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Timber structures — Glued laminated timber — Test methods for determination of physical and mechanical properties

Structures en bois — Bois lamellé-collé — Méthodes d'essai pour la détermination de certaines propriétés physiques et mécaniques

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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 8375 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

This second edition cancels and replaces the first edition (ISO 8375:1985), which has been technically revised.

Timber structures — Glued laminated timber — Test methods for determination of physical and mechanical properties

1 Scope

This International Standard specifies test methods for determining the following characteristic values of glued laminated timber: modulus of elasticity in bending; shear modulus; bending strength; modulus of elasticity in tension parallel to the grain; tension strength parallel to the grain; modulus of elasticity in compression parallel to the grain; compression strength parallel to the grain; modulus of elasticity in tension perpendicular to the grain; tension strength perpendicular to the grain; modulus of elasticity in compression perpendicular to the grain; compression strength perpendicular to the grain and shear strength.

In addition, the determination of dimensions, moisture content, and density are specified.

The methods apply to rectangular shapes of glued laminated timber.

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.

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

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

ASTM D198, *Standard test methods of static tests of lumber in structural sizes*

ASTM D2915, *Standard practice for evaluating allowable properties for grades of structural lumber*

ASTM D3737, *Standard practice for establishing allowable properties for structural glued laminated timber*

ASTM D4933, *Standard guide for moisture conditioning of wood and wood-based materials*

JAS 235, *Standard for structural glued laminated timber*

3 Terms and definitions

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

3.1
characteristic density
mean density obtained at a 75 % confidence limit with mass and volume corresponding to equilibrium moisture content at a temperature of 20 °C and a relative humidity of 65 %

3.2
characteristic strength
lower 5-percentile value at a 75 % confidence limit obtained from the results of tests using test specimens at an equilibrium moisture content resulting from a temperature of 20 °C and a relative humidity of 65 % or the strength value at the observed moisture content when full size members are tested

3.3
characteristic stiffness
mean stiffness at a 75 % confidence limit obtained from the results of tests using test specimens at an equilibrium moisture content resulting from a temperature of 20 °C and a relative humidity of 65 %

NOTE Annex A provides a set of guidelines for statistical processing of data to determine characteristic values as defined in 3.1, 3.2 and 3.3.

3.4
minimum number of test specimens
for the determination of all characteristic values a minimum number of 30 test specimens is required unless otherwise noted for the specific test involved

3.5
population
test specimens used to determine characteristic values should be representative of the population that they are intended to represent

NOTE *Specimen* is used throughout this International Standard to mean *test specimen* as used in 3.4 and 3.5.

4 Symbols

A	cross-sectional area (mm^2)
a	distance between a loading position and the nearest support in a bending test (mm)
b	width of cross section in a bending test, or the smaller dimension of the cross section (mm)
$E_{c,0}$	modulus of elasticity in compression parallel to the grain (MPa)
$E_{c,90}$	modulus of elasticity in compression perpendicular to the grain (MPa)
$E_{m,g}$	global modulus of elasticity in bending (MPa)
$E_{m,l}$	local modulus of elasticity in bending (MPa)
$E_{m,app}$	apparent modulus of elasticity in bending (MPa)
$E_{t,0}$	modulus of elasticity in tension parallel to the grain (MPa)
$E_{t,90}$	modulus of elasticity in tension perpendicular to the grain (MPa)
F	load (N)
$F_{c,90}$	compressive load perpendicular to the grain (N)
$F_{c,90,max}$	maximum compressive load perpendicular to the grain (N)
$F_{c,90,max,est}$	estimated maximum compressive load perpendicular to the grain (N)
F_{max}	maximum load (N)

$F_{max,est}$	estimated maximum load (N)
$F_{t,90}$	tensile load perpendicular to the grain (N)
$F_{t,90,max}$	maximum tensile load perpendicular to the grain (N)
$f_{c,0}$	compressive strength parallel to the grain (MPa)
$f_{c,90}$	compressive strength perpendicular to the grain (MPa)
f_m	bending strength (MPa)
$f_{t,0}$	tensile strength parallel to the grain (MPa)
$f_{t,90}$	tensile strength perpendicular to the grain (MPa)
f_v	shear strength parallel to the grain (MPa)
G	shear modulus (MPa)
G_{est}	estimated shear modulus (MPa)
h	depth of cross section in a bending test, or the larger dimension of the cross section, or the test specimen height in perpendicular to grain tests (mm)
h_0	gauge length (mm)
I	second moment of area (mm^4)
K, k	coefficients (—)
k_G	coefficient for shear modulus (—)
l	span in bending, or length of test specimen between the testing machine grips in compression and tension (mm)
l_1	gauge length for the determination of modulus of elasticity (mm)
l_{pt}	plate thickness (mm)
S	section modulus (mm^3)
w	deformation (mm)

NOTE Suffixes “1” and “2”, refer to loads or deformations at particular points of a test, and are referred to throughout this International Standard.

5 Determination of dimensions of test specimens

The dimensions of the test specimen shall be measured to an accuracy of 1 %. The dimension-measuring devices shall be such as to permit measuring dimensions in millimetres to three significant figures. All measurements shall be made when the test specimens are conditioned as specified in Clause 8. If the width or thickness varies within a test specimen, these dimensions should be recorded as the average of three separate measurements taken at different positions on the length of each specimen.

Where possible, the measurements should not be taken closer than 150 mm to the ends of the specimen.

6 Determination of moisture content of test specimens

The moisture content of the test specimen shall be determined on a section taken from the test specimen.

In strength tests for bending, tension parallel and perpendicular to grain and compression parallel and perpendicular to grain, the moisture content of the test specimen shall be determined as soon as practical after testing, or the specimen shall be sealed to prevent any further moisture change until testing can be initiated. The section shall be cut as close as possible to the fracture.

As an alternative, the provisions of ISO 3130 may be used for determining moisture content.

7 Determination of density of test specimens

If a density value is needed, the density shall be determined on a portion of the cross section or the entire cross section taken from the test specimen near the fracture area.

In strength tests such as bending and parallel to grain, the density of the test specimen shall be determined after the testing and the section shall be cut as close as possible to the fracture.

For perpendicular to grain test specimens, the density of the test specimens shall be determined prior to testing from the measurements of mass and volume of the whole test specimen.

As an alternative, the provisions of ISO 3131 or ASTM D2915 may be used for determining density.

8 Conditioning of test specimens

The tests shall be carried out on specimens that are conditioned at the standard environment of (20 ± 2) °C and (65 ± 5) % relative humidity. A test piece is conditioned when it attains constant mass. Constant mass is considered to be attained when the results of two successive weighings, carried out at an interval of 6 h, do not differ by more than 0,1 % of the mass of the test specimen.

As an alternative, the provisions of ASTM D4933 may be used to establish moisture conditioning.

Where the timber to be tested cannot be readily conditioned to the above standard environment, that fact shall be reported and the moisture content of the test specimen shall be reported with the test results.

For small specimens, unless otherwise protected, test specimens shall not be removed from the conditioning environment more than 1 h before testing.

Test specimens may be stored in the test area for up to 24 h if they are closely piled and vapour-tight wrapped.

9 Determination of local (shear-free) modulus of elasticity of the beam in bending

9.1 Test specimen

The test specimen shall have a minimum length to permit testing with a span of approximately 18 times the depth of the section. The test span shall be reported.

9.2 Procedure

The test specimen shall be symmetrically loaded in bending at two points over a span of (18 ± 3) times the depth as shown in Figure 1. The span between load heads shall be six times the specimen depth. All spans and distances shall be noted and measured to the nearest millimetre.

NOTE 1 The intent of this International Standard is to test with a span equal to 18 times the depth; tolerances are provided to enable testing of a broader range of specimens.

The test specimen shall be simply supported.

NOTE 2 Small steel plates of length not greater than one-half of the depth of the test specimen can be inserted between the specimen and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the specimen to deflect without significant frictional resistance.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE 3 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The maximum load applied shall not exceed the proportional limit load or cause damage to the piece.

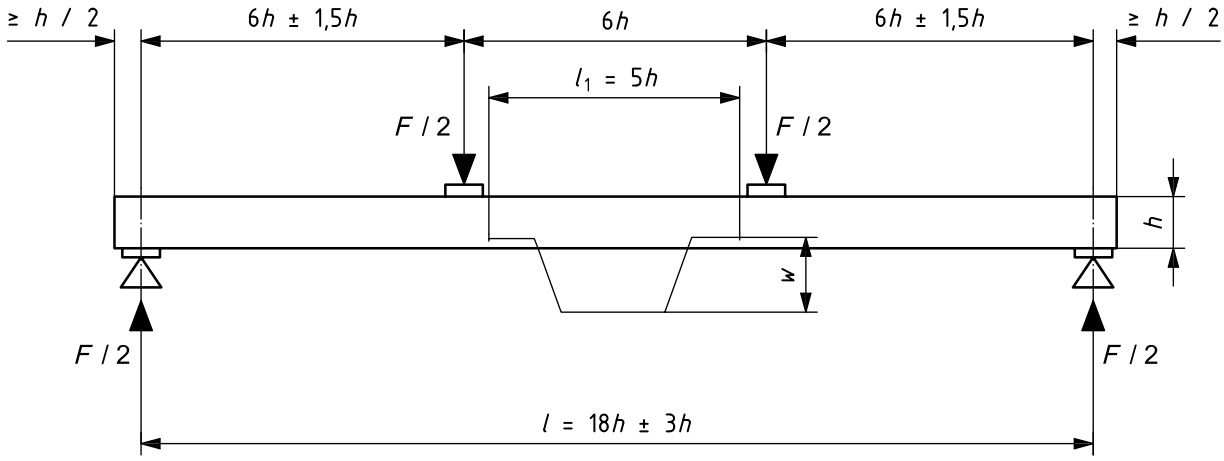


Figure 1 — Test arrangement for measuring local modulus of elasticity in bending

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

The deformation, w, shall be measured at the neutral axis, at the centre of a central gauge length of five times the depth of the section as shown in Figure 1.

The deformation measuring devices and recording system shall be such as to permit measuring deflections to the nearest millimetre.

NOTE 4 ASTM D198 provides a description of an acceptable deflection measuring device and the yoke.

9.3 Expression of results

The local modulus of elasticity in bending, $E_{m,l}$, is given by the equation

$$E_{m,l} = \frac{a l_1^2 \left(F_2 - F_1\right)}{16 l \left(w_2 - w_1\right)} \quad (1)$$

where

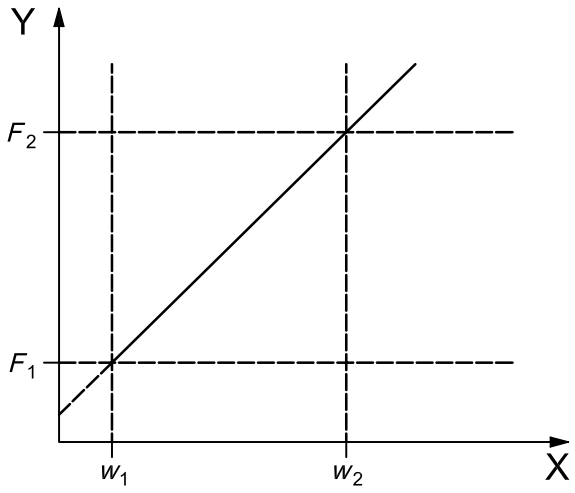
$F_2 - F_1$ is an increment of load on the straight-line portion of the load deformation curve, in newtons

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres

(see Figure 2 for $F_2 - F_1$ and $w_2 - w_1$ plot).

The other symbols are as given in Clause 4.

The local modulus of elasticity should be reported to no more than three significant figures.



Key

X deformation (mm)
Y load (N)

Figure 2 — Load-deformation graph within the range of elastic deformation

10 Determination of global modulus of elasticity of the beam in bending

10.1 Test specimen

The test specimen shall have a minimum length to permit testing with a span of approximately 18 times the depth of the section as shown in Figure 3. The test span shall be reported.

10.2 Procedure

The test specimen shall be symmetrically loaded in bending at two points over a span of (18 ± 3) times the depth. The span between the load heads shall be six times the specimen depth. All spans and distances shall be noted and measured to the nearest millimetre.

NOTE 1 The intent of this International Standard is to test with a span equal to 18 times the depth; tolerances are provided to enable testing of a broader range of specimens.

The test specimen shall be simply supported.

NOTE 2 Small steel plates of length not greater than one-half of the depth of the test specimen can be inserted between the specimen and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the specimen to deflect without significant frictional resistance.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE 3 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The maximum load applied shall not exceed the proportional limit load or cause damage to the specimen.

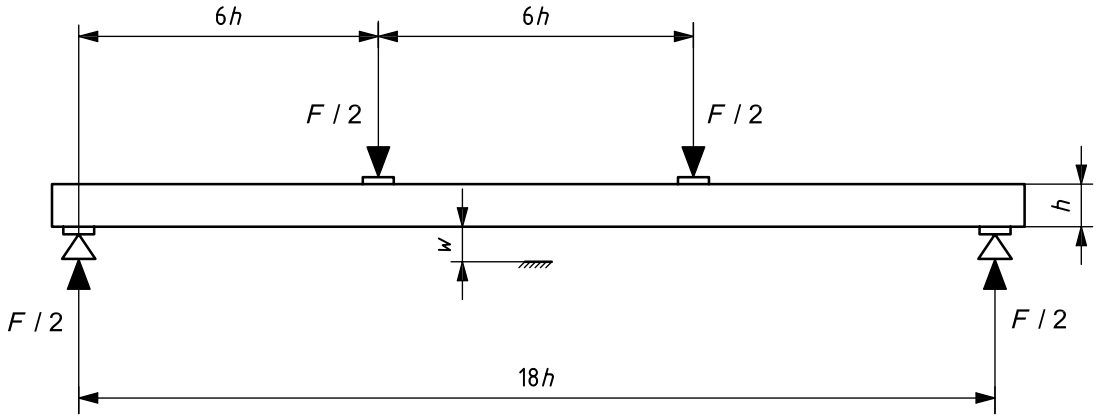


Figure 3 — Test arrangement for measuring global modulus of elasticity in bending

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

The deformation, w, shall be measured at the neutral axis at the centre of the span.

The deformation measuring devices and recording system shall be such as to permit measuring deflections to the nearest millimetre.

NOTE 4 ASTM D198 provides a description of an acceptable defection measuring device and the yoke.

10.3 Expression of results

The global modulus of elasticity in bending, $E_{m,g}$, is given by the equation

$$E_{m,g} = \frac{l^3(F_2 - F_1)}{bh^3(w_2 - w_1)}\left[\left(\frac{3a}{4l}\right) - \left(\frac{a}{l}\right)^3\right] \quad (2)$$

where

$F_2 - F_1$ is an increment of load on the straight-line portion of the load deformation curve, in newtons

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres

(see Figure 2 for $F_2 - F_1$ and $w_2 - w_1$ plot).

The other symbols are as given in Clause 4.

The global modulus of elasticity should be reported to no more than three significant figures.

11 Determination of shear modulus of the beam — single span method

11.1 General

This method involves the determination of the local modulus of elasticity in bending, $E_{m,l}$, and the apparent modulus of elasticity, $E_{m,app}$, for the same length of test specimen.

NOTE Measurement of the shear modulus of glued laminated timber presents considerable difficulty but values suitable for use in design can be obtained by either one of the methods described in Clauses 11 and 12. The fixed span method as described in this clause is commonly preferred due to its relative simplicity and reliability. The shear modulus can also be estimated as $G_{est} = E/16$.

11.2 Determination of modulus of elasticity in bending

The local modulus of elasticity in bending shall be determined in accordance with Clause 9.

11.3 Determination of apparent modulus of elasticity

11.3.1 Test specimen

The test specimen shall be that used for the determination of the local modulus of elasticity in bending, see 9.1.

11.3.2 Procedure

The test specimen shall be loaded in centre point bending over a span equal to the gauge length used in 9.2 and including the same test length, as shown in Figure 4 (see also Figure 1). In this case, $l = l_1$.

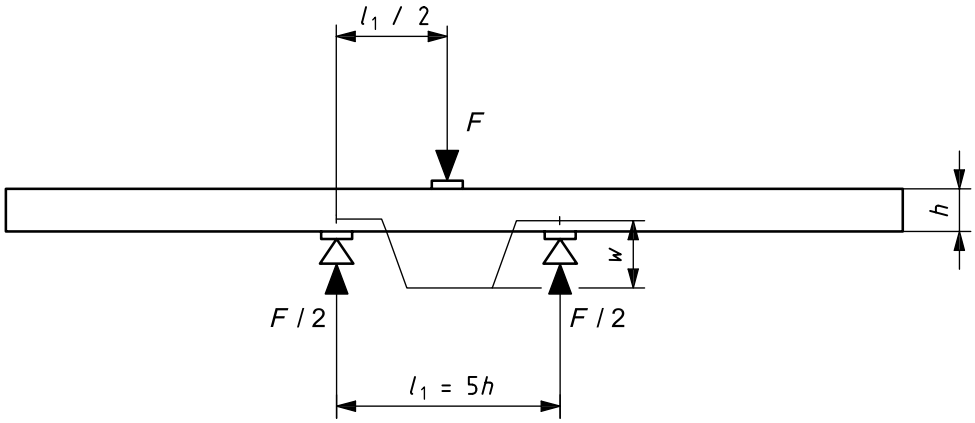


Figure 4 — Test arrangement for measuring apparent modulus of elasticity

The test specimen shall be simply supported.

NOTE 1 Small steel plates of length not greater than one-half of the depth of the test specimen can be inserted between the specimen and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the specimen to deflect without significant frictional resistance.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE 2 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The maximum load applied shall not exceed the proportional limit or cause damage to the piece.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece or, for loads less than 10 % of the maximum applied load, with an accuracy of 0,1 % of the maximum applied load.

Deformations shall be measured at the centre of the span.

The deformation measuring devices and recording system shall be such as to permit measuring deflections to the nearest millimetre.

NOTE 3 ASTM D198 provides a description of an acceptable deflection measuring device and the yoke.

11.3.3 Expression of results

The apparent modulus of elasticity, $E_{\mathrm{m,app}}$, is given by the equation

$$E_{\mathrm{m,app}} = \frac{{l_1}^3 \left(F_2 - F_1\right)}{48 l \left(w_2 - w_1\right)} \tag{3}$$

where

$F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres

(see Figure 2 for $F_2 - F_1$ and $w_2 - w_1$ plot).

The other symbols are as given in Clause 4.

The apparent modulus of elasticity should be reported to no more than three significant figures.

11.4 Calculation of shear modulus

The shear modulus, G, is given by the equation

$$G = \frac{k_{\mathrm{G}} h^2}{{l_1}^2 \left[\frac{1}{E_{\mathrm{m,app}}} - \frac{1}{E_{\mathrm{m},l}} \right]} \tag{4}$$

where

k_{G} = 1,2 for rectangular or square cross sections.

The other symbols are as given in Clause 4.

The shear modulus should be reported to no more than three significant figures.

12 Determination of shear modulus of the beam — variable span method

12.1 General

This method involves the determination of the apparent modulus of elasticity, $E_{m,app}$, for each test specimen over a number of spans with the same cross section at the centre.

12.2 Test piece

The test specimen shall have a minimum length of 18 times the depth of the section.

12.3 Procedure

The test specimen shall be loaded in centre point bending over at least four different spans with the same cross section at the centre of each. The spans shall be chosen so as to have approximately equal increments of $(h/l)^2$ between them, within the range 0,0025 to 0,035. The test spans shall be reported.

NOTE 1 Small steel plates of length not greater than one-half of the depth of the test specimen can be inserted between the piece and the loading heads or supports to minimize local indentation.

The test specimen shall be simply supported.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the specimen to deflect without significant frictional resistance.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE 2 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The maximum load applied shall not exceed the proportional limit load or cause damage to the specimen.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformations shall be measured at the centre of the span.

The deformation measuring devices and recording system shall be such as to permit measuring deflections to the nearest millimetre.

12.4 Expression of results

12.4.1 General

The apparent modulus of elasticity for each specimen and each test span shall be calculated as described in 11.3.2 and 11.3.3.

12.4.2 Determination of K_1 *and* K_2

For each specimen, the values of $1/E_{m,app}$ shall be plotted against $(h/l)^2$ as shown in Figure 5 and the slope, K_1, of the best straight line through the points shall be determined.

K_2 is the intercept of the line at zero $(h/l)^2$.

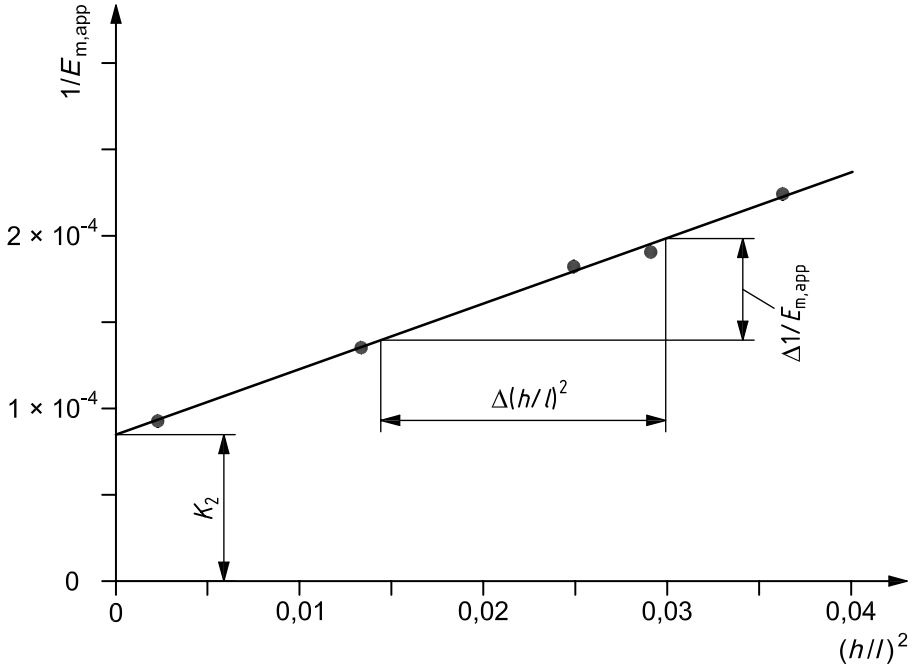
12.4.3 Shear modulus

The shear modulus, G, is given by the equation

$$G = k_G / K_1 \tag{5}$$

where

k_G = 1,2 for rectangular or square cross sections, and K_1 is the slope of the straight line (see Figure 5).



$$K_1 = \frac{\Delta \dfrac{1}{E_{\mathrm{m,app}}}}{\Delta (h/l)^2}$$

Figure 5 — Determination of shear modulus — variable span method

13 Determination of bending strength of the beam

13.1 Test specimen

The test specimen shall have a minimum length to permit testing with a span of approximately 18 times the depth of the section as shown in Figure 3. The test span shall be reported.

13.2 Procedure

The test specimen shall be symmetrically loaded in bending at two points over a span of (18 ± 3) times the depth. The span between the load heads shall be six times the specimen depth. All spans and distances shall be noted and measured to the nearest millimetre.

NOTE 1 The intent of this International Standard is to test with a span equal to 18 times the depth; tolerances are provided to enable testing of a broader range of specimens.

The test specimen shall be simply supported.

NOTE 2 Small steel plates of length not greater than one-half of the depth of the test specimen can be inserted between the specimen and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the specimen to deflect without significant frictional resistance.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE 3 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The time to failure for each test piece shall be recorded and reported.

13.3 Expression of results

The bending strength, f_m, is given by the equation

$$f_m = a\, F_{max}\, l/(2W). \quad (6)$$

The symbols are as given in Clause 4.

The mode of fracture and the growth characteristics at the fracture section of each test piece shall be recorded.

14 Determination of the modulus of elasticity in tension parallel to the grain of the glued laminated timber

14.1 General

The measurement of modulus of elasticity in tension parallel to grain of glued laminated timber presents considerable difficulty but values suitable for use in design can be obtained using the method of this section. The axial modulus of elasticity may also be estimated as the average weighted average of the modulus of elasticity of the individual laminations.

14.2 Test specimen

The test specimen shall be of sufficient length to provide a test length clear of the testing machine grips of at least nine times the larger cross-sectional dimension.

14.3 Procedure

The test specimen shall be loaded using gripping devices that will permit the application of a tensile load without inducing bending. The gripping devices and loading conditions actually used shall be reported.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The maximum load applied shall not exceed the proportional limit load or cause damage to the test specimen. If significant movement occurs, for example with wedge type grips, preliminary tests may be needed to establish a rate of movement of the machine cross-head.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformation shall be measured over a length of five times the width of the specimen, located not closer to the ends of the grips than twice this width. Two extensometers shall be used, and shall be positioned to minimize the effects of distortion.

The deformation measuring devices and recording system shall be such as to permit measuring deformations in millimetres to three significant figures.

14.4 Expression of results

The modulus of elasticity in tension, $E_{t,0}$, is given by the equation

$$E_{t,0} = \frac{l_1\left(F_2 - F_1\right)}{A\left(w_2 - w_1\right)} \tag{7}$$

where

$F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres

(see Figure 2 for $F_2 - F_1$ and $w_2 - w_1$ plot).

The other symbols are as given in Clause 4.

The modulus of elasticity in tension should be reported to no more than three significant figures.

15 Determination of the parallel to the grain tension strength of the glued laminated timber

15.1 Test specimen

The test specimen shall be of sufficient length to provide a test length clear of the testing machine grips of at least nine times the larger cross-sectional dimension.

15.2 Procedure

The test specimen shall be loaded using gripping devices that will permit the application of a tensile load without inducing bending. The gripping devices and loading conditions actually used shall be reported.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen.

Load shall be applied at a constant loading-head movement and adjusted so that maximum load is reached within approximately 300 s but not less than 180 s.

NOTE Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The time to failure for each test specimen shall be recorded and reported.

15.3 Expression of results

The tensile strength, $f_{t,0}$, is given by the equation

$$f_{t,0} = F_{max} / A \quad (8)$$

The symbols are as given in Clause 4.

The mode of fracture and growth characteristics at the fracture section of each test specimen shall be recorded. If failure is associated with the grips, this shall be reported.

When failure is associated with the grips, the result should be disregarded in the evaluation of the results.

16 Determination of the modulus of elasticity in compression parallel to the grain of the glued laminated timber

16.1 General

The measurement of modulus of elasticity in compression parallel to grain of glued laminated timber presents considerable difficulty but values suitable for use in design can be obtained using the method of this clause. The axial modulus of elasticity can also be estimated as the average weighted average of the modulus of elasticity of the individual laminations.

16.2 Test specimen

The test specimen shall have a length of six times the smaller cross-sectional dimension. The end surfaces shall be accurately prepared to ensure that they are plane and parallel to one another and perpendicular to the axis of the piece.

16.3 Procedure

The test specimen shall be loaded concentrically using spherically seated loading-heads or other devices that permit the application of a compressive load without inducing bending. After an initial load has been applied, the loading-heads shall be locked to prevent angular movement. The gripping devices and loading conditions actually used shall be reported.

Load shall be applied at a constant rate and the test should be completed within approximately 300 s but not less than 180 s.

NOTE Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The maximum load applied shall not exceed the proportional limit load or cause damage to the specimen.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece, or for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformation shall be measured over a central gauge length of four times the smaller cross-sectional dimension of the piece. Two extensometers shall be used, and shall be positioned to minimize the effects of distortion.

The deformation measuring devices and recording system shall be such as to permit measuring deformations in millimetres to three significant figures.

16.4 Expression of results

The modulus of elasticity in compression, $E_{c,0}$, is given by the equation

$$E_{c,0} = \frac{l_1(F_2 - F_1)}{A(w_2 - w_1)} \quad (9)$$

where

$F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres

(see Figure 2 for $F_2 - F_1$ and $w_2 - w_1$ plot).

The other symbols are as given in Clause 4.

The modulus of elasticity in compression should be reported to no more than three significant figures.

17 Determination of the parallel to grain compression strength of the glued laminated timber

17.1 Test specimen

The test specimen shall have a length of six times the smaller cross-sectional dimension. The end surfaces shall be accurately prepared to ensure that they are parallel to one another and perpendicular to the axis of the piece.

17.2 Procedure

The test specimen shall be loaded concentrically using spherically seated loading-heads or other devices, which permit the application of a compressive load without inducing bending. After an initial load has been applied, the loading-heads shall be locked to prevent angular movement. The gripping devices and loading conditions actually used shall be reported.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece.

Load shall be applied at a constant loading-head movement so adjusted that maximum load is reached within approximately 300 s but not less than 180 s.

NOTE Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The time to failure of each test specimen shall be recorded and reported.

17.3 Expression of results

The compressive strength, $f_{c,0}$, is given by the equation

$$f_{c,0} = F_{max} / A \quad (10)$$

The symbols are as given in Clause 4.

The mode of fracture and growth characteristics at the fracture section of each test piece shall be reported.

18 Determination of the modulus of elasticity in compression and tension perpendicular to the grain of the glued laminated timber

18.1 Requirements for test specimens

Specimens for perpendicular to grain tests shall be planed to obtain a smooth surface to allow for uniform application of the loads to the test pieces.

For tension tests, the test specimen shall be glued to steel plates. The gluing process shall be capable of ensuring the specified position of the test specimen during testing.

NOTE A suitable adhesive for fixing the steel plates to the timber test-specimen is a two-part epoxy. Immediately prior to gluing, the surfaces to be joined are prepared by planing the timber test-specimen surfaces and cleaning the steel plates.

The loaded surfaces shall be accurately prepared to ensure that they are parallel to each other and perpendicular to the test specimen axis. This preparation shall be carried out after conditioning.

The test specimens shall have the dimensions given in Table 1, with the object of achieving a volume of 0,01 m^3 for tension test specimens and be as shown in Figure 7.

18.2 Procedure

The test specimen shall be mounted vertically between the test machine platens and the appropriate compression or tension loads applied. The gauge length, h_0 (approximately 0,6 h), shall be located centrally in the test piece height and not closer than b/3 to the loaded ends of the test piece, see Figure 8.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the maximum load, with an accuracy of 0,1 % of the maximum load.

The test specimen shall be loaded concentrically such as by applying the load through a pin located at the geometric centre of the specimen cross-section.

NOTE 1 This can also be achieved using spherically seated loading-heads

In the case of the compression test, after an initial load has been applied, the loading-heads shall be locked to prevent rotation or angular movement during the test.

In the case of either a tension test or a compression test, the longitudinal axis of the test specimen shall be aligned with the axis of the machine and fixed in such a way that no initial stresses in the test piece are introduced, except those due to the weight of the test specimen and the equipment.

In the case of tension tests on glued laminated timber the test specimen shall have pinned ends, with the axis of the pin parallel to the grain direction of the test specimen.

The load, F, shall be applied at a constant rate of cross head movement throughout the test and adjusted so that the maximum load, $F_{c,90,max,est}$, or, $F_{t,90,max}$, is reached within approximately 300 s but not less than 180 s.

NOTE 2 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

NOTE 3 The relationship between $F_{c,90,max,est}$ and $F_{c,90,max}$ is given in 18.3.1.

The maximum load applied shall not exceed the proportional limit load or cause damage to the specimen.

Two extensometers shall be used, and shall be positioned to minimize the effects of distortion. The extensometers shall permit the measurement of the deformations to three significant figures and shall be

determined to an accuracy of 1 %. The deformation in the load direction refers to the centre of the loaded section and is calculated on the basis of measurements on two opposite sides of the test piece.

The data from each extensometer shall be recorded separately.

18.3 Expression of results

18.3.1 Compression perpendicular to the grain

The modulus of elasticity, $E_{c,90}$, shall be calculated from the equation

$$E_{c,90} = \frac{(F_{40} - F_{10})h_0}{(w_{40} - w_{10})bl} \tag{11}$$

where

$F_{40} - F_{10}$ is an increment of load on the straight line portion of the load-deformation curve, in newtons (F_{10} shall be 10 % and F_{40} shall be 40 % of $F_{c,90,max}$)

$w_{40} - w_{10}$ is the increment of deformation corresponding to $F_{40} - F_{10}$, in millimetres.

The other symbols are as given in Clause 4.

The modulus of elasticity shall be reported to no more than three significant figures.

The physical characteristics of the test specimen (presence of knots, other growth characteristics or seasoning characteristics) shall be reported.

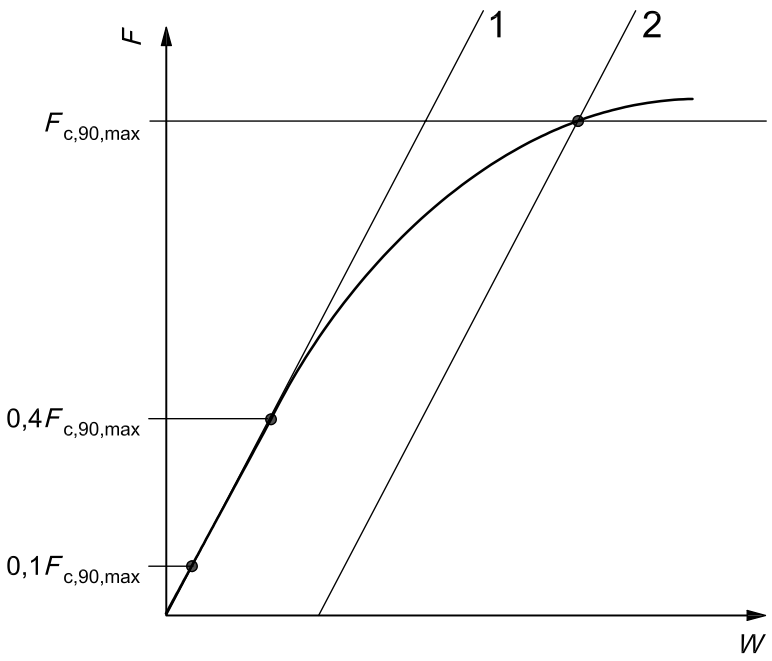


Figure 6 — Load-deformation diagram (compression)

The determination of $F_{c,90,max}$ shall be carried out using the iterative process as follows.

a) Using the test results, plot the load-deformation diagram in the form shown in Figure 6.

b) A value of $F_{c,90,max}$ shall be estimated and values of $0{,}1F_{c,90,max}$ and $0{,}4F_{c,90,max}$ are calculated and located on the load-deformation curve.

c) The slope of a line through these two points shall be determined, and a parallel line drawn through the point corresponding to a load of $F = 0$ and a deformation of $w = 0{,}01h_0$.

d) The intersection of the line and the load-deformation curve shall be taken as the next estimate of $F_{c,90,max}$.

e) Steps b) to d) shall be repeated until the value of $F_{c,90,max}$ determined in step d) is within 5 % of the previously estimated value.

18.3.2 Tension perpendicular to the grain

The modulus of elasticity, $E_{t,90}$, shall be calculated from the equation

$$E_{t,90} = \frac{(F_{40} - F_{10})h_0}{(w_{40} - w_{10})bl} \tag{12}$$

where

$F_{40} - F_{10}$ is an increment of load on the straight line portion of the load-deformation curve, in newtons (F_{10} shall be 10 % and F_{40} shall be 40 % of $F_{t,90,max}$)

$w_{40} - w_{10}$ is the increment of deformation corresponding to $F_{40} - F_{10}$, in millimetres.

The other symbols are as given in Clause 4.

The modulus of elasticity shall be reported to no more than three significant figures.

The physical characteristics of the test specimen (presence of knots, other growth characteristics or seasoning characteristics) shall be reported.

19 Determination of tension and compression strengths perpendicular to the grain of the glued laminated timber

19.1 Requirements for test specimens

19.1.1 Fabrication

Specimens for perpendicular-to-grain tests shall be planed to obtain a smooth surface to allow for uniform application of the loads to the test pieces.

For tension tests, the test specimen shall be glued to steel plates. The gluing process shall be capable of ensuring the specified position of the test specimen during testing.

NOTE A suitable adhesive for fixing the steel plates to the timber test-specimen is a two-part epoxy. Immediately prior to gluing, the surfaces to be joined are prepared by planing the timber test-specimen surfaces and cleaning the steel plates.

19.1.2 Surface preparation

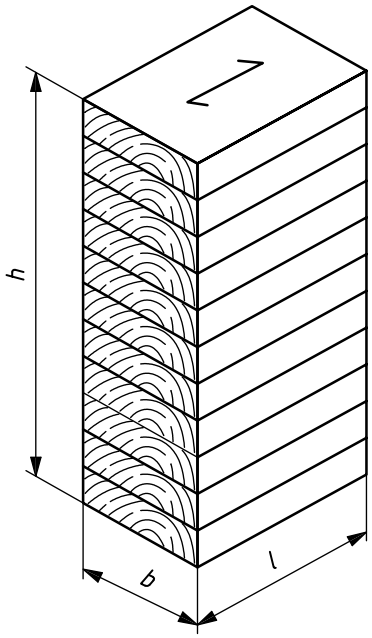
The loaded surfaces shall be accurately prepared to ensure that they are plane and parallel to each other and perpendicular to the test specimen axis. This preparation shall be carried out after conditioning. The test specimens shall have the dimensions given in Table 1, with the object of achieving a volume of 0,01 m^3 for tension test specimens, and be as shown in Figure 7.

Table 1 — Dimensions of glued laminated timber test specimen for perpendicular to grain tests

Test method	Glued laminated timber dimensions			
	Volume	A (mm^2)	minimum b (mm)	h (mm)
Tension perpendicular to grain	0,01 m^3	25000	100	400
Compression perpendicular to grain	—	25000	100	200

19.2 Procedure

The test specimen shall be mounted vertically between the test machine platens and the appropriate compression or tension loads applied.



Key

indicates parallel to grain orientation

Figure 7 — Glued laminated timber test specimen

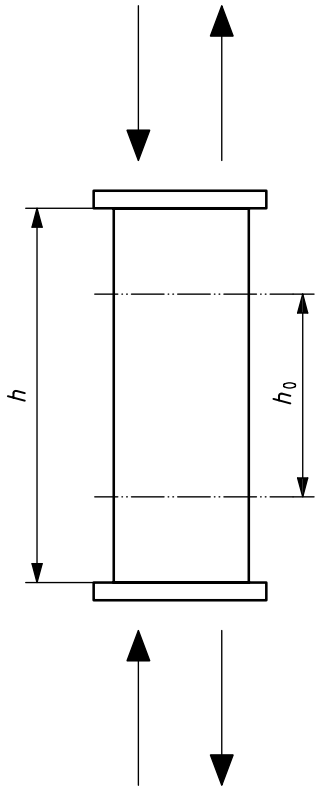


Figure 8 — Test principle

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the maximum load, with an accuracy of 0,1 % of the maximum load.

The test specimen shall be loaded concentrically such as by applying the load through a pin located at the geometric centre of the specimen cross-section.

NOTE 1 This can also be achieved using spherically seated loading-heads

In the case of the compression test, after an initial load has been applied, the loading-heads shall be locked to prevent rotation or angular movement during the test.

In the case of either a tension test or a compression test the longitudinal axis of the test specimen shall be aligned with the axis of the machine and fixed in such a way that no initial stresses in the test piece are introduced, except those due to the weight of the test specimen and the equipment.

In the case of tension tests on glued laminated timber, the test specimen shall have pinned ends, with the axis of the pin parallel to the grain direction of the test specimen.

The load, F, shall be applied at a constant rate of cross head movement throughout the test adjusted so that the maximum load, $F_{c,90,max,est}$, or, $F_{t,90,max}$, is reached within approximately 300 s but not less than 180 s.

NOTE 2 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

NOTE 3 The relationship between $F_{c,90,max,est}$ and $F_{c,90,max}$ is given in 19.3.1.

19.3 Expression of results

19.3.1 Compression perpendicular to the grain

The compressive strength, $f_{c,90}$, shall be determined from the equation

$$f_{c,90} = \frac{F_{c,90,max}}{bl} \tag{13}$$

The determination of $F_{c,90,max}$ shall be carried out using the iterative process as follows.

a) Using the test results, plot the load-deformation diagram in the form shown in Figure 6.

b) A value of $F_{c,90,max}$ shall be estimated and values of $0{,}1F_{c,90,max}$ and $0{,}4F_{c,90,max}$ are calculated and located on the load-deformation curve.

c) The slope of a line through these two points shall be determined, and a parallel line drawn through the point corresponding to a load of $F = 0$ and a deformation of $w = 0{,}01h_0$.

d) The intersection of the line and the load-deformation curve shall be taken as the next estimate of $F_{c,90,max}$.

e) Steps b) to d) shall be repeated until the value of $F_{c,90,max}$ determined in step d) is within 5 % of the previously estimated value.

The symbols are as given in Clause 4.

The physical characteristics of the test specimen (presence of knots, other growth characteristics or seasoning characteristics) shall be reported.

19.3.2 Tension perpendicular to the grain

The tensile strength, $f_{t,90}$, shall be determined from the equation

$$f_{t,90} = \frac{F_{t,90,max}}{bl} \tag{14}$$

The symbols are as given in Clause 4.

The result of a test shall be disregarded where failure occurs on the system used to connect the test specimen to the testing machine (e.g. in the glue line between the steel plates and the timber of the test specimen).

If the failure occurs partly in the glued area of the test specimen/steel plate interface, the result is valid only if this area is less than 20 % of the area of failure.

The physical characteristics of the test specimen (presence of knots, other growth characteristics or seasoning characteristics) shall be reported.

20 Determination of shear strength parallel to the grain – small-specimen test

20.1 Requirements for test specimens

20.1.1 Fabrication

The test specimen shall be representative of the lamina used in the core of the glued laminated timber (approximately the centre 50 % of the depth of the member) and not include glue lines. It shall be glued to steel plates which shall be tapered, as shown in Figure 9.

NOTE A suitable adhesive for fixing the steel plates to the timber test-specimen is a two-part epoxy. Immediately prior to gluing, the surfaces to be joined are prepared by planing the timber test-specimen surfaces and cleaning the steel plates.

20.1.2 Surface preparation

All surfaces shall be accurately prepared to ensure that adjacent surfaces are perpendicular and opposite surfaces are parallel to each other. This preparation shall be carried out after conditioning.

The test specimen shall satisfy the requirements shown in Figure 9 and the values of the dimensions shown shall be as follows:

$l = (300 \pm 2)$ mm

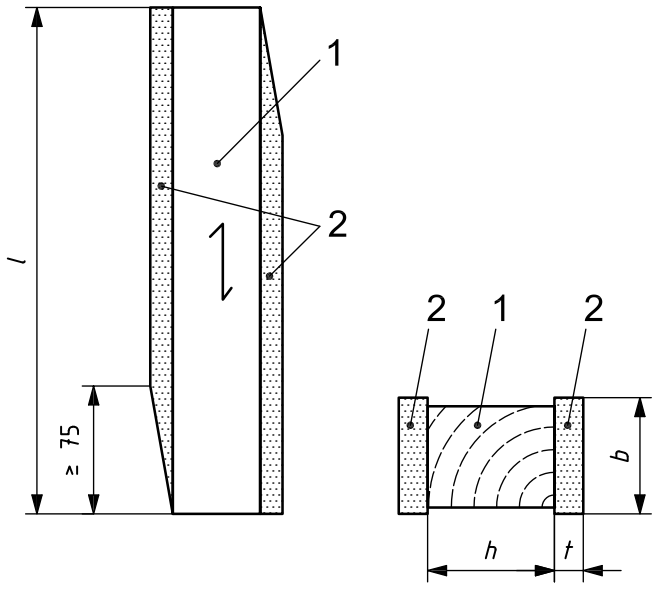
$b = (32 \pm 1)$ mm

$h = (55 \pm 1)$ mm

The steel plate thickness shall be (10 ± 1) mm.

NOTE The tolerances given for these dimensions are to facilitate a test angle of 14°.

Dimensions in millimetres



Key

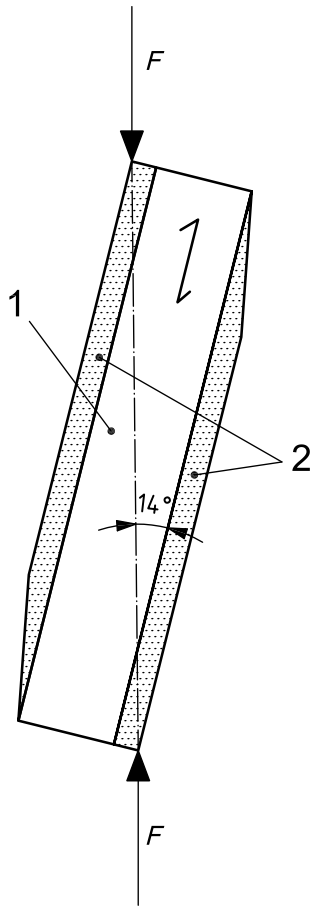
1 lamina test specimen
2 steel plates

↗ indicates parallel to grain orientation

Figure 9 — Test specimen shown glued to steel plates

20.2 Procedure

The test specimen shall be mounted in a test machine as shown in Figure 10. The test piece shall be aligned such that continuous contact is maintained where the line loads, F, are applied. The angle between the load direction and the longitudinal axis of the test piece shall be 14°.



Key

1 lamina test specimen

2 steel plates

indicates parallel to grain orientation

Figure 10 — Loading arrangement

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test specimen or, for loads less than 10 % of the maximum load, with an accuracy of 0,1 % of the maximum load.

If the failure occurs partly in the glued area of the test specimen/steel plate interface, the result is valid only if this area is less than 20 % of the area of failure.

Load, F, shall be applied at a constant rate of loading-head movement so adjusted that the load, F_{max}, is reached within approximately 300 s but not less than 180 s.

NOTE Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The time to failure for each test piece shall be recorded and reported.

20.3 Expression of results

The shear strength, f_v, shall be determined from the equation

$$f_v = \frac{F_{max} \cos 14°}{lb} \quad (15)$$

The symbols are as given in Clause 4.

The physical characteristics of the test specimen (presence of knots, other growth characteristics or seasoning characteristics) shall be reported.

21 Determination of shear strength parallel to the grain – full size beam test

21.1 Specimen

As an alternative to using the test described in Clause 20, the shear strength parallel to grain may be determined using a beam test. The minimum width of the test specimen shall be 140 mm and the minimum depth shall be 460 mm. The specimen length shall be approximately seven to eight times the depth of the specimen.

To minimize flexural failures, the use of end joints should be avoided in the outer two tension laminations. Specially selected high strength tension laminations are permitted to be used to minimize flexural failures.

NOTE This full-size beam test procedure for determining shear strength has been adapted from ASTM D3737.

21.2 Procedure

The loading shall be applied using a two-point loading method with the configuration shown in Figure 11 such as to induce a shear parallel to the grain failure. The clear distance between the edge of the bearing plate to the edge of the nearest load bearing block must be at least two times the specimen depth. The clear distance indicated is regarded as critical to prevent the shear stress distribution from being influenced by the compression perpendicular to grain stress. The loading blocks shall have a radius of two to four times the specimen depth and a bearing length not exceeding the specimen depth. The bearing length shall be sufficient to prevent bearing failure, but shall not exceed the specimen depth. All specimens are to be cut to the exact length with no overhangs allowed. All spans and distances shall be noted and measured to the nearest millimetre.

NOTE 1 The test setup will generally require a specimen with a total length of approximately seven to eight times its depth and a total span of approximately six to seven times the specimen depth.

Load, F, shall be applied at a constant rate of loading-head movement so adjusted that the load, F_{max}, is reached within approximately 300 s but not less than 180 s.

NOTE 2 Ideally, the load application rate is determined from the results of preliminary tests. The objective is that the average time to reach F_{max} is 300 s.

The time to failure for each test piece shall be recorded and reported.

All failure modes shall be recorded to permit the use of either a censored or uncensored data set analysis. A shear failure is one that fails along the length of the member in the approximate mid-depth area of the beam and is not precipitated by a typical bending failure mode that usually starts in the bottom tension lamination.

Dimensions in millimetres

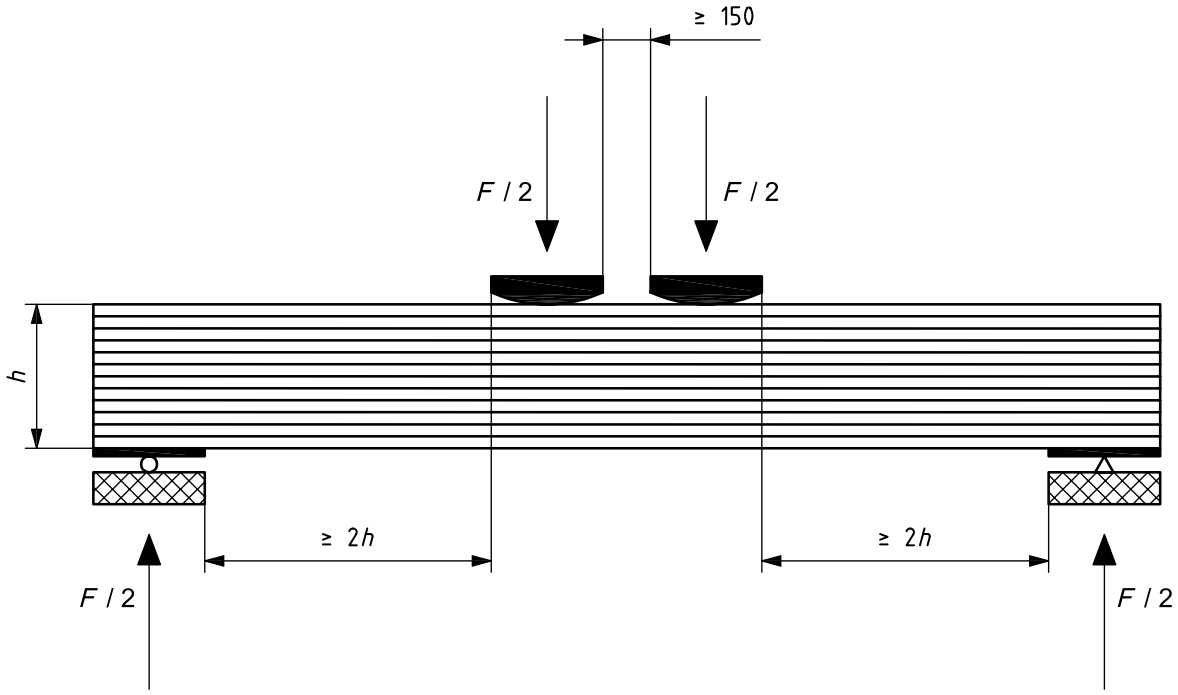


Figure 11 — Full size beam test setup (not to scale)

21.3 Expression of result

The shear stresses (f_v) at the time of specimen failure shall be calculated using the following equation

$$f_v = \frac{3\,F_{max}}{4\,b\,h} \tag{16}$$

where

f_v is the shear stress, in megapascals

F_{max} is the ultimate total load, in newtons

b is the measured beam width, in millimetres

h is the measured beam depth, in millimetres.

If the specimens are not pre-conditioned to a standard moisture content level of 12 % prior to testing, which may not be feasible given the relative size of the test specimens, the calculated shear stress shall be adjusted to a 12 % moisture content condition.

The test data may be analysed based on those data due to shear failures only (uncensored data) and those data obtained from all failure modes combined (censored data) for each species and tested widths. A data set shall have a minimum of 28 shear failures of the type defined in 21.1. In either case, a lower 5th percentile tolerance limit with 75 % confidence shall be determined. If both statistics are calculated, the higher value shall be permitted to be used.

NOTE 1 Based on experience with this test method, a sample size of 40 is generally required to ensure a shear failure in a minimum of 28 specimens.

NOTE 2 For the censored data analysis, the uncensored mean and standard deviation can be estimated by using the methodology for the maximum likelihood estimators (MLEs). The estimates of the uncensored statistics from the censored data are critical due to the fact that although the uncensored mean is expected to be higher than the mean based on the censored data, the standard deviation might also be higher. As a result, the lower 5th percentile tolerance limit based on the uncensored data might or might not actually be higher than the value determined from the censored statistics.

22 Test report

22.1 General

The test report shall include details of the test specimen, the test method used and the test results.

22.2 Test specimen

The following information shall be given:

a) description of the test specimen, including: specification and quality of material (including a description of any strength reducing characteristics such as slope of grain or knots or seasoning characteristics), species or type, grade, density, number and orientation of laminations and the presence of unbonded edge joints (if used);

b) size of test specimen, the type of adhesive used and the orientation and the number of laminations;

c) country, region and factory of origin of the material sampled;

d) method of selection of test specimens;

e) method of conditioning;

f) any other information which may have influenced the test results, for example drying history.

22.3 Test method

The following information shall be given:

a) methods of test used;

b) ambient temperature and relative humidity at the time of test;

c) description of the load testing device, the test equipment and the measuring instruments used;

d) any other information which may influence the use of the test results.

22.4 Test results

The following information for each test specimen shall be given:

a) moisture content at time of test;

b) density;

c) actual dimensions;

d) modulus of elasticity and/or strength values;

e) location and mode of failure and any parts of glued areas in the failure section shall be recorded;

f) times to reach the maximum load;

g) any other information which may influence the use of the test results.

Annex A
(informative)

Special processing of data

A.1 General

The test data may be used to estimate characteristic values at a 75% confidence limit taking into account the finite size of the test sample. In no case should a sample size of less than 30 be used.

A.2 Estimate of the characteristic mean at a 75% confidence limit

The characteristic mean is estimated using the expression

$$\bar{X} = \bar{X}_{\text{data}}\left(1 - 0{,}7V/\sqrt{N}\right)$$

where

$\bar{X}$ is the characteristic mean value

$\bar{X}_{\text{data}}$ is the mean value estimated from the test data

V $= \sigma/\bar{X}_{\text{data}}$

σ is the standard deviation

N is the sample size.

A.3 Estimate of the characteristic lower 5th percentile at a 75% confidence limit

The characteristic lower 5th percentile is estimated using the expression

$$X_{0,05} = X_{0,05,\text{data}}\left(1 - 2{,}7V/\sqrt{N}\right)$$

where

$X_{0,05}$ is the characteristic lower 5th percentile value

$X_{0,05,\text{data}}$ is the lower 5th percentile value estimated from the test data.

NOTE The lower 5th percentile value can be determined using any valid statistical method. Such methods might include:

— non-parametric methods – use cumulative frequency, $F = (i-1)/(n-1)$, and linear interpolation or alternatively use cumulative frequency, $F = (i-0.5)/n$, and linear interpolation;

— parametric methods – fit the results to a statistical distribution and extract the 5th percentile from the distribution.

Bibliography

[1] EN 408:2003, *Timber structures — Structural timber and glued laminated timber — Determination of some physical and mechanical properties*[1)]

1) EN 408:2003 is an aggregate of the former edition of EN 408 and the former EN 1193. This International Standard differs in principle from EN 408:2003 by: being limited to glued laminated timber; giving an extra method for the determination of shear strength parallel to the grain by full scale beam tests; not giving informative examples of compression and tension perpendicular to grain test arrangements.

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