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Timber structures — Structural insulated panel roof construction — Test methods

Structures en bois — Panneaux sandwich porteurs isolants pour toitures — Méthode d'essais

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 165, *Timber structures*.

Introduction

This International Standard includes tests for tensile bonding strength of the panels, ageing, shear, creep performance, horizontal in-plane performance and out-of-plane bending performance. The tests applicable to panels for particular applications are indicated, while the test requirements include laboratory conditions, some advice is given in notes on the numbers of samples to be tested and the reporting of results.

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

Timber structures — Structural insulated panel roof construction — Test methods

1 Scope

This International Standard specifies test methods for determining, for use in roofs, the structural properties of double-sided load bearing structural insulated panels 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 can be used as one face layer.

NOTE 2 Panels can contain internal framing or bracing.

NOTE 3 The performance of panels with non-structural insulation is generally calculable according to design codes such as EN 1995–1-1, or tested according to appropriate standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 D7446-09, *Standard Specification for Structural Insulated Panel (SIP) Adhesive for Laminating Oriented Strand Board (OSB) to Rigid Cellular Polystyrene Thermal Insulation Core materials*

ASTM D1183, *Standard Practices for Resistance of Adhesives to Cyclic Laboratory Aging Conditions*

3 Terms and definitions

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

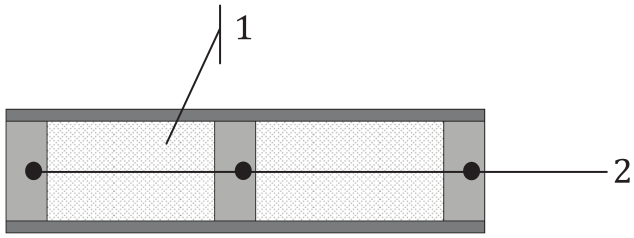
3.1
structural insulated panel
SIP
panel with two load bearing skins, one *bonded* (3.4) to each face of a rigid, lightweight, homogenous core material with sufficient shear strength to cause the face layers to act together structurally

Figure 1 — Cross section of a structural insulated panel

Note 1 to entry: Homogenous core is made of one material with no internal joints requiring bonding.

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* (3.4) to the frame and core forming a closed box

Note 1 to entry: The skins, core and frame all contribute to the load bearing capacity of the panel.



Key
1 core
2 internal structural frame

Figure 2 — Structural insulated panel with internal structural frame

3.3
slabstock
core material pre-formed into slabs of thickness equal to the required depth of the core and then *bonded* (3.4) with a suitable adhesive

Note 1 to entry: When the length and width of a slab of core material is less than or equal to the length and width of the SIP, they may be internally bonded.

3.4
bonded
components of a *structural insulated panel* (3.1) that have been joined together, usually by adhesive

Note 1 to entry: Alternatively, some foams used for cores are foamed *in situ* and are self-adhesive whilst expanding and curing, thus, bonding automatically to the enveloping components.

4 Symbols

$A_{F1} A_{F2}$	area of cross-section of the faces of the test panel, in square millimetres
a, b, c	distance, in mm
B	width of full panel, in mm
$E_{F1} E_{F2}$	Young's modulus of faces of the test panel, in N/mm^2
F	load, in N
F_{max}	maximum load, in N
F_u	ultimate load, in N
$F_{max,est}$	estimated maximum load, in N
F_V	applied vertical load, in N

D	panel thickness, in mm
Δs	real shear deformation, in mm
$\Delta s'$	apparent shear deformation, in mm
Gc	shear modulus of core, in N/mm^2
G'	apparent shear stiffness, in N/mm^2
F_g	self weight of loading element
F_{g_1}	self weight of the panel in N
F_{g_2}	applied permanent load, in N
F_{lever}	weight of lever arm, in N
F_{plate}	weight of loading plate and rod, in N
F_Q	variable load, in N
H	height of full panel, in mm
L	span, in mm
l	length of panel sample, in mm
M	mass, in kg
M_U	ultimate moment capacity, in kNm
P	load, in kN
R	stiffness, in N/mm; strength, in N/mm
R_U	maximum reaction at failure, in kN
S_U	ultimate shear strength, in N/mm
T	loading time, in seconds
T_r	recovery time, in seconds
W	impact energy, in J
b	width of panel sample, in mm
d_c	depth (thickness) of core, in mm
e	depth between the centroids of the faces, in mm
f_{cv}	shear strength of core material, in N/mm^2
f_{ct}	tensile strength of core material, in N/mm^2

t_1, t_2, t_3	overall thickness of the face in mm
Δt	total deflection under vertical diaphragm load, in mm
w	deformations, in mm;
w_u	ultimate deformation, in mm
w_t	total deflection under constant load at time t, in mm;
w_0	initial static deflection under constant load and temperature, in mm;
η	factor of less than unity modifying $F_{max,est}$
v	panel racking deformation, in mm

5 Product evaluation

5.1 Tests applicable to the panel construction

The following test regimes described in this International Standard relate to tests applicable to the panel construction:

a) tensile test on core and its bond to faces;

b) shear strength of solid core and its bond to faces.

5.2 Tests applicable to roof panels

The following test regimes described in this International Standard relate to tests applicable to the roof panel:

a) out of plane bending (stiffness and strength);

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

c) creep test;

d) long-term ageing/durability.

6 Structural testing

6.1 Conditioning

6.1.1 Standard conditioning

With the exception of 6.1.2, all test pieces in 6.2 to 6.6 shall be conditioned to constant mass in an atmosphere of relative humidity (65 ± 5) % and temperature (20 ± 2) °C. Constant mass is deemed to be attained when the results of at least three successive weighings indicate the moisture content has stabilized to within ±0,5 % for at least 48 h period.

If the conditions of the testing room are not the same as those in the conditioning chamber, test pieces shall remain in the conditioning chamber until testing and the test completed within 4 h.

6.1.2 Alternative conditionings

Test pieces may be differently conditioned and/or unconditioned.

Unless otherwise noted in the test report, results shall be corrected to reflect conditioning in accordance with 6.1.1. The procedure for correcting structural properties shall be technically sound and shall be recorded in the test report.

6.2 Tensile test on the 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 thickness of the panel (D). The width (b) shall be 150 mm and the length (l) shall be 150 mm.

NOTE The purpose of the test is to determine the tensile strength and critical failure mechanism, in the 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 middle and the outer 10 % of the panel perimeter, as shown in Figure 3 below.

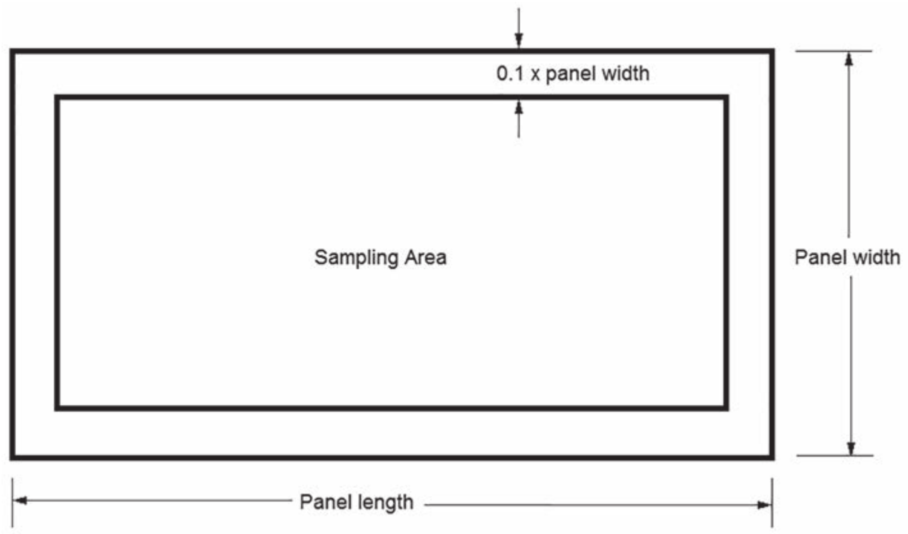


Figure 3 — Specimen sampling from panel

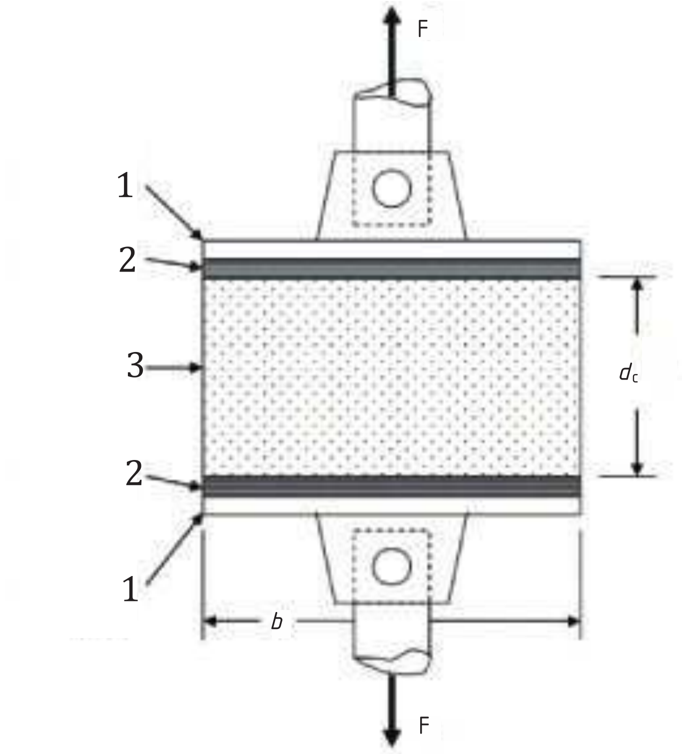
6.2.2 Conditioning

Specimens shall be conditioned in accordance with either 6.1 or to a specified elevated temperature conditioning. Specimens shall be tested immediately after removal from the conditioning chamber when performing an elevated temperature test.

Testing at elevated temperature may be appropriate for certain SIP applications. The 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 in accordance with 6.1, platens shall be bonded to the specimen after conditioning. Specimens of square cross-section shall be prepared as shown in Figure 4.



Key

1 load distributing platen

2 panel face

3 core

Figure 4 — Test arrangements in the tension test of the core

Load (F) shall be applied in increments or continuously such as to reach maximum load in 1 min to 5 min.

For structural insulated panels with OSB and polystyrene thermal insulation core materials, ASTM D7446-09, 13.2 should be reviewed and considered for use, where 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:

$$f_{ct} = \frac{F_u}{bl} \tag{1}$$

where

F_u is the ultimate load (kN) carried by the specimen failing in tension;

b is the specimen width (mm);

l is the specimen length (mm).

The test report shall include the following information:

a) sampling procedure;

b) number of specimens tested;

c) the specification for the test panel construction;

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

e) a 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 other 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} (MPa), of each specimen and the mean of all test results;

i) any other information believed to be appropriate.

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

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 6.4).

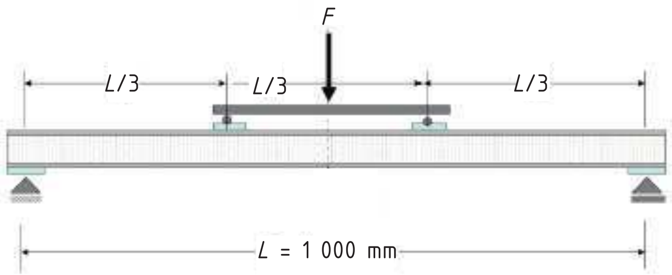
6.3.1 Specimen size and sampling

Specimens (1 000 mm × 150 mm) shall be cut from full-size SIPs (single panel units before assembly/jointing, often 1,2 m × 2,4 m). Specimens shall be conditioned in accordance with 6.1.

The test specimens shall be taken from a range of positions covering the width of the panel. At least one specimen shall be taken at a minimum distance from an outside edge of 10 % of the cover width of the panel and at least one specimen from the middle of the panel (see Figure 3).

NOTE The intent is to induce a shear failure in the specimen. If the recommended span does not result in a shear failure, the span is reduced in increments of 100 mm until a shear failure is obtained. Subsequent tests are then carried out at the reduced span.

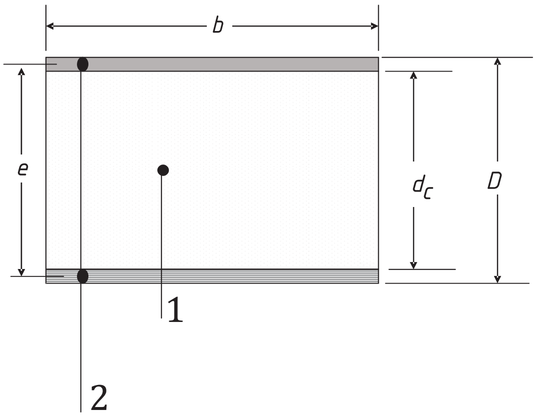
6.3.2 Loading method and test procedure



NOTE 1 The width of metal strips or similar at the support and load points is typically 60 mm with the length of the strip matching the panel width. The size is increased, when necessary, to avoid local crushing of the core. The radius of the ball bearings is typically 15 mm.

NOTE 2 If the SIP has two dissimilar faces, the weaker of the two board materials is placed in the compression zone because the intent is to induce shear failure.

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



Key

1 core

2 panel faces t_1, t_2

Figure 6 — Illustration of depths of components of panel

The depths (D and d_C), width (b) and the net face thickness of both faces (t_1, t_2) of each test specimen shall be measured.

The loading rate shall be such as to result in failure between 1 min and 5 min after the commencement of the test.

6.3.3 Reporting results

The ultimate shear stress, f_{Cv} (MPa), of the core material shall be calculated from the maximum load attained in a specimen failing in shear as follows:

$$f_{Cv} = \frac{F_u}{2be} \tag{2}$$

where load, F_u (kN), 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) the specification for the test panels;

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

e) a detailed description of the test specimens and setup including any deviations from the specification;

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

g) type and position of any failure;

h) moisture content of the timber-based materials as tested;

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

j) the ultimate shear stress, f_{Cv}, of the core material for each specimen, and the mean;

k) any other information believed to be appropriate.

6.4 Out of plane bending (stiffness and strength test)

This test is used to determine the bending stiffness and strength of panels in which the span, *L*, is sufficiently large to ensure a bending failure based on EN 14509. Alternative methods for evaluating out of plane bending capacity are presented in ASTM E72-15, Section 11 and ASTM E1803-14, Section 6.

6.4.1 Panels subjected to uniform loading

The test shall be carried out by subjecting a simply supported panel to four line loads (see Figure 7 or 8) extending across the full width of the panel, or to air pressure caused by either a partial vacuum chamber test apparatus or air bags (see Figure 9). The total applied load (including weight of load distribution rig and the specimen) shall be measured by load cells located at the supports.

NOTE There are a number of alternative load systems which simulate a uniformly distributed load on a panel. These all give similar results for the bending strength and stiffness of the panel.

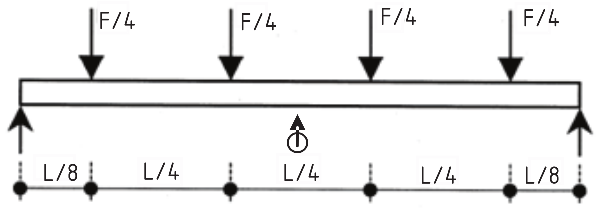


Figure 7 — Loading system 1

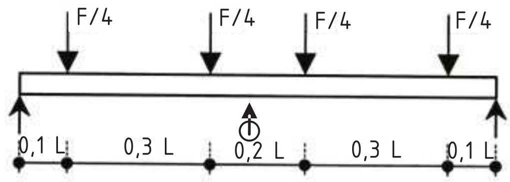
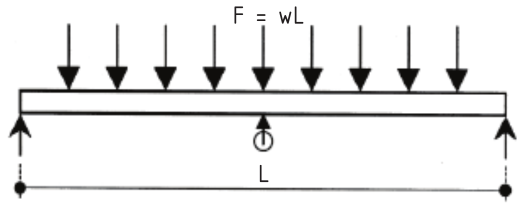


Figure 8 — Loading system 2



Key

w load per unit strength

deflection measured at L/2

Figure 9 — Loading system 3

6.4.1.1 Support conditions

A suitable panel support detail is shown in Figure 10. The width of the supports shall be within the range of 38 mm to 100 mm and shall be sufficiently large to prevent local crushing of the core.

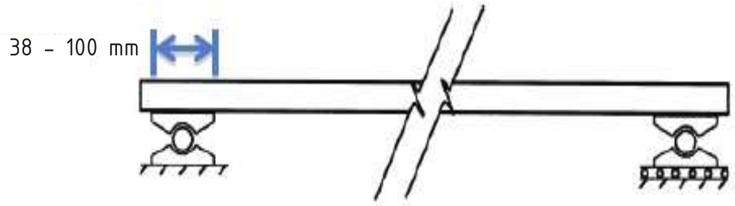


Figure 10 — Support condition

6.4.1.2 Test specimens

The necessary span is dependent on several factors including the overall depth, *D*, of the panel and shall be chosen to give a bending failure. The minimum width of the panel shall be 610 mm. If the chosen span results in panel failing in shear, the span shall be increased in increments of 1,0 m until a bending failure is obtained.

In the case of panels from the same family (design), panels of the greatest and least thicknesses shall be tested together with a panel from the middle of the range. The minimum results for ultimate moment or stiffness (EI) shall apply to all products of intermediate thickness.

In the case of panels of the same type, but with different face-thickness, panels with the thinnest face shall be tested.

6.4.1.3 Test procedure

For panels with similar upper and lower faces, this test shall be carried out on either face orientation of the panel. For panels with dissimilar upper and lower faces, this test shall be carried out with the weakest face in tension.

Prior to the test, a small load, which shall be not greater than 10 % of the failure load, shall be applied for no more than 5 min and then removed.

Laboratory conditions of temperature and humidity shall be recorded.

The panel shall be loaded steadily in at least 10 increments until failure occurs. The deflection speed shall not exceed 1/50 of the span per minute at any time during the test. Both the load and the central deflection shall be recorded. Displacement transducers shall have an accuracy of 0,1 mm.

6.4.1.4 Determination of the bending moment capacity, M_u

The bending moment capacity, M_u, for a simulated uniformly distributed load shall be given by

$$M_u = F_u L/8 \tag{3}$$

where

M_u is the ultimate moment capacity including the effect of the self-weight of the specimen and the mass of the loading equipment, in kN-m;

F_u is the total load recorded in the test including an allowance for the self-weight of the specimen and the mass of the loading equipment, in kN;

L is the test span, in m.

The type of failure shall be recorded. Bending failures include the buckling of board in compression, tension failure of board in tension, tension failure within core or a combination of these. If shear failure is apparent, the test needs to be repeated at increased span.

In addition to the moment capacity, the EI of the composite panel unit shall be determined, assuming a uniformly distributed load pattern.

6.4.2 Panels subjected to concentrated loads

This test checks the safety and serviceability of roof panels with respect to concentrated loads, such as a single person walking on the panel, for access both during and after erection. Facings shall be capable of supporting the designated concentrated load (see 6.4.2.3) without failure.

6.4.2.1 Test apparatus

The test shall be conducted on a simply supported panel with a load applied at the centre of the panel.

6.4.2.2 Test specimens

The test specimen shall be a single panel of full width. The length (span) shall be the largest envisaged in practice for a given depth of panel based on 6.4.1.2.

6.4.2.3 Procedure

The tests shall be carried out on single span panels with the ends of the panels supported on a minimum 38 mm wide bearing plate.

For each face and core combination, a minimum of three tests is recommended.

A load of 1,8 kN shall be applied, unless an alternate load is required otherwise by the national regulatory requirements/standards. The load shall be applied at mid-span through a 76 mm diameter disc in order to avoid local stresses.

6.4.2.4 Calculations and results

Panels shall meet one of the following three possible outcomes:

a) if the panel carries the applied load without permanent visible damage, there are no restrictions for occasional access onto the roof either during or after erection;

b) if the panel supports the load, but with permanent visible damage, measures shall be taken to avoid damage during erection (e.g. walking boards). Furthermore, there shall be no provision for access to the roof after building work is completed;

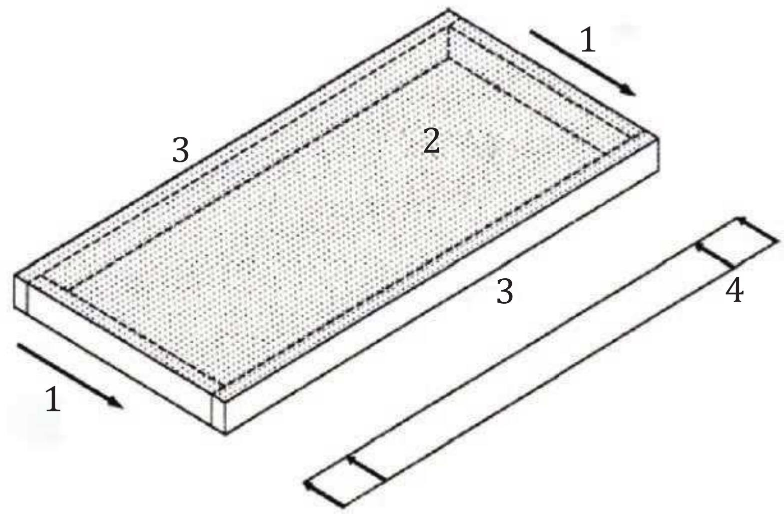
c) if the panel fails to support the load for the span and depth tested, it shall be retested for a different span/depth combination such that it meets criteria a) or b).

In addition, deflection shall be verified to meet the national requirements.

6.5 In-plane (diaphragm) monotonic load racking stiffness and strength test

This test method covers procedures designed (1) to evaluate the static shear capacity of a typical segment of a framed diaphragm under simulated loading conditions and (2) to provide a determination of the stiffness of the construction and its connections based on ASTM E455. Alternate test procedures as provided in EN 594 may be used to determine the monotonic performance of SIP roof diaphragms.

A diaphragm construction is an assembly of materials designed to transmit shear forces in the plane of the construction. A typical simple span diaphragm is shown in Figure 11.



Key

1 reaction to shear wall or frame

2 diaphragm web

3 diaphragm chord

4 applied lateral force

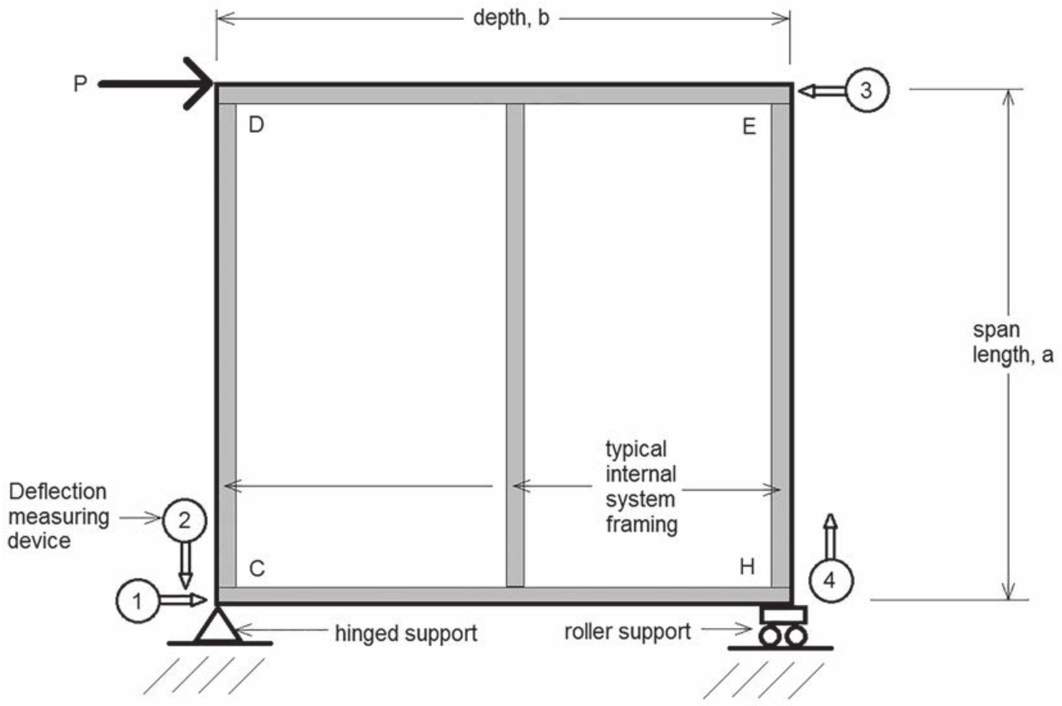
Figure 11 — Schematic span diagram

6.5.1 Test assembly

The diaphragm test assembly shall consist of a frame or framing system on which the elements comprising the SIP diaphragm panels are placed. The elements shall be fastened to the frame in a manner equivalent to their attachment in the field. The assembly may be tested horizontally or vertically. Either a cantilever or a simple span diaphragm assembly may be used, with concentrated or distributed loading.

6.5.1.1 Cantilever frame

A pinned frame reaction at corner (C) shall be provided to transfer the horizontal force (P) through the diaphragm into the support system as shown in Figure 12. The pin shall be located as close as possible to the diaphragm-to-frame contact plane to minimize warping of the diaphragm surface. A vertical reaction roller or rollers shall be provided in the diaphragm plane at corner (H). The frame shall be laterally supported at adjacent corners (D) and (E) on rollers and at other locations, as necessary, to prevent displacement of the diaphragm from the plane of testing, but not to restrict in-plane displacements.



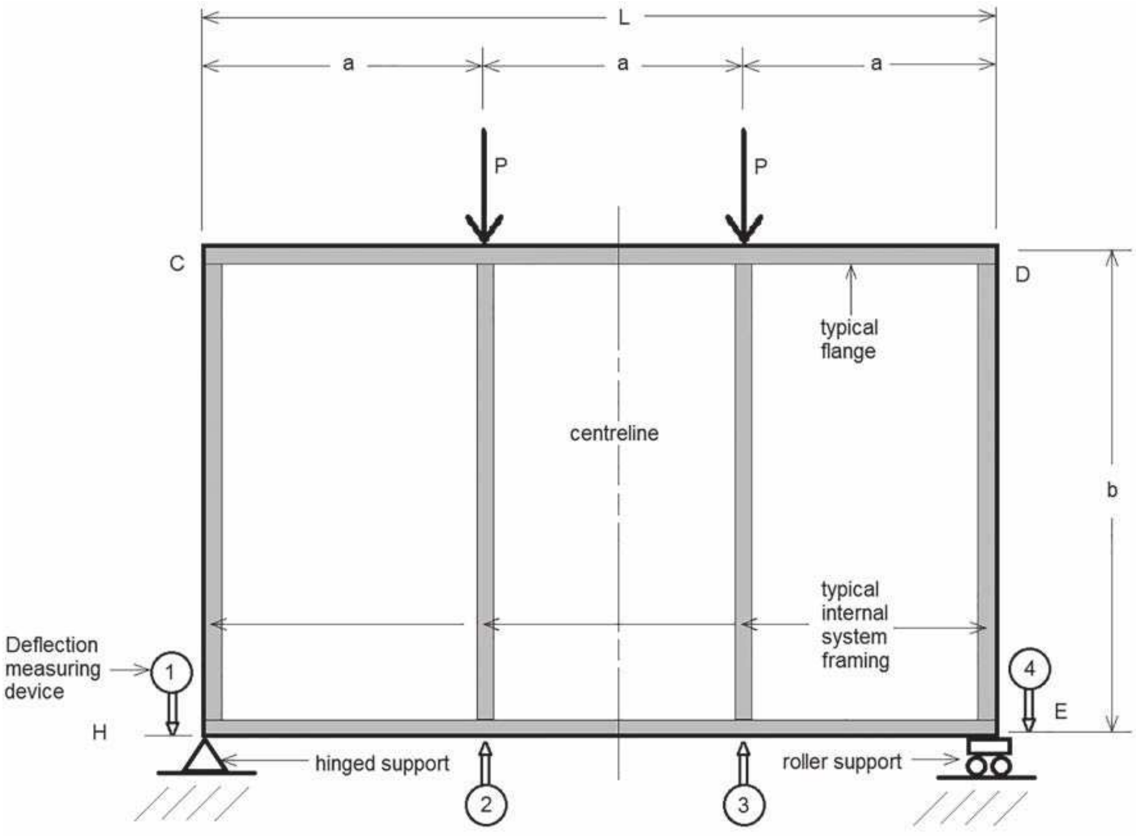
NOTE 1 1, 2, 3 and 4 represent dial gage or other deflection measuring device.

NOTE 2 Lateral restraint devices are not shown and should not restrict movement in the plane of the diaphragm.

Figure 12 — Cantilever beam diaphragm test

6.5.1.2 Simple span frame

In-plane reactions shall be provided at points (E) and (H) as shown in Figure 13 to resist the applied test load or loads. The frame shall be supported with rollers at points (C), (D), (E) and (H) and under each loading point. Hold-downs with rollers shall be provided to prevent displacement of the specimen from the plane of testing, but not to restrict in-plane displacements. The diaphragm may also be supported by tension reactions at points (C) and (D), instead of reactions shown at points (E) and (H) in Figure 12.



NOTE 1 1, 2, 3 and 4 represent dial gage or other deflection measuring device.

NOTE 2 Lateral restraint devices are not shown and should not restrict movement in the plane of the diaphragm.

Figure 13 — Beam diaphragm with third-point loading

6.5.1.3 Diaphragm size

The diaphragm shall be tested on a span length, *a*, as shown in Figure 12 for a cantilever test, equal to or greater than the typical support spacing likely to be used in the building. The test assembly shall not be less than 3,55 m (12 ft) in either length or width, nor shall it contain less than two elements if the diaphragm consists of individual elements.

The diaphragm length and depth shall be as shown in Figure 13 for a simple span frame, where the dimensions *a* and *b* have the same connotation as above with a minimum dimension in either case of 3,55 m. (12 ft).

NOTE It is preferable to use a minimum diaphragm size of 7,2 m (24 ft) for each dimension for a simple span test.

6.5.1.4 Number of tests

A minimum of two specimens shall be tested to determine the value of a given construction. If the plan of the diaphragm is unsymmetrical, the second test shall be run with the specimen orientation reversed with respect to the load application used on the first specimen. If the tested strengths do not agree within 10 % of the lower value, a third specimen shall be tested with this specimen oriented in the same manner as the weaker of the two previous tests. A mean value shall be computed from the lowest two values of the three tests.

6.5.1.5 Test procedure

The loads shall be applied to the diaphragm in a manner duplicating, as far as practical, the in-service loading conditions.

Out-of-plane movement of the test shall be minimized. Any suitable means that do not restrict in-plane movement of the diaphragm are acceptable. Possible ways are to apply the load as close as practical to the shear centre of the test assembly; along the loaded framing member, apply a vertical load to the end of the framing member at the opposite end from the load application or apply a restraining device (such as wheel or roller to the frame).

The loading shall be chosen such that P_{max} or R_{max} will be reached in not less than 10 min. At least 10 sets of uniformly spaced deformation readings prior to failure to establish the load-deformation curve shall be recorded. The rate of load application shall permit load and deformation readings to be recorded. The loads shall be applied by hydraulic jacks or other suitable types of loading apparatus that have been previously calibrated. If it is anticipated that the weight of the specimen and loading apparatus will affect the results, these shall be measured. Deformations shall be recorded to the nearest 0,2 mm. Load-measuring devices shall be accurate to within ±2 %. At load levels such as approximately one third and two thirds of the estimated ultimate load, the load may be removed and the recovery of the diaphragm be recorded after 5 min. A record of the total length of time the diaphragm is under load shall be kept.

6.5.1.6 Calculations

The evaluation is based on the mean values resulting from the tests of matching specimens. The following information is obtained from these tests:

Ultimate shear strength, S_u, as

$$S_u, N/m = 1\,000\, R_u / b \quad (4)$$

where R_u is the maximum reaction at failure in a simple beam test (kN), or the maximum reaction acting parallel to the applied load in a cantilever beam test and b is the diaphragm depth (m), as indicated in Figures 11, 12 and 13.

Apparent shear stiffness, G' (MPa), shall be determined for the entire assembly on the basis of an applied load at a reference load level below the proportional limit for use in deflection calculations. In the following formulae, Δ_b is determined using the appropriate formulae based on the type of beam and loading conditions using the following formulae.

Table 1 — Useful deflection equations

Type of beam	Loading condition	Maximum deflections[a]		
		Δ_b	Δ_s	Δ_s'
Simple beam	uniform load	$5wL^4/384EI$	$wL^2/84Gbt$	$wL^2/84G'b$
Simple beam	third-point load[b]	$23PL^3/648EI$	$PL/3Gbt$	$PL/3G'b$
Cantilever beam	uniform load	$wa^4/8EI$	$wa^2/2Gbt$	$wa^2/2G'b$
Cantilever beam	concentrated load at free end	$Pa^3/3EI$	Pa/Gbt	$\mathrm{Pa}/G'b$

NOTE Other formulae may be applicable depending on the number of load points used.

[a] At midspan of simple beam and free end of cantilever beam. Make appropriate adjustment in units as required for compatibility when SI units are used.

[b] For bending deflection at the load points under a third-point load, use the following formula: $\Delta_{b\,(\text{at }L/3)} = (5PL^3/162EI)$

For use in determining the apparent shear stiffness, calculate the total deflection at any load level, Δ_t, taking account of the support movements, as follows:

$$\begin{aligned}&\text{Cantilever beam test: } \Delta_t = \Delta_3 - [\Delta_1 + a/b\,(\Delta_2 + \Delta_4)]\\&\text{Simple beam test: } \Delta_t = (\Delta_2 + \Delta_3 - \Delta_1 - \Delta_4)/2\end{aligned} \quad (5)$$

where Δ_1, Δ_2, Δ_3 and Δ_4 are measured deformations with appropriate signs at locations indicated in Figures 12 and 13 and *a/b* is the ratio of the diaphragm assembly dimensions. The load-deformation curve can then be plotted on the basis of the test results.

Calculate the real (Δ_s) and apparent ($\Delta_{s'}$) shear deformations at any load level as follows:

$$\begin{aligned}\Delta_s &= \Delta_t - \Delta_b - \Delta_k\\ \Delta_{s'} &= \Delta_t - \Delta_b\end{aligned} \quad (6)$$

For the concentrated load conditions shown in Figures 12 and 13, calculate the apparent shear stiffness, *G'*, of the diaphragm as follows:

$$G' = (P/\Delta_{s'})\,(a/b) \quad (7)$$

The test setups and loading pattern used in Figures 12 and 13 may be used to determine the apparent shear stiffness of the construction.

NOTE The apparent shear stiffness, *G'*, varies with the length of the panel span. Unless multiple tests are to be made for various lengths, the following method can be used for determining the apparent shear stiffness based on the results of limited tests.

The test shall be performed for the longest and shortest reasonable diaphragm lengths. Determine *G'* as above; for any non-tested panel length, *G'* may be obtained by interpolation.

6.5.1.7 Test report

The report shall provide the following information:

a) date of test and of report;

b) identification of the specimens (manufacturers, sources of supply, dimensions, types, materials, other pertinent information);

c) detailed drawings of the specimen which provide a description of the physical characteristics, including dimensioned section profiles and any other pertinent construction details. Any modifications made on the specimen to obtain the reported values shall be noted on the drawings. Describe any noted defects existing in the diaphragm construction prior to test;

d) details of structural design of the test specimen and test assembly;

e) details of attachment of specimens in test fixture;

f) location of load points, strain gages, deformation points and other items for test as applicable;

g) general ambient conditions at

    1) date of construction,

    2) during curing (time from construction to test), and

    3) date and time of test;

h) details of materials of construction (that is, yield point, tensile strength, compressive strength, density and so forth, as appropriate for materials used);

i) include a statement that the test was conducted in accordance with this method or with certain deviations, which shall be described;

j) a statement indicating whether or not the construction of the test diaphragm represents actual or intended construction. If the construction does not represent typical field construction, deviations shall be noted;

k) load-deformation graphs visually depicting diaphragm stiffness;

l) record of maximum load applied to test specimens and description of mode of failure;

m) other required data in tabular and graphical form;

n) total time under load at various load levels;

o) photographs of the tested specimens to show.

6.6 Creep testing

Where required for the design of roof or ceiling panels, a simply supported panel with a constant uniform load can be used to determine the creep characteristics of a particular panel assembly aligned with the principles in EN 14509.

Alternate methods of assessing creep performance of structural insulated panels are provided in Annex A and ASTM D6815.

It is important to note that creep performance may be controlled by a shear type failure or by failure in a bending mode and both should be evaluated.

Testing should be performed under temperature and RH conditions specified in the test standard.

7 Accelerated ageing (durability) testing

Accelerated aging test regime given in ASTM D7446 and modified ASTM D1183 “C” shall be followed as the main procedure for durability testing of SIPs.

Each specimen shall be subjected to six complete cycles of laboratory ageing.

After completion of the six cycles of exposure, further condition the specimen at a temperature of 20 °C ± 2 °C and relative humidity of 50 % ± 20 % 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 in which stage of the regime it appeared.

After completion of the cycles, the specimens shall be subjected to a tensile test as described in 6.2.

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 may also be used to evaluate creep behaviour of adhesives for use in sandwich panels.

A.2 Apparatus

The apparatus for loading the specimen shall conform to ASTM 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.

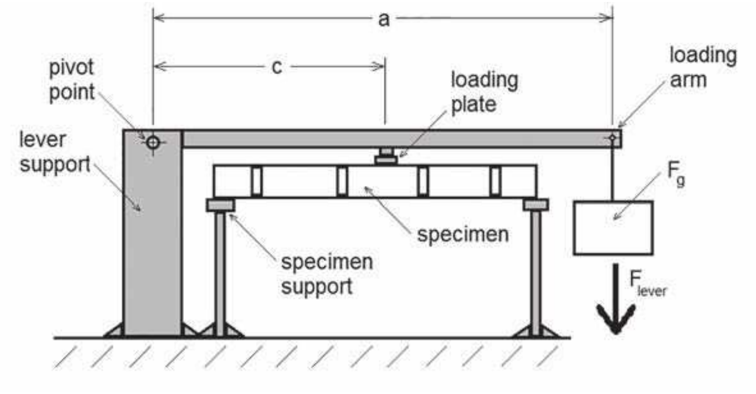


Figure A.1 — Creep test apparatus and loading systems

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

$$F = \left[\left(F_g a + F_{lever} b \right) / c \right] + F_{plate} \quad (A.1)$$

where

F is the load applied to specimen;

F_g is the self weight of loading element (including weight of tray) applied at distance, a, from the pivot point;

F_{lever} is the weight of lever arm;

F_{plate} is the weight of 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 ASTM C393. The specimen depth, width and span length to the nearest of 0,5 %.

The number of test specimens and the method of their section 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 specimen 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 weight before testing, preferably in a conditioning room with temperature and humidity control. The tests, preferably, should be made in a room under the same conditions. This will provide specimens having uniform moisture content and changes in moisture content will not occur during test. A temperature of 23 °C ± 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 conducted at an elevated temperature, pace, apparatus and specimen in the oven and up to the desired test temperature, allow sufficient time for the oven and specimen to stabilize at the test temperature. Remove the temporary support and apply the load slowly.

Measure deflection to the nearest 0,01 mm by apparatus supported on puns located at the neutral axis of the sandwich at each reaction (see ASTM C393-11, 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 mm per hour or mm per day for portion of the curve (beyond the initial deformation) by obtaining the different 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 of time as follows:

$$\text{Creep, \% of original deflection} = \left[\frac{\left(w_t - w_0\right)}{w_0}\right] \times 100 \qquad \text{(A.2)}$$

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:

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

b) test conditions including apparatus, test temperatures, span, loads and test time;

c) creep deflection curve;

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

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