BS EN 594:2011

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Timber structures — Test methods — Racking strength and stiffness of timber frame wall panels

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/518, Structural timber.

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

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Holzbauwerke - Prüfverfahren - Wandscheiben-Tragfähigkeit und -Steifigkeit von Wandelementen in Holztafelbauart

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Foreword

This document (EN 594:2011) has been prepared by Technical Committee CEN/TC 124 “Timber structures”, 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of an identical text or by endorsement, at the latest by December 2011, and conflicting national standards shall be withdrawn at the latest by December 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 594:1995.

The changes compared to the previous version are:

1) the test standard opened the scope for more types of panels;

2) the test protocol is changed to allow a more straight forward comparison between results of different panels.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies the test method to be used in determining the racking strength and stiffness of timber frame wall panels.

The test method is intended primarily for panels as described, to provide:

comparative performance values for the materials used in the manufacture of the panels, and

data information for use in structural design.

The principle of the test method is suited to other sizes and shapes of panels and to other methods of hold down as well as panels which are partially sheathed and to combinations of panels.

NOTE The method is detailed for a general situation where the client for the test knows the materials to be used in the construction, which may cover a range of different panels and walls and therefore wishes to test a standard configuration of panel. Where specific details are fixed they may be incorporated into the test but any additions or changes to the standard configuration are indicated in the test report and, later, can lead to limitations on the use of the test data.

2 Normative references

EN 322, *Wood-based panels — Determination of moisture content*

EN 323, *Wood-based panels — Determination of density*

EN 14358, *Timber structures — Calculation of the characteristic 5-percentile values and acceptance criteria for a sample*

ISO 3130, *Wood — Determination of moisture content for physical and mechanical tests*

ISO 3131, *Wood — Determination of density for physical and mechanical tests*

3 Terms and definitions

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

3.1
timber frame wall panel
structural wall panel consisting of timber framing with sheathing material fixed to one or both faces and are referred to herein as 'panels'

3.2
head binder
piece of timber fixed to the top of the panel for test purposes

3.3
packer
piece of timber fixed to the base of the test rig for test purposes

3.4
racking strength
capacity of a panel to resist a horizontal load in the plane of the panel

3.5
racking stiffness
calculated stiffness of a panel when it is loaded to approximately 40 % of its racking strength

4 Symbols

F applied racking load, in newtons;

F_{max} maximum racking load, in newtons;

$F_{max,est}$ estimated maximum racking load, in newtons;

F_v applied vertical load, in newtons;

R racking stiffness, in newtons per millimetre;

ν panel deformation, in millimetre.

5 Requirements for test panels

The dimensions of panels shall be as given in Figure 1. The requirements for other panel sizes and shapes and their testing are given in Annex A.

The edges of all sheathing materials shall be fixed or partly fixed.

Frame fixings should be those used in practice but where this is not known, two 3,87 mm diameter nails of any type with adequate pointside penetration should be used at each rail to stud joint. Frame material should be that recommended for use in practice. Care should be taken to use timber of a quality no better than could be expected in practice. Special care should be taken to ensure that the bottom rail and centre stud timbers (and leading stud if a holding down restraint is attached) are not above average for the timbers used in the tests.

The specification of the timber should follow that used in practice but where this is not known C16 timber with a nominal size of 90 mm $\times$ 40 mm is recommended.

NOTE 1 2,4 m is the recommended height of the panel if the height to be used in practice is not known or can vary. The test method is appropriate for panel heights between 2,1 m and 3,0 m.

NOTE 2 If the sheathing is unsuitable for joining two sheets on a single stud, that stud may be replaced by two studs adequately connected along their length. Gaps between sheets should be typical of that used in practice. Where this is unknown a 3 mm gap is recommended.

The standard configuration is for studs at nominal 600 mm centres.

NOTE 3 The number, location and orientation of intermediate studs are not critical to the test panel, and should reflect the normal construction practice except with relation to vertical load. If the construction requires the sheets to be laid with the long edge horizontal, the vertical joint shown in Figure 1 can be replaced by a mid height horizontal joint. The sheathing to one face of the panel will normally consist of two sheets approximately 1,2 m $\times$ 2,4 m. Where other sizes of sheet are used in practice they may be substituted and suit the size of the timber frame.

NOTE 4 Test panels may include sheathing on both faces of the panel or more than one layer of sheathing on one face if required by construction practice and if all sheets are considered to contribute to the racking strength or stiffness.

The position and spacing of fixings shall be consistent and follow the specification for the panel.

NOTE 5 Sheathing thickness, sheathing fixings and their spacing are all related directly to test performance. Variation from specification can limit the use of the test results.

6 Test method

6.1 Principle

The test method measures the resistance to racking load of panels which can deform both vertically and horizontally in the plane of the panel.

In this test method, the panel is either fixed to the test rig in the same manner as that used in practice or, if the site fixing arrangement is unknown, the bottom rail of the panel is bolted (or similar) to the test rig and uplift is resisted by the sheathing fixings and also by the vertical loads on the top rail of the panel or holding down restraints.

NOTE 1 Different panels should be tested for each condition of vertical load (see 6.4.2 and 6.4.3). Normally, it is sufficient to test the maximum and minimum conditions of vertical load appropriate to the design of the panel.

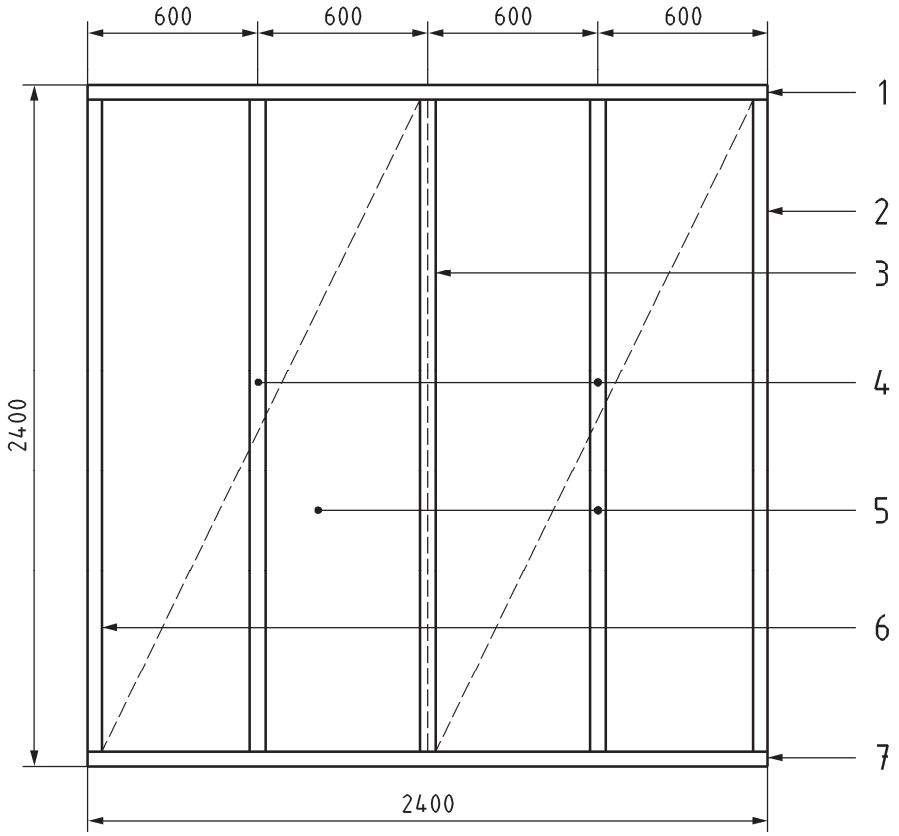
NOTE 2 The number of panels tested will depend on the variability in materials and manufacture, the required level of confidence and the number of loading conditions to be applied. Wherever possible more than three panels of the same design and loading regime should be tested to permit the assessment of the likely variability in performance.

6.2 Apparatus

The test apparatus shall be as shown in Figure 3, and shall be capable of applying separately both racking load F and vertical load F_v. The method of application of loads shall be such that no significant resistance to the in plane racking deformation of the panel is induced.

The apparatus shall be capable of continuously recording the loads F and F_v with an accuracy of ± 3 % of the load applied, or, for loads of less than 0,1 F_{max} with an accuracy of ± 0,3 % F_{max}. The panel displacements shall be measured to the nearest 0,1 mm.

Dimensions in millimetres



Key
1 top rail
2 trailing stud
3 centre stud
4 intermediate studs
5 two 1 200 mm wide sheets joined on centre stud
6 leading stud
7 bottom rail

Figure 1 — Details of test panel

6.3 Base and loading frame

6.3.1 General

The base of the test rig shall provide a level bed to receive the test panel and packer. The base shall be sufficiently stiff so as not to distort during the test. A rigid point reference (independent of the test rig) shall be provided for the measurement of the deformation of the panel.

6.3.2 Mounting of test panel

The panel should be mounted on a packer and secured through the packer to the base of the test rig in such a way that the base fixing detail models that used in practice.

Where the site fixing is unknown or may vary in practice, the bottom rail may be fixed in a manner so as to restrain the bottom rail from sliding, rotating and cupping under uplift forces in order to provide an upper bound datum such that the maximum racking capacity of the panel and its components can be tested.

Figure 2 details a typical example using holding down bolts or other fixings with equivalent performance. The bolts are normally used with large washers (75 mm diameter or equivalent is recommended for use with 90 mm wide framing timber) and shall be tightened until the washers start to embed in the bottom rail of the panel. Other forms of fixing may also be used to obtain a similar degree of restraint but shall not prevent rotation of the boards or framing members other than the bottom rail unless similar restraints can be guaranteed in practice. Where washers are not appropriate the fixings may be increased to provide equivalent resistance and spread across the width of the rail if necessary to reduce cupping forces.

The cross-sectional dimensions and position of the packer shall be such as to provide a firm base to the panel and to allow the free movement of the panel sheathing during the test.

The head binder shall be rigidly attached to the top rail of the panel, Figure 3. The cross-sectional dimensions and position shall be such as to provide a firm interface between the loads and the panel and to allow the free movement of the panel sheathing during the test.

Lateral restraints shall be provided through the head binder so that the head of the panel will deflect only in the plane of the panel.

Where special methods of base fixing are used the results obtained may be limited to the use of such fixings in practice.

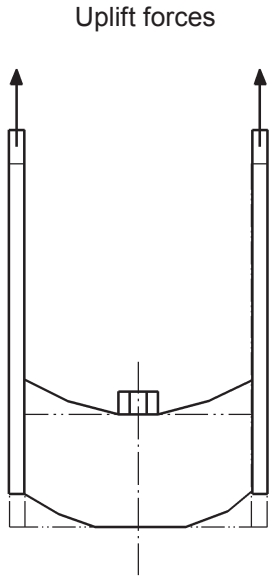


Figure 2 — Explanation of cupping deformation of bottom rail

6.3.3 Preparation of the specimens

The materials of manufacturer for the panels shall be conditioned at the standard environment of (20 ± 2) °C and (65 ± 5) % relative humidity. The test laboratory shall normally be maintained at the standard environment, but when other conditions apply, they shall be reported.

6.4 Procedure

6.4.1 General

Racking loads shall be applied with and without vertical loads.

If applicable, the vertical loads F_v shall be applied at the stud positions as shown in Figure 3. The method of application of the vertical loads shall allow for racking deflections up to 100 mm; if fixed jacking points are used, the vertical load on the stud nearest the point of application of the racking load shall be positioned approximately 100 mm from the end of the panel (see Figure 3). Additional requirements are given in 6.4.3. The racking load F shall be applied as shown in Figure 3. The metal plate through which the racking load is applied in the test shall not bear on the sheathing. The displacements of the panel shall be monitored at points 1, 2 and 3 (see Figure 3). The deformations v shall be taken as displacement at point 1 minus the displacement at point 2. The displacement at point 3 shall be reported separately.

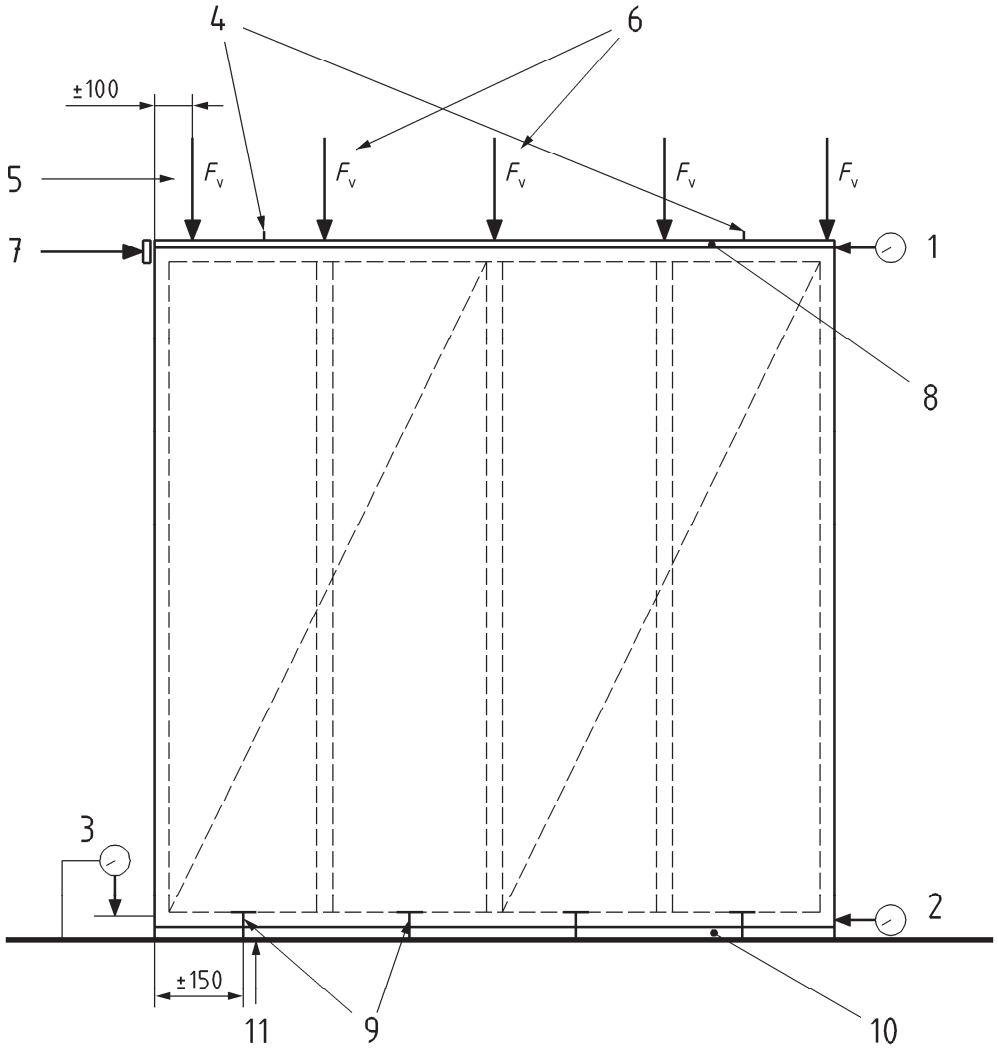
The procedure for applying the racking load, shown in Figure 4, shall be used.

The rate of loading should ensure that 90 % of the racking load F_{max} is reached within (300 ± 120) s.

NOTE 1 It is advised that the mean time to this load is about 300 s.

NOTE 2 More locations of measurements can be added, where requested.

Dimensions in millimetres



Key

1 measures the racking displacement of the panel at the top rail
2 measures the horizontal displacement of the panel at the bottom rail
3 measures the vertical displacement of the leading stud near the bottom rail from the sole plate
4 lateral restraints arranged so as not to impede movement of panel in its plane
5 leading loading point set back if using fixed loading position so as to allow 100 mm maximum racking deflection
6 vertical load spread equally to each stud and applied so as not to impede racking deflection of panel
7 racking load, *F*, applied to the top of panel on to a metal plate attached to top rail of panel and head binder
8 head binder
9 holding down bolts or other fixings with equivalent performance, minimum of four evenly spread along the panel
10 timber packer of similar section to bottom rail
11 base of test rig or sole plate

Figure 3 — Typical example of test apparatus

6.4.2 Stabilizing load cycle

The vertical loads F_v of 1 kN shall be applied to the head binder at the stud positions, as shown in Figure 3 and maintained for 120 s. This load shall then be removed and the panel allowed a recovery period of (600 ± 300) s before continuing the test.

6.4.3 Strength test

If the test is carried with vertical loads F_v of 5 kN shall be applied to the head binder at the stud positions, as shown in Figure 3 and maintained constant throughout the test procedure. During the test the vertical loads, if applicable, shall not vary more than ±10 % of the initial value.

The racking load F shall then be applied. The racking load F shall be increased until F_{max} is reached. The racking load shall be applied at the rate specified above (see 6.4.1). The deformations v_2 to v_4 and the corresponding racking loads F_2 to F_4 shall be recorded (see Figure 4).

F_{max} is reached when either:

1) the panel collapses, or

2) the panel attains a deformation v (see 6.4.1) of 100 mm, whichever occurs first.

The deformations v_2 to v_4 and the corresponding racking loads shall be recorded (see Figure 4).

Characteristic 5-percentile values shall be determined with EN 14358.

NOTE 1 The measurements indicated are minimum requirements and it is recommended that loads and deformations are continuously monitored.

NOTE 2 It is important to ensure that the panel has totally failed when the racking load begins to reduce. It is common for panels to recover after individual fixing fails. Load can be redistributed to remaining fixings.

6.4.4 Moisture content and density

After termination of the test representative samples shall be cut from the timber and sheathing material to determine the moisture content and density in accordance with ISO 3130 and ISO 3131 for the timber and EN 322 and EN 323 for the sheathing material.

6.5 Expression of the results

The test results shall contain:

a) racking stiffness of the panel, calculated from the equation

$$R = \left[\frac{F_4 - F_2}{v_4 - v_2} \right] \text{N/mm}$$

where

F_2 is the racking load of 0,2 F_{max}, in Newtons;

F_4 racking load of 0,4 $F_{max,}$, in Newtons;

v_2 and v_4 is the deformation, in millimetres;

b) racking strength, expressed as the value of the maximum racking load F_{max};

c) if applicable, the vertical loads F_v and the total vertical load during the test, and the nominal spacing of the studs;

d) a record of the displacements at 3 (see Figure 3).

NOTE The values for load relate to the maximum load. Where continuous readings have been taken the nearest reading to that required should be used.

Characteristic 5-percentile values shall be determined with EN 14358.

6.6 Test report

The test report shall include the following information:

a) sampling procedure;

b) test loads attained during the tests together with the corresponding deformations at all measurement positions; the vertical loads F_v applied in the racking test;

c) values of R and F_{max} and the circumstances in which F_{max} occurred; expression of the results of 6.5.1;

d) the mean value of F_{max} for all similar type of panels (per test series or batch);

e) specification of the materials and fixings used in the manufacture of the test panels, with a note of any defects;

f) detail of any hold down restraint used during test, including location of and method used in securing to the wall panel and to the test equipment;

g) gap between the sheets in the panel (if any);

h) direction of the greater strength of the sheathing material with respect to the studs;

i) specification of the mechanical fasteners (including corrosion protection), and their quantity and position;

j) any deviation in panel construction from that shown in Figure 1;

k) description of the fixings of the panel to the test rig;

l) description of the method of loading the panel and of measuring the panel deformations;

m) type and position of any failure;

n) where required moisture content of the timber framing and the sheathing material at the time of test.

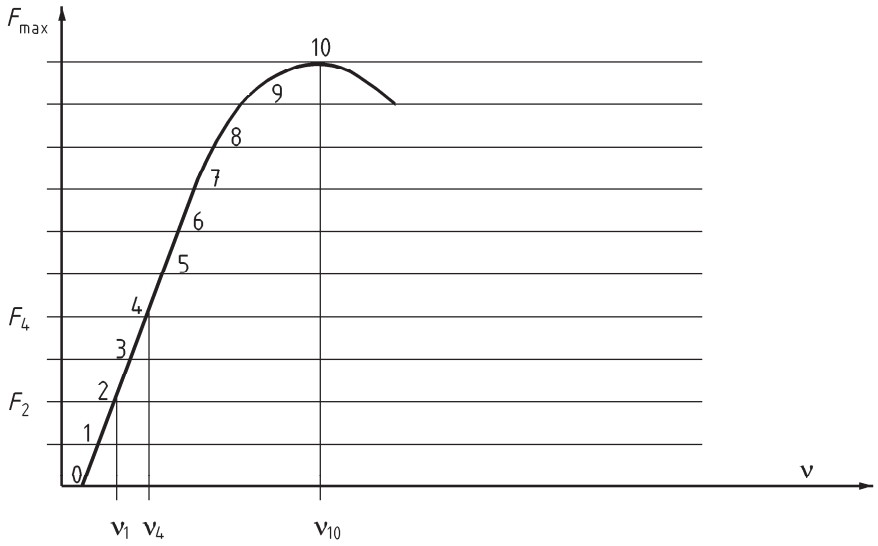


Figure 4 — Test procedure

NOTE The measurement points are considered a minimum and a continuous measuring system is recommended.

Annex A
(normative)

The testing of units of dimensions other than 2,4 m × 2,4 m

A.1 General

The purpose of this annex is to adapt the principle of the test method:

to other sizes of panel;

to combinations of panels; and to panels, which are partially sheathed;

to other panel fixings.

It is intended primarily to provide performance data, which may be used for quality assurance or for structural design. The intended use of the test results shall be clearly stated in the test report.

A.2 Requirements for panels

The wall panels tested shall generally correspond to those used in practice as far as the essential structural details and service conditions are concerned, in particular, with regard to:

a) dimensions of the wall panels, width *b* and height *h* (see, Figure A.1);

b) number, type, strength class and dimensions of the vertical studs, and intermediate horizontal members;

c) number, type and dimensions of the sheathing and the manner of the fixing to the studs, special features (e.g. horizontal joints and gap between sheets) shall also be taken into consideration;

d) fixing the panels to the base of the test rig and connections between panels;

NOTE 1 Fixing the base of the panel to the test rig should simulate the strength and stiffness to be found in practice.

e) vertical load (except that uniformly distributed loads may be simulated by stud loads);

f) test environment. Lateral restraint shall be provided so that the head of the panel will deform only in the plane of the panel.

NOTE 2 Non-structural components that might affect the test results (e.g. windows of non-structural linings) should be omitted from the panel.

Examples of test panels are shown in Figures A.1 and A.2.

A.3 Apparatus

The apparatus used in the testing of the panel shall be generally described in Clause 6. Differences in apparatus shall be agreed before testing is carried out and shall be described in the test report. Where there is a need, additional deformation measuring points may be adopted. Typical points are shown in Figure A.1.

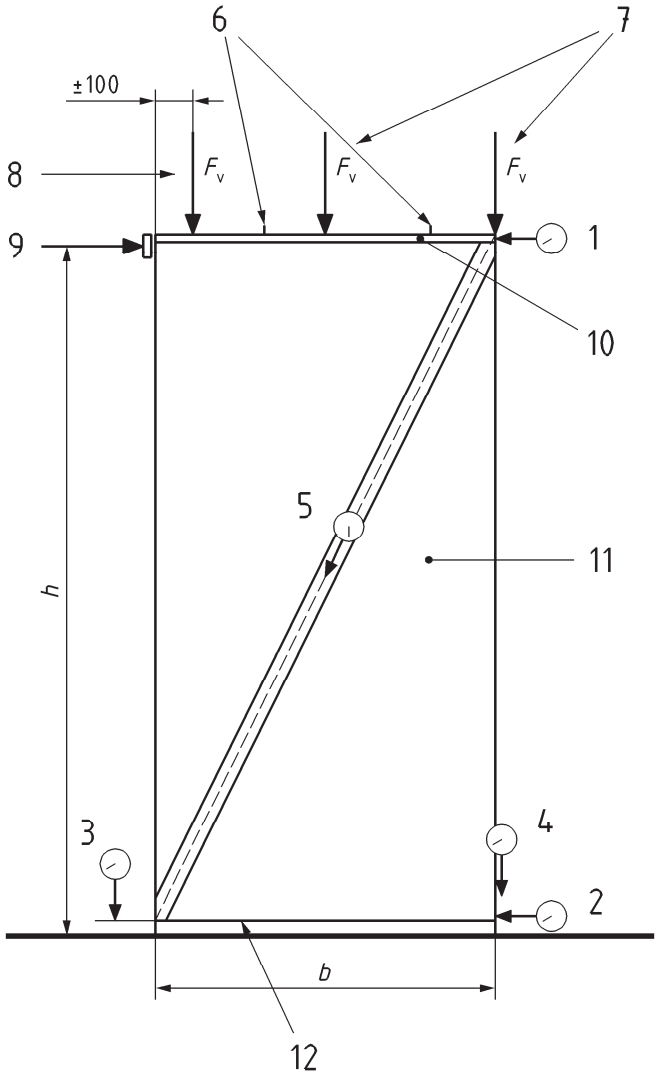
A.4 Procedure

The test procedure used in the testing of the panel shall generally follow those given in Clause 6. Departures from those procedures shall be agreed before the testing is carried out and shall be described in the test report.

A.5 Test report

The test report shall include the intended use of the test results, a detailed description of the panel tested and give the dimensions and construction of the panel. The appropriate items of 6.6 shall also be given.

Dimensions in millimetres



Key
1 measures the racking displacement of the panel at the top rail
2 measures the horizontal displacement of the panel at the bottom rail
3 measures the vertical displacement of the panel at the base point
4 measures the vertical displacement of the panel at the base point
5 measures the diagonal deformation of the panel
6 lateral restraints arranged so as not to impede movement of panel within its plane
7 vertical load applied so as not to impede racking deflection of panel
8 loading point set back 100 mm if using a fixed loading position
9 racking load, *F*, applied to the top rail via metal plate
10 head binder where necessary
11 test panel
12 base fixing of panel as in practice

Figure A.1 — Diagrammatic layout for single panel test set-up

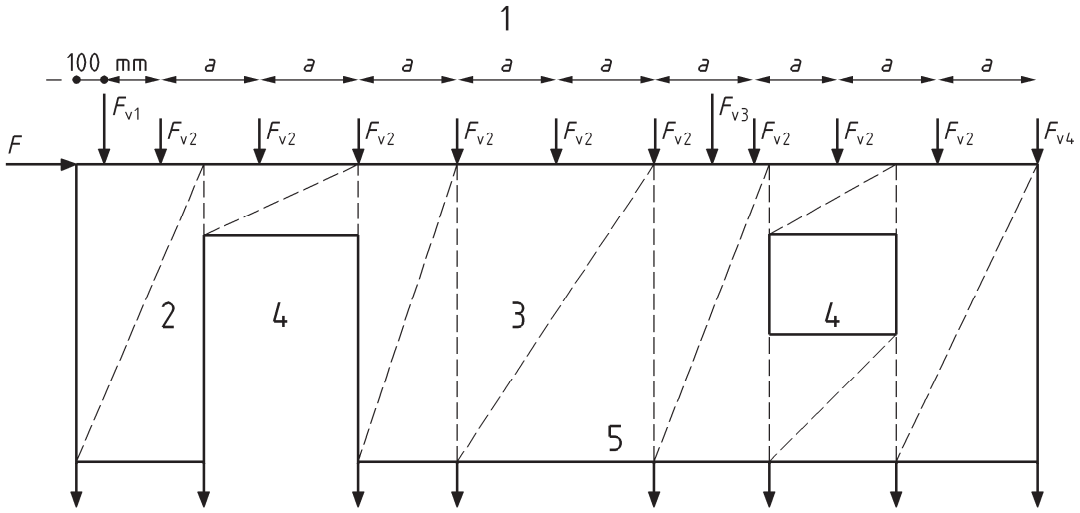


Figure A.2 — Diagrammatic layout for typical wall test using combination of panels

The numbers refer to the notes below.

NOTE 1 The vertical loading should be applied as required, but its application may be simplified to a uniform series of loads equally distributed along the top rail. In the particular case shown F_{v1}, F_{v2} and F_{v4} represent differing values of, but approximately equally spaced, point loads, and F_{v3} represents a possible concentrated point load.

NOTE 2 The sheathing lay out should be as in practice.

NOTE 3 The fixing between panels should be as in practice, allowing for combinations of panels to be tested.

NOTE 4 Non structural components that might affect the test results (e.g. doors, windows or non-structural linings) should be omitted from the panel.

NOTE 5 The base fixing of the panel should be as in practice including, where appropriate, holding down restraints. The diagram shows the normal layout of restraints related to panel openings which would allow for racking in both directions (to the right and left) along the plane of the panel.

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