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Timber — Finger joints — Minimum production requirements and testing methods

Bois — Aboutages — Exigences minimales de production et méthodes d'essais

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Foreword

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

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

This second edition cancels and replaces the first edition (ISO 10983:1999), which has been technically revised.

Introduction

This International Standard sets out minimum production and testing requirements for structural finger joints. It includes requirements for documentation of manufacturing and test procedures in a quality manual to ensure ongoing consistent quality. TC 165 is not prepared to recommend the use of finger joints in structural timber components where the manufacturing process is not described by a production facility's quality manual for the following reasons.

a) Structural properties can only be assigned to a finger joint that is clearly defined. Such a definition requires a clear description, within the production facility's quality manual, of the raw material inputs (wood and adhesive), the manufacturing process, and quality assurance procedures.

b) Processes which are not written in a production facility's quality manual and promulgated to the personnel responsible for manufacturing the finger joint are unlikely, over lengthy periods of time, to be manufactured consistently.

Other principles built into the development of this International Standard are as follows.

— This International Standard applies only to the finger-joint production and makes reference only to the maintenance of finger-joint strength. Finger joints are found in both glulam laminations and finger-jointed timber used directly for structural applications. No attempt is made in this International Standard to relate compliance testing to the properties of either glulam or finger-jointed timber.

— Qualification testing is undertaken to establish characteristic strengths and target strengths for compliance (daily quality control) testing. The precise test configurations are not specified in this International Standard, which permits the use of a wide variety of test equipment. However, it is a requirement that the same equipment and configuration used for qualification testing also be used for compliance testing. Both bending and tension tests are provided.

Timber — Finger joints — Minimum production requirements and testing methods

1 Scope

This International Standard specifies minimum requirements for the manufacture and testing of bonded finger joints in structural wood products such as glued laminated timber, cross-laminated timber, and finger-jointed timber.

Although most finger joints are produced in coniferous species (softwoods), this International Standard also applies to broadleafed species (hardwoods) where information is available to enable them to be satisfactorily bonded.

It does not cover impressed (die-formed) joints and, in the case of laminated timber products, it applies only to individual laminations. Large finger joints in glued laminated timber are not covered by this International Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms and definitions

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

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

3.2
production batch
group of finger joints, all of which have the same profile, are manufactured from the same species of timber, have the same nominal cross section, are bonded with the same adhesive, and are made during a continuous run on one production line

3.3
qualification testing
testing in bending or tension performed to establish the mean and lower 5 % tolerance limit strength with 75 % confidence when the finger joint process is first established

3.4
compliance testing
testing in bending or tension to verify that ongoing production complies with the characteristic and target strengths established during qualification testing

4 Symbols

For the purposes of this International Standard, the following symbols apply.

a distance between support and nearest applied load in bending test (mm)

b smaller dimension of cross section (mm)

h larger dimension of cross section (mm)

f_m bending strength of a single finger joint

f_t tension strength of a single finger joint

l distance between supports in bending test

P maximum force applied to finger jointed specimen during bending test

T maximum force applied to finger jointed specimen during tension test

5 Production requirements

5.1 General

The cutting and the bonding operations of finger joints shall result in reliable and durable bonds of the required strength. The premises shall meet the requirements of cleanliness, air temperature, and relative humidity to ensure a satisfactory production environment. Procedures for the operation of the production facility and for the initial and ongoing quality evaluation shall be documented in a quality manual. All machinery and equipment necessary for the production process shall be available and in good working order. Timber shall be properly graded. Adhesives shall be compatible with the species and treatment in conformance with the adhesive manufacturer's recommendations. Cutting, bonding, and handling of finger-jointed timber shall be in conformance with the production facility's quality manual.

5.2 Timber

5.2.1 Species

Any wood species shall be permitted provided that sufficient information on the species is available to enable the timber to be bonded satisfactorily. Different species with similar strength and bonding characteristics shall be permitted to be grouped together for qualification and compliance testing.

5.2.2 Timber grading

Individual pieces of timber to be finger-jointed shall be graded according to the product requirements as described in the production facility's quality manual. Specific limits shall be defined for knots, grain deviations, wane, and other characteristics determined to be detrimental to the performance of the product. The maximum size and extent of knots and other strength-reducing characteristics at the ends of the pieces to be finger-jointed shall be limited as defined in the quality manual to minimize their effect on the strength of the joint.

5.2.3 Moisture content and temperature

During assembly and curing, the moisture content and temperature of the wood at the joint shall be within the range specified by the adhesive manufacturer.

Moisture content shall be measured by the use of a regularly calibrated moisture meter.

5.2.4 Chemically treated timber

Wood treated with chemicals such as those used to improve durability or fire performance shall be considered as a separate species for the purposes of finger joint production and quality control.

5.3 Adhesive

5.3.1 General

The adhesive shall have sufficient strength and durability to ensure that the integrity of the bond will be maintained throughout the intended lifetime of the structure. Compatibility of the adhesive, wood substrate, and plant procedures shall be demonstrated through qualification tests prior to production. The adhesive used shall meet the requirements of ISO 20152-1.

5.3.2 Adhesive manufacturer's specifications

The specifications of the adhesive manufacturer shall be followed with respect to the following:

a) mixing of the adhesive;

b) use of fillers;

c) preheating of the timber (by high frequency, infrared, or other methods);

d) adhesive application;

e) open and closed assembly times;

f) curing of the adhesive;

g) temperature of the air and the timber before and during curing;

h) moisture content of the timber at the joint;

g) other parameters deemed necessary by the adhesive manufacturer to maintain a consistent bond quality.

5.4 Processing

5.4.1 Application of adhesive

The method used for adhesive application shall ensure that all finger surfaces in the assembled joint are covered with the adhesive.

5.4.2 Assembly

Joints shall be bonded as soon as possible, and not later than 24 h, after machining. Between machining and assembly, care shall be taken to keep the cut surfaces of the fingers clean. The members shall not be stored in conditions likely to lead to distortion.

5.4.3 End pressure

The application of end pressure shall be adequate to bring the mated joint surfaces into contact and extrude excess adhesive, while maintaining proper tip gaps and joint alignment. End pressure shall be maintained until the joint has cured adequately to enable the jointed timber to be moved without weakening the joint. Curing of the adhesive shall be completed before further processing, unless it has been demonstrated that the finger joints will have sufficient and reliable strength to allow immediate processing.

5.5 Quality control

5.5.1 General

The manufacturer shall establish and document requirements for lumber, adhesive, and processing with corresponding quality control procedures.

Each step in the production process, including lumber grading, finger joint machining and fit, adhesive application, joint assembly and handling, adhesive curing, and final finishing shall be assessed for each production batch. Finger joint strength shall be established through initial qualification testing and verified for each production batch through ongoing compliance testing.

5.5.2 Facilities, equipment, and personnel

All necessary facilities, equipment, and personnel shall be available to carry out the necessary inspections and tests. The manufacturer shall control, calibrate, and maintain inspection, measuring, and test equipment, to demonstrate the conformity of the finger joints to the requirements of this International Standard. Equipment shall be used in a manner which ensures that measurement tolerances are known and are consistent with the required measurement capability.

5.5.3 Responsibility and authority

The responsibility, authority, and interrelation of all personnel who manage, perform, and verify work affecting quality shall be defined. Persons responsible to initiate action to prevent the occurrence of non-conformity of finger joints and to identify and record any quality problems with finger joints shall be clearly identified.

5.5.4 Factory production control

At every production facility, the manufacturer shall appoint a person or persons who shall have appropriate authority, knowledge, and experience of the production of finger joints to be responsible for conducting and supervising factory production and quality control procedures and ensuring that the requirements given in this International Standard are implemented and maintained.

5.5.5 Review

The quality control system adopted to satisfy the requirements of this International Standard shall be reviewed at appropriate intervals by the manufacturer's management to ensure its continuing suitability and effectiveness.

Records of such reviews shall be maintained.

5.5.6 Quality manual

The manufacturer shall document all procedures relevant to the production and quality control of finger joints in a quality manual. At a minimum, the quality manual shall describe

a) the organizational structure, including responsibilities and powers of the management with regard to conformity of the finger joints,

b) all procedures for specifying and verifying the quality of the timber and the adhesive,

c) each step in the production process, and

d) all inspections and tests that will be carried out before, during, and after manufacture, and the frequency with which they are to be carried out.

The quality manual shall be available to production and quality personnel as needed to ensure consistent application of production and quality control procedures.

6 Testing requirements

6.1 General

Finger joint strength shall be established through qualification testing and verified for each production batch through ongoing compliance testing. Specimens are permitted to be tested in either bending or tension as chosen by the manufacturer or as required by an accreditation agency; however, the same configuration used for qualification testing shall also be used for compliance testing.

6.2 Materials

Finger joints with differences in processing, treatment, timber species (or species group), joint geometry, or adhesive shall be evaluated separately. Sample joints shall be selected from and represent normal production. The timber densities shall be representative of the species and grade concerned. At the time the sample joints are manufactured, the timber shall be at the moisture content at which production joints would normally be made. The surface finish of the specimens at the time of testing shall be typical of the jointed timber normally supplied by the manufacturer.

Specimens for qualification testing shall be tested in the fully cured condition. Specimens for compliance testing are permitted to be tested in the fully cured condition or in a partially cured condition, provided that a consistent relationship has been established between fully cured strength and partially cured strength. Where partially cured specimens are tested for compliance, the time between bonding of the joint and testing shall be consistent to ensure that a similar degree of cure is achieved for each specimen. The relationship between partially cured end joint strengths and fully cured end joint strengths shall be re-evaluated periodically at intervals of one month or less.

NOTE The re-evaluation period for the relationship between partially and fully cured end joint strengths should be established considering all parameters that may influence the relationship. These include changes to the manufacturing facilities ambient conditions such as temperature and relative humidity, the wood condition such as temperature and moisture content, and the adhesive sensitivity to the manufacturing conditions. The sensitivity of the partially and fully cured end joint strength relationship to these conditions should be included in the evaluation to establish an appropriate re-evaluation interval.

6.3 Testing procedure

Testing shall be conducted in accordance with Annex A for bending tests or Annex B for tension tests. Each specimen shall contain a finger joint at mid-length. Where possible, the whole jointed cross section shall be tested. However, test specimens not covering the full cross section of the jointed timber may be used provided that two specimens, each making up at least one-third of the cross section, are tested. In bending tests, these specimens shall include the edges of the original cross section and these edges shall be on the tension side of the specimen in the bending test. Only the lower test result shall be considered.

6.4 Recording requirements

For the finger joints tested, the following information shall be recorded and signed by the person responsible for the testing:

a) date of production;

b) date of testing;

c) wood species;

d) timber grade;

e) chemical treatment;

f) type of resin and hardener;

g) width and thickness of the timber;

h) test load at failure;

i) bending or tension strength;

j) description of the failure mode (wood failure percentage).

All documentation shall be registered so that the raw materials and production conditions for the finger joints are traceable.

6.5 Qualification testing

6.5.1 General

During the running-in period of a new finger-jointing line, or in the case of significant changes in an existing line (including changes of profile), specimens shall be tested in either bending or tension. The cross sections of the specimens shall be equal to the maximum which the manufacturer intends to finger-joint.

6.5.2 Sample size

A minimum of 30 jointed specimens shall be sampled and tested. Where failure of a specimen occurs away from the joint, with a strength below the target characteristic value for the test, the test results for that specimen can be excluded in the assessment. The test results for a maximum of two such specimens shall be permitted to be excluded. If such exclusions leave fewer than 30 valid results, then tests on further specimens shall be carried out to give at least 30 valid results.

6.5.3 Characteristic strength

The characteristic bending or tension strength, as appropriate, defined as the lower 5 % tolerance limit strength with 75 % confidence, shall be determined by an appropriate statistical method. The mean bending or tension strength, as appropriate, shall also be determined.

6.6 Compliance testing

6.6.1 General

Daily testing in either bending or tension is used to help ensure that the required finger joint strength is maintained over time and to provide a level of confidence that a production batch is satisfactory. The approval of a production batch is contingent on a successful demonstration of compliance with the strength requirements.

NOTE In addition to the basic requirements of this Clause, additional testing can be specified for some production to meet requirements of applicable product standards. For example, in-line or other frequent proof loading is frequently required for finger-jointed timber to be used as individual members in tension or bending. Recommended tests for proof loading in bending or tension are shown in Annex C and Annex D.

6.6.2 Sampling

A representative sample of finger joints shall be drawn at random from each work shift and each production line. Specimens shall be taken for testing from the production of each shift and each production line, as far as possible, evenly distributed in time and timber sizes over the shift. Minimum requirements for sampling shall be established by the relevant product standard and included in the plant quality manual.

6.6.3 Compliance requirements

Minimum requirements for compliance shall be established by the relevant product standard and included in the plant quality manual. Statistical process control techniques shall be permitted to be used to determine compliance with the strength requirements.

6.6.4 Action in case of non-conformity

6.6.4.1 General

If there is a reason to doubt the quality of any production operation or of the raw materials used, the internal quality control shall be increased and intensified.

6.6.4.2 Correction of problem

If the quality of a production batch is unsatisfactory, as assessed by the compliance requirements, the manufacturer shall immediately take the necessary steps to rectify the non-compliance. After the cause of the non-compliant production is corrected, additional testing shall be required to demonstrate compliance as established in the relevant product standard.

6.6.4.3 Disposition of non-conforming production

The production batch(es) involving non-conforming finger joints shall be rejected, set aside, and marked accordingly. Associated test data shall be maintained, but are permitted to be disregarded for subsequent compliance evaluations.

Upon inspection of all joints in the affected production batch, visibly mismanufactured joints shall be discarded. A random sample of 30 joints shall be permitted to be tested to determine a characteristic value for the batch. The remainder of the batch shall be permitted to be used where its characteristic strength exceeds the product requirements.

Annex A
(normative)

Finger-joint bending test

A.1 General

This annex presents examples of test set-ups for testing of finger-joints in bending.

A.2 Principle

The finger joint is tested in three- or four-point bending on the flat or on edge in a testing machine, and the bending stress at failure (modulus of rupture) is calculated. The test specimen shall contain at least one finger joint in the region of maximum bending moment. Several test configurations are provided to suit individual manufacturer's test equipment. Once the mean and lower 5th percentile strengths are obtained from qualification testing, all compliance testing shall be undertaken on identical equipment.

A.3 Apparatus

Testing shall be performed using a machine of adequate capacity and capable of measuring loads to an accuracy of 2 %. The test apparatus shall be capable of applying load at a controlled rate to produce specimen failure in no less than 30 s and shall accommodate specimens with a span-to-depth ratio of 10 or more. The apparatus shall include bearing plates at least as wide as the specimen at points of support and load application. Bearing plates shall be sufficiently long to prevent crushing of the specimen.

A.4 Test configuration

A.4.1 General

The specimen length and test configuration is unspecified for this in-factory test, but the length-to-depth ratio shall be not less than ten; see Figure A.1. The same specimen length, test configuration, and orientation (flatwise or edgewise) shall be used for the qualification testing and for the compliance testing.

A.4.2 Flatwise bending

A.4.2.1 Three-point loading

For specimens tested in three-point loading (Figure A.1), the finger joint shall be placed at mid-span directly under the point of load application. The stress at failure shall be calculated using Formula A.1.

$$f_{\mathrm{m}} = \frac{3Pl}{2hb^2} \tag{A.1}$$

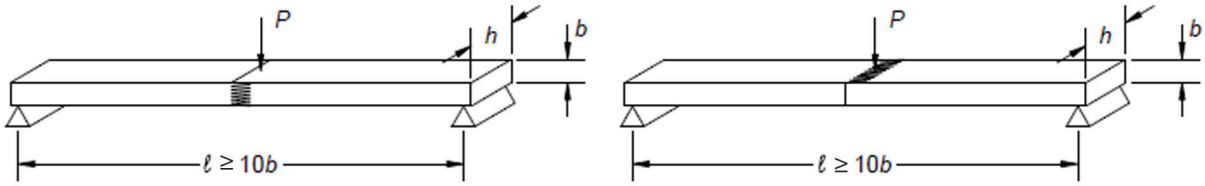

Figure A.1 — Flatwise bending with three-point loading

A.4.2.2 Four-point loading

For specimens tested in four-point loading (Figure A.2), the finger joint shall be placed at mid-span, between the points of load application. The stress at failure shall be calculated using Formula A.2.

$$f_{\mathrm{m}} = \frac{3Pa}{hb^2} \tag{A.2}$$

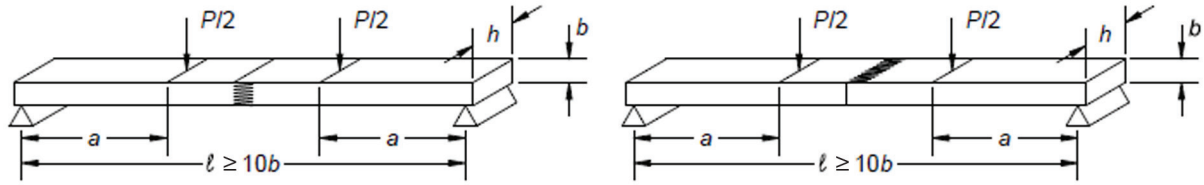

Figure A.2 — Flatwise bending with four-point loading

A.4.3 Edgewise bending

A.4.3.1 Three-point loading

For specimens tested in three-point loading (Figure A.3), the finger joint shall be placed at mid-span directly under the point of load application. The stress at failure shall be calculated using Formula A.3.

$$f_{\mathrm{m}} = \frac{3Pl}{2bh^2} \tag{A.3}$$

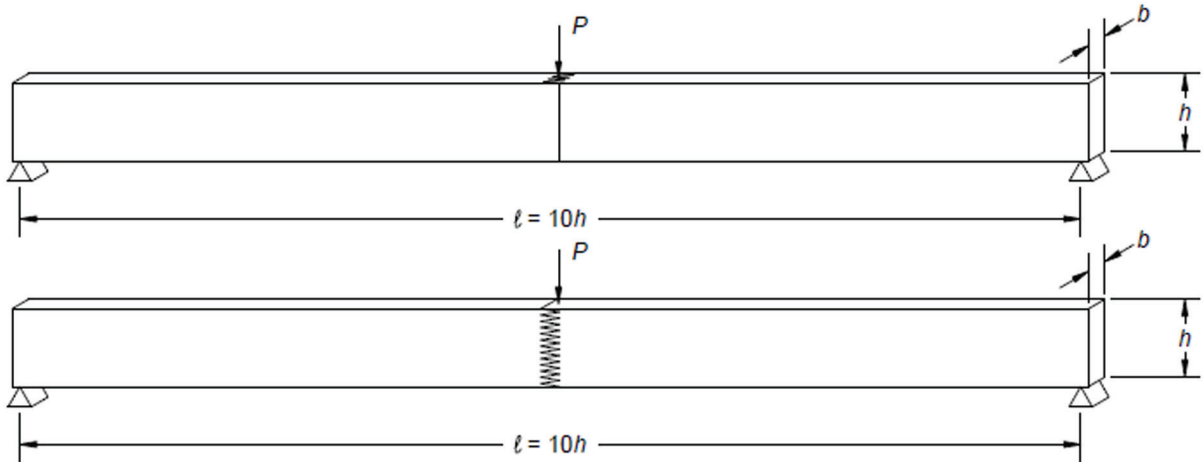

Figure A.3 — Edgewise bending with three-point loading

A.4.3.2 Four-point loading

For specimens tested in four-point loading (Figure A.4), the finger joint shall be placed at mid-span between the points of load application. The stress at failure shall be calculated using Formula A.4.

$$f_{\mathrm{m}} = \frac{3Pa}{bh^2} \tag{A.4}$$

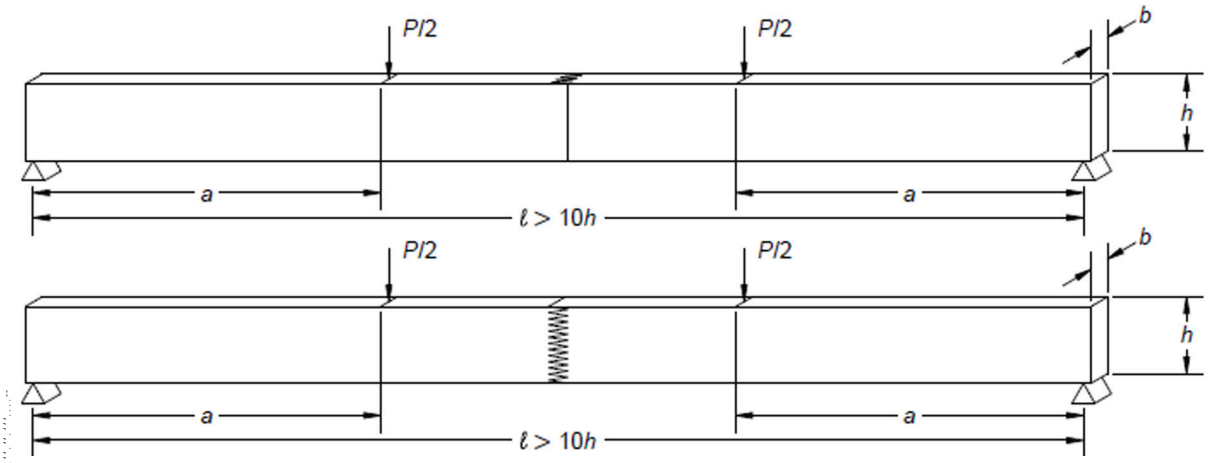

Figure A.4 — Edgewise bending with four-point loading

A.5 Load rate

Loading shall be applied at a rate such that failure takes place at a time between 30 s and 300 s.

A.6 Test report

The following details shall be recorded in the test report:

a) date of production;

b) date of testing;

c) wood species;

d) timber grade;

e) preservative treatment;

f) type of resin and hardener;

g) finger-joint profile;

h) cross-section dimensions *b*, *h*;

i) load at failure;

j) failure stress (modulus of rupture) as determined by the formulae given in Figures A.1 to A.4;

k) description of the failure mode;

l) time to failure.

Annex B
(normative)

Finger-joint tension test

B.1 General

This annex presents examples of test set-ups for testing of finger-joints in tension.

B.2 Principle

The finger joint is tested in tension in a testing machine, and the tensile stress at failure is calculated. The test specimen must contain at least one finger joint.

NOTE For failures away from a finger joint, the finger joint can be assumed to fail at that load, or a replacement specimen tested.

B.3 Apparatus

Testing shall be performed using a machine of adequate capacity to break all joints tested and capable of measuring loads to an accuracy of 2 %. The test apparatus shall be capable of applying load at a controlled rate to produce specimen failure in no less than 30 s. Grips or clamping devices shall minimize damage to the specimen and shall minimize slip during load application.

B.4 Test configuration

For specimens tested in tension (see Figure B.1), the finger joint shall be placed at mid-span between the grips. The stress at failure shall be calculated using Formula B.1. The distance between grips shall be 600 mm or more. The same test configuration shall be used for the qualification testing and for the compliance testing. The specimen length for compliance testing shall be equal to or greater than the specimen length for qualification.

$$f_t = \frac{T}{bh} \tag{B.1}$$

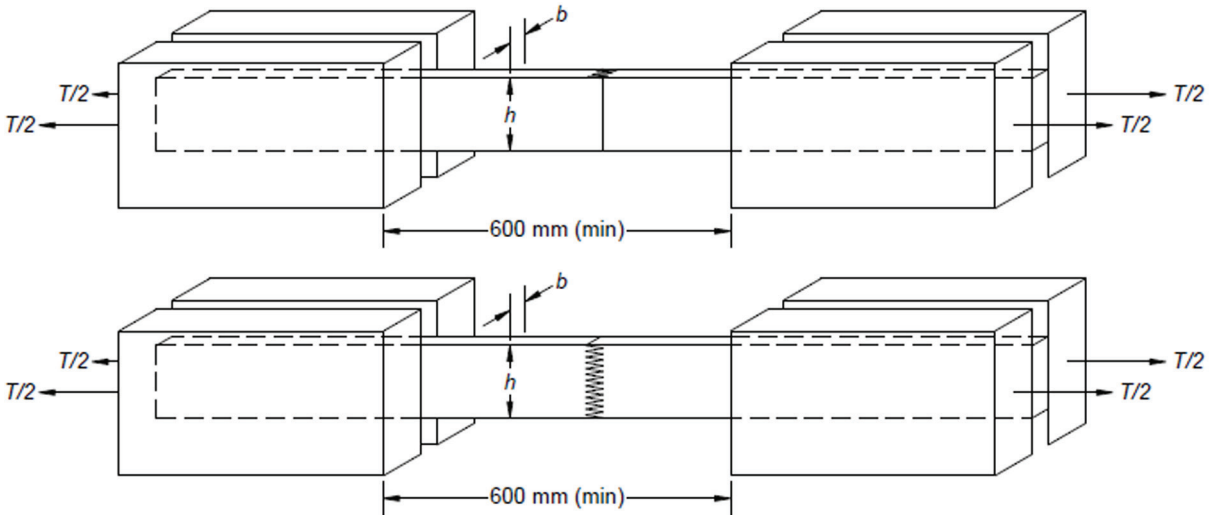

Figure B.1 — Test configuration for finger joints in tension

B.5 Load rate

Loading shall be applied at a rate such that failure takes place at a time between 30 s and 300 s.

B.6 Test report

The following details shall be recorded in the test report:

a) date of production;

b) date of testing;

c) wood species;

d) timber grade;

e) preservative treatment;

f) type of resin and hardener;

g) finger-joint profile;

h) cross-section dimensions *b*, *h*;

i) load at failure;

j) tensile strength at failure;

k) description of the failure mode;

l) time to failure.

Annex C
(informative)

Proof-loading of finger joints in bending

C.1 General

This annex presents a test method for in-line proof loading of finger joint specimens using a bending test. This method is intended to eliminate finger joints with unacceptably low strength from the finished production. It is not adequate to fully characterize a population's strength parameters and it is not intended to replace off-line tests in bending or tension for daily quality control.

C.2 Principle

The finger joint is tested in bending. Force is applied until a preselected load is reached or the specimen fails. Acceptable specimens continue to the next production step. Joints with abnormally low strength are destroyed by the proof loader and removed from the production process. Specimens with abnormally low stiffness are identified, marked, and removed from production.

C.3 Apparatus

C.3.1 Proof loader

Any machine or device capable of providing a known bending load to the end joint shall be acceptable. Testing shall be performed using a machine of adequate capacity and capable of measuring loads to an accuracy of 2 %. The loading device shall be capable of applying different loads for use with different timber sizes and stress levels. The proof loader shall have all of the necessary controls, gauges, etc. to permit proof-loading of all widths and thicknesses intended for production.

C.3.2 Failure indicators

The proof loader shall be capable of detecting breaks or damage to low-strength joints. The following devices are required:

a) a device capable of detecting excessive deflection which results in rejection of the end joint;

b) an audible warning device that sounds an alarm when a predetermined deflection is exceeded;

c) a device that applies a mark on one edge and face at the end joint or point where the deflection has been exceeded.

C.3.3 Calibration

All measuring equipment shall be calibrated prior to initial use and at least annually thereafter. Deflection limit for predetermined moduli of elasticity shall be calculated based on the loading and support conditions. The calculated deflections shall be verified using pieces of timber with known moduli of elasticity or other suitable means.

C.4 Test configuration

C.4.1 Span

The test span shall permit a predetermined bending moment to be applied to the end joint, either from two, equal, concentrated loads equidistant from the supports or a single, concentrated load at mid-span. Typical spans range from 15 times to 30 times the thickness of the timber.

C.4.2 Support conditions

Any support conditions are permitted provided that any rotational restraint or other factors such as overhang at the ends is properly considered in the determination of the applied bending moment and deflection limit.

C.4.3 Joint placement

The specimen shall be placed with a finger joint located in the maximum moment zone.

C.4.4 Load rate

The load rate shall be consistent for all finger joints within a production run. Typical line speeds result in the proof load being reached in less than 3 s.

C.5 Test specimens and conditioning

The specimen shall be tested as produced, without modification of the cross section or moisture conditioning. Finger joints are permitted to be proof loaded in either the fully cured or partially cured state. Proof loading of partially cured finger joints shall only be performed after it has been established that the proof load will not adversely affect the fully cured bond strength.

C.6 Determination of proof load level

The applied proof load should be sufficiently high to reject low-strength joints, but low enough to minimize failure of acceptable joints. For partially cured joints, the proof load might need to be reduced to account for the degree of cure and the temperature of the joints at the time of test.

Annex D
(informative)

Proof-loading of finger joints in tension

D.1 General

This annex presents a test method for in-line proof loading of finger joint specimens using a tension test. This method is intended to eliminate finger joints with unacceptably low strength from the finished production. It is not adequate to fully characterize a population's strength parameters and it is not intended to replace off-line tests in bending or tension for daily quality control.

D.2 Principle

The finger joint is tested in tension. Force is applied until a preselected load is reached or the specimen fails. Acceptable specimens continue to the next production step. Joints with abnormally low strength are destroyed by the proof loader and removed from production.

D.3 Apparatus

D.3.1 Proof loader

Any machine or device capable of providing a known tension load to the end joint shall be acceptable. Testing shall be performed using a machine of adequate capacity and capable of measuring loads to an accuracy of 2 %. The loading device shall be capable of applying different loads for use with different timber sizes and stress levels. The proof loader shall have all of the necessary controls, gauges, etc. to permit proof-loading of all widths and thicknesses intended for production. The proof loader shall have grips or clamping devices capable of transferring the load from the machine to the specimen without damage.

D.3.2 Failure indicators

The proof loader shall be capable of detecting breaks or damage to low-strength joints. The following devices are required:

a) an audible warning device that sounds an alarm when a failure occurs;

b) a device that applies a mark on one edge and face at the end joint or point where the failure has occurred.

D.3.3 Calibration

All measuring equipment shall be calibrated prior to initial use and at least annually thereafter. The calibration shall take into consideration dynamic effects, such as the inertia of the grips on the applied load.

D.4 Test configuration

D.4.1 Distance between grips

The distance between grips shall be at least 600 mm apart.

D.4.2 Joint placement

The specimen shall be placed with a finger joint centred between the grips. If multiple joints are tested simultaneously, the distance between either grip and the nearest finger joint being tested should be at least 300 mm.

D.4.3 Load rate

The load rate shall be consistent for all finger joints within a production run. Typical line speeds result in the proof load being reached in less than 3 s.

D.5 Test specimens and conditioning

The specimen shall be tested as produced, without modification of the cross section or moisture conditioning. Finger joints are permitted to be proof loaded in either the fully cured or partially cured state. Proof loading of partially cured finger joints shall only be performed after it has been established that the proof load will not adversely affect the fully cured bond strength.

D.6 Determination of proof load level

The applied proof load should be sufficiently high to reject low-strength joints, but low enough to minimize failure of acceptable joints. For partially cured joints, the proof load might need to be reduced to account for the degree of cure and the temperature of the joints at the time of test.

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