INTERNATIONAL STANDARD

ISO 18100

First edition
2017-03

Timber structures — Finger-jointed timber — Manufacturing and production requirements

Structures en bois — Bois assemblé par entures multiples — Exigences de fabrication et de production

Reference number
ISO 18100:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, 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.

This document was prepared by ISO/TC 165, *Timber structures*.

Introduction

Finger-jointed timber is viewed as an alternative and substitute for sawn timber. Finger-jointed timber makes use of timber of various lengths and enables localized defects, particularly knots, to be docked out of otherwise high-quality sawn timber.

Qualification (initial type testing) and compliance (factory production control) testing are specified to assess if the components and manufacturing procedures used (finger joint profile, end pressure and other production variables) are appropriate for the characteristic values being claimed. A representative sample of the potential production is evaluated for tension and bending strength and finger joints are assessed for bond quality using delamination or wood fibre failure tests.

Timber structures — Finger-jointed timber — Manufacturing and production requirements

1 Scope

This document specifies the product and performance requirements for finger-jointed structural timber made from sawn timber elements.

The document does not cover products made using impressed (die-formed) joints or finger-jointed laminations for glued laminated timber, which is covered in ISO 12578.

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.

ISO 9709, *Structural timber — Visual strength grading — Basic principles*

ISO 10983, *Timber — Finger joints — Minimum production requirements and testing methods*

ISO 12122-2, *Timber structures — Determination of characteristic values — Part 2: Sawn timber*

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

ISO 13912, *Structural timber — Machine strength grading — Basic principles*

ISO 20152-1, *Timber structures — Bond performance of structural adhesives — Basic requirements*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
finger joint
end joint formed by machining a number of similar, tapered, symmetrical fingers in the ends of timber pieces that are then bonded together

3.2
finger-jointed timber
timber that contains two or more component pieces end-joined by *finger joints* (3.1)

Note 1 to entry: All pieces are of a single species or recognized species group, have the same nominal cross-section and the finger joints are formed using a common adhesive and production method.

3.3
production batch
finger-jointed timber (3.2) made during a continuous run on one production line

3.4
strength grade
population of timber having a set of structural properties and utility requirements

Note 1 to entry: Strength grade is defined in accordance with principles detailed with ISO 9709 (visual grading) or ISO 13912 (machine grading).

3.5
service class
service conditions to which *finger-jointed timber* (3.2) is subjected

Note 1 to entry: Service classes are defined in ISO 20152-1.

3.6
qualification
initial type testing
testing of *finger joints* (3.1) or *finger-jointed timber* (3.2) that is used to establish the statistical variables that describe the finger joint strength applicable to *strength grade* (3.4) and the parameters appropriate to the bond quality of the *service class* (3.5)

3.7
compliance
factory production control testing
process of demonstrating that *finger-jointed timber* (3.2) has strength values and bond quality of the specified *strength grade* (3.4) and *service class* (3.5)

3.8
standard length
length used in testing to determine characteristic values

Note 1 to entry: Standard lengths are defined in ISO 13910.

Note 2 to entry: Characteristic values are defined in ISO 12122-2

Note 3 to entry: Finger-jointed timber can be used as a substitute for sawn timber and therefore has its properties determined over the same test lengths.

4 Symbols

d	depth of finger-jointed timber in millimetres
b	width of finger-jointed timber in millimetres
$f_{k,m}$	characteristic strength in bending of a strength grade in megapascals
$f_{k,t}$	characteristic strength in tension of a strength grade in megapascals
$f_{k,m,verif} = k_{fj} f_{k,m}$	characteristic finger joint strength in bending of a single finger joint required for verification in megapascals
$f_{k,t,verif} = k_{fj} f_{k,t}$	characteristic finger joint strength in tension of a single finger joint required for verification in megapascals
k_{fj}	factor that allows for the effect of multiple finger joints in a standard length
L	standard test length for tension or bending as defined in ISO 13910 in millimetres
M	number of finger joints that occur in a standard length

NOTE Factor k_{fj} makes allowance for the negative impact of multiple finger joints on characteristic strengths and is used with the analytical method of assigning characteristic strengths. With the empirical method, the allowance is unnecessary.

5 Conformance

5.1 Quality systems requirements

Products conforming to this document shall be manufactured to a formalized manufacturing specification covering all relevant process variables under a quality system that includes

— in plant process control and internal auditing procedures, and

— auditing of plant process control and end-product quality.

5.2 Manufacturing specifications

The manufacturing specifications shall set the limits on all variables that affect or correlate with final product quality properties, including

a) materials,

b) glue bond quality,

c) manufacturing process, and

d) secondary processes and treatment, when applicable.

NOTE The above list is not necessarily exhaustive.

6 Requirements

6.1 Structural strength

6.1.1 Timber components

All timber components between finger joints shall have strength and stiffness characteristics of a declared strength grade. Where preservative or flame retardant treatment is used, the properties shall be determined after completion of the treatment.

6.1.2 Grading methods

All timber grading methods shall comply with the requirements of either ISO 9709 in the case of visual grading or ISO 13912 in the case of machine grading.

6.1.3 Finger-jointed timber

Bending and tension strengths are defined by reference to standard lengths defined in ISO 13910. Over these test lengths, finger-jointed timber shall have characteristic structural strengths in both bending and tension not less than the bending or tension strengths of the declared strength grade. The bending and tension strengths of the finger-jointed timber shall be determined during qualification and verified for each production batch except, if tension tests are omitted, then, in stress terms, the tension strength shall be deemed equal to 0,55 times the declared bending strength ($f_{k,t} = 0{,}55\, f_{k,m}$).

NOTE 1 For verification of performance requirements in 6.1, refer to 7.1.

NOTE 2 Increasing the number of finger joints in these standard test lengths potentially lowers the overall tension strength. This is most obvious in tension tests where there is an increased tendency to fail at the weakest finger joint; see Annexes F and H for details.

6.2 Adhesive

The adhesive shall comply with the Service Class 2 or 3 requirements of ISO 20152-1. For product intended for use under full weather exposure, the adhesive shall meet the requirements for Service Class 3 conditions.

NOTE For verification of performance requirements in 6.2, refer to 7.2.

6.3 Finger joint glue bond integrity

When determined in accordance with either Annex D or Annex E, the glue bond quality shall exhibit characteristics appropriate to the Service Class claimed by a manufacturer. Alternatively, a nationally accepted test method may be used.

NOTE 1 For verification of performance requirements in 6.3, refer to 7.3.

NOTE 2 Annex D involves wood fibre failure assessment and Annex E involves cyclic delamination testing. Cyclic delamination testing is unsuitable for testing of finger joint of length less than 12 mm.

6.4 Utility

Finger-jointed structural timber produced to a declared strength grade shall meet the utility requirements that correspond to those listed for the relevant strength grade.

NOTE For verification of performance requirements in 6.4, refer to 7.4.

6.5 Product identification

Finger-jointed structural timber shall be identified with sufficient information to facilitate its correct use and to allow for traceability from end user to manufacturer.

NOTE For verification of performance requirements in 6.5, refer to 7.5.

7 Verification

7.1 Structural strength

7.1.1 Qualification

Compliance with the declared strength grade shall be assessed by either analytical or empirical method.

7.1.1.1 Analytical method

Single joint specimens shall be sampled and tested in accordance with ISO 10983 in both bending and tension (if necessary, see 6.1.3) and the test data evaluated in accordance with ISO 12122-2 to determine the characteristic finger joint strengths. In addition, the finger joint strengths shall meet the requirements of Annex F.

ISO 10983 requires at least 30 test specimens for both bending and tension (if necessary) strength tests.

Qualification is required to establish that all the requirements of this document have been met for each strength grade that is to be produced by the manufacturer. Qualification target test loads are required to take into account multiple joint effects; see Annex F for magnitude of the effects.

7.1.1.2 Empirical method

A representative sample shall be drawn from production, then tested and evaluated in accordance with ISO 12122-2. The qualification specimens shall have a representative number of joints as anticipated in typical length put on the market. The characteristic values for bending and tension strengths shall equal or exceed the declared strength grade values.

If the number of joints between pieces and batches are likely to vary, it is recommended that the qualification specimens contain the maximum number of joints that is expected to occur in typical length put on the market. This provides assurance that the qualification testing adequately assesses the representativeness of the components selected.

ISO 12122-2 requires testing in accordance with ISO 13910 which means that specimens are tested at the same standardized lengths used to define the characteristic strengths of sawn timber. This document specifies the requirements for finger-jointed timber that can be used in place of sawn timber so that testing to the standardized lengths provides the characteristic tension and bending strengths on the same basis. Other structural properties are ensured by grading the timber components to a national grading standard.

7.1.2 Compliance testing

7.1.2.1 Analytical method

a) Finger joints shall be sampled in accordance with Annex A and tested in accordance with ISO 10983. Finger-jointed timber components shall be graded as described in 6.1, sampled in accordance with Annex A, tested in accordance with ISO 10983 in either bending or tension and shall comply with the criteria of Annex A.

b) Where finger-jointed timber is proof loaded in reverse bending or in tension as defined in Annex B or C at a level of 0,5 $f_{k,m}$ or 0,5 $f_{k,t}$, respectively, or non-destructively assessed by other nationally accepted destructive methods of finger joint testing, reduced sampling rates shall apply as detailed in Annex A.

7.1.2.2 Empirical method

Finger-jointed timber shall be verified by one of the following methods applicable to standard length finger-jointed timber.

a) Finger-jointed timber shall be sampled in accordance with Annex A, tested in accordance with ISO 13910 in either bending or tension and shall comply with the criteria of Annex A.

b) Where finger-jointed timber is proof loaded in reverse bending or in tension as defined in Annex B or C at a level of 0,5 $f_{k,m}$ or 0,5 $f_{k,t}$, respectively, or non-destructively assessed by other nationally accepted destructive methods of finger joint testing, reduced sampling rates shall apply as detailed in Annex A.

Monitoring the average number of joints per piece may be used to assess if the sample tested at qualification (i.e. number of joints) continues to be applicable. The information may also be used to initiate qualification testing involving a greater number of joints per piece by reference to the analytical method.

7.2 Adhesive

Documentary evidence shall be available to verify compliance with the provisions of ISO 20152-1.

7.3 Finger-joint glue bond integrity

7.3.1 Verification at qualification

7.3.1.1 Sampling

Five specimens of the same type used for strength testing shall be taken.

7.3.1.2 Testing

Finger joints shall be tested in accordance with either Annex D for assessment of wood fibre failure or Annex E for cyclic delamination.

7.3.1.3 Acceptance criteria

In the case of assessment of wood fibre failure, the levels given in Table D.1 may be used as a guideline; otherwise it shall be necessary to establish wood failure levels appropriate for the wood species, adhesive and Service Class conditions. In the case of cyclic delamination, the criteria given in Annex E shall be met.

7.3.2 Verification for compliance testing

7.3.2.1 Sampling

The sample shall be

a) one specimen at the commencement of each adhesive batch, and

b) one specimen per machine per day (24 h period) with at least five specimens per week.

7.3.2.2 Testing

Finger joints shall be tested in accordance with either Annex D for assessment of wood fibre failure or Annex E for cyclic delamination.

7.3.2.3 Acceptance criteria

The criteria specified in 7.3.1.3 shall apply.

7.4 Utility requirements

The utility requirements of this document including dimension, wane, machine skip and distortion shall be deemed to comply with this document if they meet those of the declared strength grade.

7.5 Product identification requirements

The product shall be deemed to comply with this document if it is identified as described in Annex G.

Annex A
(normative)

Compliance (factory production control) testing — Strength verification of finger-jointed timber

A.1 General

This annex sets out the procedures by which finger joint and finger-jointed timber strengths of a production batch are verified. It applies to both analytical and empirical methods. With the analytical method, the finger joint strengths determined at qualification and used as a basis for a strength grade declaration are based on testing only a single finger joint within a standard test length. To allow for the presence of multiple joints, an upwards adjustment is made to the target strengths for verification.

NOTE The factor k_{fj} has the effect of increasing the target values to allow for more than one finger joint in a standard length.

A.2 Verification criteria

A.2.1 Sampling rate

The minimum sampling rate required depends on the minimum cross-sectional dimension, b.

A.2.1.1 Dimension b ≤50 mm

a) One specimen per hour during a shift (8 h) with no fewer than five specimens collected during any production shift of less than 5 h.

b) When all finger-jointed timber production is subjected to a proof load of at least 0,5 times the assigned characteristic strength (0,5 $f_{k,m}$ or 0,5 $f_{k,t}$) or non-destructively assessed by other nationally accepted methods, the frequency may be reduced to one specimen per 4 h during a shift (8 h) with no fewer than two specimens collected during any production shift of less than 8 h.

A.2.1.2 Dimension b >50 mm

a) One specimen per 2 h during a shift (8 h) with no fewer than two specimens collected during any production shift of less than 5 h.

b) When all structural glued timber production is subjected to a proof load of at least 0,5 times the assigned characteristic strength (0,5 $f_{k,m}$ or 0,5 $f_{k,t}$) or non-destructively assessed by other nationally accepted methods, the frequency may be reduced to one specimen per 8 h shift with no fewer than one specimen collected during any production shift of less than 8 h.

A.2.2 Verification criteria

All pieces tested shall equal or exceed the minimum joint strength for the property tested except for the following.

a) When a batch test value falls below the fifth percentile value for the property tested, but not below 0,9 of the fifth percentile value, the test values of at least 27 of the next 28 pieces shall equal or exceed the fifth percentile target value.

b) Other acceptance criteria shall be permitted, provided it can demonstrate that the procedures provide an equivalent or better degree of control and ability to detect non-complying product.

c) Failure to meet the above criteria shall indicate an “out-of-control” condition, requiring corrective action and requalification.

Annex B
(normative)

Verification of the strength of finger-jointed timber by double-bending proof loading

B.1 General

This annex sets out a method based on subjecting both edges to tension stress using double-bending proof testing for verification of the minimum strength of finger-jointed timber containing fully-cured finger joints. Finger-jointed timber that survives the proof stress without failure, excessive deformation or other signs of damage shall be deemed to satisfy the minimum finger-jointed timber strength requirements of this document.

B.2 Specimens

Test specimens shall be representative of all finger-jointed timber for which verification status is sought.

B.3 Testing

B.3.1 General

The specimens shall be subjected to a double-bending proof test in a machine where the ability of the specimen to survive without failure or other damage is determined.

B.3.2 Equipment

The proof loading machine shall be capable of maintaining an applied load with a tolerance of ±5 % of any calibration setting.

The proof loading machine shall be fitted with a break sensor that detects failure. Activation of the break sensor shall unload the timber and initiate the procedure to classify that piece as rejected from the strength grade.

The proof loading machine shall be checked for calibration at a frequency required to confirm the applied load tolerances.

When calibrating under static loads, care shall be taken to ensure that machine friction acts in the most conservative direction during calibration. During calibration, normal operating pressure shall be used. The proof load level and the break sensor shall be set in accordance with Table B.1.

The recommended pinch roller pressure for normal operations is zero; this leads to the most consistent value of proof load.

To ensure that friction acts in a conservative direction when using the calibration bar, first apply a suitable load to the bar then push the bar centre lock towards the unloaded configuration and release slowly.

Table B.1 — Proof load setting

Load type	Proof load	Break sensor limit
Three-point bending	$P = \frac{2bd^2}{3L} f_{m,PL}$	$\Delta = \frac{L^2}{4Ed} f_{m,PL}$
Four-point bending	$P = \frac{bd^2}{3a} f_{m,PL}$	$\Delta = \frac{3L^2 - 4a^2}{8Ed} f_{m,PL}$

where

a is the shear span, in millimetres;

b timber dimension as defined in Figure B1, in millimetres

d timber dimension as defined in Figure B1, in millimetres

$f_{m,PL}$ is the applied proof stress, in megapascals;

E is the design characteristic modulus of elasticity (MOE), in megapascals;

L is the test span, in millimetres;

P is the proof load, in newtons;

Δ is the deflection to position the break sensor, in millimetres.

NOTE The depth direction is the dimension in the direction of the proof load.

B.3.3 Preparation

Finger-jointed timber shall be tested as single piece.

B.3.4 Procedure

The timber shall be loaded by the proof grading machine in either three-point or four-point bending, as shown in Figure B.1, in reverse bending at a load that induces a stress ($f_{m,PL}$) given by Formula (B.1):

$$f_{m,PL} = 0{,}5 f_{k,m} \tag{B.1}$$

where

$f_{m,PL}$ is the proof stress in bending, in megapascals.

NOTE The level of proof loading represents approximately 1 in 10^4 pieces for log-normal distributions with a coefficient of variation of 0,25.

B.3.5 Test results

A pass or fail test result shall be determined for each specimen subjected to the proof double-bending test. The test result for each specimen shall be determined as follows.

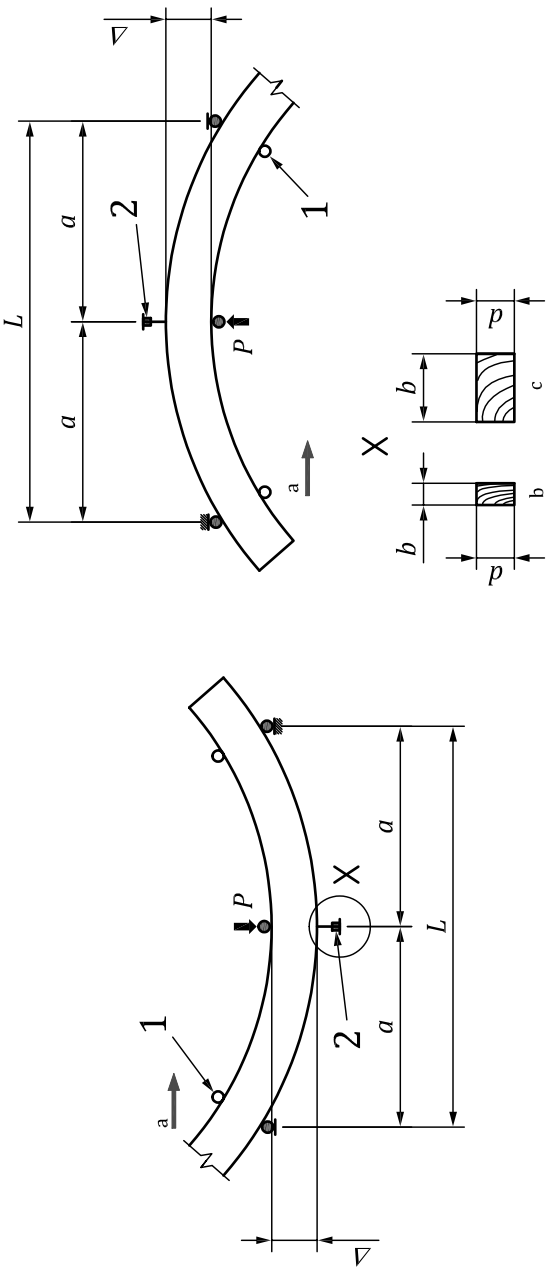
a) Pass: where the piece survives the proof double-bending test without failure or other damage.

b) Fail: where the piece does not survive the proof double-bending test without failure or other damage.

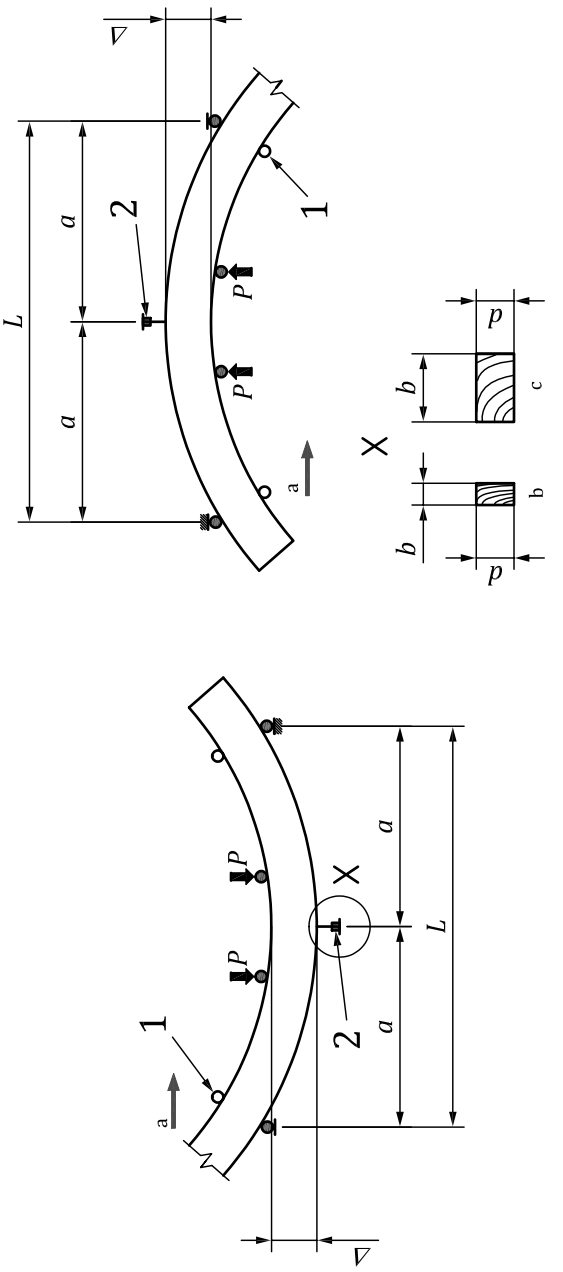
B.4 Acceptance criteria

The strength of finger-jointed timber shall be considered verified where all pieces failing below the proof load are discarded or reworked.

Dimensions in millimetres



a) Three-point loading with two proof loading machines in series



b) Four-point loading with two proof loading machines in series

Key

1	pinch roller	Δ	deflection to position the break sensor
2	break sensor	a	Direction of travel.
a	shear span	b	Edgewise proof loading.
P	proof load in newtons	c	Flatwise proof loading.
L	test span		

Figure B.1 — Schematic illustration of loading systems for double-bending proof loading

Annex C
(normative)

Verification of the minimum strength of finger-jointed timber by tension proof loading

C.1 General

This annex sets out a method based on tension proof testing for verification of the strength of finger-jointed timber containing fully-cured finger joints.

Verification of the minimum strength of finger-jointed timber is undertaken by proof loading in tension at a level that is high enough to detect and reject low strength joints but low enough to avoid damaging pieces that pass the test. Finger-jointed timber that survives the proof stress without failure, excessive deformation or other signs of damage shall be deemed to satisfy the minimum finger-jointed timber strength requirements of this document.

C.2 Specimens

Test specimens shall be representative of the finger-jointed timber for which verification status is sought.

C.3 Testing

C.3.1 General

The specimens shall be subjected to a proof tension testing in a tension test machine and the ability of the specimen to survive without failure or other damage determined.

C.3.2 Equipment

Any machine or device that can grip the specimen without damage and apply a predetermined tension load to the end joints shall be acceptable. The loading device shall have the capacity and all the necessary controls and gauges to permit proof loading of all widths and thicknesses for the intended production.

The proof loading machine shall be capable of maintaining an applied load with a tolerance of ±1 % of any calibration setting. The proof loading machine shall be fitted with a reject switch that detects failure. Activation of the reject switch shall immediately unload the timber and initiate the procedure to classify that piece as rejected from the stress grade.

The proof loading machine shall be checked for calibration at a frequency required to confirm the above tolerances.

The proof load level shall be set in accordance with Formula (C.1):

$$P = bdf_{t,PL} \tag{C.1}$$

where

P is the proof load, in newtons;

$f_{t,PL}$ is the proof stress in tension, in megapascals.

C.3.3 Preparation

Finger-jointed timber shall be tested as single piece.

C.3.4 Procedure

All finger joints of finger-jointed timber shall be proof loaded in tension at a load that induces a stress ($f_{t,PL}$) given by Formula (C.2):

$$f_{t,PL} = 0{,}5 f_{k,t} \tag{C.2}$$

NOTE The level of proof loading represents approximately 1 in 10^4 pieces for log-normal distributions with a coefficient of variation of 0,25.

C.3.5 Test results

A pass or fail test result shall be determined for each specimen subjected to the proof tension test. The test result for each specimen shall be determined follows.

a) Pass: where the piece survives the tension test without failure or other damage.

b) Fail: where the piece does not survive the proof tension test without failure or other damage.

C.4 Acceptance criteria

The strength of finger joints shall be considered verified where all pieces failing below the proof load are discarded or reworked.

Annex D
(normative)

Verification of finger joint bond quality by assessment of wood fibre failure

D.1 General

This annex sets out a method for measuring the effects of an accelerated exposure test (vacuum-pressure soak, boil or steam, referred to as pre-treatment A, B or C, respectively) on the bonds of finger joint samples from structural finger-jointed timbers.

For qualification and on-going verification, all pre-treatments are considered to be equivalent and finger-jointed structural timber need only be subjected to a single pre-treatment.

D.2 Specimens

Test specimens shall be drawn from production.

The test specimen shall be prepared from a full cross-section piece of length with a span-depth ratio L/h greater than 12. The sample shall contain a joint in the centre of the length.

D.3 Testing

D.3.1 General

The specimens shall be subjected to pre-treatment A, B or C, as described below, then broken in bending at or near the finger joint on a testing machine and the wood failure percentages assessed.

D.3.2 Equipment

D.3.2.1 For pre-treatment A — Vacuum pressure soak

An autoclave or similar pressure vessel designed to safely withstand a vacuum of 65 kPa and a pressure of 500 ± 30 kPa shall be required for impregnating the specimens with water. The pressure vessel shall be equipped with a vacuum pump or similar device capable of drawing a vacuum of at least 65 kPa (gauge pressure) in the vessel and a pump or similar device for obtaining pressure of at least 500 kPa (gauge pressure).

D.3.2.2 For pre-treatment B — 72 h boil

a) A water bath fitted with a constant level device capable of maintaining 100 °C and of sufficient size to accommodate test pieces described in D.2.

b) Racks or other means of keeping all test pieces separated and completely immersed in water.

D.3.2.3 For pre-treatment C — 6 h steam

a) An adequately drained autoclave or similar vessel of sufficient size to accommodate test pieces described in D.2, designed to withstand safely a pressure of at least 220 kPa above atmospheric pressure and capable of controlling pressure within ±7 kPa of the prescribed pressure.

b) Racks or other means of keeping all test pieces separated and completely immersed in steam. They shall not contaminate the water or be corroded by it.

D.3.2.4 For evaluation

A minimum 150 W lamp or 15 W fluorescent tube.

D.3.3 Preparation

D.3.3.1 General

For the treatment of all test pieces, the water or steam shall have free access to all surfaces of every test piece. All test pieces shall be free of any edge coating or sealing that is likely to prevent or hinder the entry of water or steam into the edges.

D.3.3.2 For pre-treatment A — Vacuum pressure soak

Specimens shall have all excess beads of glue removed prior to being conditioned as follows.

a) Place the finger joints in an autoclave. Immerse them in water between 10 °C and 27 °C and weigh down so that the test specimens are completely submerged.

b) Draw a vacuum of at least 65 kPa (500 mm Hg) and hold for 1,5 h, then release the vacuum and apply a pressure of 500 ± 30 kPa for 1,5 h. Repeat this vacuum-pressure cycle once more.

For higher density species, longer pressure and vacuum cycles may be required to achieve acceptable penetration.

D.3.3.3 For pre-treatment B — 72 h boil

Submerge the test pieces in water at 100 °C for 72 h +1 h −0 min.

NOTE The 72 h submersion in boiling water can be the aggregate of shorter periods, provided the test pieces are stored in water between periods of boiling.

D.3.3.4 For pre-treatment C — 6 h steam

Steam the test pieces in an adequately drained vessel at 200 ± 7 kPa above atmospheric pressure for 6 h +15, −0 min.

At the conclusion of the vacuum pressure, boil or steam treatment, immerse the test pieces in water at normal room temperature until they are cooled to room temperature. The test pieces must be kept wet until they are tested.

Testing should be completed within 24 h of the removal of the test pieces from the vacuum pressure, boiling water or steam.

D.3.4 Procedure

The procedure shall be as follows.

a) The specimens shall be ruptured in bending by any convenient method.

b) The two surfaces of the finger joint shall be placed side by side and the joint assessed as a single unit. The specimen shall be placed under a light source and the wood fibre assessed by orientating the fingers in a horizontal plane and rotating the specimen through a 90° arc so that each side of each finger can be observed clearly under lighting. The specimens shall then be inverted and the joint and fingers viewed in the alternate orientation.

c) The fractured surfaces from each side of the joint shall be examined for percentage wood failure (WF_i).

d) Wood fibre assessment shall exclude the following:

1) areas at the tips of the fingers and at the base of the grooves (see Figure D.1);

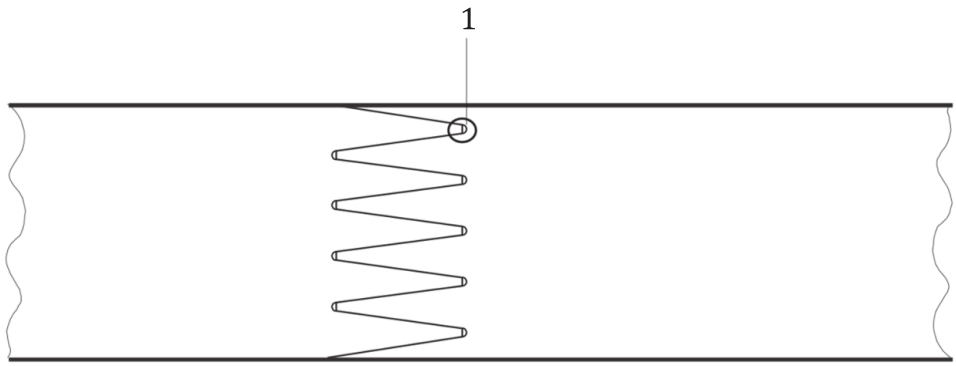
2) loose surface fibres;

3) areas of the joint affected by knots, resin pockets and other naturally occurring characteristics. If the area affected by these characteristics exceeds 30 % of the cross-section, the specimen shall be replaced.

It may be necessary to dry the test specimens overnight to facilitate the examination of the wood failure.

A hand-held lens or microscope may be required to identify loose surface fibres.

The failing load from the bending test described in D.4 may provide useful information on bond strength and could be recorded.



Key

1 exclude from assessment

Figure D.1 — Area to exclude from bond assessment

D.3.5 Test results

The average percentage wood failure shall be calculated using Formula (D.1):

$$WF_{av} = \sum \left(WF_i \right) / N \tag{D.1}$$

where

WF_{av} is the average wood failure of all surfaces or fingers, in percentage;

WF_i is the wood fibre failure of a surface or finger, in percentage;

N is the number of surfaces or fingers examined.

D.4 Acceptance criteria

To verify the finger joint integrity, it is recommended that the minimum wood failure percentages shall not be less than those specified in Table D.1.

Table D.1 — Minimum wood fibre failure levels for finger joints

Timber density kg/m^3	Average percentage of the last five joints tested	Minimum percentage of the most recent joint tested
Less than or equal to 650	60	40
Greater than 650	40	30

NOTE The values provided are indicative of the minimum performance level required. Some jurisdictions may adopt different criteria that local experience has shown are required to provide satisfactory performance suited to local species, service conditions and experience.

D.5 Recording

The following shall be recorded.

a) The pre-treatment (i.e. A, B or C) applied to the test material as described in D.3.

b) The measured or nominal density used to establish the acceptance criteria in D.4.

c) The percentage wood failure of each individual joint.

d) The average percentage wood failure for all fingers.

Annex E
(normative)

Verification of finger joint bond quality by cyclic delamination

E.1 General

This annex sets out a method for measuring the effects of accelerated cyclic exposure (vacuum-pressure soak and rapid drying) on the bonds of finger joint samples from structural finger-jointed timbers.

E.2 Specimens

Test specimens shall be drawn from production.

Each test specimen shall be prepared from a full cross-section piece of length approximately 150 mm containing the joint in the centre of the length. The specimen shall be cross-cut to expose the bond lines yielding two test specimens approximately 75 mm long.

E.3 Testing

E.3.1 General

The specimens are subjected to a vacuum-pressure soak cycle in an autoclave followed by a drying period in an oven. The bond lines are evaluated for delamination on the sawn (end) faces of the samples.

E.3.2 Equipment

An autoclave or similar pressure vessel designed to safely withstand a minimum of 500 kPa pressure shall be required for impregnating the specimens with water. The pressure vessel shall be equipped with a vacuum pump or similar device capable of drawing a vacuum of at least 85 kPa in the vessel and a pump or similar device for obtaining pressure of at least 500 kPa (gauge pressure).

A drying oven capable of maintaining a temperature of approximately 70 °C and conditions of relative humidity to dry the specimen to within 15 % of its original weight within 10 h to 15 h shall be required.

NOTE An oven with the capacity to maintain a relative humidity of 8 % to 10 % and to circulate the air at a rate of approximately 150 m/min past the end grain surfaces of the test specimens has shown to be sufficient to meet this requirement.

E.3.3 Preparation

Specimens shall have all excess beads of glue removed. The sample blocks shall be dried rapidly (10 h to 15 h) if the optimum test on the bond line is to be achieved. The delamination percentage shall be determined immediately after removal from the oven.

NOTE If the delamination percentage is not determined immediately, areas of poor bond may close up as the moisture gradient in the piece lessens due to the core drying and the surface picking up moisture.

E.3.4 Procedure

The procedure shall be as follows.

a) The weight of each test specimen shall be measured to the nearest gram and recorded.

b) The test specimens shall be placed in the autoclave or pressure vessel and weighted down. Stickering, wire screens or other means shall be used to separate the test specimens so that all end grain surfaces are freely exposed to water.

c) Sufficient water shall be admitted at a temperature of 18 °C to 29 °C so that the test specimens are completely submerged.

d) A vacuum of 68 kPa to 85 kPa shall be drawn and held for 30 min then released.

e) A pressure of (500 ± 30) kPa shall be applied for a period of 2 h.

f) The test specimens shall be dried using air at a temperature of (70 ± 2) °C. The air circulation and number of specimens in the oven at any time shall be selected such that the specimens are dried to within 12 % to 15 % of their original weight in 10 h to 15 h.

g) During drying, the specimens shall be placed at least 50 mm apart, with the exposed bond lines on the end grain surfaces parallel to the direction of the airflow. The actual time in the drying oven shall be controlled by the change in weight of the test specimens.

h) When the weight has returned to within 12 % to 15 % of the original test specimen weight prior to the beginning of the test, the specimens shall be removed from the oven and the delamination is immediately measured and recorded.

i) The delamination shall be measured along the bond lines and is reported as a percentage of the sum of bond line lengths on both sections of a single end joint that has been sawn in two parts prior to testing.

E.3.5 Test results

For batch tests, if the delamination observed after one cycle exceeds 5 %, a second cycle of the procedure detailed in E.3.4 shall be performed on the same specimen.

Test specimens shall be drawn from production and shall be prepared from a full cross-section piece of length with a span-depth ratio $L/h > 12$ with a joint in the centre of the length.

E.4 Acceptance criteria

The finger joint integrity shall be verified where

a) after a single cycle, the delamination shall not exceed 5 % for softwoods or 8 % for hardwoods, or

b) if a second cycle is required, the delamination observed and recorded at the end of the second cycle shall not exceed 10 %.

E.5 Recording

The following shall be recorded:

a) the weights before and after the conditioning;

b) the temperature of the oven, relative humidity and time to final delamination reading.

Annex F
(normative)

Verification of finger joint strength properties using the analytical method

F.1 General

This annex sets out the acceptance criteria when assessing if finger-jointed timber meets the requirements of a strength grade. It applies to both qualification testing and to compliance (factory production) control testing.

F.2 Specimens

Specimens shall comply with the requirements of ISO 10983.

F.3 Testing

Testing shall comply with the requirements of ISO 10983.

F.4 Acceptance criteria

F.4.1 Qualification

Where there is more than one finger joint in a standard length, the finger joint strengths shall have fifth percentile bending and tension strengths that exceeds the strength grade values in tension and bending, respectively, by the factor k_{fj} given in Table F.1.

F.4.2 Compliance

Where there is more than one finger joint in a standard length, the target value for compliance testing described in Annex A in tension or bending shall be determined by Formulae (F.1) or (F.2) as appropriate to the test method (bending or tension). The factor k_{fj} shall be selected from Table F.1.

$$f_{k,m,verif} = k_{fj} f_{k,m} \quad \text{(F.1)}$$

$$f_{k,t,verif} = k_{fj} f_{k,t} \quad \text{(F.2)}$$

Table F.1 — Factor k_{fj}

	Coefficient of variation					
	0,15	0,20	0,25	0,30	0,35	0,40
Number of finger joints, M	Factor k_{fj}					
1	1,00	1,00	1,00	1,00	1,00	1,00
2	1,05	1,07	1,09	1,10	1,12	1,14
3	1,08	1,11	1,13	1,16	1,19	1,22
4	1,09	1,13	1,16	1,19	1,23	1,25
5	1,11	1,15	1,18	1,22	1,26	1,30
10	1,15	1,20	1,26	1,31	1,37	1,43

Annex G
(normative)

Product identification

Where timber is purported to comply with this document, each piece shall be clearly marked to identify the following:

a) the product strength grade or manufacturer description;

b) the manufacturer of the finger joint timber (entity responsible for claiming its service class and strength grade);

c) reference to this document;

d) if classed as seasoned, the inclusion of either S if seasoned, or KD or DG if kiln dried;

e) adhesive service class as SC2 or SC3.

The timber shall be marked either

a) indelibly with a brand or stamp, or

b) with a label that cannot be removed without obvious damage to the mark or tagged with an end tag, only where an appearance requirement is specified.

In many applications, pieces are used in lengths shorter than the production lengths, and strength grade marking at 1 200 mm centres, or less, will give the appropriate stress grade information on shorter pieces that are cut from the original longer lengths.

Stress-graded timber may be identified by branding, labelling, stamping or marking. Where face or edge branding would be unacceptable, timber with an appearance requirement may be tagged with an end tag.

Removable marks (for example, paper labels) are normally considered as having sufficient durability if they cannot be removed without obvious damage being done to the mark.

Additional information may also be incorporated in the marking.

Annex H
(informative)

Basis of factor k_{fj}

H.1 Assumptions

a) The finger joint number, M, is determined by counting the number of finger joints over a standard length for tension testing.

b) A conservative value for k_{fj} is obtained by consideration of the tension case only. In tension, each finger joint is subject to the same load which means that the factor k_{fj} can be expressed purely in terms of M and the coefficient of variation, V. In bending, finger joints are subject to bending moments that vary along the member length. More complex modelling is required for this case but it is thought that the bending case is less critical.

c) The finger joint strengths can be described in terms of a log-normal distribution.

d) The finger jointing statistical characteristics remain unaltered from qualification.

Therefore, the value of k_{fj} is given by Formula (H.1):

$$k_{fj} = X_{05} / \min\left(X_1..X_i..X_M\right)_{05} \quad \text{(H.1)}$$

where

X_{05} is the characteristic strength of finger joints tested singly and making all adjustments for sample size;

X_i is the strength of a randomly chosen finger joint based on single finger joint testing.

H.2 Algorithm for tension strength

a) Input the number of finger joints, M, and coefficient of variation, V, and assume that a tension having a mean of unity (m = 1) is applied, then transform m and V to their log-normal equivalents using $\mu = \ln[m/\sqrt{(1 + V^2)}]$ and $\Lambda = \sqrt{[\ln(1 + V^2)]}$; μ and Λ remain fixed throughout the simulation. Compute the fifth percentile of a single finger joint using an inverse log-normal routine.

b) Set up an outer loop to count the simulation number.

c) Set up an inner loop for each finger joint.

d) Select a random number (Mersenne Twister generator has been used which is standard in the Free Pascal Compiler) to compute the natural logarithm of the strength of a random finger joint using a high-speed inverse normal routine.

e) The natural logarithm strength is converted to the usual strength value using $X = \exp(\mu(1 + \Lambda))$.

f) Repeat c) to f) M times and select $\min(X_1..X_i..X_M)j$ for the jth simulation.

g) Repeat b) to g), for say 10 000 simulations, sort the results, identify the fifth percentile value (500th lowest) and compute k_{fj} using Formula (H.1).

Bibliography

[1] ISO 12578, *Timber structures — Glued laminated timber — Component performance requirements*

ICS 91.080.20

Price based on 26 pages