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Timber structures — Glued laminated timber — Component performance and production requirements

Structures en bois — Bois lamellé-collé — Performance des composants et exigences de production

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12578 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

Introduction

Glued laminated timber is obtained by bonding together a number of laminations with their grain essentially parallel. In this way, a member with a rectangular solid cross-section can be produced. Other non-rectangular shapes can also be produced.

The purpose of the requirements in this International Standard is to provide minimum production requirements, which, when coupled with applicable structural performance requirements, assure the in-service performance of the glued, laminated timber. It can be necessary to supplement the requirements to take into consideration special conditions, materials or functional requirements.

Timber structures — Glued laminated timber — Component performance and production requirements

1 Scope

This International Standard specifies requirements for the components of glued laminated timber members and minimum requirements for the production of such members for structural use.

This International Standard is applicable to products with a finished lamination thickness of not more than 50 mm.

Although most glued laminated timber is made from coniferous species, this International Standard also applies to broad-leaf species if the tests specified in this International Standard show that a satisfactory glue bond can be achieved.

The basic requirements apply to structural members of all service classes; however, special precautions are necessary for service class 3, for example, the use of weather-resistant adhesives (see 5.3).

This International Standard does not apply to the determination of strength and stiffness characteristics (see EN 1194).

2 Normative references

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

ISO 8375, *Timber structures — Glued laminated timber — Test methods for determination of physical and mechanical properties*

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

ISO 10983:1999, *Timber structures — Solid timber finger-jointing — Production requirements*

ISO 12579:2007, *Timber structures — Glued laminated timber — Method of test for shear strength of glue lines*

ISO 12580:2007, *Timber structures — Glued laminated timber — Method of test for glue-line delamination*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 301, ISO 12579, ISO 12580 and the following apply.

3.1
adhesive types
adhesive types I and II are adhesives according to the respective durability classes in accordance with EN 301

3.2
glued laminated timber
glulam
structural member formed by bonding together timber laminations with their grain running essentially parallel to the beam's longitudinal axis

3.3
horizontal glulam
glued laminated timber with the wide faces of the laminations perpendicular to the direction of the larger cross-sectional dimension

See Figure 1 a).

3.4
vertical glulam
glued laminated timber with the wide faces of the laminations perpendicular to the direction of the smaller cross-sectional dimension

See Figure 1 b).

3.5
service class
group designation characterized by the moisture content of the members corresponding to the temperature and relative humidity of the surrounding air

3.5.1
service class 1
group designation characterized by a moisture content in the materials corresponding to a temperature of 20 °C and the relative humidity of the surrounding air exceeding 65 % for a few weeks per year

NOTE In service class 1, the average equilibrium moisture content of most softwoods does not exceed 12 %.

3.5.2
service class 2
group designation characterized by a moisture content in the materials corresponding to a temperature of 20 °C and the relative humidity of the surrounding air exceeding 85 % for a few weeks per year

NOTE In service class 2, the average equilibrium moisture content of most softwoods exceeds 12 % but is less than 20 %.

3.5.3
service class 3
group designation characterized by climatic conditions leading to moisture contents higher than service class 2, such as when a member is fully exposed to the weather

NOTE In service class 3, the average equilibrium moisture content of most softwoods exceeds 20 %.

3.6
maximum delamination percentage
maximum delamination length of one glue line in the test piece, measured on both end-grain surfaces of the test specimen multiplied by 100 and divided by the total length of glue lines on the two end-grain surfaces of each test piece for a single glue line in a test piece

Modified from ISO 12580:2007, 8.3.

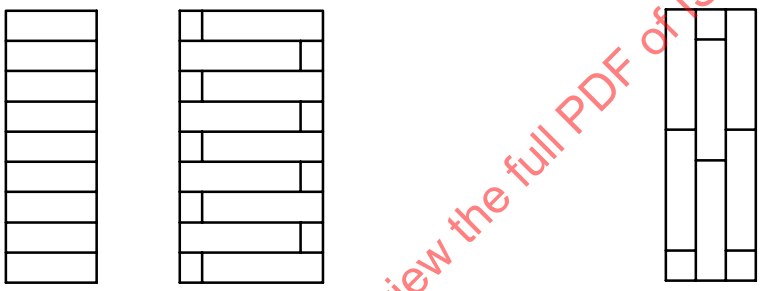
3.7
total delamination percentage
delamination length of all glue lines on the two end-grain surfaces in the test piece multiplied by 100 and divided by two times the length of one glue line

Modified from ISO 12580:2007, 8.2.

3.8
wood failure percentage
percentage of the wood-failure area in relation to the total sheared area

ISO 12579:2007, 3.6

3.9
lamination
piece or pieces of timber not more than 50 mm thick with or without end joints that form(s) part of a glulam member



a) Horizontal glulam b) Vertical glulam

Figure 1 — Glue lines in cross-sections showing the normal position of the glue lines

4 Symbols

A	area, expressed in square millimetres
f_x	strength of a single end joint, expressed in megapascals
$f_{x,k}$	characteristic strength of the end joints (5th percentile at 75 % confidence), expressed in megapascals
$f_{x,dc,k}$	required characteristic strength of the end joints, expressed in megapascals
$f_{x,15,k}$	characteristic strength of 15 tested end joints, expressed in megapascals
f_v	shear strength, expressed in megapascals
r	radius of curvature, expressed in millimetres
t_{fin}	finished thickness, expressed in millimetres
t_{lam}	lamination thickness, expressed in millimetres
x	subscript indicating bending or tension

5 Component requirements

5.1 General

The grading of the timber shall result in reliable strength and stiffness properties in the laminations. The bonding operations shall result in reliable and durable bonds in end joints and between laminations.

5.2 Timber

The timber shall be graded in accordance with either ISO 9709 or ISO 13912. The strength and stiffness properties of the glued laminated timber shall be established in accordance with ISO 8375.

5.3 Adhesives

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

The adhesive shall be chosen considering the conditions in service, including climate, moisture conditions, exposure to elevated temperatures, the timber species, the preservative used (if any) and the production methods.

Adhesives of type I, as classified in accordance with EN 301, may be employed for structural members used in all service classes.

For structures in service classes 1 or 2, an adhesive of type II, as classified in accordance with EN 301, may be used, provided the temperature of the member in the structure is always below 50 °C.

Special precautions shall be taken for service class 3, for which weather-resistant adhesives shall be used. For structures in service class 3, the required strength and durability can be achieved by a phenolic- or aminoplastic-type poly-condensation adhesive classified as type 1 in accordance with EN 301.

For adhesives of types other than those covered by EN 301, a bond with an equivalent durability and strength shall be achieved. Structural-wood-adhesive standards, such as ASTM D2559 and CSA 0112.9, have provisions defining these strength and durability requirements.

5.4 End joints in laminations

The characteristic strength, $f_{x,k}$ (5th percentile at the 75 % confidence level) obtained from flat-wise bending or tension tests of the end joints shall meet the requirement of Equation (1):

$$f_{x,k} \geqslant f_{x,dc,k} \tag{1}$$

where $f_{x,dc,k}$ is the required characteristic strength of the end joint in flat-wise bending or tension to achieve the end-use beam performance, which shall be determined in accordance with a documented process in accordance with the applicable standard.

The tests shall be carried out as follows.

a) Bending tests shall be carried out in accordance with ISO 10983:1999, 7.1.4.2.

b) Tension tests shall be carried out in accordance with ISO 10983:1999, 7.1.4.3.

If the distribution is not known, the characteristic strength, $f_{x,k}$, shall be determined from the log-normal probability distribution function in accordance with ISO 10983.

5.5 Glue-line integrity and strength

5.5.1 The glue-line integrity shall be based on testing the glue line in a full cross-sectional specimen cut from the manufactured glulam member. The specimens shall be representative of the manufactured product and of any pre-gluing chemical treatment of the laminations. For all service classes, bond strength shall be determined using block-shear tests in accordance with ISO 12579. Delamination tests shall be performed based on the service class as specified in 5.5.2.

5.5.2 For structures of service class 3, delamination tests shall be made in accordance with methods A, B or D plus E of ISO 12580:2007.

For structures of service class 2, delamination tests shall be performed according to methods A, B, C or D plus E of ISO 12580:2007.

For structures of service class 1, delamination tests shall not be required.

For quality control, the test methods are specified in 7.3.2.

5.5.3 Depending on the method and number of cycles as required in ISO 12580, the total delamination percentage of each cross-sectional specimen shall be less than the values given in Table 1.

Table 1 — Maximum delamination

Adhesive type	Delamination method	Delamination %	
		After cycle 1	After cycle 2
Type I	A	5	10
	B	5	10
	D E [c]	— —	5 5
Type II	A [d]	5	10
	B [d]	5	10
	C	5	—
	D E [c]	5 5	— —

[a] In accordance with EN 301.

[b] In accordance with ISO 12580.

[c] It is necessary that methods D and E be used together.

[d] Methods A and B are not required for type II adhesives; but if they are used, the same delamination requirements apply as for type I adhesives.

For all delamination methods, the maximum delamination percentage of any single glue line shall be $\leqslant$ 20 %.

5.5.4 Each test result from the block-shear tests of each cross-sectional specimen performed in accordance with ISO 12579 shall comply with the following requirements with regard to the shear strength and wood-failure percentage (WFP).

The average glue-line shear strength shall be no less than 90 % of the shear strength of the unbonded wood of the same species. The average shear strength of all glue lines in a cross-section shall be at least 6 mPa. For coniferous wood, poplar and broad leaf species with a specific gravity of 0,5 or less, a shear strength of 4 mPa for all glue lines in a cross-section shall be regarded as acceptable if the wood-failure percentage is 100.

The average wood-failure percentage for all glue lines in a cross-section and any individual value shall exceed the minimum wood-failure percentages stated in Table 2. Linear interpolation shall be used for intermediate values.

Table 2 — Relationship of the minimum wood failure percentage to the required shear strength

Shear strength f_v mPa		Minimum wood-failure percentage % [a]	
Average	6	Average [a]	90
	8		70
	⩾ 11		45
Individual values	4 to < 6	Individual values [b]	100
	6		75
	⩾ 10		20

[a] For average values, the minimum wood-failure percentage is equal to $144 - (9f_v)$.

[b] For individual values, the minimum wood-failure percentage for $f_v \geqslant 6$ mPa is equal to $153{,}3 - (13{,}3f_v)$.

6 Manufacturing requirements

6.1 General

The manufacturer shall produce reliable glulam. Production conditions that are usually necessary are given in Annex A.

6.2 Adhesives

The adhesives shall comply with the requirements of 5.3.

6.3 Timber

The timber species, moisture content and lamination dimensions shall be suitable for glulam production. Commonly used species, moisture content and lamination dimensions are given in Annex A.

7 Quality control — Factory production internal quality control

7.1 General

To ensure that the glulam members produced conform with this International Standard, the manufacturer shall establish and maintain documented, internal, factory-production quality control. The effectiveness of the production control shall be assessed in accordance with 7.2 and 7.3.

The production quality control shall be undertaken in accordance with the requirements of the appropriate regulatory authority or recognized agency.

7.2 End joints

From each work shift and each production batch, a representative sample of end joints shall be selected and tested in accordance with the requirements of ISO 10983. End joints shall meet the requirements of 5.4.

When bending or tension proof loading of end joints is used as an in-line quality assurance measure to augment physical testing, it shall be assured that the proof-load level used does not cause incipient damage to the end joint.

7.3 Glue-line integrity

7.3.1 The glue lines shall be tested in a full cross-sectional specimen, which shall be cut from a cured glulam member produced during each working shift. For each shift in which gluing is carried out, one full cross-sectional specimen shall be taken based on the lesser of every press load or every 10 m^3 of production.

If all tests for a three-month period satisfy the requirements, the number of samples may be reduced to not less than half the number prescribed above. At any time, if a sample fails to meet the requirements, corrective action shall be taken and sampling shall return to the frequency described above.

7.3.2 The results of the testing for glue-line integrity shall be documented as described in ISO 12580 and ISO 12579 for delamination and block shear, respectively.

7.4 Gluing record

A gluing record containing the following shall be kept:

a) date and identification of production;

b) species;

c) timber quality/grade;

d) dimensions of the member;

e) moisture content of the timber;

f) start time of the adhesive application;

g) time between the start of adhesive application to the start of clamping;

h) time at the start and the end of clamping process;

i) clamping pressure;

j) type of adhesive;

k) adhesive spread, expressed in grams per square metre;

l) temperature of the air in timber storage, end-jointing room, gluing and clamping area.

The gluing record shall be signed by the nominated responsible member of staff.

8 Quality system

The manufacturing process shall be in accordance with appropriate code and regulatory requirements and shall include periodic review by the appropriate authority or recognized third-party agency.

Annex A
(informative)

Personnel, facilities, manufacture and species

A.1 Personnel

The staff should have the necessary skills for the production of glulam and the grading of timber.

A.2 Facilities

A.2.1 Premises

A.2.1.1 The premises should be suitable for all phases of the production, taking into consideration the requirements given in this International Standard.

Special consideration should be given to

a) the size of the members,

b) the air temperature.

A.2.1.2 If the temperature and relative humidity of the air is critical to gluing then it is necessary to maintain the appropriate temperature and relative humidity throughout the gluing and curing cycle.

A.2.1.3 Drying and storage facilities of sufficient capacity should be available to enable the achievement of the required moisture content and temperature.

A.2.1.4 Where pre-dried timber is used, storage facilities should be available to maintain the required moisture content of the timber.

A.2.1.5 Unless resin and hardener are pumped directly from storage tanks and mixed automatically during application, there should be a separate room for the preparation of the adhesive (mixing resin and hardener). There should be suitable resin and hardener storage facilities and an area for cleaning the adhesive equipment. For single-component adhesives, these references to resin and hardener are not applicable.

The resin and hardener storage should be arranged so that the “first in - first out” principle is maintained.

A.2.2 Equipment

Equipment and personnel should be available

a) to monitor continuously the temperature of the air in storage, production and curing areas;

b) to measure the moisture content of the timber and to check the calibration of moisture meters;

c) for machine and visual grading where these operations are carried out by the producer;

d) to make finger joints in the laminations with sufficient and reliable strength to meet end-use requirements;

e) to measure lamination thickness;

f) to provide surfaces fulfilling the requirements of the thickness tolerances and surfaces quality (usually a lamination planer);

g) for weighing and mixing resin and hardener in the required proportions;

h) for the uniform application of the required quantity of adhesive;

i) to obtain the required glue-line pressure and temperature during the curing of the adhesive;

j) to test the strength of end joints in the laminations;

k) to test the integrity of the glue lines.

A.3 Manufacture

A.3.1 Laminations

A.3.1.1 When laminations are end-joined by finger joints, these joints should be produced as described in ISO 10983.

A.3.1.2 The individual laminations should be end-joined to the final length before planing if re-surfacing of the laminations prior to face bonding is required. During the end-jointing operation, the temperature of the timber should not be less than that required to assure an adequate bond.

A.3.1.3 In order to reduce cupping, laminations with a width larger than 200 mm may be grooved. In each lamination, one groove is permitted in the middle part of the cross section, with a maximum width of 4 mm and a maximum depth of one third of the lamination thickness.

A.3.1.4 Where a lamination for horizontal glulam consists of two or more boards positioned side by side and the edges are not bonded, the edge joints in adjacent laminations should be staggered laterally by at least the lamination thickness. For members for use in service class 3, the outer laminations on each face should be edge bonded.

Two or more laminations positioned edge to edge in a vertical glulam to be used in service class 1 or 2 are not required to be edge bonded, but the unbonded edge joints in adjacent laminations should be staggered by at least the lamination thickness. In addition, in members used in service class 3 the outer laminations should be edge-bonded.

A.3.1.5 The laminations should be planed or similarly finished before face bonding. The planing should be carried out within a time period before the face-bonding operations that assures adequate bonding. With species that are difficult to bond, for example those having a high resin content or where the laminations have been treated with preservatives, planing should be carried out within 8 h of bonding or within such a time that can be shown to result in an adequate bond.

A.3.1.6 The maximum permitted deviation from the average thickness within a lamination length of 1 m is 0,2 mm for gap-filling adhesives and 0,1 mm for non-gap-filling adhesives.

The difference in thickness over the cross-sectional width of the lamination should be less than 0,15 % of the width and in no case should it exceed 0,3 mm.

A.3.1.7 At assembly, the moisture content in every lamination of non-treated timber should be in the range of 8 % to 15 %. This range in acceptable moisture content may vary for treated timber.

A.3.1.8 The finished thickness, t_{fin}, and cross-sectional area, A, of any lamination should not exceed the values given in Table A.1.

Table A.1 — Maximum finished thickness and maximum cross-sectional area of the laminations used in structures in the designated service class

Species type	Service class					
	1		2		3	
	Thickness t_{fin} mm	Area A mm^2	Thickness t_{fin} mm	Area A mm^2	Thickness t_{fin} mm	Area A mm^2
Coniferous	50	10 000	50	9 000	50	7 000
Broad leaf	50	7 500	50	7 500	50	6 000
NOTE It is recommended that grooves be cut into the laminations as described in A.3.1.3 when the cross-sectional area exceeds 7 500 mm^2.						

For curved members the maximum thickness is also governed by the radius, r, of curvature and the characteristic bending strength of the finger joints. The finished thickness, t_{fin}, should comply with Equation (A.1):

$$t_{fin} \leqslant \frac{r}{250}\left(1+\frac{f_{x,k}}{80}\right) \quad \text{(A.1)}$$

where $f_{x,k}$, determined as in 5.4, is expressed in megapascals.

As an alternative, an r/t ratio of 100 for southern pine and hardwoods and an r/t ratio of 125 for other softwoods may be used.

A.3.1.9 At the time of bonding, the surfaces of the laminations should be clean.

A.3.2 Bonding

The adhesive spread should be uniform and at the spread rate recommended by the adhesive manufacturer. Usually a minimum spread of 350 g/m^2 is required, except for high-frequency curing, where the minimum is 200 g/m^2.

A.3.3 Clamping

A.3.3.1 The clamping arrangement should ensure a uniform pressure over the glue line.

A.3.3.2 The pressure should be that recommended by the adhesive manufacturer. In the absence of manufacturer's recommendations, the values given in Table A.2 may be used. For curved members, higher clamping pressures should be applied and in such a way that the laminations can slide over each other in the lengthwise direction to avoid open glue lines.

Table A.2 — Recommended clamping pressures

Lamination thickness t_{lam} mm	Pressure mPa
$t_{lam} \leqslant 35$	0,6
$35 < t_{lam} \leqslant 50$	0,8 with grooves 1,0 without grooves

A.3.3.3 Sufficient pressure should be maintained during clamping. Tightening-up should be carried out as necessary and, in all cases, immediately after clamping.