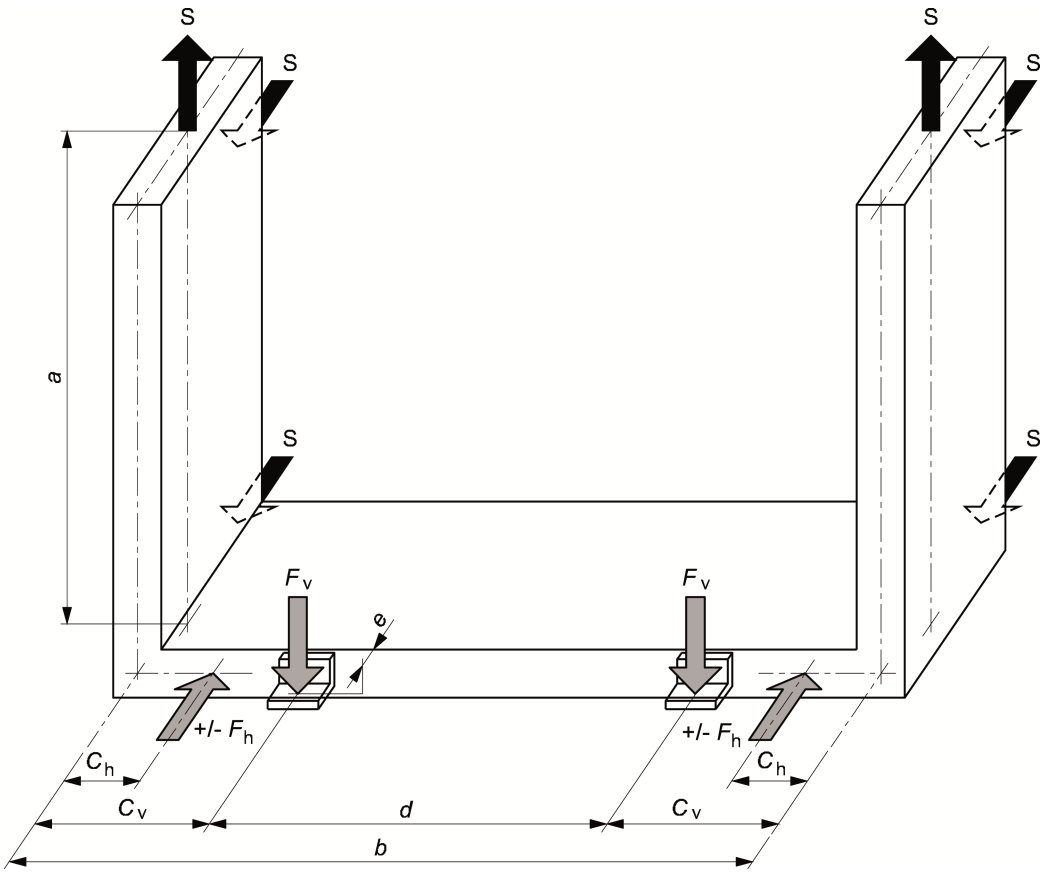


Figure 5 — Schematic L- connection and loading points

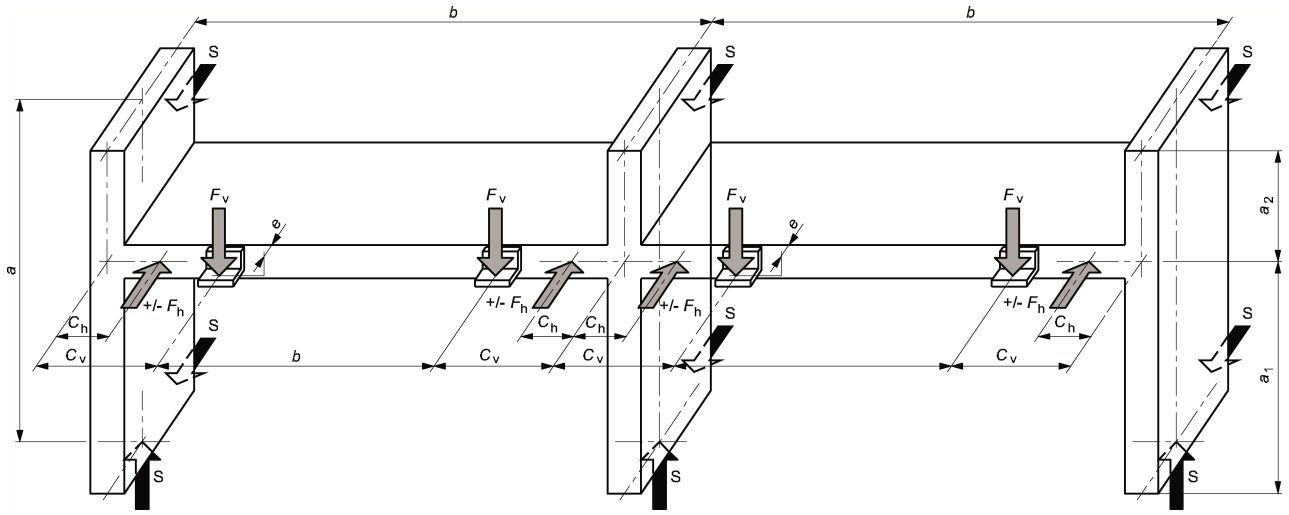


Figure 6 — Multiple schematic T- connection and loading points

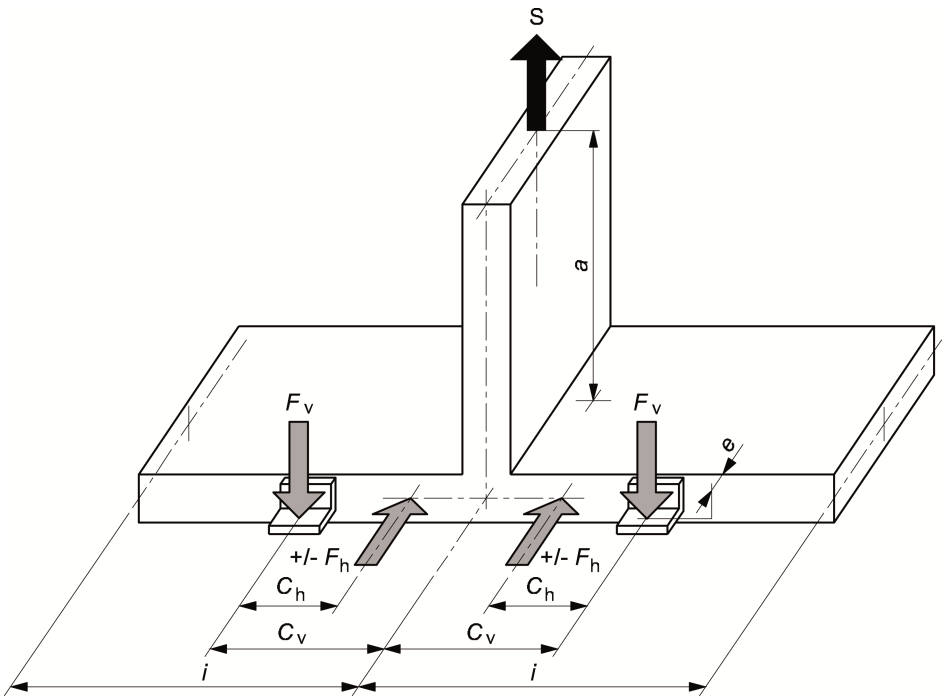


Figure 7 — Axial resistance for an intermediate mullion

NOTE: Figure 7 can be considered as a principle for axial resistance of transoms.

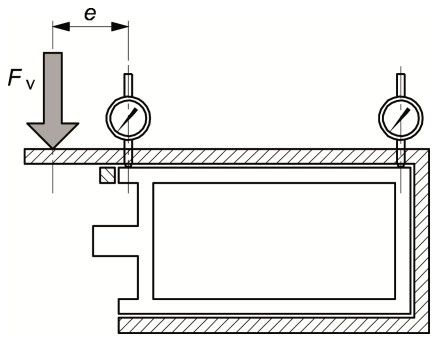


Figure 8 — Dead load (*Fv*)

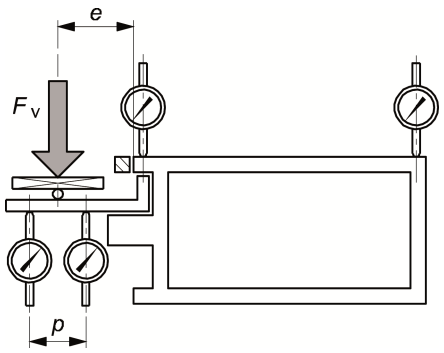


Figure 9 — Dead load (*Fv*) for serviceability limit state

Where the glass supports are tested together with the shear connection a dead load (F_v) should be applied to the glass support as in practice. To establish the serviceability limit state (Annex A) it is advised to limit the the deformation of the glass support at a maximum displacement of 1mm, midway between the two displacement transducer (DT1 and DT2).

The samples are built according to Figure 1 to 3 or Figure 4 to 7 and Figure 8 and 9, for which the following apply:

— a = 300 mm[1)], a_1 = 200 mm and a_2 = 100 mm;

— b ≥ 500 mm[1)], b = 750 mm;

— c_v, c_h [2)] d, e: dimensions of the actual loading points and typical of the construction tested;

— e: the distance from the position of (a) the contact area of the internal glazing gasket and the transom, AND (b) the centre of gravity of the infill the manufacturer is willing to use on his/her curtain walling;

— g = 250 mm[1)];

— i = 250 mm;

— S: fixing of the samples on the test rig (according to the respective loadings).

1) Depending on the circumstances (project specifications or product's details) sizes could differ.

2) Depending on the actual geometry of the connection, F_h must be located on the transom as close as possible to the mullion with a recommended maximum of $c_h \leq 50$mm.

5.3 Loadings

5.3.1 General

The design load for the Serviceability Limit State is determined according to the procedure described on Annex A.

The design load for the Ultimate Limit State is determined according to the procedure described on Annex B.

5.3.2 Preloading

Prior to loading, a force of 100 N will be applied after which the displacement transducers (DT) will be reset.

5.3.3 Vertical loading

The design static loading is defined as follow:

- Minimum n = 5 connections are submitted to vertical loading until they break using a deformation speed of 5 mm/min, the force/deformation curve is recorded.

- The design vertical load $F_{v,des}$ is determined according the procedure described in Annex A.

5.3.4 Horizontal loading

5.3.4.1 Positive (pressure) loading

It is defined as follow:

- Minimum n = 5 connections are submitted to horizontal positive loadings until they break, using a deformation speed of 5 mm/min, the force/deformation curves are recorded.

- The design positive horizontal load $F_{h,des,+}$ is determined according the procedure described in Annex A.

5.3.4.2 Negative (suction) loading

It is defined as follow:

- Minimum n = 5 connections are submitted to horizontal negative loading until they break, using a deformation speed of 5 mm/min, the force /deformation curve is recorded.

- The design negative horizontal load $F_{h,des,-}$ is determined according the procedure described in Annex A.

6 Calculation for combined horizontal and vertical loadings

6.1 Method A

The samples which were used to calculate the $F_{v,des}$, $F_{h,des,-}$ and $F_{h,des,+}$ (see 5.3) are used.

For each series of n samples, the vertical $(F_{v,des,x\%})$ and the positive and negative design horizontal ($F_{h+,des,x\%}$, $F_{h-,des,x\%}$) loadings are determined according the procedure described in Annex B. When the serviceability limit state is specifically required,-the methodology is as described in Annex A.

$$F_{h,des} = \min\left(F_{h,des,+}; F_{h,des,-}\right) \quad (1)$$

All the combinations included in the area A (0, $F_{v,des}$, $F_{h,des}$) are acceptable, as shown in Figure 10.

The points "m" of maximum combinations of vertical and horizontal design loadings belong to the straight line of formula:

$$F_{v,m} = F_{v,des} - F_{h,m} \times \frac{F_{v,des}}{F_{h,des}} \quad (2)$$

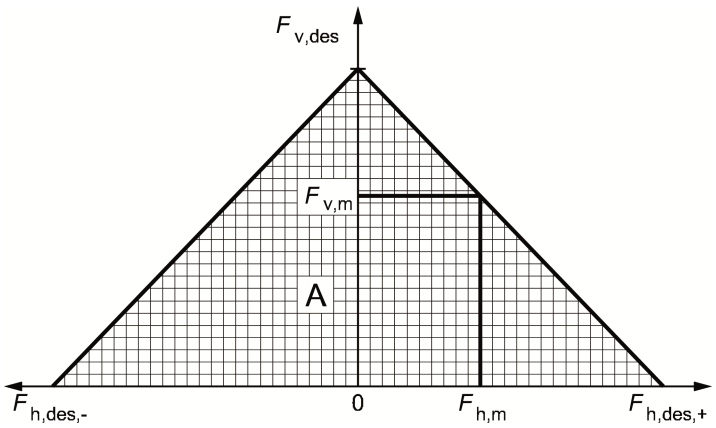


Figure 10 — Area of acceptable combination of vertical and horizontal loadings

6.2 Method B (detailed, optional)

A series of 5 connections are loaded with combined vertical and horizontal loadings as shown in Table 1:

Table 1 — Examples of loading combinations

Minimum number of samples *n* =	Vertical loadings	Positive and negative horizontal loadings
5	$F_{v,des,20\ \%} = 20\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,-}$
5	$F_{v,des,40\ \%} = 40\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,-}$
5	$F_{v,des,60\ \%} = 60\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,-}$
5	$F_{v,des,80\ \%} = 80\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,-}$
5	$F_{v,des,100\ \%} = 100\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,-}$
5	$F_{v,des,20\ \%} = 20\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,+}$
5	$F_{v,des,40\ \%} = 40\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,+}$
5	$F_{v,des,60\ \%} = 60\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,+}$
5	$F_{v,des,80\ \%} = 80\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,+}$
5	$F_{v,des,100\ \%} = 100\ \% \cdot F_{v,des}$	From *0N to* $F_{h,des,+}$

The deformation speed is 5 mm/min and the force/deformation curve is recorded.

For each series of *n* samples, the vertical $(F_{v,des,x\%})$ and the positive and negative design horizontal ($F_{h+,des,x\%}$, $F_{h-,des,x\%}$) loadings are determined according to the procedure described in Annex B. When the serviceability limit state is specifically required, the methodology is as described in Annex A.

The pairs of values ($F_{h+,des,x\%}$, $F_{v+,des,x\%}$) are graphically represented in Figure 11 as follows for positive and negative horizontal values. The area A represents the acceptable combinations of horizontal and vertical loadings.

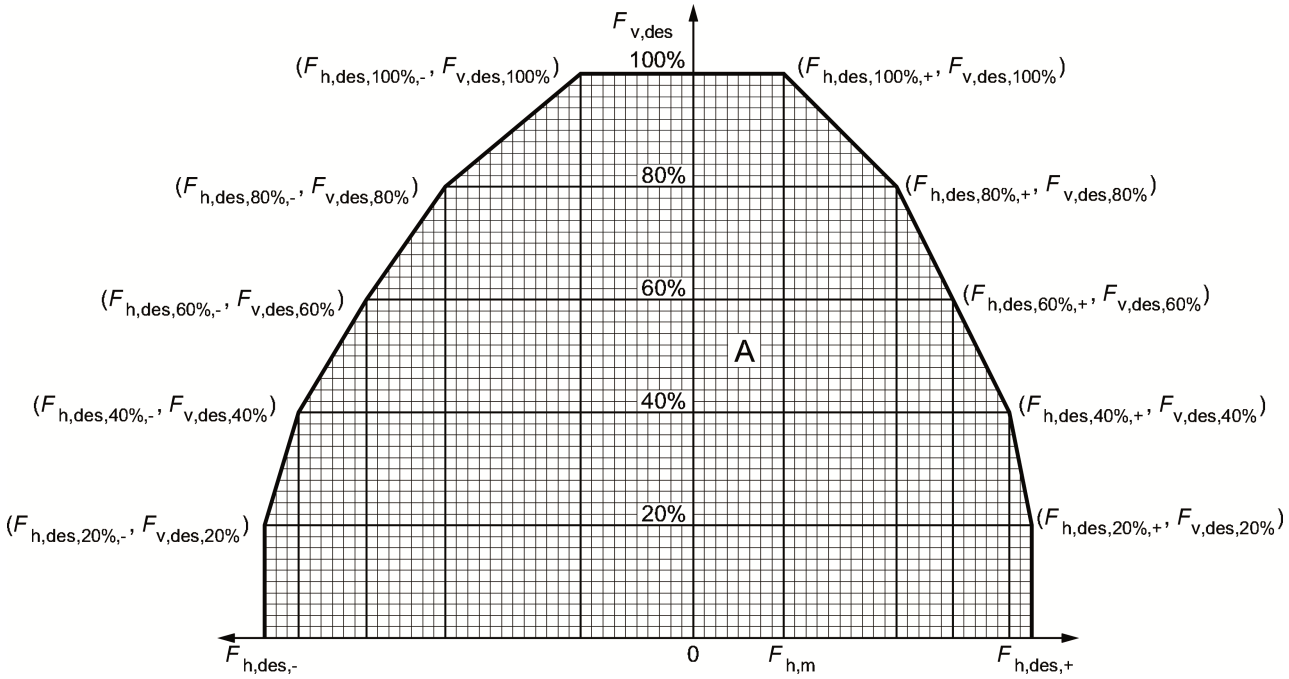


Figure 11 — Area of acceptable combinations of vertical and horizontal loadings

7 Test report

A report shall be prepared on any initial and further testing and/or calculation according to this standard. It shall include full information on, but not limited to, the following:

— product type;

— type/s of construction;

— fixings - screws, cleats, shear pins;

— fixings - material specification; including compliance with Standard/s;

— profile references;

— origin of materials and type/s of materials;

— dimensioned drawings of specimens;

— the manufacturer;

— the test laboratory

— the test method and apparatus;

— the test results.

Evaluation reports shall be retained by the manufacturer and the test laboratory as long as the product is under fabrication and made available on the market, otherwise for at least 10 years.

Annex A
(informative)

Determination of the design loading of a connection - Serviceability limit state

The purpose is to determine the vertical and horizontal loadings corresponding to the elastic deformation limit of the connection thanks to the analysis of the recorded curves during the loading test. The procedure comprises the following steps, as shown in Figure A.1:

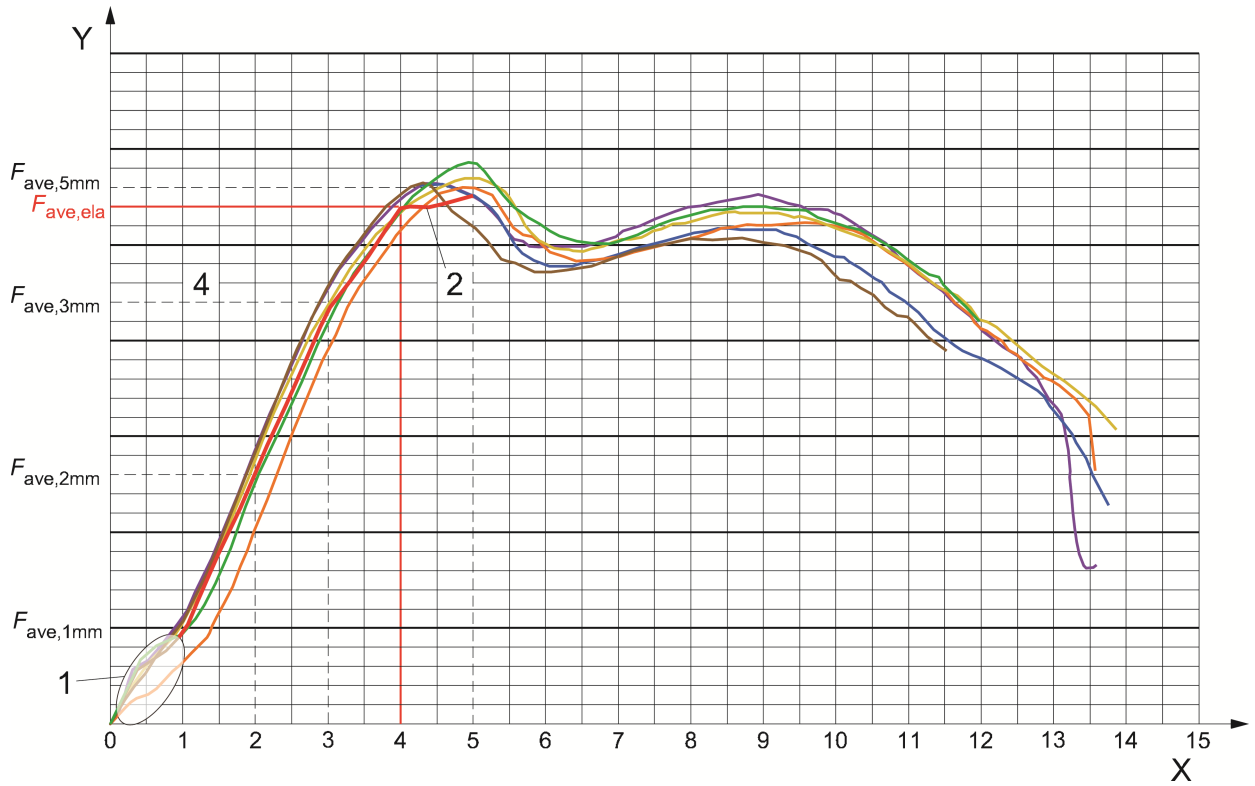
1) Clean the recorded curves of the test with the origin irregularities;

2) With the cleaned curves, build a reference graph with the points corresponding to the average forces F_{ave} of the n cleaned curves for four equal increments of deformation;

3) The linear part of the reference graph is corresponding to the maximum number of points of the reference graph for which the linear regression coefficient $R \geq 0,98$, as shown in Figure A.2.

In case where the curve shows a second maximum value, only the first one shall be taken into account;

4) The maximum average elastic force $F_{ave,ela}$ corresponds to the maximum deformation of the elastic part of the reference graph.



Key

X Deformation [mm]

Y Force [N]

1 Step 1 Irregularity

2 Step 2 Reference graph

4 Step 4

Samples

A

B

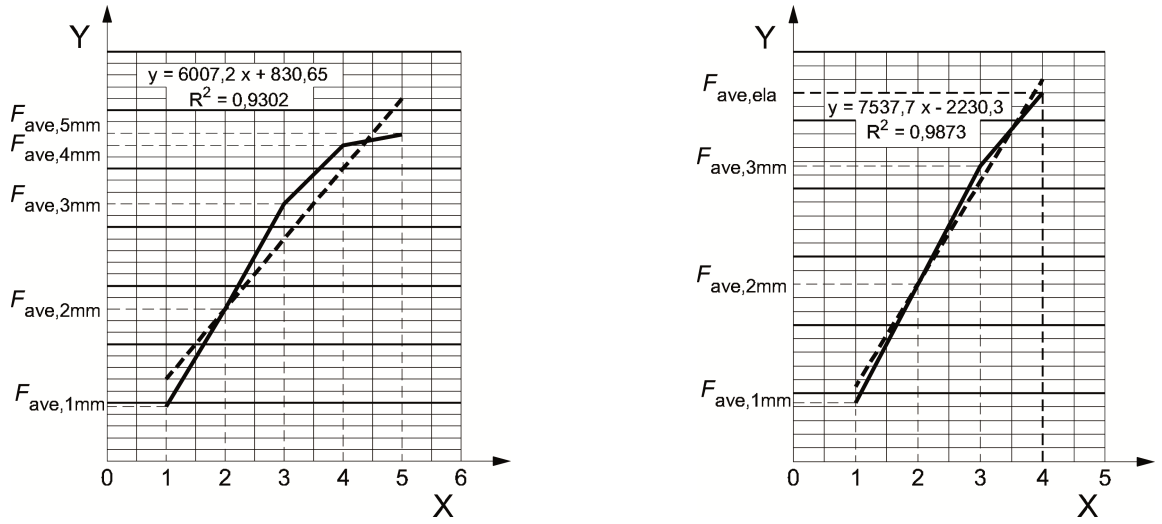
C

D

E

F

Figure A.1 —Force/deformation – original measurement in laboratory



a) First trial with 5 points

R = 0,9645 < 0,98 – KO !

b) Second trial with 4 points

R = 0,9936 > 0,98 – <u>OK</u>

Key

X	Deformation [mm]
Y	Force [N]
———	Average
- - - -	Linear (Average)

Figure A.2 — Steps in the analysis of the Force/deformation for the determination of the $F_{ave,ela}$

In order to calculate a deflection according to the glass infill used the following calculation should be followed:

$$c_w = F_{ave,ela} / f_{ave,ela}$$

$$w = F_v / c_w$$

where:

c_w elasticity constant [kN/mm]

$F_{ave,ela}$ average elasticity force [kN]

$f_{ave,ela}$ average of deflection glass support by $F_{ave,ela}$ [mm]

w deflection glass support [mm]

The variability of the elastic limit (Serviceability Limit State – SLS) of the connection is expressed by

$$F_{u,5} = F_{ave,ela} - s \tag{A.1}$$

where

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(F_{i,ela} - F_{ave,ela}\right)^2}{n}} \tag{A.2}$$

$$F_{des,s} = F_{u,5} \tag{A.3}$$

Annex B
(normative)

Determination of the design loading of a connection - Ultimate limit state

The safety related to rupture (Ultimate Limit State – ULS) is evaluated with the following procedure:

For each recorded curve, the maximum force $F_{max,i}$ is noted and the characteristic maximum force $F_{des,u}$ is calculated as follow:

$$F_{\max,u5} = \frac{\sum_{1}^{n} F_{\max,i}}{n} - s \tag{B.1}$$

where

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(F_{i,ela} - F_{ave,ela}\right)^2}{n}} \tag{B.2}$$

$$F_{des,u} = \frac{F_{\max,u,5}}{\gamma_u} \tag{B.3}$$

where, in the absence of any national provisions the following can be applied:

γ_u = 1,33 for extraction of screws from steel or aluminium screw ports as well as screw breakage in clamping connections

γ_u = 1,25 for failure of steel or aluminium components

γ_u = 1,30 for extraction of screws from timber substructures as well as for failure of timber components due to tensile force at right angles to the grain (lateral tensile failure)

γ_u = 1,50 for failure of thermoplastic components (e.g. for components made from glass fibre reinforced polyamide).

Annex C
(normative)

Field of direct application

Based on their test experience, the manufacturer may decide to use those test results for connections of a similar design, where it has been assessed and demonstrated by calculation, that the shear resistance and the bending resistance are not reduced.

Bibliography

[1] ISO 16269-6:2014, *Statistical interpretation of data — Part 6: Determination of statistical tolerance intervals*

[2] EN 13830, *Curtain walling - Product standard*

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