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Timber structures — Structural insulated panel walls — Test methods

Structures en bois — Murs en panneaux isolants structurels — Méthodes d'essai

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 22452 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

Introduction

The objective of this International Standard is to provide the means for the structural testing of structural insulated panel (SIP) walls.

It includes tests for tensile bonding strength of the panels, ageing, shear, vertical load performance, horizontal in-plane performance and out-of-plane bending performance. A creep test has been included in the annex for information (and trial). The tests applicable to panels for particular applications are presented, the test requirements, including laboratory conditions, are given and the numbers of samples to be tested and the reporting of results are specified.

This International Standard is not intended for quality control testing or for conformity assessment.

Timber structures — Structural insulated panel walls — Test methods

1 Scope

This International Standard specifies test methods for determining the structural properties of double-sided, wood-based, load-bearing structural insulated panels (SIPs) for use in walls.

It is applicable to SIPs having

— two face layers, at least one of which is a wood-based structural panel, and

— a core made of a thermally insulating material having sufficient shear strength to cause the face layers to act together structurally.

NOTE 1 Gypsum-based structural boards are commonly used as a face layer.

NOTE 2 Panels can contain internal framing or bracing.

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.

ASTM C393/C393M-06, *Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure*

ASTM D7446-09, *Standard Specification for Structural Insulated Panel (SIP) Adhesives for Laminating Oriented Strand Board (OSB) to Rigid Cellular Polystyrene Thermal Insulation Core Materials*

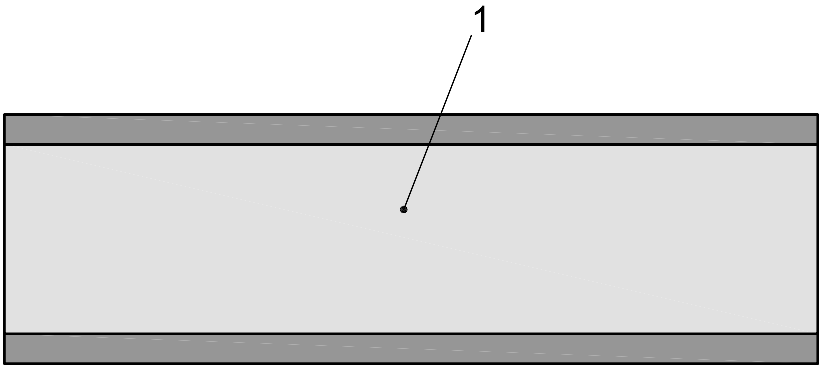
3 Terms and definitions

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

3.1
structural insulated panel
SIP
panel with two load-bearing skins, one bonded to each face of a rigid, lightweight, homogenous core material with sufficient shear strength to cause the face layers to act together structurally

See Figure 1.

NOTE The homogenous core is made of one material with no internal joints requiring bonding.



Key

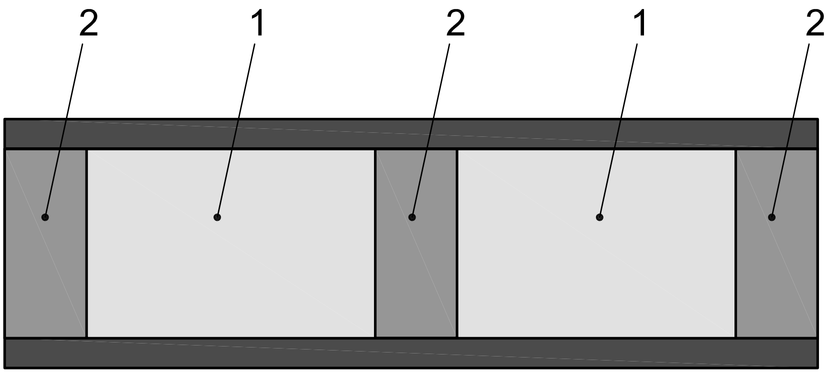
1 rigid core

Figure 1 — Cross-section of structural insulated panel

3.2
double-skin box with structural core-type structural insulated panel
panel with a rigid core surrounded by a structural frame, with or without internal ribs, and two skins mechanically fastened and/or bonded to the frame and core, forming a closed box

See Figure 2.

NOTE The skins, core and frame are all load-bearing.



Key

1 core

2 internal structural frame

Figure 2 — Structural insulated panel with internal structural frame

3.3
slabstock
core material which is pre-formed into slabs of thickness equal to the required depth of the core and then bonded with a suitable adhesive

NOTE The length and width of a slab of core material are less than or equal to the length and width of the SIP.

3.4
bonded
condition of components of a structural insulated panel in which they are bonded to each other by adhesive or where foams used for cores are foamed *in situ* and become self-adhesive while expanding and curing so that they bond automatically to the enveloping components

4 Symbols

a, b, c distances, in millimetres (mm)

B width of full panel, in millimetres (mm)

F load, in newtons (N)

F_{max} maximum load, in newtons (N)

F_{u} ultimate load, in newtons (N)

$F_{max,est}$ estimated maximum load, in newtons (N)

F_{v} vertical load, in newtons (N)

D panel thickness, in millimetres (mm)

F_{g} self load of loading element, in newtons (N)

F_{g1} self load of panel, in newtons (N)

F_{g2} applied permanent load, in newtons (N)

F_{l} lever arm load, in newtons (N)

F_{p} loading plate and rod load, in newtons (N)

F_{Q} variable load, in newtons (N)

H height of full panel, in millimetres (mm)

L span, in millimetres (mm)

l length of panel sample, in millimetres (mm)

R stiffness, in newtons per millimetre (N/mm); strength, in newtons per millimetre (N/mm)

T loading time, in seconds (s)

T_{r} recovery time, in seconds (s)

b width of panel sample, in millimetres (mm)

d_{c} depth (thickness) of core, in millimetres (mm)

e depth between the centroids of the faces, in millimetres (mm)

f_{ct} tensile strength of core material, in newtons per square millimetre (N/mm^2)

f_{cv} shear strength of core material, in newtons per square millimetre (N/mm^2)

t_1, t_2 overall thickness of the face in millimetres (mm)

w deformations, in millimetres (mm)

w_{t} total deflection under constant load at time t, in millimetres (mm)

w_{0} initial static deflection under constant load and temperature, in millimetres (mm)

η factor of less than unity modifying $F_{max,est}$

v panel racking deformation, in millimetres (mm)

5 Product evaluation

5.1 Tests applicable to panel construction

The following test regimes are applicable to the panel construction:

a) tensile testing on the core and its bonding to faces;

b) ageing test;

c) shear strength of the solid core and its bonding to faces.

5.2 Tests applicable to wall panels

The following test regimes are applicable to the wall panel:

a) vertical load (stiffness and strength);

b) horizontal in-plane load (racking stiffness and strength);

c) out-of-plane bending (stiffness and strength).

6 Structural testing

6.1 Conditioning

6.1.1 Standard conditioning

Where standard conditioning is required for the tests specified in 6.2 to 6.8, the test pieces used shall be conditioned to constant mass in an atmosphere of relative humidity of (65 ± 5) % and temperature of (20 ± 2) °C. Constant mass is deemed to be attained when the results of at least three successive weighings indicate that the moisture content has stabilized to within ±0,5 % for at least a 48 h period.

If the conditions of the testing room are not the same as those in the conditioning chamber, the test pieces shall remain in the conditioning chamber until testing.

6.1.2 Alternative conditionings

Where test pieces are not conditioned or are conditioned differently from the procedure given in 6.1.1, the alternative shall be described in the test report.

When required or appropriate, results may be corrected to reflect conditioning according to 6.1.1. The procedure for adjusting structural properties shall be technically sound and shall be recorded in the test report.

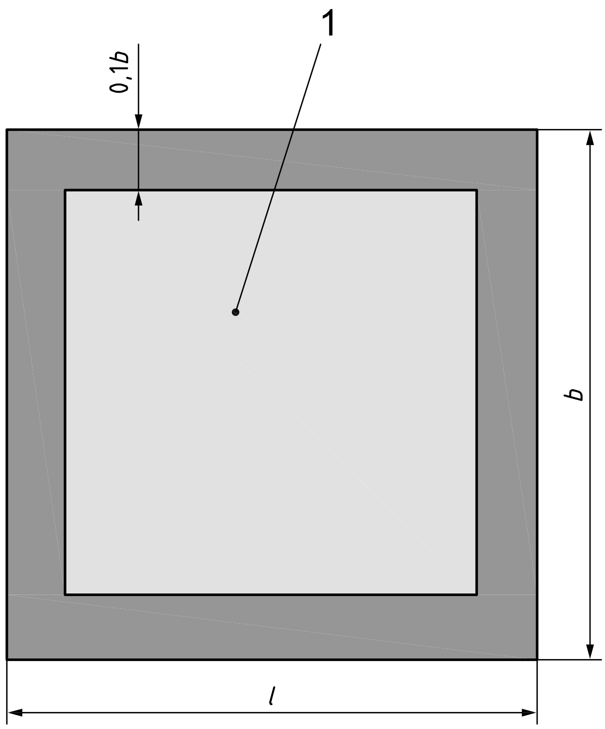
6.2 Tensile test on core material and bonding between faces and core

6.2.1 Specimen size and sampling

The depth of the specimen shall be equal to the panel thickness, D. The width, b, shall be 150 mm and the length, l, shall be 150 mm (see Figure 3).

NOTE The purpose of this test is to determine the critical failure mechanism, in core or glue line of the SIP.

The test specimens should be sampled from a range of positions covering the width and length of the panel, including the centre and edge of the sampling area, shown in Figure 3. The outer 10 % of the panel perimeter is excluded from testing.



Key

1 sampling area

b panel width

l panel length

Figure 3 — Specimen sampling from panel

6.2.2 Conditioning

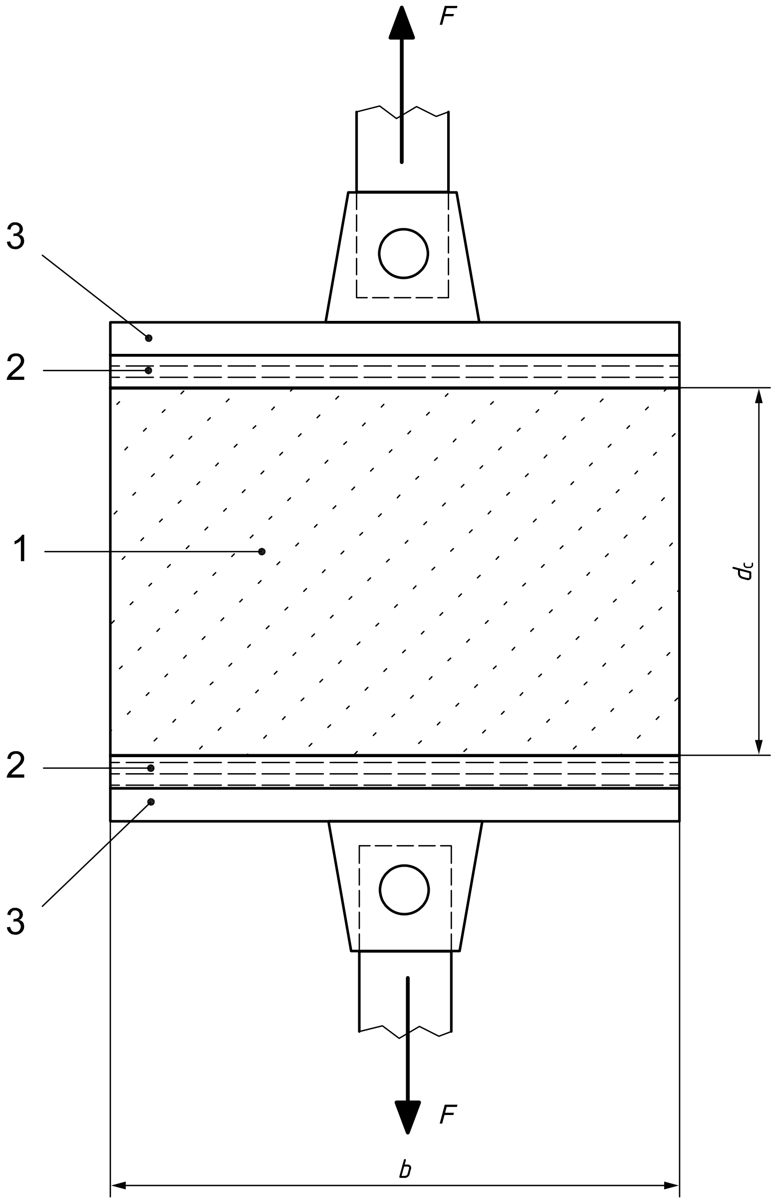
Specimens shall be conditioned either in accordance with 6.1 or to a specified elevated temperature.

Specimens shall be tested immediately after removal from the conditioning chamber when performing an elevated temperature test.

Testing at an elevated temperature may be appropriate for certain applications, and performance of the panel unit should be verified at these conditions. If uncertain of in-service temperature levels, elevated temperature test specimens should be conditioned at 80 °C for at least 4 h. No further temperature measurement is required after conditioning.

6.2.3 Loading method and test procedure

Specimens shall be bonded, using a suitable adhesive, to platens of sufficient stiffness to ensure a uniform tensile stress over the area of specimen. When conditioned according to 6.1, platens shall be bonded to the specimen after conditioning. Specimens of square cross-section shall be prepared in accordance with Figure 4.



Key

1 core

2 panel face

3 load-distributing platen

Figure 4 — Test arrangements in core tension test

The load, F, shall be applied in increments or continuously so as to reach maximum load in a period of 1 min to 5 min.

For SIPs with OSB (oriented strand board) and polystyrene thermal insulation core materials, ASTM D7446-09, 13.2, should be referred to and considered for use, as appropriate.

NOTE This test is not intended for paper-faced lining materials.

6.2.4 Reporting results

The tensile strength, f_{ct}, of the core material shall be calculated from the maximum load attained in a specimen failing in tension as follows:

$$f_{ct} = \frac{F_u}{bl}$$

where F_u is the ultimate load carried by the specimen failing in tension.

The test report shall include the following information:

a) sampling procedure;

b) number of specimens tested;

c) specification for the test panels;

d) specification of the materials used in the manufacture of the test panels;

e) detailed description of the test specimens, including any deviations from the specification;

f) type of any failure, stating whether failure was in adhesion, cohesion or another mode; failure of the bond between board face and loading platen should be recorded separately;

g) any conditioning applied to the specimens, and the test laboratory conditions;

h) the tensile strength, f_{ct}, of each specimen and the mean of all test results;

i) any other appropriate information.

NOTE If failure occurs at bond, then the f_{ct} value is quoted as the default.

6.3 Shear test on panel assembly (short-term loading)

6.3.1 General

This test shall be applied to SIPs with no additional internal frames. The behaviour of panels with internal frames or internal ribs shall be established from the out-of-plane bending test (see 6.8). Specimens shall be conditioned in accordance with 6.1.

6.3.2 Specimen size and sampling

The specimen (1 000 mm × 150mm) shall be cut from full-sized SIPs (single-panel units before assembly/jointing, often 1,2 m × 2,4 m).

The test specimens should be sampled from a range of positions covering the width and length of the panel, including the centre and edge of the sampling area shown in Figure 3. The outer 10 % of the panel perimeter is excluded from testing.

If the 1 000 mm span does not result in a shear failure in the first test, the span shall be reduced in increments of 100 mm in subsequent tests until shear failure is obtained. Subsequent tests shall then be carried out at the reduced span.

NOTE The intent is to induce a shear failure in the specimen.

6.3.3 Loading method and test procedure

The load, F, shall be applied equally at the 1/3 points of the span between the supports (see Figure 5). Apply the load until failure occurs. The loading rate shall be such as to result in failure between 1 min and 5 min after the start of the test. If the SIP has two dissimilar faces, the weaker of the two faces shall be placed in compression.

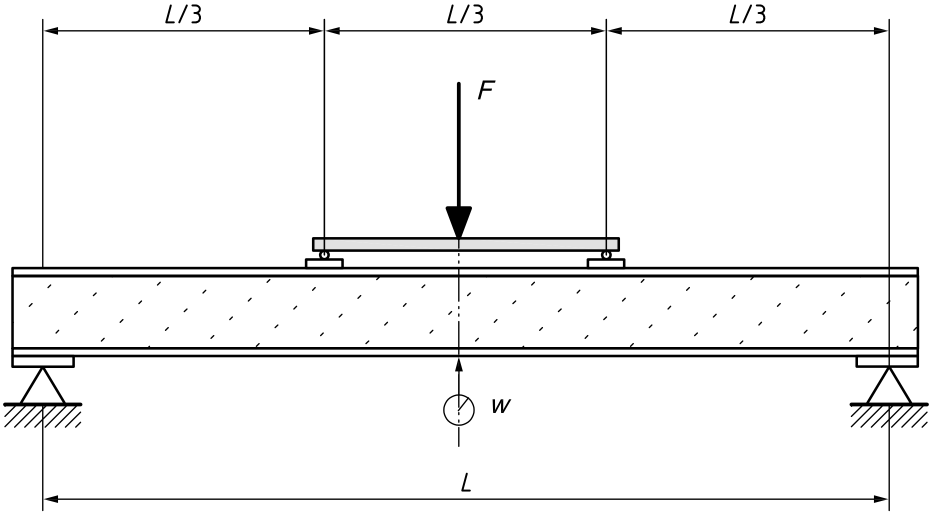
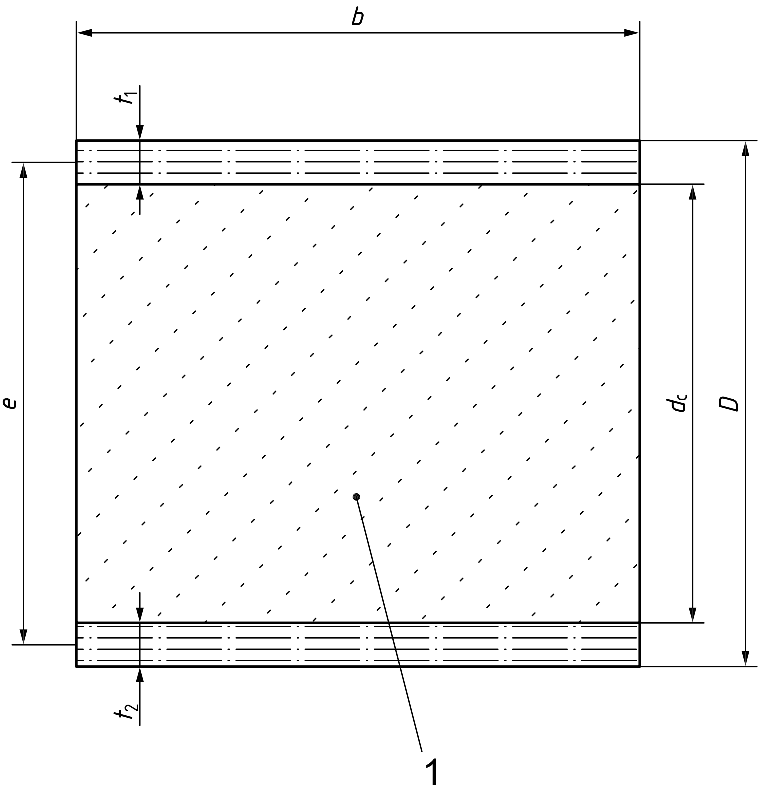


Figure 5 — Test arrangement in shear test on SIP (no internal frame)

The metal strips or similar at the supports and load points shall equal the specimen width plus 50 mm in length, 50 mm in width and 15 mm in thickness. If local crushing of the core occurs in the first test, increase the width until crushing is prevented. See Figure 6.

NOTE The radius of the ball bearings are typically in the range of 15 mm.



Key

1 core

t_1, t_2 panel faces

Figure 6 — Cross-section of shear test specimen

The loading rate shall be such as to result in failure between 1 min and 5 min after the start of the test and shall be monitored by specimen deflection.

6.3.4 Reporting results

For each test specimen, measure depths D and d_c, width b and the net face thicknesses, t_1 and t_2, of both panel faces of each test specimen.

Calculate the shear strength, f_{cv}, of the core material from the maximum load attained in a specimen failing in shear as follows:

$$f_{cv} = \frac{F_u}{2be}$$

where F_u is the ultimate load carried by the specimen failing in shear.

The test report shall include the following information:

a) sampling procedure;

b) number of specimens tested;

c) specification for the test panels;

d) specification of the materials used in the manufacture of the test panels;

e) detailed description of the test specimens and set-up, including any deviations from the specification;

f) direction of greater strength of the facing material, if applicable;

g) type and position of any failure;

h) any conditioning applied to the specimens, and the test laboratory conditions;

i) shear strength, f_{cv}, of the core material for each specimen, and the mean of all tests;

j) any other appropriate information.

6.4 Accelerated ageing tests

Conduct the dry soak test and modified D1183 C tests in accordance with ASTM D7446-09, Section 14, with a minimum of five specimens.

Subject each specimen to six complete cycles of laboratory ageing.

After completion of the six cycles of exposure, further condition the specimen at a temperature of (20 ± 2) °C and relative humidity of (50 ± 2) % back to a constant weight (±0,5 %) before testing. Report the time required to attain constant weight.

The specimen shall be frequently inspected during the ageing cycles for any signs of delamination or other disintegration. If there is any apparent damage to the material, report the damage and the stage of the regime in which it appeared.

After completion of the cycles, subject the specimens to the following tests:

— tensile test (see 6.2);

— shear test (see 6.3).

6.5 Vertical load capacity (stiffness and strength)

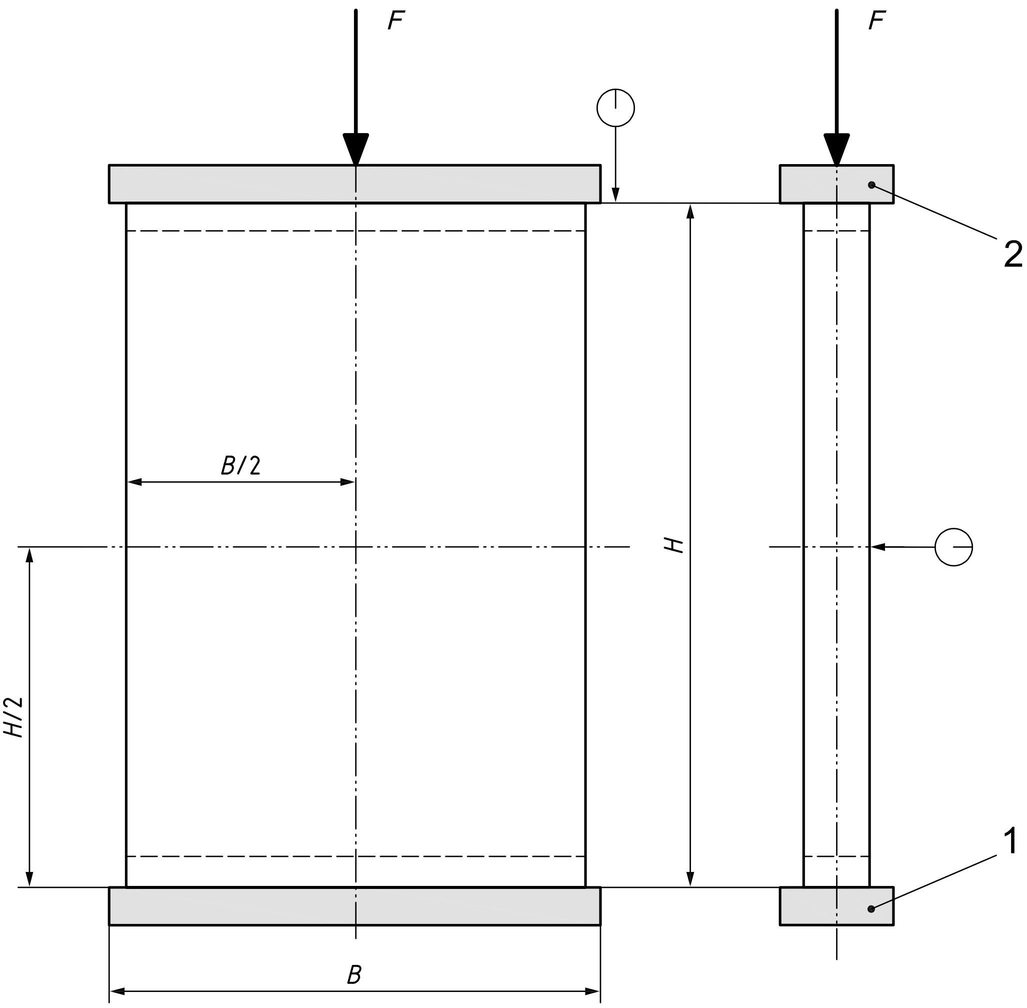
6.5.1 Specimen size and sampling

Panels shall be tested individually. They shall be of sizes typical in service, and of formats for which structural design data is required. Specimens shall be conditioned in accordance with 6.1.

6.5.2 Loading method and test procedure

6.5.2.1 General

In-service installation details and top- and bottom-support conditions shall be simulated. The test loading shall be both applied and resisted in a manner approximating the actual in-service conditions. The specimen shall be loaded either concentrically (see Figure 7) or eccentrically (see Figure 8). The eccentricity shall be at least one-sixth the panel thickness to the interior or towards the weaker facing of material of an interior panel. Eccentricities other than those necessary to simulate in-service conditions shall be avoided at points of loading and reaction, and care shall be taken to ensure that no inadvertent restraints are present. If eccentricities in the service conditions are larger, they shall be used in testing.



Key

1 solid base

2 load spreader

NOTE Top and bottom rail configurations to match in-service conditions.

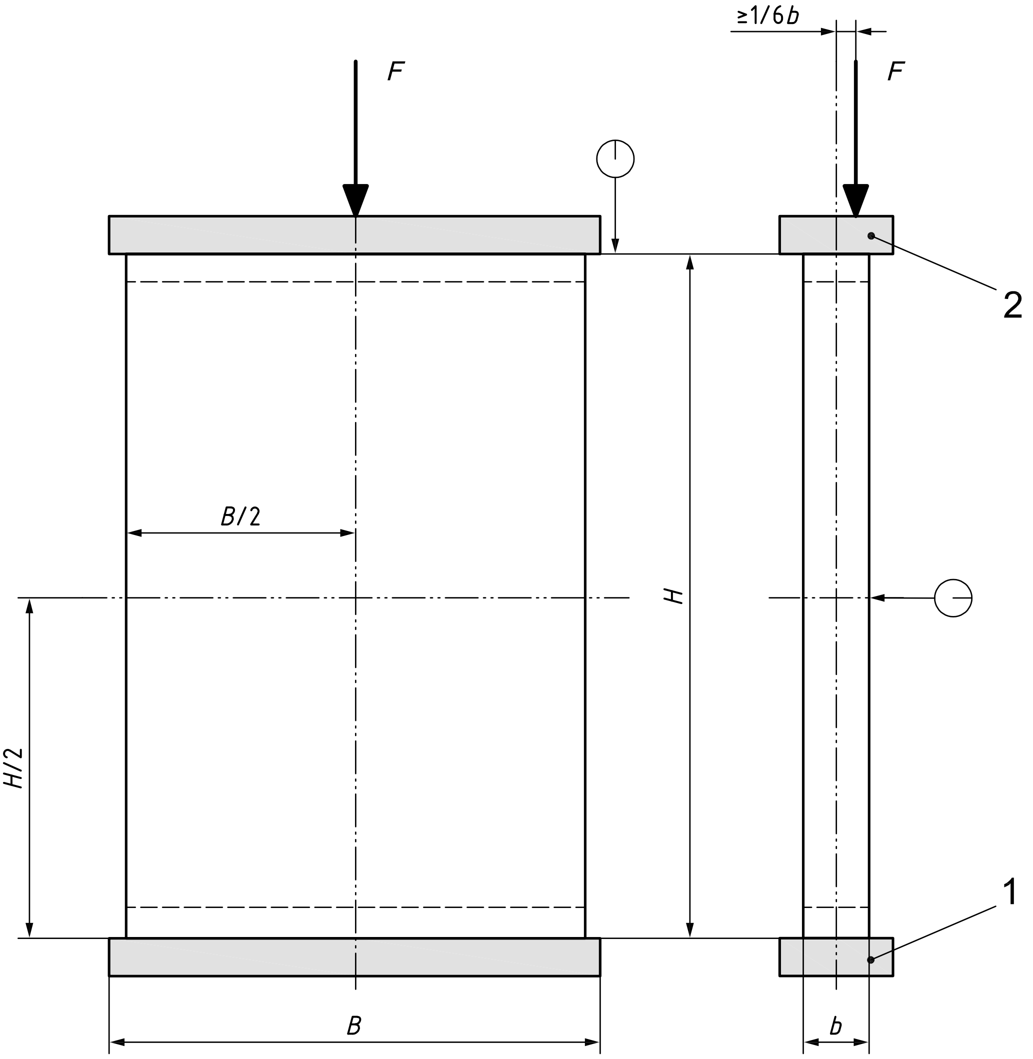
Figure 7 — General test set-up for vertical load capacity

Alternative panel sizes may be tested if required.

A minimum of three, ideally five, identical panels or assemblies of the same design should be tested.

It might be appropriate to cover the impact of the inclusion of pre-cut conduits or electrical boxes. These can control the capacity of the SIP and should be considered when testing.

Figure 7 illustrates a typical test set-up for measuring vertical load capacity for a concentrically applied load. Deflection shall be measured at mid-point and mid-height to monitor out-of-plane deformations, and at the top of the panel to monitor in-plane compression.



Key

1 solid base

2 load spreader

NOTE Top and bottom rail configurations to match in-service conditions.

Figure 8 — General test set-up for eccentric vertical loading conditions

The accuracy of loading and of deflection and load measurement shall be within ±3 %. Departures from the required test procedure and values shall be reported.

6.5.2.2 Basic loading procedure

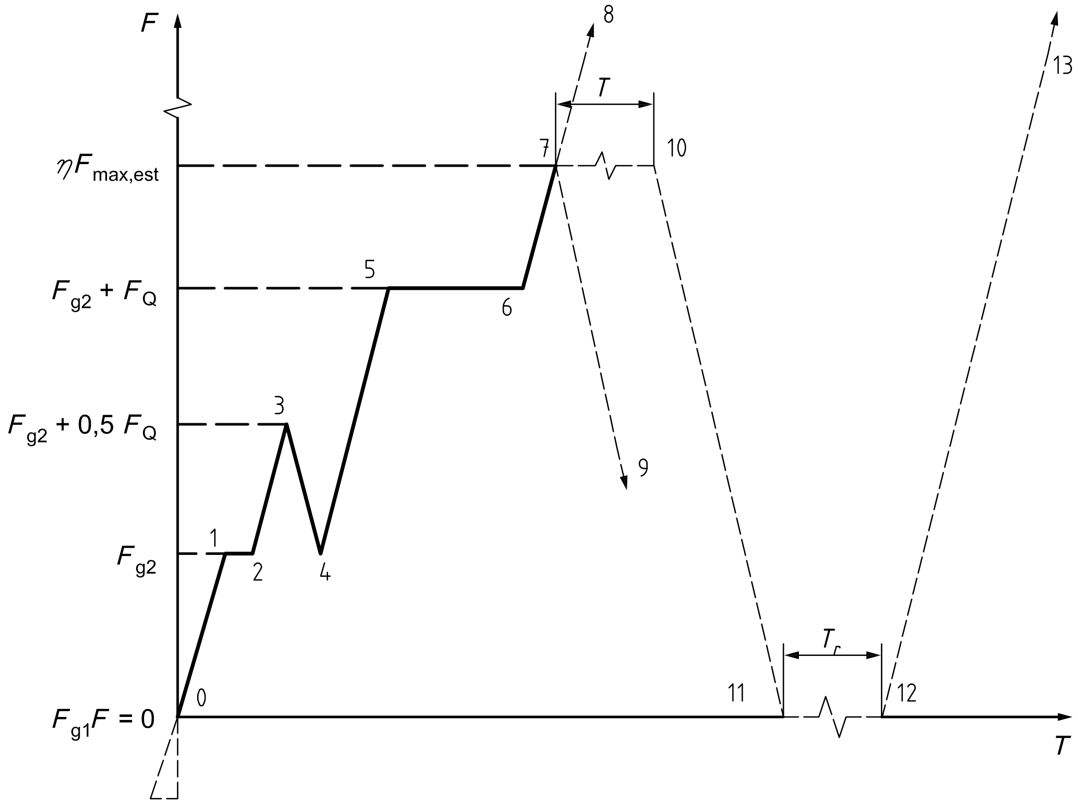
The basic loading procedure shall consist of the procedural steps (0–7) given in Table 1. A diagrammatic representation of the loading procedure is given in Figure 9.

It is strongly recommended that a vertical preload of 5 kN be applied and maintained for 120 s, then released. Allow the panel to recover for a minimum of 300 s before starting the test.

Table 1 — Basic loading procedure

Procedural step	Loading procedure	Time s
0	Only F_{g1} acting, and $F = 0$	—
0–1	Apply $F = F_{g2}$	—
1–2	Maintain $F = F_{g2}$	≥120
2–3	Apply $F = F_{g2} + 0{,}5F_Q$	≥120
3–4	Remove $0{,}5F_Q$	≥120
4–5	Apply $F = F_{g2} + F_Q$	≥240
5–6	Maintain $F = F_{g2} + F_Q$	≥1 200
6–7[a]	Increase F until $\eta F_{max,est}$ is reached	≥600

[a] The maximum loading rate shall not exceed $0{,}25F_Q$ per 60 s.



Key

T time

F load

Figure 9 — Schematic of loading procedure

6.5.2.3 Maximum load — Procedure 1

Procedure 1 shall consist of the basic loading steps (0–7), concluded by increasing the load up to the maximum load, F_{max}, (step 7–8), as shown in Figure 9.

If considerable deformation occurs during the application of the load, the rate of loading should be reduced.

6.5.2.4 Proof loading — Procedure 2

Procedure 2 shall consist of the basic loading steps (0–7). The load shall be removed after a prescribed load, $\eta F_{max,est}$ ($\eta < 1$), has been reached and the test ended (steps 7–9), as shown in Figure 9.

NOTE This procedure is intended for proof loading and where the capacity at more than one load combination is tested. The value of η depends on the confidence required in estimating the maximum load capacity. Typically, η ranges between 60 % and 80 % of F_{max}. This can be adjusted in subsequent tests.

6.5.2.5 Long-term deformation — Procedure 3

Procedure 3 shall consist of the basic loading steps (0–7). The load, $\eta F_{max,est}$, shall be kept constant for a chosen period of time, T, and then removed and the recovery measured during a chosen period, T_r, (steps 7–12), as shown in Figure 9.

6.5.2.6 Capacity after long-term loading — Procedure 4

This is the same as procedure 3 except that the structure shall be reloaded to failure (steps 7–13), as shown in Figure 9.

NOTE Whereas procedure 3 is intended for the study of deformation under long-term loading, procedure 4 is intended for the study of maximum load capacity after long-term loading.

6.5.3 Instrumentation and data recording

Deformation (e.g. deflection) shall be measured at the number of locations necessary for estimating the performance of the structure. At a minimum, the deformation shall be measured at the point of expected maximum deformation.

At a minimum, the load and deformation shall be recorded at each load application or removal, i.e. at the points marked by circles in Figure 9, and, additionally, at loading increments of above $0{,}1F_{max,est}$.

During constant load, time and deformation shall be recorded continuously or, where this is not possible, at least five times during the period of constant load (three points between the starting and final points).

NOTE In-plane deformation is only critical for compression, crushing-type failure, which is not specifically evaluated with this test regime.

Measurements of load and deformation should be recorded continuously.

6.5.4 Reporting results

The test report shall include the following information:

a) number of panels tested;

b) specification of the test panels;

c) specification of the materials used in the manufacture of the test panels;

d) specification of any mechanical fasteners (including corrosion protection), and their quantity and positioning;

e) detailed description of the test panels, including any deviations from the specification;

f) any gaps within the test specimen;

g) direction of greater strength of the facing material, if applicable;

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

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

j) test loads attained during the tests, together with the corresponding deformations at all measurement positions and the application points, load/deformation curves and deformation/time curves;

k) type and position of any failure;

l) any conditioning applied to the panel, and the test laboratory conditions;

m) any other appropriate information.

6.6 Bending properties for SIP headers (stiffness and strength)

6.6.1 General

Bending tests shall be conducted for structural insulated panels used as window or door headers.

The SIP headers are normally cut out from large panels along the strength axis of the facing materials. SIP headers are typically fabricated with solid timber splines attached to the top and bottom of the header with nails. The units are generally loaded edgewise, with the load being transferred parallel to the plane of the facing materials and perpendicular to the strength axis of the facing materials. Due to the complexity of the available material and connection combinations, the bending properties of SIP headers should be evaluated based on the full-scale testing described in the following subclauses using representative specimens and details recommended by the SIP manufacturer. Other proprietary header systems used for SIP construction can also be tested using this method.

NOTE Depending on the span-to-depth ratio of the header, the thickness and properties of the facing materials and the connection details between the facing materials and the spline set-up, the failure mode of SIP headers could range from flexural failure to shear failure of the facing materials, shear failure along the connection, flexure failure of the timber tension spline and bearing failure of the facing materials.

6.6.2 Specimen size and sampling

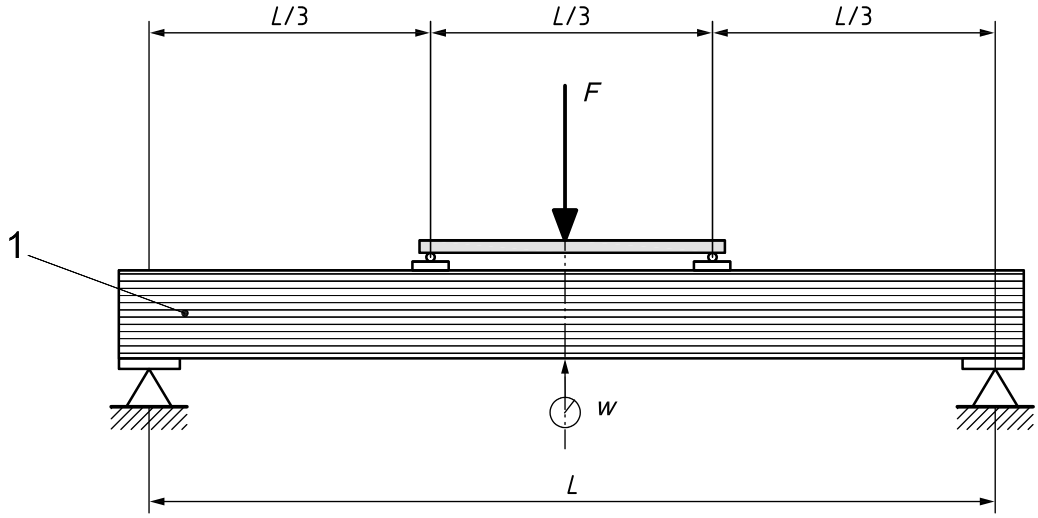
Specimen size shall be determined in accordance with the intended applications. The specimen size shall include the minimum and maximum thicknesses and depths, and the maximum, minimum and intermediate lengths intended for the header applications.

The long edges of each specimen shall be assembled from a SIP and fixed as recommended by the SIP manufacturer to produce the test header unit. If finger-jointed splines are used, at least one finger joint shall be located near the centre of the test span on the tension side of the specimen.

Specimens shall be conditioned in accordance with 6.1.

6.6.3 Loading method and test procedure

The specimen shall be set up in accordance with Figure 10 and the load, F, shall be applied equally at the 1/3 points of the span between the supports. Apply the load until failure occurs. The loading rate shall be such as to result in failure between 1 min and 5 min after the start of the test. Deflection shall be measured as far as is practical, without risking test equipment damage. The accuracy of loading and of deflection and load measurement shall be within ±3 %.



Key

1 header section

Figure 10 — SIP header section

Where applicable, check creep performance (see Annex A).

6.6.4 Reporting results

The test report shall include the following information:

a) sampling procedure;

b) specification of the header section;

c) specification of the materials used in the manufacture of the test panels, including the grade and species of the solid timber inserts, the grade and direction of the facing materials, and the grade of the foam core materials;

d) location of timber inserts;

e) specification of any mechanical fasteners (including corrosion protection), and their quantity and positioning;

f) detailed description of the header section, including any deviations from the specification;

g) description of the method of loading the header and of measuring the header deformations;

h) ultimate loads attained during the tests, together with the corresponding deformations at all measurement positions, load/deformation curves and deformation/time curves;

i) type and position of any failure;

j) moisture content of the timber splines at the time of failure;

k) any conditioning applied to the header, and the test laboratory conditions;

l) any other appropriate information.

6.7 Horizontal in-plane monotonic load racking stiffness and strength test

6.7.1 General

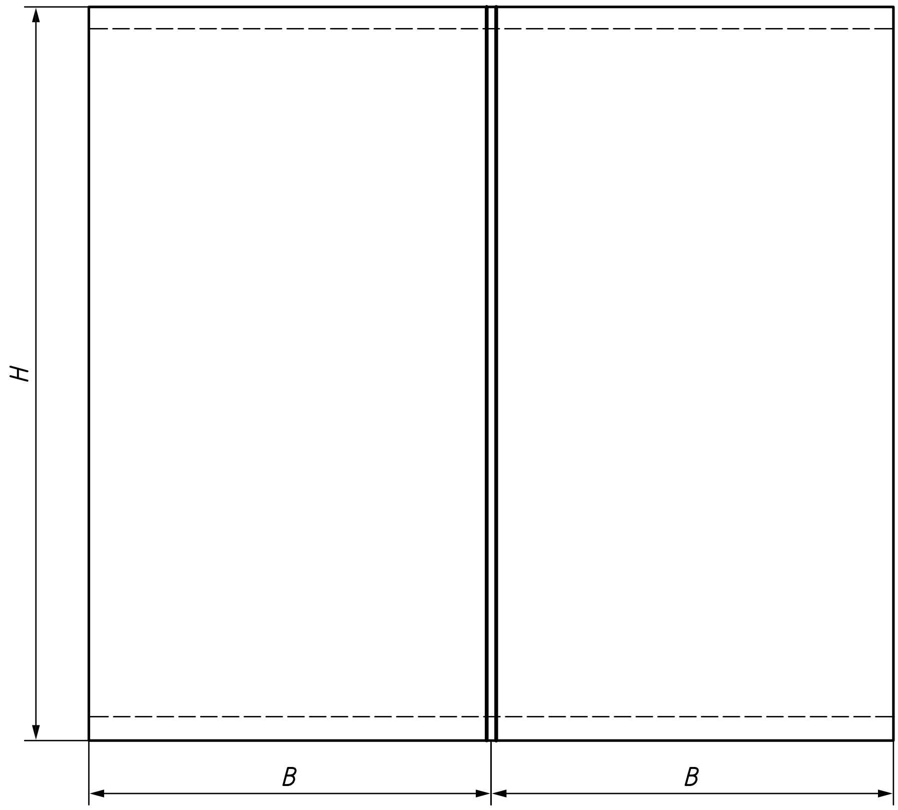
When required and where appropriate, SIPs shall be tested taking into account seismic and cyclic loading.

NOTE ISO 21581[2] is an International Standard suitable for static and cyclic testing.

6.7.2 Specimen size and sampling

Two panels shall be mounted side by side horizontally and connected in the appropriate manner for the system, with top, bottom and vertical joint configurations to match in-service conditions. The dimensions of panels shall be as given in Figure 11.

Dimensions in millimetres



Key

H height of full panel (2 400 mm or other)

B width of full panel (1 200 mm, 910 mm or other)

Figure 11 — Test panels for racking

Different panels should be tested for each condition of vertical load (see 6.7.3.4). Normally, it is sufficient to test the maximum and minimum conditions of vertical load appropriate to the design of the panel. However, a test with an intermediate vertical load is also recommended.

Alternative panel sizes may be tested if required.

A minimum of three, ideally five, identical panels or assemblies of the same design should be tested.

6.7.3 Loading method and test procedure

6.7.3.1 General

The test apparatus shall be as shown in Figure 12 and shall be capable of applying, separately, racking load F and vertical load F_V. The method of application of the loads shall be such that no significant resistance to movement in the panel is induced.

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

6.7.3.2 Base and loading frame

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

6.7.3.3 Mounting of test panels

The panels shall be bolted through a packer to the base of the test rig with holding-down bolts positioned as shown in Figure 12. However, other methods of fixing the panels to the bottom rail, including a representation of installation in practice, shall be permitted, provided they have approximately the same or better retaining performance as the bolted method. All fixings shall act through large washers (50 mm diameter or equivalent is recommended) and shall be tightened until the washers are tight to the bottom rail of the panel. The cross-sectional dimensions and position of the packer shall provide a firm base to the panel and replicate the normal base and top of the panel junction detail. If appropriate, the packer shall allow the free movement of the panel facings during the test. Top and bottom rig connections shall allow free movement/rotation of the specimen.

The head binder shall be rigidly attached to the top rail of the panel. The cross-sectional dimensions and position shall be such as to apply the loads to the facings of the panel.

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

6.7.3.4 Loading conditions

Racking tests shall be applied both with and without vertical loads.

If applicable, the vertical load, F_V, shall be applied as shown in Figure 12 at about 600 mm centres. Where no internal studding is present within the panel, the vertical load shall be applied uniformly. The method of application of the vertical loads shall allow for racking deflections of up to 100 mm; if fixed jacking points are used, the vertical load on the stud (where available) nearest the point of application of the racking load shall be positioned approximately 100 mm from the end of the panel (see Figure 12).

The racking load, F, shall be applied as shown in Figure 12. 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 in Figure 12. The deformation, v, shall be taken as displacement at point 1 minus the displacement at point 2. The displacement at point 3 shall be reported separately.

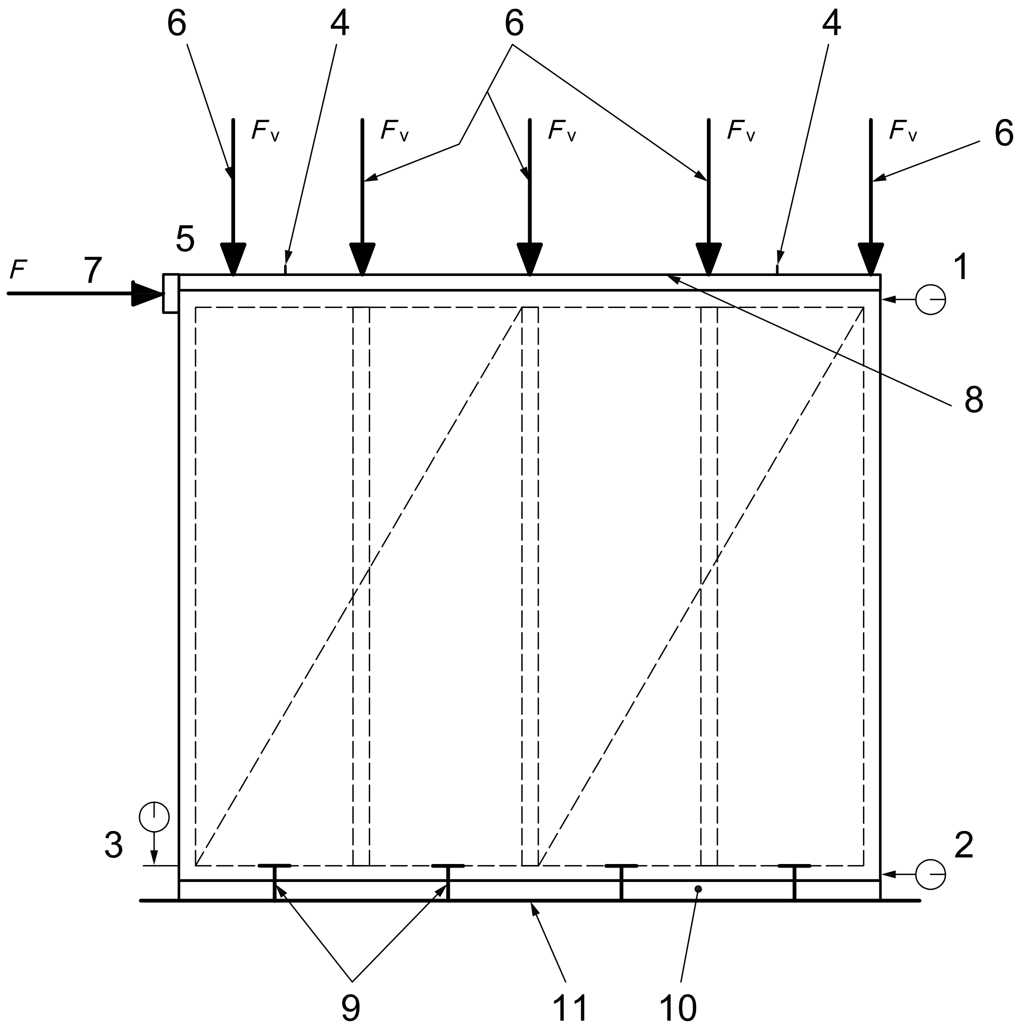
The procedure for applying the racking load in accordance with Figure 13 shall be used. The rate of loading should ensure that 90 % of the maximum load, F_{max}, is reached within (300 ± 120) s.

NOTE 1 The mean time to this load is about 300 s.

NOTE 2 More locations of measurements can be added if desired.

In circumstances where the application of the vertical load is not representative of end-use and would therefore render non-conservative results, the testing should be completed without it. This should be decided in collaboration with the test laboratory upon review of all relevant details and applications of the wall unit.

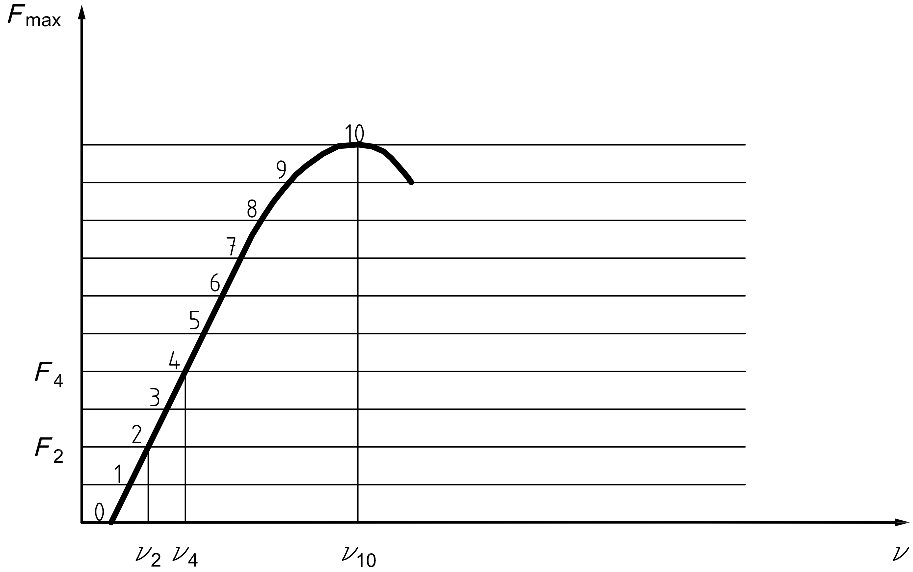
Dimensions in millimetres



Key

1 point of measurement of racking displacement of panel at top rail
2 point of measurement of horizontal displacement of panel at bottom rail.
3 point of measurement of vertical displacement of leading stud near bottom rail from sole plate
4 lateral restraints (arranged so as not impede movement of panel in its plane)
5 leading loading point (set back if using a fixed loading position to allow 100 mm max. racking deflection)
6 vertical load, F_v (spread equally to each stud and applied so as not to impede racking deflection of panel)
7 racking load, F (applied to top panel onto 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 spread evenly along panel
10 timber packer of similar section to bottom rail
11 base of test rig or sole plate

Figure 12 — Typical example of racking test apparatus
(2,4 m long panel with vertical joint at 1,2 m)



Key

F load

v deformation

Figure 13 — Racking test procedure

6.7.3.5 Stabilizing load cycle

Vertical loads, F_v, of 1 kN shall be applied to the head binder, as shown in Figure 12, and maintained for 120 s. This load shall then be removed and the panel allowed a recovery period of (600 ± 300) s before the test is continued.

6.7.3.6 Strength test

If this test is carried out with vertical loads, then an F_v equal to 5 kN shall be applied to the head binder at the stud positions, as shown in Figure 12, and maintained constant throughout the test procedure. If applied, F_v shall not vary during the test by more than ±10 % of the initial value.

The racking load, F, shall then be applied at the rate specified in 6.7.3.4 and increased until F_{max} is reached. Deformations v_2 to v_4 and corresponding racking loads F_2 to F_4 shall be recorded (see Figure 13). F_{max} is reached when either

— the panel collapses, or

— the panel attains a deformation, v, of 100 mm,

whichever occurs first.

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

It is important to ensure that the panel has totally failed when the racking load begins to reduce, as it is common for panels to recover the load loss when individual fixings fail by redistributing the load to the remaining fixings.

6.7.4 Reporting results

6.7.4.1 General

The test report shall include the following information:

a) sampling procedure;

b) number of replicates tested;

c) specification of the test panels;

d) specification of the materials used in the manufacture of the test panels;

e) specification of any mechanical fasteners (including corrosion protection), and their quantity and positioning;

f) detailed description of the test panels including any deviations from the specification;

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

h) direction of greater strength of the facing material, if applicable;

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

j) any deviation in the test set-up from that shown in Figure 12, including a detailed description of bottom and top rail configurations, as tested and as in practice

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

l) type and position of any failure;

m) test loads attained during the tests, together with the corresponding deformations at all measurement positions; the application points and total value of the vertical load, F_v, applied in the racking stiffness and strength tests;

n) values of the racking stiffness, R, and maximum load, F_{max}, and the circumstances in which F_{max} occurred;

o) $F_{max,est}$ related to F_{max} for each panel and the mean value of F_{max} for all similar tests (see 6.7.3.4);

p) any conditioning applied to the panel, and the test laboratory conditions;

q) any other information believed to be appropriate.

6.7.4.2 Racking stiffness and strength, vertical loads and displacement

The reported test results shall also contain the following:

r) the racking stiffness, R, of the panel, expressed in newtons per millimetre, calculated using

$$R = \frac{F_4 - F_2}{v_4 - v_2}$$

where

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

F_4 is the racking load of 0,4F_{max}, in newtons.

s) the racking strength, expressed as the value of the maximum racking load, F_{max}, as found in the strength test;

t) if applicable, the vertical load, F_v, the total vertical load, and the nominal spacing of the studs;

u) a record of the displacement at point 3 in Figure 12.

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

6.8 Out-of-plane bending (stiffness and strength)

6.8.1 Specimen size and sampling

Panels shall be tested individually. They shall be typical of sizes in service and formats for which structural design data is required.

Specimens shall be conditioned in accordance with 6.1.

NOTE 1 Bending tests may cause shear failure in the core and any framing or planes of adhesion or, alternatively, tensile or compressive failure in the faces. Tests over short spans are likely to promote shear failure, while tests over long spans are likely to promote failure in the faces. Accordingly, and particularly for panels with framing or slabstock cores, it may be appropriate to determine the bending strength of both short and long panels, in order to determine performance against both failure modes.

NOTE 2 The bending test is normally applied to single panels, but can be applied to two or more panels connected together to test the connection system.

6.8.2 Loading method and test procedure

6.8.2.1 General

The test loading shall be both applied and resisted in a manner approximating actual in-service conditions. Four-point bending, as illustrated in Figure 14, shall be the preferred method of loading; alternatively, three-point bending or a distributed load may be applied. Eccentricities other than those necessary to simulate in-service conditions shall be avoided at points of loading and reaction, and care shall be taken to ensure that no inadvertent restraints are present.

NOTE Panels are normally supported horizontally. If panels have an asymmetric construction (particularly two different faces), it may be appropriate in the case where they will experience loading in both directions (e.g. wind loads) to measure the bending strength of one set of panels in one direction and another set of panels in the other direction.

The accuracy of deflection and load measurement shall be to within ±3 %.

Two deflection gauges should be employed, one on each side of the specimen at mid-span.

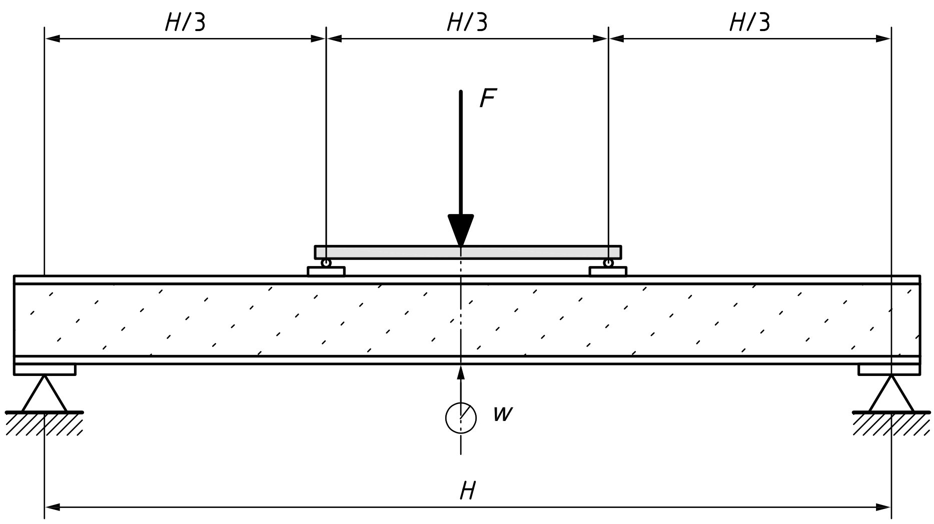


Figure 14 — General test set-up for out-of-plane bending

6.8.2.2 Basic loading procedure

The basic loading procedure shall consist of the procedural steps (0–7) specified in Table 1 and shown schematically in Figure 9.

6.8.2.3 Maximum load — Procedure 1

Procedure 1 shall consist of the basic loading steps (0–7), concluded by increasing the load up to the maximum load, F_{max}, (step 7–8), as shown in Figure 9.

If considerable deformation occurs during the application of the load, reduce the rate of loading.

6.8.2.4 Proof loading — Procedure 2

Procedure 2 shall consist of the basic loading steps (0–7). The load shall be removed after a prescribed load, $\eta F_{max,est}$ ($\eta < 1$), has been reached and the test ended (steps 7–9), as shown in Figure 9.

NOTE This procedure is intended for proof loading and where the capacity at more than one load combination is tested. The value of η depends on the confidence required in estimating the maximum load capacity.

6.8.2.5 Long-term deformation — Procedure 3

Procedure 3 shall consist of the basic loading steps (0–7). The load, $\eta F_{max,est}$, shall be kept constant for a chosen period of time, T, and then removed and the recovery measured during a chosen period, T_r, (steps 7–12), as shown in Figure 9.

6.8.2.6 Capacity after long-term loading — Procedure 4

This is the same as procedure 3 except that the structure shall be reloaded to failure (steps 7–13), as shown in Figure 9.

NOTE Procedures 3 and 4 are intended for the study of deformation under long-term loading and maximum load capacity after long-term loading.

6.8.3 Instrumentation and data recording

Deformation (e.g. deflection) shall be measured at the number of locations that is necessary for estimating the performance of the specimen. At a minimum, the deformation shall be measured at the point of expected maximum deformation.

At a minimum, the load and deformation shall be recorded at each load application or removal, i.e. at the points marked by circles in Figure 12, and, additionally, at loading increments of above $0{,}1F_{max,est}$.

During constant load, time and deformation shall be recorded continuously or, where this is not possible, at least five times during the period of constant load (at three points between the starting and final points).

Measurements of load and deformation should be recorded continuously.

6.8.4 Reporting results

The test report shall include the following information:

a) sampling procedure;

b) number of panels tested;

c) specification for the test panels;

d) specification of the materials used in the manufacture of the test panels;

e) specification of any mechanical fasteners (including corrosion protection) and their quantity and positioning;

f) detailed description of the test panels, including any deviations from the specification and additional inserts, especially at load supports;

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

h) direction of greater strength of the facing material, if applicable;

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

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

k) test loads attained during the tests, together with the corresponding deformations at all measurement positions and the application points, load/deformation curves and deformation/time curves;

l) type and position of any failure;

m) any conditioning applied to the panel, and the test laboratory conditions;

n) any other information believed to be appropriate.

Annex A
(informative)

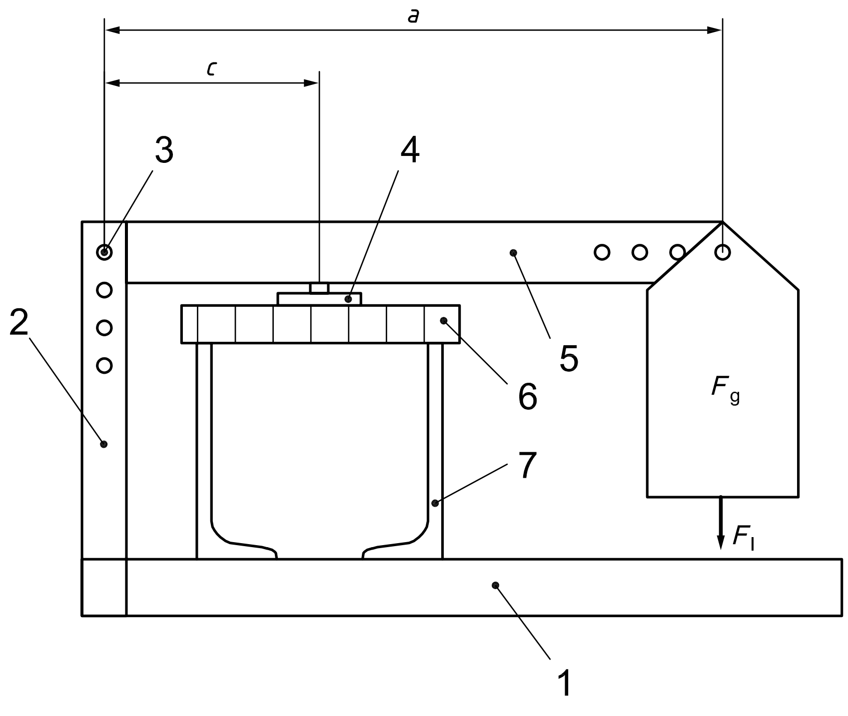
Testing for creep by means of ASTM C480

A.1 Significance and use

The determination of the creep rate provides information on the behaviour of sandwich constructions under constant load. Creep is defined as deflection under constant load over a period of time, beyond the initial deformation due to the application of load. Deflection data obtained from this test method can be plotted against time and a creep rate determined. By using standard specimen constructions and constant loading, the test method can also be used to evaluate the creep behaviour of adhesives for use in sandwich panels.

A.2 Apparatus

The apparatus for loading the specimen shall conform to ASTM C480-99(2005)[3], test method C393, except that a constant load shall be applied by means of weight or weights and a lever system. Figure A.1 shows a lever and weight-loading apparatus that has been found satisfactory.



Key

1 base
2 lever support
3 pivot point
4 loading plate
5 loading arm
6 sandwich specimen
7 specimen support

Figure A.1 — Creep test apparatus and loading systems

The load applied to the specimen by the lever system shown in Figure A.1 is calculated as follows:

$$F = \frac{\left(F_{\text{g}}a + F_{\text{l}}b\right)}{c} + F_{\text{p}}$$

where

- F is the load applied to the specimen;
- F_{g} is the self load of the loading element (including the mass of the tray) applied at distance a from the pivot point;
- F_{l} is the load of the lever arm;
- F_{p} is the load of the loading plate and rod;
- b is the distance from pivot point to centre of gravity of the loading arm;
- c is the distance between pivot point and load point.

A.3 Test specimen

The test specimen shall be of sandwich construction of a size and proportion conforming to the flexure test specimen described in test method C393. The specimen depth, width and span length shall be to the nearest 0,5 %.

The number of test specimens and the method of their selection depend on the purpose of the particular test under consideration and no general rule can be given to cover all cases. However, when specimens are to be used for acceptance tests, not less than five specimens of a type shall be selected.

A.4 Conditioning

When the physical properties of the component materials are affected by moisture, bring the test specimens to constant mass before testing, preferably in a conditioning room with temperature and humidity control. The tests should preferably be carried out in a room under the same conditions. This will provide specimens of uniform moisture content, and changes in moisture content will not occur during the test. A temperature of (23 ± 1) °C and a relative humidity of (50 ± 2) % are recommended for standard control conditions.

A.5 Procedure

Attach the weight tray to the lever arm and support it temporarily so that no load is applied to the specimen. If the test is to be conduced at an elevated temperature, place the apparatus and specimen in the oven and heat to the desired test temperature. Allow sufficient time for the oven and specimen to stabilize at the test temperature. Remove the temporary support and slowly apply the load.

Measure deflection to the nearest 0,01 mm by apparatus supported on pins located at the neutral axis of the sandwich at each reaction (see test method C393's Figure 1). Read the initial deflection and record it. Take deflection readings at sufficient time intervals to define completely a creep curve with deflection plotted as the ordinate and time as the abscissa.

A.6 Calculation

Calculate the creep deflection rate in millimetres per hour or per day for a portion of the curve (beyond the initial deformation) by obtaining the difference of the two deflections and dividing by the period of time.

For comparison of materials, the creep deflection may be expressed as a percentage of the initial after a period time, as follows:

Creep, as a percentage of original deflection:

$$= \frac{w_t - w_0}{w_0} \times 100$$

where

w_t is the total deflection under constant load at time t;

w_0 is the initial static deflection under the same load and at the same temperature.

A.7 Report

The report shall include the following:

— complete description of the test specimens including gage, temper, material of facings, core material cell size density, orientation, adhesive and specimen dimensions;

— test conditions, including apparatus, test temperatures, span, loads and test time;

— creep deflection curve;

— type and location of failure, if any, such as excessive creep in adhesive, core shear, etc.

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