



BSI Standards Publication

Timber structures — Cross laminated timber — Requirements

National foreword

This British Standard is the UK implementation of EN 16351:2021. It supersedes BS EN 16351:2015, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/518, Structural timber.

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

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Date	Text affected
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English Version

Timber structures - Cross laminated timber - Requirements

Structures en bois - Bois lamellé croisé - Exigences

Holzbauwerke - Brettsper Holz - Anforderungen

This European Standard was approved by CEN on 4 January 2021.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 16351:2021) has been prepared by Technical Committee CEN/TC 124 “Timber structures”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by September 2021, and conflicting national standards shall be withdrawn at the latest by December 2022.

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

This document supersedes EN 16351:2015.

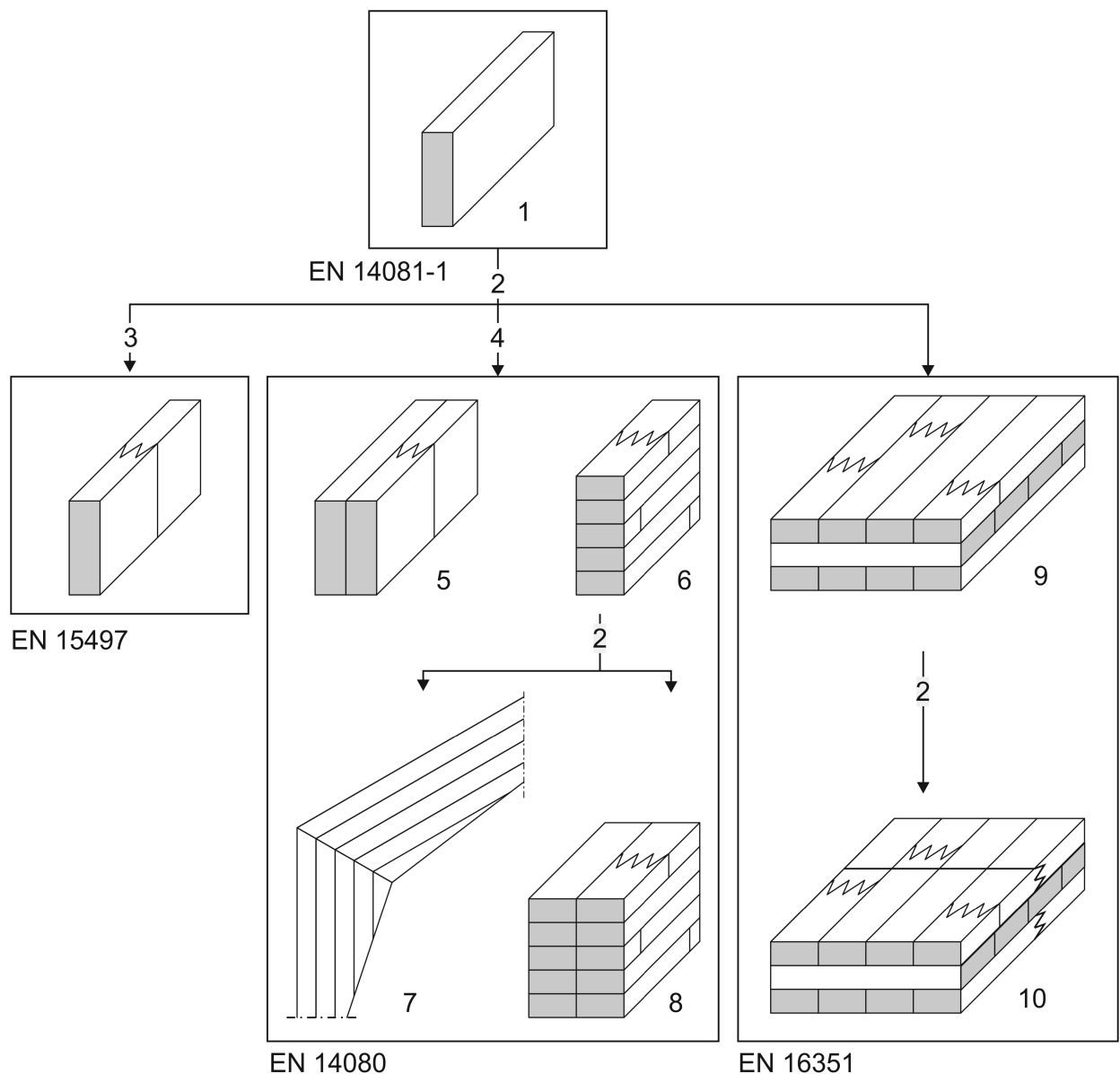
The following changes have been made:

- the standard has been adjusted to the latest versions of standards for adhesives;
- the provisions for reaction and resistance to fire have been modified;
- the provisions for gap widths and ratios of lamination width by thickness have been modified;
- missing provisions for factory production control have been added;
- the provisions for determination of strength, stiffness and density characteristics of cross laminated timber have been modified;
- the standard has been adjusted to the latest templates;
- Annex ZA has been deleted.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Figure 1 shows the relation of some European Standards on structural timber products.



Key

- | | | | |
|---|----------------------------------|----|---|
| 1 | boards | 6 | glued laminated timber (glulam) |
| 2 | is a component for | 7 | glulam with large finger joints |
| 3 | structural finger jointed timber | 8 | block glued glulam |
| 4 | glued laminated products | 9 | cross laminated timber |
| 5 | glued solid timber | 10 | cross laminated timber with large finger joints |

Figure 1 — Relation of some European Standards on structural timber products

Cross laminated timber in accordance with this document and multilayer solid wood panels in accordance with EN 13353 may have the same layup, but for cross laminated timber the timber is strength graded according to EN 14081-1 and the adhesives are tested according to the provisions of this document.

The following standards mentioned in Clause 2, EN 13986, EN 14080, EN 14081-1, EN 14374 and EN 15497, are harmonized product standards. The applicable version cited in the Official Journal of the EU are not necessarily the latest published by CEN.

1 Scope

This document sets out provisions regarding the performance of characteristics of the following Types of cross laminated timber for use in buildings and bridges:

- Type 1: Straight or curved cross laminated timber comprising only timber layers but no large finger joints;
- Type 2: Straight cross laminated timber comprising only timber layers and large finger joints;
- Type 3: Straight cross laminated timber comprising timber and wood-based panel layers but no large finger joints.

This document covers cross laminated timber of all three Types of cross laminated timber:

- manufactured according to this document, which sets up provisions for:
 - boundary conditions during manufacture of cross laminated timber;
 - moisture content and temperature of timber to be bonded;
 - production of finger joints and bonds between layers;
- to be used in service class 1 or 2 according to EN 1995-1-1;
- made of coniferous species and poplar listed in this document;
- which may be made of layers made of different species;
- bonded with phenolic or aminoplastic or moisture curing one-component polyurethane or emulsion polymer isocyanate adhesives of adhesive Type I according to the respective standard;
- made of timber laminations having a nominal width between 40 mm (including) and 300 mm (including);
- built up of at least three orthogonally bonded layers (at least two of them timber layers);
- which may have, depending on the number of layers, adjacent layers bonded parallel to the grain;
- made of timber layers which are made of strength graded timber according to EN 14081-1;
- made of timber layers having nominal thicknesses between 6 mm (including) and 47 mm (including);
- made of timber layers which may comprise edge bonds;
- having nominal overall thicknesses up to 500 mm.

Additional provisions of this document apply for straight cross laminated timber comprising only timber layers and comprising large finger joints (Type 2):

- made from cross laminated timber pieces having the same cross-section and layup;
- made from cross laminated timber pieces having nominal cross-sectional thicknesses from 51 mm (including) up to 345 mm (including) and nominal minimum thicknesses of the outer layers not less than 17 mm (including);

- made from cross laminated timber pieces solely comprising timber layers;
- made from plane cross laminated timber pieces;
- with parallel x-axes of the jointed components;
- with large finger joints having a finger length of at least 45 mm and fingers which are visible at the two narrow sides of the components;
- having large finger joints bonded with phenolic or aminoplastic or moisture curing one-component polyurethane adhesives of adhesive Type I according to the respective standard.

Additional provisions of this document apply for straight cross laminated timber comprising timber and wood-based panel layers but no large finger joints (Type 3):

- made of structural wood-based panels specified in this document;
- made of one panel per layer and;
- having thicknesses between 6 mm (including) and 45 mm (including).

This document applies to cross laminated timber untreated or treated against biological attack.

This document does not cover:

- cross laminated timber treated with fire retardants;
- cross laminated timber which is produced from re-used timber or wood-based panels comprising re-used timber.

It also lays down procedures for assessment and verification of constancy of performance (AVPC) of cross laminated timber.

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.

EN 301:2017, *Adhesives, phenolic and aminoplastic, for load-bearing timber structures - Classification and performance requirements*

EN 302-1, *Adhesives for load-bearing timber structures - Test methods - Part 1: Determination of longitudinal tensile shear strength*

EN 302-2, *Adhesives for load-bearing timber structures - Test methods - Part 2: Determination of resistance to delamination*

EN 338, *Structural timber - Strength classes*

EN 335, *Durability of wood and wood-based products - Use classes: definitions, application to solid wood and wood-based products*

EN 350, *Durability of wood and wood-based products - Testing and classification of the durability to biological agents of wood and wood-based materials*

EN 351-1, *Durability of wood and wood-based products - Preservative-treated solid wood - Part 1: Classification of preservative penetration and retention*

EN 408:2010+A1:2012, *Timber structures - Structural timber and glued laminated timber - Determination of some physical and mechanical properties*

EN 717-1, *Wood-based panels - Determination of formaldehyde release - Part 1: Formaldehyde emission by the chamber method*

EN 789, *Timber structures - Test methods - Determination of mechanical properties of wood based panels*

EN 1995-1-1, *Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings*

EN 1995-1-2, *Eurocode 5: Design of timber structures - Part 1-2: General - Structural fire design*

EN 12369-2, *Wood-based panels - Characteristic values for structural design - Part 2: Plywood*

EN 12369-3, *Wood-based panels - Characteristic values for structural design - Part 3: Solid-wood panels*

EN 13183-1, *Moisture content of a piece of sawn timber - Part 1: Determination by oven dry method*

EN 13183-2, *Moisture content of a piece of sawn timber - Part 2: Estimation by electrical resistance method*

EN 13183-3, *Moisture content of a piece of sawn timber - Part 3: Estimation by by capacitance method*

EN 13238, *Reaction to fire tests for building products - Conditioning procedures and general rules for selection of substrates*

EN 13501-1, *Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests*

EN 13501-2, *Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN 13823, *Reaction to fire tests for building products - Building products excluding floorings exposed to the thermal attack by a single burning item*

EN 13986, *Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking*

EN 14081-1, *Timber structures - Strength graded structural timber with rectangular cross-section - Part 1: General requirements*

EN 14358, *Timber structures - Calculation and verification of characteristic values*

EN 14374, *Timber structures - Structural laminated veneer lumber - Requirements*

EN 15228:2009, *Structural timber - Structural timber preservative treated against biological attack*

EN 15425:2017, *Adhesives - One component polyurethane (PUR) for load-bearing timber structures - Classification and performance requirements*

EN 16254:2013+A1:2016, *Adhesives - Emulsion polymerized isocyanate (EPI) for load bearing timber structures - Classification and performance requirements*

EN ISO 9239-1, *Reaction to fire tests for floorings - Part 1: Determination of the burning behaviour using a radiant heat source (ISO 9239-1)*

EN ISO 11925-2:2020, *Reaction to fire tests - Ignitability of products subjected to direct impingement of flame - Part 2: Single-flame source test (ISO 11925-2)*

3 Terms, definitions and symbols

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 Terms and definitions

3.1.1

actual size

measured size of a cross laminated timber at a given moisture content

[SOURCE: EN 14080:2013, 3.1 - modified]

3.1.2

bonding strength

structural effectiveness of adhesives between timber pieces when subjected to stresses

[SOURCE: EN 14080:2013, 3.2]

3.1.3

contact-free application

application without contact between timber and application unit

3.1.4

corrected size

size of a cross laminated timber corrected by calculation from its actual size to its size at the reference moisture content

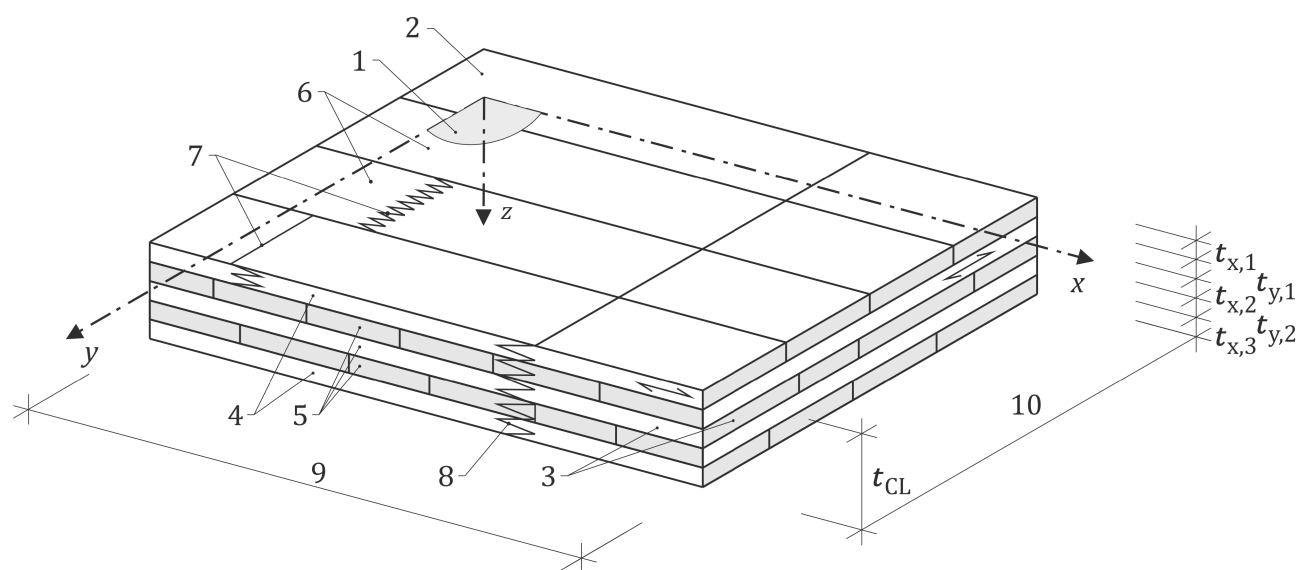
[SOURCE: EN 14080:2013, 3.6 - modified]

3.1.5

cross laminated timber

structural timber member composed by at least three face-bonded layers which comprise solid timber laminations and may comprise wood-based panels, at least one layer orthogonally oriented to the two adjacent layers

Note 1 to entry: See also Figure 2.

**Key**

1	plane of the element	2	wide face	3	narrow faces	4	outer layers
5	inner layers	6	laminations	7	finger joints in lamination	8	large finger joint
9	usually the length	10	usually the width b_{CL} of a plate or height h_{CL} of a beam				

Figure 2 — Cross laminated timber**3.1.6****delamination length**

sum of the lengths of delaminations in one glue line measured around the circumference of a test piece

[SOURCE: EN 14080:2013, 3.8 - modified]

3.1.7**edge bond**

bond between adjacent laminations within a timber layer

3.1.8**finger angle**

inclination α of each side of the fingers of a finger joint

[SOURCE: EN 14080:2013, 3.10]

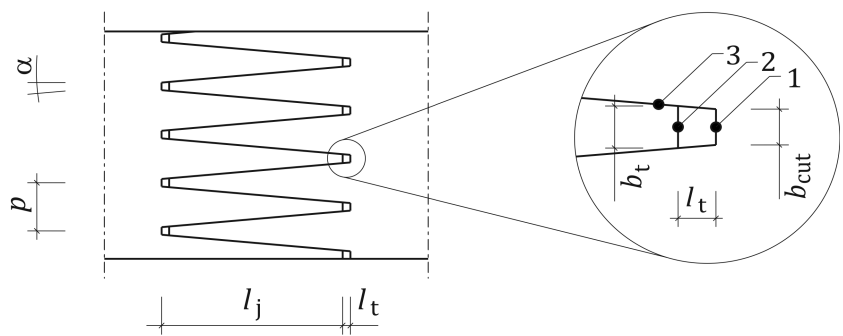
Note 1 to entry: See Figure 3.

3.1.9**finger joint**

interlocking end joint formed by machining a number of similar, tapered, symmetrical fingers in the ends of timber components using a finger joint cutter and then bonded together

[SOURCE: EN 14080:2013, 3.11]

Note 1 to entry: In this document, the term finger joint is used for finger joints in laminations whereas finger joints between cross laminated timber are defined as large finger joints (see 3.1.13).



Key

b_{cut}	tip width of the cutter	b_t	tip width	l_j	finger length	l_t	slot base	p	pitch
α	finger angle	1	tip base	2	fingertip	3	finger flank		

Figure 3 — Typical profile of a finger joint

**3.1.10
finger length**

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

[SOURCE: EN 14080:2013, 3.12]

Note 1 to entry: See Figure 3.

**3.1.11
finished thickness**

thickness after machining

[SOURCE: EN 14080:2013, 3.13]

**3.1.12
lamination**

part of a structural glued timber product consisting of one board or two or more finger-jointed boards

[SOURCE: EN 14080:2013, 3.19 - modified]

**3.1.13
large finger joint**

finger joint through the full cross-sectional area of two cross laminated timber components

[SOURCE: EN 14080:2013, 3.20 - modified]

Note 1 to entry: See Figure 4.

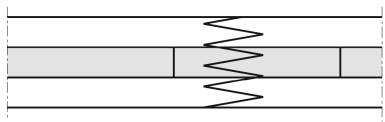


Figure 4 — Cross laminated timber with large finger joint

**3.1.14
layer**

courses lying over or under another

3.1.15**layup**

cross-sectional arrangement of timber layers which may be assigned to different strength classes according to EN 338 or different sets of individual values of strength, stiffness and density characteristics or wood-based panel layers which may be assigned to different strength classes according to EN 12369-2 or EN 12369-3 or different sets of individual values of strength, stiffness and density characteristics

[SOURCE: EN 14080:2013, 3.21 - modified]

3.1.16**maximum delamination length**

largest delamination length in any single glue line

[SOURCE: EN 14080:2013, 3.24 - modified]

3.1.17**mean moisture content**

mean value of the moisture content of cross laminated timber calculated from at least two measurements

[SOURCE: EN 14080:2013, 3.25 - modified]

Note 1 to entry: See D.2.

3.1.18**minimum mean density**

required mean density at reference moisture content, estimated as the weighted mean of the mean densities of the layers, if necessary

[SOURCE: EN 14080:2013, 3.26]

Note 1 to entry: Minimum mean density is used for the classification of the reaction to fire.

3.1.19**nominal size**

size specified at the reference moisture content to which deviations are related

3.1.20**pitch**

distance between centres of adjacent fingertips

[SOURCE: EN 14080:2013, 3.27]

Note 1 to entry: See Figure 3.

3.1.21**ratio of resin to hardener**

proportion of resin to hardener by mass with the resin set at 100 parts

[SOURCE: EN 14080:2013, 3.28]

3.1.22

reduction factor

ratio v between tip width b_t and pitch p

[SOURCE: EN 14080:2013, 3.29 - modified]

Note 1 to entry: See Figure 3.

3.1.23

reference moisture content

moisture content of 12 % at which nominal sizes are established

[SOURCE: EN 14080:2013, 3.30]

3.1.24

relative tip gap

ratio e between tip gap l_t and finger length l_f

[SOURCE: EN 14080:2013, 3.31 - modified]

Note 1 to entry: See Figure 3.

3.1.25

re-used timber

timber product made from timber which has been used before

3.1.26

rolling shear

shear stress for which both complementary stress components are perpendicular to the grain

3.1.27

solid wood failure

wood failure which is invariably more than two cell layers away from the adhesive layer

3.1.28

straight cross laminated timber

cross laminated timber having a precamber of up to 1 % of the respective span

3.1.29

timber layer

layer made of timber laminations with or without edge bonds

3.1.30

tip gap

distance l_t between fingertip and slot base in a bonded finger joint

[SOURCE: EN 15497:2014, 3.11]

Note 1 to entry: See Figure 3.

3.1.31

tip width

distance b_t between finger flanks, measured at the tip of the finger

[SOURCE: EN 14080:2013, 3.35 - modified]

Note 1 to entry: See Figure 3.

3.1.32

total delamination length

sum of delamination lengths of all glue lines

[SOURCE: EN 14080:2013, 3.36 - modified]

3.1.33

wood-based panels

structural plywood and structural solid wood panels according to EN 13986

and structural LVL according to EN 14374

3.1.34

wood-based panel layer

layer made of one piece of wood-based panel

3.1.35

wood failure percentage

percentage of the solid wood failure area after splitting in relation to the glued area before splitting

[SOURCE: EN 14080:2013, 3.38 - modified]

3.1.36

x-axis

axis parallel to grain of the timber layers or outer layers or veneers of wood-based panel layers

Note 1 to entry: See Figure 2.

3.1.37

z-axis

axis perpendicular to the layers

Note 1 to entry: See Figure 2.

3.2 Symbols

3.2.1 Main symbols

A	area, in mm ² ;
A_w	area of wane, in mm ² (see Figure F.1);
A^*	net sehar area,
a	size or distance between support and load introduction or excess length in mm;
a_w	length of the diagonals of wane, in mm (see Figure F.1);
$a_{w,max}$	maximum length of the diagonal of wane, in mm (see Figure F.2);
b	width, in mm;
b_{cut}	tip width of the cutter (see Figure 3);
b_t	tip width, in mm (see Figure 3);
b_{gap}	gap width, in mm;
d	diameter, in mm;
d	distance, in mm (see Figure 6);
$Delam_{max}$	maximum delamination, in %;
$Delam_{tot}$	total delamination, in %;
e	relative tip gap;
E	modulus of elasticity, in N/mm ² ;
E_{local}	modulus of elasticity related to $I_{CL,net}$, in N/mm ² ;
$(EI)_{CL,app,net}$	apparent bending stiffness, in N·mm ² ;
$(EI)_{CL,local,net}$	bending stiffness of cross laminated timber, in N·mm ² ;
$(ES)_{CL,v(r),net}$	first moment of inertia taking into account the modulus of elasticity of each layer, in N·mm;
f	strength, in N/mm ² ;
F	load, in N;
F_u	ultimate load, in N;
G	shear modulus, in N/mm ² ;
$(GA)_{CL}$	shear stiffness of cross laminated timber, in N;
h	height, in mm;
h_0	gauge length, in mm;
I	second moment of inertia, in mm ⁴ ;
$I_{CL,net}$	moment of inertia calculated from properties of the layers having its fibres parallel to the span only, in mm ⁴ ;

k	factor;
$k_{\text{cor},\alpha}$	moisture deformation factor;
k_{15}	statistical factor;
l	span or length, in mm;
l_j	finger length, in mm (see Figure 3);
l_t	slot base, in mm (see Figure 3);
p	pitch, in mm (see Figure 3);
m	moment per unit length, in Nmm/mm (see Figure C.1);
n	normal force per unit length, in N/mm (see Figure C.1);
r	radius of curvature, in mm;
t	thickness, in mm;
S	Static moment, in mm ³ ;
u	moisture content, in %;
w	deflection, in mm;
v	shear force per unit length, in N/mm (see Figure C.1);
V	shear force, in N;
α	finger angle, in degree (see Figure 3);
κ	shear factor;
ρ	density, in kg/m ³ ;
σ	stress, in N/mm ² ;
τ	shear stress, in N/mm ² ;
v	reduction factor of a finger joint.

3.2.2 Subscripts

a	actual;
app	apparent;
$bond$	property related to bonded area;
c	compression;
CL	property related to cross laminated timber;
cor	corrected;
$delam$	property related to delamination;
$edge$	edgewise

<i>global</i>	global;
<i>glue line</i>	property related to glue line;
<i>i</i>	belonging to number <i>i</i> ;
<i>j</i>	properties of finger joints in laminations;
<i>k</i>	characteristic;
<i>l</i>	properties of laminations;
<i>lay</i>	properties of layers;
<i>lff</i>	properties of large finger joints;
<i>local</i>	local;
<i>m</i>	bending;
<i>max</i>	maximum;
<i>mean</i>	mean value;
<i>pl</i>	performance level;
<i>r</i>	rolling shear;
<i>ref</i>	reference;
<i>t</i>	tension;
<i>tor,node</i>	torsional property linked to a nodal area;
<i>tot</i>	total;
<i>v</i>	shear;
<i>x</i>	global axis in plane of the cross laminated timber and parallel to the fibre direction of the outer layers, (see Figure 2);
<i>y</i>	global axis in plane of the cross laminated timber and orthogonal to the fibre direction of the outer layers, (see Figure 2);
<i>z</i>	global axis perpendicular to the plane of the cross laminated timber, (see Figure 2);
<i>0</i>	local axis parallel to the grain;
<i>15</i>	property determined from 15 test results;
<i>90</i>	local axis perpendicular to the grain (both tangential and radial);
<i>α</i>	angle, in degree.

4 Characteristics

4.1 Modulus of elasticity, bending strength, compressive strength, tensile strength and shear strength

4.1.1 General

Modulus of elasticity, bending strength, compressive strength, tensile strength and shear strength of cross laminated timber shall be expressed either according to a) or b) or c), see also Figure 5.

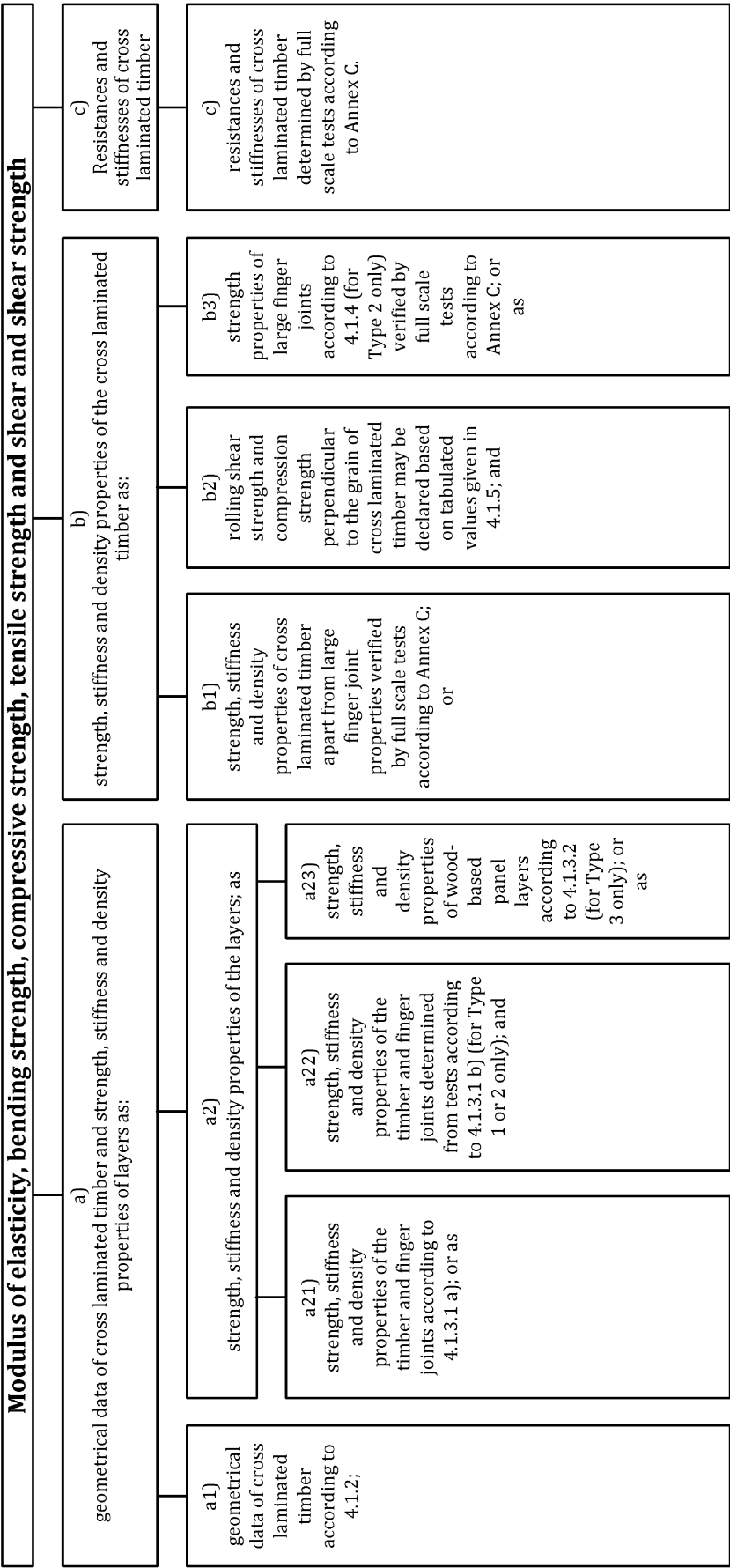


Figure 5 — Options for the determination of modulus of elasticity, bending strength, compressive strength, tensile strength and shear strength

- a) geometrical data of cross laminated timber and strength, stiffness and density properties of layers as:
 - 1) geometrical data of cross laminated timber according to 4.1.2;
 - 2) strength, stiffness and density properties of the layers; as
 - i) strength, stiffness and density properties of the timber and finger joints according to 4.1.3.1 a); or as
 - ii) strength, stiffness and density properties of the timber and finger joints determined from tests according to 4.1.3.1 b) (for Type 1 or 2 only); and
 - iii) strength, stiffness and density properties of wood-based panel layers according to 4.1.3.2 (for Type 3 only); or as
- b) strength, stiffness and density properties of the cross laminated timber as:
 - 1) strength, stiffness and density properties of cross laminated timber apart from large finger joint properties verified by full scale tests according to Annex C; or
 - 2) rolling shear strength and compression strength perpendicular to the grain of cross laminated timber may be declared based on tabulated values given in 4.1.5; and
 - 3) strength properties of large finger joints according to 4.1.4 (for Type 2 only) verified by full scale tests according to Annex C; or as
- c) resistances and stiffnesses of cross laminated timber determined by full scale tests according to Annex C.

Declarations according to method a) and b) can be combined.

4.1.2 Geometrical data of cross laminated timber

4.1.2.1 General

The following geometrical data shall be declared:

- a) nominal cross-sectional sizes according to 4.1.2.2;
- b) presence of grooves in laminations according to 4.1.2.3;
- c) layup as layer thickness according to 4.1.2.4 and layer orientation according to 4.1.2.5;
- d) ratio of nominal lamination width to nominal lamination thickness according to 4.1.2.6.

4.1.2.2 Nominal cross-sectional sizes

The nominal cross-sectional sizes of the cross laminated timber shall be declared as single values.

The corrected thickness of the cross-section of the cross laminated timber determined according to F.9 shall not deviate from the nominal thickness by more than ± 2 mm or 2 % of the nominal thickness whichever is greater.

4.1.2.3 Grooves in laminations

The presence of grooves in laminations shall be expressed as indication "grooves".

4.1.2.4 Layer thickness

The nominal layer thicknesses according F.9 shall be declared as single values in mm.

The corrected thickness of the single layers and laminations within a layer, respectively, determined according to F.9 shall not deviate from the nominal thickness by more than ± 1 mm.

4.1.2.5 Layer orientation

The layer orientation shall be declared as x for an orientation parallel to the x-axis and y for an orientation parallel to the y-axis.

The layer orientation shall be expressed in combination with the layer thickness.

EXAMPLE The layer thickness and orientation of a five - layered cross laminated timber with two cross layers having layer thicknesses of 40 mm could read: 40x-40y-40x-40y-40x.

4.1.2.6 Ratio of nominal lamination width to nominal lamination thickness

For timber layers the ratio of nominal lamination width to nominal lamination thickness width b_l/t_l shall be expressed as single values.

EXAMPLE A declaration could read: $b_l/t_l \geq 4$.

The nominal width b_l of the laminations shall be taken as:

- a) the minimum width of the laminations for laminations without grooves; or
- b) the minimum spacing between adjacent grooves in laminations; or
- c) the minimum distance between grooves and edges of laminations;

whichever is the smallest, disregarding the lamination widths at both ends of the layer width.

The corrected width of a single lamination determined according to F.9 shall not deviate from the nominal width by more than ± 1 mm.

NOTE For certain ratios of nominal lamination width to nominal lamination thickness, the rolling shear strength can be determined according to 4.1.5.

4.1.3 Strength, stiffness and density properties of layers

4.1.3.1 Timber layers

Timber shall be strength graded according to EN 14081-1.

The timber layers may comprise finger joints. The characteristic tension strength or the characteristic bending strength of finger joints be determined in accordance with Annex B shall meet Formula (1) or (2) for strength classes according to EN 338 based on tension tests and Formula (3) for strength classes based on bending tests.

$$f_{t,j,k} \geq f_{t,0,l,k} + 5N / mm^2 \quad (1)$$

$$f_{m,j,k} \geq 1,4 f_{t,0,l,k} + 8N / mm^2 \quad (2)$$

$$f_{m,j,k} \geq f_{m,l,k} + 8N / mm^2 \quad (3)$$

where

$f_{t,j,k}$ is the characteristic tension strength of the finger joint, in N/mm²;

$f_{m,j,k}$ is the characteristic bending strength of the finger joint in flatwise bending of the lamination, in N/mm²;

$f_{t,0,l,k}$ is the characteristic tension strength of the timber, in N/mm² and;

$f_{m,l,k}$ is the characteristic edge-wise bending strength of the timber, in N/mm².

Each timber layer shall be made of timber laminations of one strength class or one set of individual strength, stiffness and density values.

The cross laminated timber may be made of layers made from different species. Each timber layer shall be made of one of the following species:

- a) Norway spruce (*Picea abies*, PCAB);
- b) Silver fir (*Abies alba*, ABAL);
- c) Scots pine (*Pinus sylvestris*, PNSY);
- d) Douglas fir (*Pseudotsuga menziesii*, PSMN);
- e) Western hemlock (*Tsuga heterophylla*, TSHT);
- f) Black Pine (*Pinus nigra* spp., PNNG);
- g) European larch (*Larix decidua*, LADC);
- h) Siberian larch (*Larix sibirica*, LASI);
- i) Dahurian larch (*Larix gmelinii* (Rupr.) Kuzen.);
- j) Poplar (*Populus* spp., POER);
- k) Maritime pine (*Pinus pinaster*, PNPN);
- l) Radiata pine (*Pinus radiata*, PNRD);
- m) Sitka spruce (*Picea sitchensis*, PCST);
- n) Southern yellow pine (*Pinus palustris*, PNPL);
- o) Western red cedar (*Thuja plicata*, THPL);
- p) Yellow cedar (*Chamaecyparis nootkatensis*, CHNT).

Norway spruce and Silver fir may be considered as one species.

Different cultivars of Poplar may be considered as one species.

NOTE 1 Letter codes according to EN 13556, if available, are given after the botanical name.

NOTE 2 EN 1912 does not provide information on all species listed above.

The strength, stiffness and density properties of the timber layers shall:

- 1) be jointly expressed as the strength class of the timber according to EN 338 or as individual values;
or
- 2) be determined from full-scale tests according to Annex C with straight cross laminated timber solely build up from timber laminations of one strength class, having outermost layers with fibres parallel to span (x-axis), evaluated according to Annex C for cross laminated timber of Type 1 or 2 and the results jointly expressed:
 - as strength class in accordance with EN 338; or as
 - individual strength, stiffness and density values.

NOTE 3 Compared to the Euler-Bernoulli beam theory, the beam theory according to Timoshenko takes into account the influence of the shear deformation on the moment of inertia of the beam.

4.1.3.2 Wood-based panel layers

Wood-based panel layers shall be made of structural plywood or structural solid wood panels according to EN 13986 or structural LVL according to EN 14374.

Each wood-based panel layer shall be made of one panel.

Wood-based panel layers shall be made of one species listed in 4.1.3.1.

Only wood-based panels which fulfil the provisions for the use in service class 2 or 3 according to EN 1995-1-1 shall be used.

The material properties of wood-based panel layers shall be taken as the material properties of the wood-based panels from which they are made of.

The strength, stiffness and density properties of the wood-based panels shall be declared as strength class according to EN 12369-2 or EN 12369-3 or as single values for plywood and structural solid wood panels according to EN 13986 or as single values for laminated veneer lumber according to EN 14374.

4.1.4 Bending strength of large finger joints

For straight cross laminated timber comprising timber layers and large finger joints (Type 2), the characteristic bending strength(s) of the large finger joints $f_{m,lff,x/y,k}$ in flatwise or $f_{m,edge,lff,x/y,k}$ in edgewise bending shall be tested and declared as single value(s) in accordance with C.2.5 and C.3.4 in the directions relevant for the intended use.

4.1.5 Rolling shear strength, compression strength perpendicular to grain and density of cross laminated timber

4.1.5.1 Rolling shear strength of cross laminated timber

For all types of cross laminated timber made from timber having a characteristic bending strength $f_{m,l,k}$ of at least 16 N/mm² either:

- made of structurally edge bonded timber layers without grooves; or
- made of timber layers, which have a thickness of up to 47 mm (including), which are not structurally edge bonded and comprise laminations having a ratio of nominal lamination width to nominal lamination thickness $b_l/t_l \geq 4$.

The characteristic rolling shear strength $f_{r,k}$ may be declared as $f_{r,k} = 1,4 \text{ N/mm}^2$.

For other ratios of nominal lamination width to nominal lamination thickness in timber layers without structural edge bonds having a thickness of up to 47 mm (including) the characteristic rolling shear strength $f_{r,k}$ may be declared as $f_{r,k} = 0,7 \text{ N/mm}^2$.

4.1.5.2 Compression strength perpendicular to the grain

The characteristic compression strength perpendicular to the grain of a cross laminated timber may be declared as $f_{c,z,k} = 3 \text{ N/mm}^2$.

NOTE The value refers to a volume as defined in C.2.4.

4.2 Bonding strength

4.2.1 General

Bonding strength shall be declared as

- a) bonding strength of finger joints in laminations expressed as bending or tension strength of finger joints in laminations expressed as bending strength of timber according to 4.1.3.1 for all types of cross laminated timber; and
- b) bonding strength of glue lines between layers according to 4.2.2 for all Types; and
- c) bonding strength of edge bonds, if any, according to 4.2.3 for all Types; and
- d) bonding strength of large finger joints expressed as characteristic bending strength of large finger joints according to 4.1.4 for Type 2.

4.2.2 Bonding strength of glue lines between layers

The glue line integrity of glue lines between layers shall be tested according to Annex A (delamination test) and jointly expressed as layer thickness according to 4.1.2.4 and layer orientation according to 4.1.2.5.

The bonding strength of glue lines between layers is proven to be sufficient,

- a) if the maximum delamination length of each specimen does not exceed 40 % of the total length of a single glue line and the total delamination length does not exceed 10 % of the sum of all glue lines; or
- b) if the the minimum wood failure percentage of each split glued area is not less than 50 %, the minimum wood failure percentage of the sum of all split glued areas shall be not less than 70 %.

Option b) may also be applied, if the maximum delamination length or the total delamination length exceeds the limits given in a) or if the delamination lengths cannot be estimated due to inadequate surface quality.

4.2.3 Bonding strength of structural edge bonds

The bonding strength of structural edge bonds shall be tested as shear strength of the bond line according to Annex G (shear test) and jointly expressed as indication “edge bond”.

The shear strength of each glue line shall be at least 6 N/mm², see Table 1, individual values. A shear strength of 4 N/mm² shall be regarded as acceptable if the wood failure percentage is 100, see Table 2, individual values.

The average wood failure percentage of a cross-sectional specimen and any individual values shall exceed the minimum wood failure percentages stated in Table 1.

Table 1 — Minimum wood failure percentages relating to the shear strength f_v ^a

	Average			Individual values		
Shear strength f_v , in N/mm ²	6	8	$f_v \geq 11$	$4 \leq f_v < 6$	6	$f_v \geq 10$
Minimum wood failure percentage, in % ^b	90	72	45	100	74	20
^a For values in between linear interpolation shall be used. ^b For average values the minimum wood failure percentage shall be: $144 - (9 f_v)$. For the individual values, the minimum wood failure percentage for the shear strength $f_v \geq 6,0$ N/mm ² shall be: $153,3 - (13,3 f_v)$.						

4.2.4 Bonding strength of large finger joints

The bonding strength of large finger joints shall be expressed by its bending strength according to 4.1.4.

4.3 Resistance to fire

The resistance to fire of cross laminated timber is the capability of the product to provide, in the event of fire and for a given time, one or more of the following behaviours:

- load-bearing capacity (R);
 - integrity (E);
 - insulation (I);
 - fire protection ability (K).
- a) for criteria (R,E,I) resistance to fire of cross laminated timber, not being treated to improve the reaction to fire performance may be determined by a designer on the basis of EN 1995-1-2 and the proxy characteristics species and density allowing to pick up the appropriate charring rate from the design code.

Mean and characteristic densities are needed for the design.

NOTE Resistance to fire of cross laminated timber can be calculated under a fire engineering design according to EN 1995-1-2 for specific end-use situation taking into account additional parameter, e.g. claddings, parametric fire exposure and corresponding charring rates.

When declared on the basis of species and characteristic density:

- 1) species shall be expressed as species according to 4.1.3.1; and
- 2) characteristic and mean density ρ_k and ρ_{mean} of timber layers according to 4.1.3.1 as

- i) strength class according to EN 338; or as:
- ii) individual values; and
- 3) characteristic and mean density ρ_k and ρ_{mean} of wood-based panel layers according to 4.1.3.2 as:
 - i) strength class according to EN 12369-2 or EN 12369-3 for plywood and structural solid wood panels according to EN 13986; or
 - ii) individual values for any type of wood-based panels.
- b) for criteria (R, E, I, K) resistance to fire may be tested.

Test results only apply for the member geometry, geometry of supports and load configuration being tested. Therefore information on any relevant test parameters, especially those on loads, span or height and layup of the elements tested, for which class(es) apply, shall be declared.

When tested according the test methods specified in the standards referred to in EN 13501-2, (the) characteristic(s) shall be expressed as:

- 1) class in minutes according to EN 13501-1 completed by the established suffixes; and
- 2) any test parameters, especially those on loads, span or height and layup of the elements tested, for which class(es) apply.

4.4 Reaction to fire

4.4.1 General

The class of reaction to fire performance of cross laminated timber (preservative treated against biological attack or not) shall be determined, classified and expressed for

- a) without the need for further testing as specified in 4.4.2 or;
- b) based on testing, as specified in 4.4.3, when the option a) cannot be used or higher class than the ones offered in the option a) is sought for cross laminated timber.

4.4.2 Classification without further testing

If the cross laminated timber meets all the provisions for certain reaction to fire class, specified either in Table 2 or in Table 3, its reaction to fire performance may be expressed as that, respective class, without any need for testing.

Table 2 — Classes of reaction to fire performance for cross laminated timber products for walls and ceilings^{1 2}

Product ^a	Product detail	Minimum mean density ^b (kg/m ³)	Minimum overall thickness (mm)	Class ^c (excluding floorings)
Cross laminated timber products covered by the present standard the harmonized standard EN 16351	Minimum layer thickness of 18 mm	350	54	D-s2, d0 ^d
^a Applies to all species and glues covered by the product standards. ^b Conditioned in accordance with standard EN 13238. ^c Class as set out in Table 1 of the Delegated Regulation (EU) 2016/364. ^d Class valid for any substrate or air gap behind.				

Table 3 — Classes of reaction to fire performance classes for cross laminated timber for floorings^{3 4}

Product ^a	Product detail	Minimum mean density ^b (kg/m ³)	Minimum overall thickness (mm)	Class for flooring ^c
Cross laminated timber products covered by the present standard the harmonized standard EN 16351	Minimum layer thickness of 18 mm and with the surface layer made of pine	430	54	DFL-s1 ^d
Cross laminated timber products covered by the present standard the harmonized standard EN 16351	Minimum layer thickness of 18 mm and with the surface layer made of spruce	400	54	DFL-s1 ^d
^a Applies also to steps of stairs. ^b Conditioned in accordance with standard EN 13238. ^c Class as set out in Table 1 of the Delegated Regulation (EU) 2016/364. ^d Class valid for any substrate or air gap behind.				

¹ This table is the same as given in Table 1 of the Commission Delegated Regulation (EU) 2017/2293 (see OJEU L329/1 of 2017-12-13).

² Deviant to the text in the first row of Table 2, EN 16351 has not been cited in the Official Journal of the EU up to now and therefore is not a harmonized product standard.

³ This table is the same as given in Table 2 of the Commission Delegated Regulation (EU) 2017/2293 (see OJEU L329/1 of 2017-12-13).

⁴ Deviant to the text in the first row of Table 2, EN 16351 has not been cited in the Official Journal of the EU up to now and therefore is not a harmonized product standard.