

Finger jointed structural timber — Performance requirements and minimum production requirements

The European Standard EN 385:2001 has the status of a
British Standard

ICS 79.040; 91.080.20

National foreword

This British Standard is the official English language version of EN 385:2001. It supersedes BS EN 385:1995 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/518, Structural timber, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

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Finger jointed structural timber - Performance requirements and minimum production requirements

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Keilzinkenverbindungen im Bauholz - Leistungsanforderungen und Mindestanforderungen an die Herstellung

This European Standard was approved by CEN on 3 September 2001.

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 124 "Timber structures", the secretariat of which is held by DS.

This European Standard supersedes EN 385:1995.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2002, and conflicting national standards shall be withdrawn at the latest by April 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This standard was written based on Recommended Standard for Finger Jointing in Coniferous Sawn Timber prepared by the ECE (Economic Commission of Europe) Timber Committee and published in the Timber Bulletin for Europe (Vol. XXXIV, Supplement 16, November 1982) with Draft Amendments, May 1988. This standard was developed on the basis of the use of European redwood and whitewood, but most of the requirements apply to any species.

Further, it was recognized that finger-jointing standards are currently in use in different countries and experience with these has influenced this standard.

1 Scope

This standard specifies requirements for bonded finger joints and minimum requirements for the manufacture of cut, interlocking, bonded finger joints in structural timber members. Requirements are given for timber, adhesive, moisture content, cutting and bonding.

This standard is only applicable to finger joints between timber members of the same species type.

Although most finger joints are produced in coniferous species this standard also applies to broad-leaved species where information is available to enable them to be satisfactorily bonded.

It does not cover impressed (die-formed) joints. In the case of glued laminated timber it applies only to individual laminations. Large finger joints in glued laminated timber are covered by EN 387.

NOTE This standard is elaborated as a supporting standard for a harmonized standard on structural timber with finger joints to be published in the future.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 301, *Adhesives, phenolic and aminoplastic for load-bearing timber structures - Classification and performance requirements.*

EN 408, *Timber structures – Structural timber and glued laminated timber – Determination of some physical and mechanical properties.*

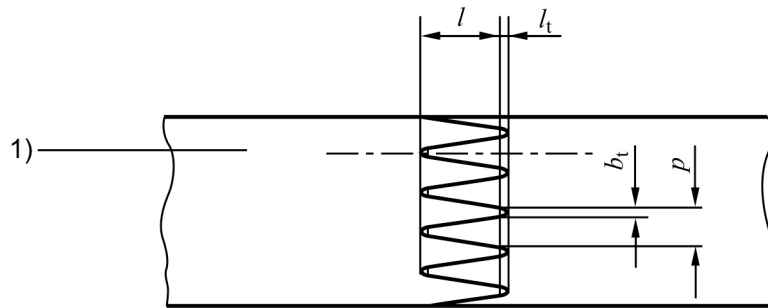
3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply:

3.1

finger joint

self-locating end joint formed by machining a number of similar, tapered, symmetrical fingers in the ends of timber members, which are then bonded together. See Figure 1



Key

- l Finger length
- p Pitch
- b_t Tip width
- l_t Tip gap
- 1) Symmetry direction

Figure 1 - Typical profile of finger joint

3.2

finger length

distance between the finger base and the tip of the finger, measured along the centre line of the finger

3.3

pitch

distance between fingers, centre to centre

3.4

production batch

joints, all of which have the same profile, manufactured from the same species of timber, the same strength class, having the same nominal cross section, bonded with the same adhesive and made during a continuous run on one production line

3.5

service class 1

service class characterized by a moisture content in the materials corresponding to a temperature of 20 °C and the relative humidity of the surrounding air only exceeding 65 % for a few weeks per year

NOTE In service class 1 the average equilibrium moisture content in most softwoods will not exceed 12 %.

3.6

service class 2

service class characterized by a moisture content in the materials corresponding to a temperature of 20 °C and the relative humidity of the surrounding air only exceeding 85 % for a few weeks per year

NOTE In service class 2 the average equilibrium moisture content in most softwoods will not exceed 20 %.

3.7

service class 3

service class characterized by climatic conditions leading to higher moisture contents than service class 2

3.8

tip gap

distance between finger tip and opposite slot base in a bonded finger joint

3.9

tip width

distance between finger faces, measured at the tip of the finger

4 Symbols

A	area, in square millimetres;
A_w	area of one wane, in square millimetres;
a_w	diagonal length of wane, in millimetres;
b	width of cross section, in millimetres;
b_t	tip width, in millimetres;
d	diameter, in millimetres;
f_m	bending strength, in newtons per square millimetre;
$f_{m,k}$	characteristic bending strength, in newtons per square millimetre;
$f_{m,15,k}$	characteristic bending strength of 15 specimens, see 7.1.4, in newtons per square millimetre;
$f_{m,15,mean}$	mean value of bending strength of 15 specimens, see 7.1.4, in newtons per square millimetre;
$f_{m,dc,k}$	characteristic bending strength, declared by the manufacturer, in newtons per square millimetre;
h	depth of cross section, in millimetres;
k_f	factor, see 7.1.4;
k_{15}	statistical factor, see 7.1.4;
l	finger length, in millimetres;
l_t	tip gap, in millimetres;
p	pitch, in millimetres;
s	standard deviation (the variable is given in parenthesis).

5 Requirements

5.1 General

The cutting and the bonding operations of finger joints shall result in reliable and durable bonds of required strength.

These general requirements shall be considered satisfied if both the requirements in this clause and the minimum production requirements in clause 6 are fulfilled.

5.2 Timber

5.2.1 Species

Sufficient information on the timber species shall be available to enable the timber to be satisfactorily bonded.

5.2.2 Knots and fissures

For the following requirements knots with a diameter not greater than 6 mm shall be disregarded.

There shall be no knots, fissures or pronounced grain disturbance within the joint itself. Outside the joint the distance between a knot and the end of the cross-cut timber shall be not less than $l + 3d$ where d is the diameter of the knot measured perpendicular to the grain direction (longitudinal direction), see Figure 2.

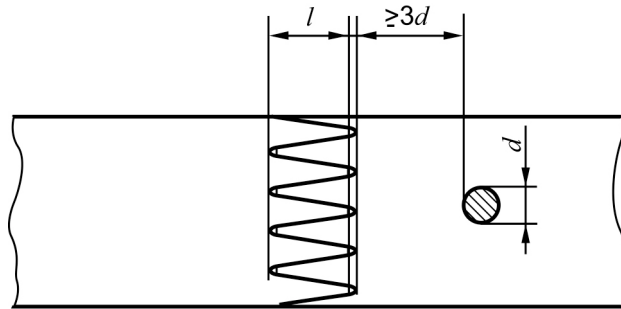


Figure 2 - Minimum distance from the end of the timber to a knot

Where a member is cross-cut to remove a knot, the cut shall be made at a distance from the knot at least equal to a length of $3d$, see Figure 3.

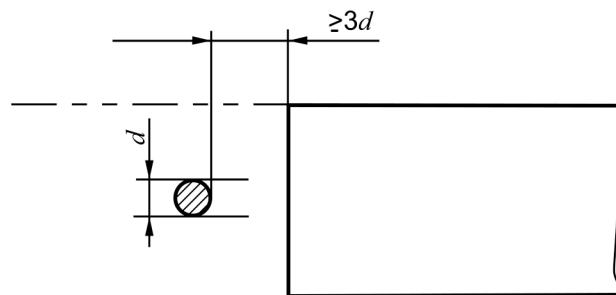


Figure 3 - Minimum distance for a cross-cut to remove a knot

5.2.3 Wane or edge damage

There shall be no wane or edge damage affecting more than two corners at the joint within the finger length and within 75 mm of the root of the fingers. The area of the wane at any corner shall not exceed 1 % of the cross-sectional area, see Figure 4.

NOTE Conformity with this requirement can be verified by measuring the diagonal a_w of the wane and demonstrating that it is less than the maximum diagonal given in figure 5 as a function of the cross-sectional area A .

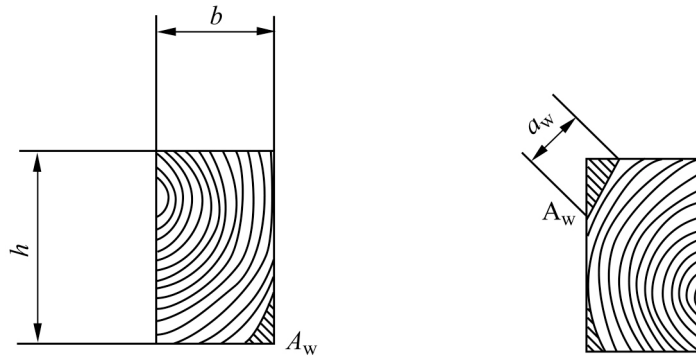


Figure 4 - Cross section of timber with wane

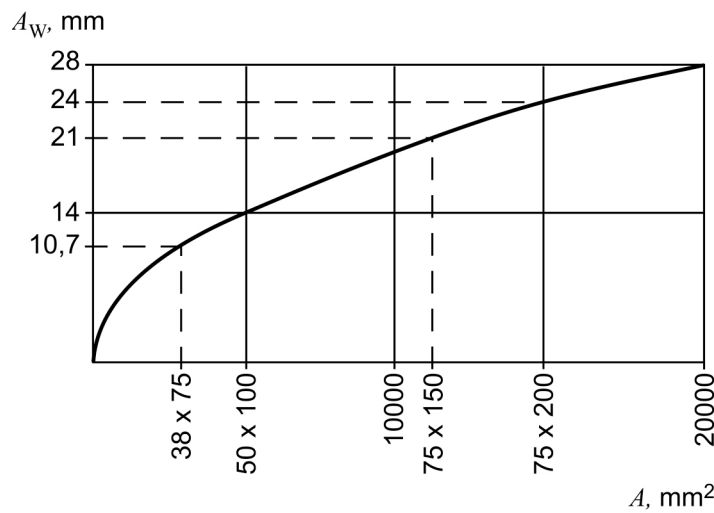


Figure 5 - Maximum diagonal of wane $a_{w,max} = \sqrt{A/5}$

5.3 Adhesives

The adhesive shall enable joints of such strength and durability to be produced in order that the integrity of the bond is maintained throughout the intended lifetime of the structure.

Acceptable strength and durability can be achieved by the use of an adhesive of type I and shall meet the requirements for this type given in EN 301. Or, for structures in service class 1 or 2 an adhesive of type II according to EN 301 can be used, provided the temperature of the member in the structure will always be below 50 °C.

NOTE 1 The adhesive should be chosen considering the climatic conditions in service, the timber species, the preservative used (if any) and the production methods.

NOTE 2 Such strength and durability can be achieved by a polycondensation adhesive of the phenolic or aminoplastic type as defined in EN 301.

For adhesives of other types than covered by EN 301 a bond with equivalent durability and strength shall be achieved. Special considerations shall be given to creep failure, the ability to maintain structural integrity during fire and elevated temperature and moisture conditions in ordinary service.

5.4 Bending strength

The characteristic bending strength $f_{m,k}$ of the finger joints shall be determined from the Log-Normal probability distribution function.

The characteristic bending strength shall meet the following requirements;

$$f_{m,k} \geq f_{m,dc,k} \quad \text{in edgewise bending,}$$

$$f_{m,k} \geq k_f f_{m,dc,k} \quad \text{in flatwise bending,}$$

where

$f_{m,dc,k}$ is the characteristic bending strength declared by the manufacturer;

k_f is a factor equal to the ratio between the characteristic bending strength in flatwise and edgewise bending determined from Table 1. For a finger joint profile not covered by Table 1 k_f shall be determined from the initial testing of the finger joint configuration in question (geometry and orientation).

The characteristic edgewise bending strength shall be larger than or equal to the characteristic edgewise bending strength of the finger joints declared by the manufacturer.

6 Manufacturing requirements

6.1 Production conditions

The premises shall meet the requirements as to temperature and relative humidity of the air to ensure a satisfactory production environment. Necessary machinery and equipment for the production process shall be available.

6.2 Timber

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

Unjointed timber shall have a moisture content within the range specified by the adhesive manufacturer according to the formulation and method of application of the adhesive.

Timber shall normally have a moisture content between 8 % and 18 %. However, some adhesives make it possible to extend the upper limit to 23 %.

The difference in moisture content between the ends of timber to be jointed shall not exceed 5 %.

At assembly the temperature of the timber at the joint shall be not less than 15 °C.

6.3 Adhesive application

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

6.3.1 Adhesive application by machine

The adhesive should be applied to both member ends over a length of at least $\frac{3}{4}$ of the finger length.

The adhesive may be applied to only one member end if it is documented that the adhesive application results in that the principle requirement is fulfilled in a reliable way. This is fulfilled if a continuous production control of the adhesive application is installed.

6.3.2 Manual adhesive application

The adhesive may be applied to only one member end. It should be checked visually that adhesive is applied to all finger flanks. It should be achieved that adhesive is squeezed-out of all four surfaces of the joint when the end pressure is applied.

6.4 Assembly and end pressure

6.4.1 Assembly

Joints shall be bonded as soon as possible and not later than 24 h after cutting. Between cutting 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.

The advice of the adhesive manufacturers shall be sought and observed with respect to the following:

- a) mixing;
- b) use of fillers;
- c) preheating of the timber (by high frequency, infra-red or other methods);
- d) application;
- e) open and closed assembly times;
- f) curing;
- g) temperature of the air and the timber before and during curing.

6.4.2 End pressure

The application of end pressure shall be adequate to enable the jointed timber to be moved with reasonable care to the curing stage prior to any subsequent machining. No damage and no relative slip shall occur in the finger joints. Initial curing of the adhesive shall be completed before further processing, unless it is proven that the finger joints will have sufficient and reliable strength to allow this.

The full end pressure shall be applied to the finger joint for at least 2 s.

NOTE The end pressure required to give optimum results in assembly will depend to some extent on the joint profile, wood species, the moisture content and cross-section of the timber and should therefore be determined accordingly. For most softwoods, an end pressure of the order of 2 N/mm² to 5 N/mm² will be sufficient for finger joints over 25 mm in length whilst for shorter joints an end pressure of 5 N/mm² to 10 N/mm² is necessary.

The end pressure shall be adjusted to minimize the risk of splitting or compression failure on assembly of the fingers. Where a fissure does occur in the cutting area due to assembly pressure it shall not exceed 0,5 mm in width at any point or penetrate from one face to another. The total length of fissures which occur in any width of 30 mm on a face shall not exceed 10 mm. Fissures which occur at a later stage as a consequence of further drying shall be within the limits for the grading class of the timber.

7 Quality control

7.1 Factory production control

7.1.1 General

To ensure that the produced finger joints conform to this standard, the manufacturer shall establish and maintain documented internal factory production control.

The documented factory production control shall be efficiently implemented by means of procedures and instructions.

7.1.2 Sampling of finger joints

7.1.2.1 A representative sample of finger joints shall be drawn at random from each work shift and each production line.

If all finger joints are proof-loaded according to a harmonized technical specification then the sampling and testing may be omitted.

7.1.2.2 For continuous production at least three sample joints shall be taken for testing from the production of each shift, as far as possible evenly distributed in time and timber sizes over the shift. At least two specimens shall be drawn per timber strength class and per adhesive.

7.1.2.3 The specimens shall contain a finger joint at mid-length and be free of defects in the middle half of their length, with major defects excluded from the end portions.

7.1.3 Testing of finger joints

7.1.3.1 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 covering at least one third of the cross section, are tested. These specimens shall include the edges of the original cross section and the edges shall be on the tension side of the specimen in the bending test. Only the lower test result shall be considered.

7.1.3.2 Only sufficiently cured finger joints shall be tested. Testing shall take place within 72 h of manufacture or when the finger joints are cured.

As far as is practicable the moisture condition of the timber at the time of manufacture shall be maintained. The surface finish of the specimens at test shall be the same as that of the jointed timber normally supplied by the manufacturer.

7.1.3.3 The test shall be done in conformity with the EN 408. It is, however, not necessary to determine the density and the moisture content and the accuracy of measuring the maximum load shall be better than $\pm 3\%$. The span may be reduced to fifteen times the depth of the specimen as positioned in the testing machine.

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

- a) date of production;
- b) date of testing;
- c) timber species;
- d) timber grade or strength class;
- e) preservative treatment;

- f) type of adhesive e.g. resin and hardener;
- g) width and thickness of the timber;
- h) finger joint profile;
- i) finger joint orientation;
- j) flatwise or edgewise bending;
- k) employed k_f value (if not related to table 1 give reference to initial testing);
- l) test load at failure;
- m) bending strength;
- n) description of the failure mode (wood failure percentage).

7.1.4 Compliance

For each production line and declared strength value and shift the bending strength is acceptable if one of the following conditions a) or b) is met:

- a) Of the last 100 joints tested, the values of the bending strength f_m of each single joint shall relate to the threshold value $k_f f_{m,dc,k}$ that is the characteristic bending strength of the finger joint $f_{m,dc,k}$ declared by the manufacturer, multiplied by a factor k_f :

Not more than 5 shall be below the threshold value and

No value shall fall below 90 % of the threshold value.

- b) The characteristic bending strength $f_{m,15,k}$ of the last 15 finger joints is larger than or equal to the characteristic bending strength of the finger joints $f_{m,dc,k}$ declared by the manufacturer, multiplied by a factor k_f :

$$f_{m,15,k} \geq k_f f_{m,dc,k}$$

The characteristic bending strength of the finger joints, declared by the manufacturer, shall be stated.

For edgewise bending k_f is equal to 1,0.

For flatwise bending k_f is the ratio between flatwise and edgewise characteristic bending strength obtained either from table 1 or from the initial testing.

Table 1 - Factor k_f for flatwise bending

Geometry $l \times p \times b_f$ mm	Orientation	k_f
$10 \times 3,7 \times 0,6$	Fingers visible on the flatside	1,1
$15 \times 3,8 \times 0,42$		1,25
$20 \times 6,2 \times 1,0$		1,25
$20 \times 6,2 \times 1,0$	Fingers visible on the edgeside	1,0
$32 \times 6,2 \times 1,0$		1,0

Using the Log-Normal probability function $f_{m,15,k}$ may be calculated from

$$f_{m,15,k} = k_{15} f_{m,15,\text{mean}}$$

where

$f_{m,15,\text{mean}}$ is the mean value of the 15 test results;

k_{15} is a statistical factor depending on the coefficient of variation for the sample, see Table 2.

Table 2 - Factor k_{15}

Coefficient of variation	0,10	0,15	0,20	0,25	0,30
k_{15}	0,84	0,77	0,70	0,64	0,58

NOTE The coefficient of variation shall not be taken less than 0,10.

7.2 Organization of factory production control

7.2.1 Responsibility and authority

The responsibility, authority and the interrelation of all personnel who manage, perform and verify work affecting quality shall be defined, particularly for personnel who need the organizational freedom and authority to

- a) initiate action to prevent the occurrence of non-conformity of finger joints;
- b) identify and record any quality problems with finger joints.

7.2.2 Delegated by the manufacturer for factory production control

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

7.2.3 Inspection by the manufacturer

The production control system adopted to satisfy the requirements of this 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.

7.3 Documentation of the quality control system

7.3.1 The manufacturer's documentation, procedures and instructions shall be relevant to the production and process control of the finger joints, and shall be adequately described in a works' quality manual, covering:

- a) quality aims and organizational structure, responsibilities and powers of the management with regard to conformity of the finger joints;
- b) procedures for specifying and verifying the quality of the timber and the adhesive;
- c) manufacturing, production control and other techniques, processes and systematic actions to be used;
- d) inspections and tests that will be carried out before, during and after manufacture, and the frequency with which they are to be carried out.

NOTE The documentation of the finger joint tests may be recorded and kept separately.

7.3.2 All documentation shall be kept for at least 10 years.

7.3.3 All documentation shall be registered so that the raw materials and production conditions for the finger joints are traceable, at least to the production week and year.

7.4 Inspection and testing

7.4.1 General

All necessary facilities, equipment and personnel shall be available to carry out the necessary inspections and tests. This requirement may also be fulfilled, if by means of a contract the manufacturer or his agent involves a subcontractor having the necessary facilities, equipment and personnel. The manufacturer shall control, calibrate and maintain inspection, measuring and test equipment, whether owned by the manufacturer, or on hire, to demonstrate the conformity of the finger joints to the specified requirements of this standard. Equipment shall be used in a manner which ensures that measurement tolerances are known and are consistent with the required measurement capability.

7.4.2 Action in case of non-conformity

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

7.4.3 Quality surveillance of non-conforming finger joints

If the result of the test or inspection of a finger joint is unsatisfactory, the manufacturer shall at once take the necessary steps to rectify the shortcoming. Finger joints which do not comply with the requirements shall be set aside and marked accordingly. When the shortcoming has been rectified, the test or inspection in question shall be repeated without delay, provided that this is technically possible and is necessary as evidence that the defects have been overcome.

If the finger joints have been dispatched before the test results are available notification shall be made to customers, if necessary, for the purpose of avoiding any consequential damage.

8 Type testing, initial determination of joint strength

8.1 General

For initial determination of joint strength and 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 bending. The cross sections of the specimens shall be equal to the maximum which the manufacturer intends to finger joint.

8.2 Materials

For every type of species and declared strength value of the finger joints at least 30 jointed specimens shall be tested. From these 15 shall be tested edgewise and 15 flatwise.

NOTE Spruce (*Picea abies*) and fir (*Abies alba*) may be regarded as one conifer species.

If the factor k_f shall be determined from the initial testing the number of specimens shall be $2 \times 30 = 60$ in total.

8.3 Preparation of specimens

Sample joints shall be made using the machinery and methods typical for normal production. The timber densities shall be representative for the species and grade concerned.

The specimens shall contain a finger joint at mid-length, be free of defects in the middle half of their length, and major defects should be excluded from the end portions.

At the time the sample joints are manufactured, the timber shall be at the moisture content at which production joints would normally be made. At least 72 h shall elapse between manufacture and testing of joints. The surface finish of the specimens at test shall be typical of the jointed timber normally supplied by the manufacturer.

8.4 Procedure

The testing comprises edgewise and flatwise bending. The bending strength of the finger joints shall be determined in accordance with EN 408.

8.5 Test report

The test report shall in addition to the requirements of EN 408 include the following data:

- a) mean value $f_{m,mean}$ and coefficient of variation (c.o.v.) of the bending strength values f_m ;
- b) characteristic bending strength $f_{m,k}$ defined as the lower fifth percentile. This shall be determined in accordance with 5.4 e.g. based on the Log-Normal probability distribution function;
- c) factor k_f for a finger configuration not given in table 1 is calculated from the characteristic value of the edgewise and flatwise bending strengths respectively.

8.6 Classification of joints

Joints shall be classified on the basis of the results of the edgewise bending tests. The joints shall be considered suitable for use with a particular species and grade of timber if the characteristic bending strength value is equal to or greater than the characteristic bending strength of the strength class of the timber.

Annex A (informative)

The tasks of the third party certification body

A.1 The task of the third party certification body are to supervise the internal control, to check by sampling the quality of the finger joints and to get an insight into the production of finger joints so that attestation of conformity document can be issued or maintained.

A.2 A minimum of two inspections per year should be carried out. These should be unannounced unless special conditions necessitate an announcement.

A.3 The third party certification body should have access to all storage and production rooms, and the manufacturer should answer any technical questions. The third party certification body should regard all technical information as confidential.

NOTE The manufacturer may be required to forward, at certain intervals some production information and test results to the third party certification body.

A.4 The third party certification body should verify the capability of the manufacturer to carry out the finger joint tests. This is carried out by parallel calibration test at a third party laboratory during the initial period and in cases where a check of the test procedures of the manufacturer is found necessary by the third party certification body.

The initial period should be maximum two years. Annually at least two samples for each test type should be selected and tested by the third party certification body.

The third party certification body can decide to stop the calibration tests before two years have elapsed.

The third party certification body should secure that the manufacturer documents from calibration tests his capability to conduct the tests. The tests are carried out in parallel with an accredited laboratory.

A.5 During the inspections the following should be inspected or checked:

- a) raw materials;
- b) production in accordance with the stated requirements of this standard;
- c) finger joints during production;
- d) finished finger joints.

A.6 The third party certification body should prepare a report of each inspection.

A.7 The testing and assesment of the adhesive should be carried out by an institute with recognised expertise in the area of structural adhesives.

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