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**Timber structures — Cross laminated  
timber —**

**Part 1:  
Component performance, production  
requirements and certification scheme**

*Structures en bois — Plaques reconstituées à base de lamelles  
croisées —*

*Partie 1: Performances des composants et exigences de production et  
système de certification*

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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.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

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

A list of all parts in the ISO 16696 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

The general principle of this document is that a certain level of performance and production techniques are required in the production of cross laminated timber (CLT) to be acceptable for structural application of the product. This document specifies the minimum requirements for CLT production and performance assessment.

This document was based heavily on the draft European Standard EN 16351 prepared by Technical Committee CEN/TC 124 and the North American Standard ANSI/APA PRG 320. The technical contents from these standards were merged and modified to bring it into conformance with ISO procedures and requirements. The ISO 16696 series consists of two parts: this document (Part 1) gives performance and production requirements for CLT, which also includes conformance requirements, as provided in [Annex D](#); ISO 16696-2 provides guidance on how CLT is to be installed and used.

The bibliography lists standards referenced during the development of this document.

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# Timber structures — Cross laminated timber —

## Part 1:

# Component performance, production requirements and certification scheme

## 1 Scope

This document establishes the basic principles for component performance and minimum production requirements for cross laminated timber (CLT). This document also contains scheme requirements for conformance, as provided in [Annex D](#).

The document is applicable to CLT products which are manufactured from solid-sawn timber or wood based panels built up of at least three layers in which the grain of adjoining layers are at right angles to each other.

This document provides CLT dimension tolerances; component requirements; performance criteria; production, testing and trade marking guidance; and minimum requirements for factory production control. This document is based on known species, species combination and/or wood based panel structural performance and bondability.

CLT qualified in accordance with the provisions of this document are intended to resist the effects of moisture on structural performance as can occur due to construction delays or other conditions of similar severity.

NOTE This document does not include how CLT is to be used and installed, as it will be detailed in ISO 16696-2.

## 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 16351, *Timber structures — Cross laminated timber — Requirements*

ISO/IEC 3130, *Wood — Determination of moisture content for physical and mechanical tests*

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

ISO/IEC 12460 (all parts), *Wood-based panels — Determination of formaldehyde release*

ISO/IEC 13910, *Structural timber — Sampling, full-size testing, and evaluation of the characteristic values of strength graded timber*

ISO/IEC 16979, *Wood based panels — Determination of moisture content*

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

ISO 20152-2:2011, *Timber structures — Bond performance of adhesives — Part 2: Additional requirements*

## 3 Terms and definitions

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

## ISO 16696-1:2019(E)

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

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

### 3.1

#### **actual size**

measured size of a CLT product at a related moisture content

### 3.2

#### **adhesive**

substance capable of bonding materials together

### 3.3

#### **adherend**

material held to another material by an adhesive

### 3.4

#### **bond**

attachment at an interface between adhesive and adherends or the act of attaching adherends together by adhesive

### 3.5

#### **bondline**

layer of adhesive which attaches two adherends

### 3.6

#### **characteristic value**

structural property estimate, typically a population mean for stiffness properties or a tolerance limit (5<sup>th</sup> percentile with 75 % confidence) for strength properties

Note 1 to entry: As estimated from the test data that is representative of the population being sampled as determined in accordance with ISO 12122-1.

### 3.7

#### **corrected size**

actual size of a CLT product corrected by calculation to the reference moisture content

### 3.8

#### **corrective action**

action to eliminate the cause of nonconformities

### 3.9

#### **cross laminated timber**

##### **CLT**

a prefabricated engineered wood product made of at least three orthogonal layers of graded sawn lumber or wood based panels that are laminated by gluing with structural adhesives

### 3.10

#### **CLT thickness**

dimension of the CLT panel measured perpendicular to the plane of the panel

### 3.11

#### **delamination**

separation of layers in a laminate due to failure of the adhesive either in the adhesive itself or at the interface between the adhesive and the adherend

### 3.12

#### **edge**

##### **panel edge**

narrow face of a panel that exposes the ends or narrow faces of the laminations

**3.13****edge gluing  
edge joints**

gluing the edges of adjacent lamination within a CLT layer

**3.14****end joint**

joint made by gluing of the finger joints of the same laminations within a CLT layer prior to laminating adjacent layers

**3.15****face**

one of the four longitudinal surfaces of a piece or panel

**3.16****face bondline**

bondline joining the wide faces of the laminations in adjacent layers

**3.17****factory production control****FPC**

procedures, regular inspections and tests which ensure that products placed on the market conform to the performance requirements stated by the manufacturer

**3.18****finger angle**

$\alpha$

inclination of the fingers of a finger joint

Note 1 to entry: see [Figure 1](#).

**3.19****finger joint**

self-locating end joint formed by machining a number of similar, tapered, symmetrical fingers in the ends of solid sawn timber components, which are formed by a finger joint cutter and then bonded together

Note 1 to entry: see [Figure 1](#).

**3.20****finger length**

$l_j$

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

Note 1 to entry: see [Figure 1](#).

**3.21****finished thickness and width**

thickness and width after planing

**3.22****lamination**

solid sawn timber or wood based panels, including stress rated boards and manufactured timber which has been prepared to be a layer

**3.23****large finger joint**

finger joint through the full cross sectional area at the end of plane cross laminated components solely made of solid sawn timber layer, having identical cross sectional layups and bonded together

Note 1 to entry: see [Figure 2](#).

**3.24**

**layer**

all laminations on one side of a face bondline and consist of one solid sawn timber grade or one grade of wood based panel

**3.25**

**layup**

cross-sectional arrangement of layers of solid sawn timber or wood based panels, which may have different species, strength classes, strength profiles, thicknesses or technical classes (3.41), into a CLT product

**3.26**

**manufacturing standard**

procedures established by manufacturer to produce and maintain a product with the stated performance requirements

**3.27**

**major strength direction**

general direction of the grain of the outermost layers of the CLT panel

**3.28**

**maximum delamination length**

largest delamination length in any single glue line measured around the circumference of the test piece

**3.29**

**minor strength direction**

direction perpendicular to the major strength direction of the CLT panel

**3.30**

**moisture content**

*u*

amount of water present in solid sawn timber or wood based panels, expresses as percentage of oven dry mass

Note 1 to entry: Determined in accordance with ISO 3130 or ISO 16979.

**3.31**

**panel**

single CLT billet formed by bonding lamination with a structural adhesive

**3.32**

**pitch**

distance between fingers, measured from centre to centre

Note 1 to entry: see [Figure 1](#).

**3.33**

**ply**

all laminations between two adjacent bondline and consist of one solid sawn timber grade or one grade of wood-based panel

**3.34**

**service class 1**

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

Note 1 to entry: In Service Class 1, the average equilibrium moisture content of most softwoods does not exceed 12 %.

[SOURCE: ISO 20152-1:2010, 3.1]

**3.35****service class 2**

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

Note 1 to entry: In Service Class 2, the average equilibrium moisture content of most softwoods does not exceed 20 %. Such conditions include resistance to the effects of moisture on structural performance due to construction delays or other conditions of similar severity.

[SOURCE: ISO 20152-1:2010, 3.2]

**3.36****service class 3**

service class characterized by climatic conditions leading to higher moisture content than Service Class 2 such as occurs when a member is fully exposed to the weather

[SOURCE: ISO 20152-1:2010, 3.3]

**3.37****solid sawn timber grade**

a solid sawn wood product population produced with standardized rules that maintain well-defined limits on strength-controlling characteristics or properties

**3.38****specific gravity**

ratio of the oven-dry mass of a specimen to the mass of a volume of water equal to the volume of the specimen at the specified moisture content

**3.39****surveillance of FPC**

continual monitoring of the factory production control test plan(s) and production processes

**3.40****target size**

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

**3.41****technical class**

class of product performance included in a standard for the purpose of relating product performance to its intended use

**3.42****tip gap**
 $l_t$ 

distance between fingertip and slot base in a bonded finger joint

Note 1 to entry: see [Figure 1](#).

**3.43****tip width**
 $b_t$ 

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

Note 1 to entry: see [Figure 1](#).

**3.44****total delamination length**

sum of delamination lengths of all glue lines around the circumference of a test piece

**3.45**

**wood based panel**

engineered wood product that is intended for structural use and bonded with adhesives, such as oriented strand board (OSB), plywood, laminated veneer lumber (LVL), and plywood and single-layered solid wood panels

**3.46**

**wood failure**

rupture in or between wood fibres

**3.47**

**wood failure percentage**

area of wood fibre remaining at the bondline following the rupture of wood fibres from the specified shear test, expressed as a percentage of total area involved in such failure

## 4 Symbols and subscripts

### 4.1 Symbols

$b_{cut}$  tip width of the cutter, in mm

$b_l$  finished lamination width, in mm

$E$  modulus of elasticity in bending, in MPa

$f_b$  characteristic bending strength of CLT, in MPa

$h$  depth of cross section, in mm

$h_a$  actual depth, in mm

$h_{cor}$  corrected depth, in mm

$k$  moisture deformation factor perpendicular to the grain for a change in moisture content of 1 % for moisture contents between 6 % and 25 %

$l$  length, in mm

$n$  number

$p$  pitch, in mm

$S$  section modulus, in mm<sup>3</sup>, of the composite CLT section for calculating the moment capacity of CLT

$t$  thickness, in mm

$t_l$  finished lamination thickness, in mm

$u_a$  actual moisture content, in %

### 4.2 Subscripts

$a$  actual

$cor$  corrected

$ref$  referenced

0	parallel to grain
05	5 <sup>th</sup> percentile
90	perpendicular to grain

## 5 CLT panel dimensional tolerances

### 5.1 Dimensional tolerances at time of manufacture

#### 5.1.1 General

The relevant geometrical data (cross sectional sizes, layup, layer thickness and orientations, presence of grooves, presence of edge bonds and ratio of lamination width to lamination thickness) shall be determined and declared. The moisture deformation factor for unhindered moisture-induced deformation shall be taken from the national design code standard governing the production for the timber species.

NOTE The actual sizes of CLT are influenced by swelling and shrinkage due to changes of moisture content.

#### 5.1.2 Panel thickness

The thickness of CLT panel shall not exceed 500 mm. The moisture corrected thickness of the cross section shall not deviate from the nominal thickness by more than  $\pm 2$  mm or 2 % of the nominal thickness whichever is greater.

#### 5.1.3 Layer thickness

The dimensional tolerance for thickness permitted at time of manufacturing for a single layer shall be  $\pm 1$  mm.

#### 5.1.4 Panel width

The dimensional tolerance for CLT panel width permitted at time of manufacturing shall be  $\pm 3$  mm of the target CLT panel width.

#### 5.1.5 Panel length

The dimensional tolerance for CLT panel length at time of manufacturing shall be  $\pm 6,5$  mm of the target CLT panel length.

Textured or other face or edge finishes may alter the tolerances specified in this clause. The designer should compensate for any loss of cross-section and/or specified strength of such alterations.

#### 5.1.6 Grooves and edge bonds

In order to reduce cupping and cracking, laminations are permitted to be grooved. Grooves shall have a maximum depth of 90 % of the thickness of the lamination and a maximum width of 4 mm ([Figure 3](#)). Adjacent laminations shall be permitted to be non-edge bonded. The width of the gaps between adjacent laminations within a CLT layer shall be less than or equal to 6 mm ([Figure 3](#)).

### 5.2 Squareness

Unless specified otherwise, the length of the two panel face diagonals measured between panel corners shall not differ by more than  $\pm 3$  mm.

### 5.3 Straightness

Unless specified otherwise, deviations of parallel edges from straight line between the adjacent panel corners shall not exceed  $\pm 1,5$  mm.

## 6 Component requirements

### 6.1 Solid sawn timber

#### 6.1.1 Solid sawn timber species

Any solid sawn timber species or species combinations recognized by national standards and having a published characteristic density of not less than  $300 \text{ kg/m}^3$  shall be permitted for use in CLT manufacturing provided it meets the performance requirements of [Clause 7](#).

Solid sawn timber shall be graded in conformity with appropriate national standards for graded material. Proprietary solid sawn timber grades shall be permitted for use provided they meet the requirements of [6.1.3](#), [6.1.4](#), and [6.1.5](#).

For grades that deviate from national standards, records shall be maintained that document the quality (grade) and characteristic values of the various layers of solid sawn timber.

#### 6.1.2 Solid sawn timber sizes

The net width of solid sawn timber shall not be less than 1,75 times the solid sawn timber thickness for the parallel layers. If the laminations in the perpendicular (cross) layers are not edge bonded, the net width of the solid sawn timber shall be at least 3,5 times the solid sawn timber thickness for the perpendicular (cross) layers unless the inter-laminar shear strength and stiffness is confirmed by testing using ISO 8375. The net thickness of solid sawn timber for all layers at the time of gluing shall not be less than 6 mm or more than 50 mm.

NOTE The width-to-thickness ratio of 3,5 for the solid sawn timber in the perpendicular (cross) layers is intended for alleviating the CLT creep deflection when the laminations are not edge bonded.

#### 6.1.3 Moisture content

The moisture content of the wood components at the time of CLT manufacturing shall be within 4 moisture content percentage points of the reference moisture content or as recommended by the adhesive manufacturer.

NOTE 1 The moisture content is the equilibrium moisture content of the product in an environment maintained at  $20 \text{ }^\circ\text{C}/65 \text{ \% RH}$  unless as specified in the governing national standard.

NOTE 2 For example, if the equilibrium moisture content of the product is expected to be 10 %, the moisture content of the wood component at the time of CLT manufacturing should be between 6 to 14 %.

#### 6.1.4 Solid sawn timber face-bonding surface

All surfaces to be bonded shall be planed prior to face bonding and except for minor local variations, shall be free of raised grain, torn grain, skip, burns, glazing or other deviation from the plane of the surface that might interfere with the contact of sound wood fibres in the bonding surfaces. All face-bonded surfaces shall be free from dust, foreign matter, and exudation that are detrimental to satisfactory bonding.

It is a common practice that planing be carried out not more than 24 hours before bonding unless the species and the storage environment are such that unacceptable surface changes will not take place. If the material is stored outside, it should be stored under cover. Additional attention should be paid

to selecting an adhesive or preparing surfaces for bonding species with high resin content or bonding chemically treated wood.

### 6.1.5 Face-bonding dimensional tolerances

At the time of face-bonding, variations in thickness across the width of a lamination shall not exceed 0,2 mm. The variation in thickness along the length of a lamination shall not exceed 0,3 mm. Warp and cup shall not be so great that they will not be straightened out by pressure in bonding.

## 6.2 Wood based panels

### 6.2.1 General

Only wood-based panels, which meet the appropriate national standard for production and fulfil the requirements for the CLT panels expected service class, shall be used. Records shall be maintained that document the quality (grade) of the various layers of wood-based material.

Only wood-based panels which can meet the appropriate national standard for formaldehyde emissions shall be used or as specified in the governing national standard.

### 6.2.2 Moisture content

The moisture content of the wood based panels at the time of CLT manufacturing shall be  $8 \pm 4$  % or as specified in the governing national standard.

### 6.2.3 Wood based panels face-bonding surface

All face-bonding surfaces shall be free from dust, foreign matter, and exudation that are detrimental to satisfactory bonding.

### 6.2.4 Face-bonding dimensional tolerances

At the time of face-bonding, variations in thickness across the width of a lamination shall not exceed 0,2 mm. The variation in thickness along the length of a lamination shall not exceed 0,3 mm. Warp and cup shall not be so great that they will not be straightened out by pressure in bonding.

## 6.3 Adhesive requirements

### 6.3.1 General

Adhesive shall provide durable bonds in CLT product for the service class in which the CLT product is to be used and shall meet the requirements of ISO 20152-1. Where local building regulations require heat durability testing, the adhesives used for CLT shall meet the requirements of ISO 20152-2:2011, Clauses 2 and 3.

### 6.3.2 Testing for minor changes of adhesive systems

If minor changes are applied to an adhesive system, such as the change in fillers or extenders, which has been already tested and fulfils the requirements of ISO 20152-1, testing shall be required only for the properties that are affected by the changes and the respective requirements shall be fulfilled.

### 6.3.3 Finger joints in laminations when used

The lamination joints of CLT shall meet the requirements specified in ISO 10983.

#### 6.3.4 Edge joints in laminations when used

The wood failure and durability of the edge (when required for structural performance) joints shall be qualified in accordance with national standards for testing of edge joints.

#### 6.3.5 Glue line integrity for glue lines between layers (face joints)

The glue line integrity of glue lines between layers (face joints) shall be qualified by the appropriate national standard delamination test for the range of moisture content specified in 6.1.3 and 6.2.2.

The maximum delamination length shall not exceed 40 % of the total length of a single glue line and the total delamination length shall not exceed 10 % of the sum of all glue lines.

NOTE 1 Some national standards may have more restrictive requirements.

NOTE 2 Delamination associated with knots and other defects permitted by national standards may be excluded. Where delamination associated with permitted defects exceed 50 % of the bond length, the test specimen may be replaced.

NOTE 3 Testing should be conducted to assess if the permitted amounts of delamination is consistent evidence of a well-manufactured bondline for the adhesive use. Different adhesive formulations may exhibit greater or lower amounts of delamination when manufacturing conditions depart from specifications. Such changes in manufacturing conditions may impact performance attributes, such as creep resistance, and long-term durability.

Where the maximum delamination length or the total delamination length exceeds the limits given above or if the delamination lengths cannot be estimated due to the inadequate surface quality of the end grain surfaces each glue line shall be split. The minimum wood failure percentage each split glued area shall be not less than 50 %, and the minimum wood failure percentage of the sum of all split glued areas shall be not less than 70 %.

#### 6.3.6 Shear strength of edge bonds in solid sawn timber layers

The bonding strength of edge bonds between solid sawn timber laminations shall be qualified by shear tests according to the appropriate national standard if these glue lines are to be declared as load bearing glue lines.

### 6.4 Large finger joints of panels

#### 6.4.1 General

The cutting and bonding operations for large finger joints of panels (Figure 2) shall follow the recommendations of EN 16351 and shall result in reliable and durable bonds.

#### 6.4.2 Bending strength

The characteristic bending strength of a large finger joint in a straight beam shall be greater than or equal to the declared characteristic bending strength and shall be qualified by edgewise bending test in accordance with the appropriate national standard.

The characteristic finger joint strength shall be qualified for the load direction of the intended use.

## 7 Cross laminated timber performance criteria

### 7.1 Layup requirements

Layers made of laminations shall be orthogonally arranged and specified in the manufacturing standard of each CLT plant when qualified in accordance with requirements specified in this clause. The layup (construction, orientation, wood species, and quality of the layers) of each CLT panel shall be

documented as in [Annexes A](#) and [C](#). Each layup shall comprise at least three layers, at least two of them made of solid sawn timber laminations ([Figure 4](#)).

Layers made of timber laminations or solid wood panels shall be orthogonally arranged ([Figure 5](#)), unless the following conditions are met: Within CLT made of four or more layers, up to three adjacent layers having a total thickness of not more than 90 mm may be glued parallel to the grain in the direction of one of the main axes of the CLT.

The sum of the thicknesses of wood based panel layers, other than structural composite lumber and plywood, in a CLT may be up to 50 % of the overall thickness of the CLT ([Figure 5](#)). Wood-based panels may be bonded to layers made of laminations in one of the main axes of the wood-based panels.

The overall thickness of the CLT panel shall not exceed 500 mm.

## 7.2 Mechanical resistance of cross laminated timber products

Mechanical resistance of CLT products shall be determined by full-scale tests with CLT products or by calculations based on properties of the layers. The methods for determining properties are detailed in [Annex D](#).

NOTE 1 For one CLT product, some properties can be determined by calculation and others by testing.

NOTE 2 In this document, "mechanical resistance" jointly covers the following essential characteristics: modulus of elasticity, and bending, compressive, tension, shear, and bonding strengths.

## 7.3 Durability against biological attack

### 7.3.1 General

If the CLT is solely built up of timber layers, the durability against biological attack shall be declared as the durability of the timber. If the cross section is built up of different species or of treated and untreated layers, only the natural durability or the preservative treatment of the layer with the lowest durability shall be declared.

If the CLT product comprises wood-based panel layers, the durability of these wood-based panels, where applicable, shall be declared additionally in accordance with the national standard. If the cross section comprises different types of wood-based panels, only the durability of the wood-based panel with the lowest durability shall be declared.

If the CLT is treated with preservative after gluing in accordance with a national standard, the durability against biological attack of the preservative-treated CLT shall be declared in accordance with the national standard for the preservative-treated wood.

### 7.3.2 Solid sawn timber layers without preservative treatment

The solid sawn timber as a component used for the CLT product shall have adequate natural durability for the intended service class specified by the designer.

### 7.3.3 Solid sawn timber layers with preservative treatment

The preservative treatment for the solid-sawn timber used for the CLT product shall be specified to provide the durability for the intended service class required by the designer. The CLT product shall indicate the type of preservative used, critical retention value, and penetration required. The bondability and chemical compatibility of the treated wood with the adhesive used shall be assessed.

### 7.3.4 CLT treated with preservative treatment

When treated with preservatives to provide the durability for the intended service class required by the designer, the CLT product shall indicate the type of preservative used, critical retention value, and

penetration required. The CLT shall be assessed to confirm the treatment process is not detrimental to the bondline performance.

#### 7.4 Formaldehyde emission

Cross laminated solid sawn timber products shall be tested for the release of formaldehyde according to ISO 12460 or as specified in other governing national standards.

#### 7.5 Dimensional stability

##### 7.5.1 General

The reference size for CLT products shall be at the moisture content corresponding to an ambient condition of 20 °C/65 % RH or as specified in a national standard. Dimensional stability of CLT product is influenced by swelling and shrinkage of CLT components due to changes of its moisture content.

NOTE 1 Swelling and shrinkage value can be regarded as a constant value in the major and minor directions of CLT products.

NOTE 2 For solid sawn timber, a condition of 20 °C/65 % RH corresponds to an equilibrium moisture content of approximately 12 %.

##### 7.5.2 Maximum deviations

The corrected depth of the cross section of a CLT panel shall not deviate from the target depth by more than ±2 mm or 2 % of the nominal depth, whichever is the greater.

The corrected depth of a single layer shall not deviate from the target depth by more than ±1 mm.

##### 7.5.3 Corrected sizes and moisture deformation factor

If the actual moisture content differs from the reference moisture content, a correction in size based on moisture deformation shall be made by using:

$$h_{cor} = h_a (1 + k_{cor,\alpha} (u_{ref} - u_a))$$

where

$h_{cor}$  is the corrected size, in mm;

$h_a$  is the actual size, in mm;

$k_{cor,\alpha}$  is the moisture deformation factor perpendicular to the grain for a change in moisture content of 1 % for moisture contents between 6 % and 25 %;

$k_{cor,90}$  = 0,002 4 for deformations perpendicular to plane;

$k_{cor,0}$  = 0,000 2 for deformation in plane;

$u_{ref}$  = 12 % is the reference moisture content, in %;

$u_a$  is the actual moisture content, in %.

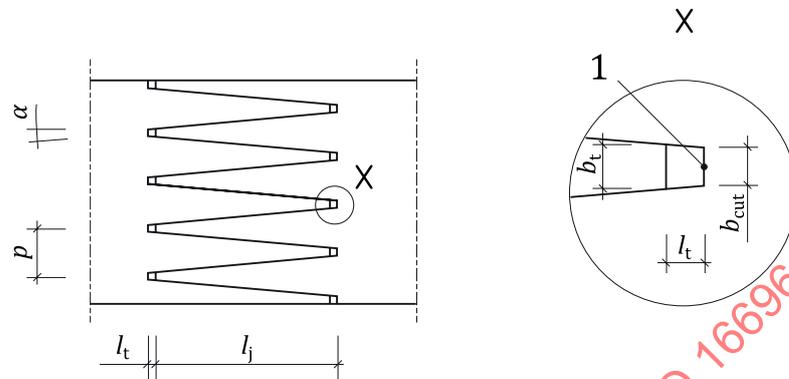
#### 7.6 Appearance classification

CLT panel appearance shall be as agreed to between the buyer and the seller.

NOTE [Annex B](#) contains examples of CLT appearance classification for reference.

## 8 Production, testing, and trade marking

The compliance of CLT products with the provisions of this document and with the performances declared by the manufacturer in the Declaration of Performance (DoP) shall be demonstrated by determination based on qualification testing and by factory production control, including product assessment and trade marking, as shown in [Annex D](#).



### Key

- $l_j$  finger length
- $p$  pitch
- $\alpha$  finger angle
- $l_t$  tip gap
- $b_{cut}$  tip width of the cutter
- $b_t$  tip width
- 1 slot base

Figure 1 — Typical profile of a finger joint

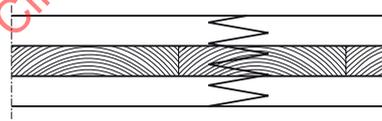
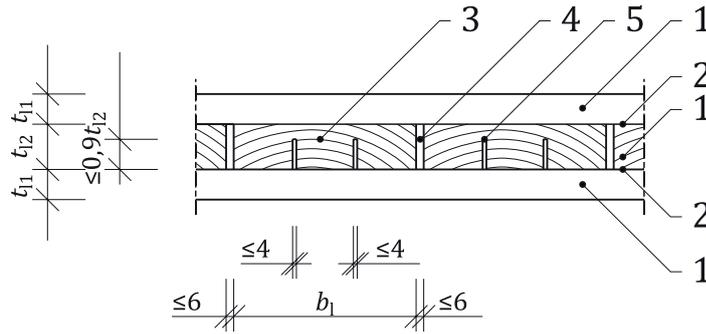


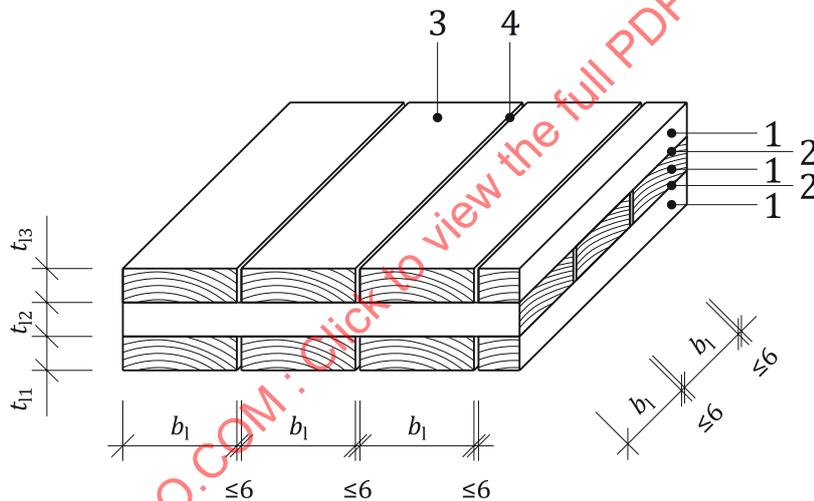
Figure 2 — Cross laminated solid sawn timber with large finger joints



**Key**

- 1 layers
- 2 bondline between layers
- 3 lamination
- 4 gap between laminations
- 5 grooves in laminations

**Figure 3 — Permissible geometry of grooves**



**Key**

- 1 timber layer
- 2 bondline between layers
- 3 lamination
- 4 gap between lamination

$$6 \leq t_{1,3} \leq 45 \quad 6 \leq t_2 \leq 60 \quad 40 \leq b_1 \leq 300$$

**Figure 4 — Example for layup made of three timber layers**



## Annex A (normative)

### Panel layup (construction)

[Table A.1](#) provides a format for defining the layup (construction) of a specified CLT panel.

**Table A.1 — Species/thickness of plies**

Ply <sup>a</sup>	Thickness (mm)	Paralell // or perpendicular $\perp$ to face ply	Layer identification	
			Species	Layer quality <sup>b</sup>
(Face) 1		//		
2		$\perp$		
3				
—				
—				
—				
—				
$n^c$				

<sup>a</sup> Plies are numbered from face (1) to back (n).  
<sup>b</sup> Quality  $Q_i$  as defined in [Annex C](#).  
<sup>c</sup>  $n$  = total number of plies.

## Annex B (normative)

### Examples of CLT appearance classification

#### B.1 General

This annex contains example of CLT appearance classification for reference only. These requirements are based on the appearance at the time of manufacturing. The actual CLT panel appearance requirements are recommended to be agreed upon between the buyer and the seller.

#### B.2 Architectural appearance classification

An appearance classification normally suitable for applications where appearance is an important but not overriding consideration. Specification characteristics of this classification are as follows:

- a) In exposed surfaces, all knot holes and voids measuring over 19 mm are filled with a wood-tone filler or clear wood inserts selected for similarity with the grain and colour of the adjacent wood.
- b) The outermost layers exposed to view are free of loose knots and open knot holes are filled.
- c) Knot holes do not exceed 20 mm when measured in the direction of the lamination length with the exception that a void may be longer than 20 mm if its area is not greater than 320 mm<sup>2</sup>.
- d) Voids greater than 2 mm wide treated by edge joints appearing on the outermost layers exposed to view are filled.
- e) Exposed surfaces are surfaced smooth with no misses permitted.

#### B.3 Industrial appearance classification

An appearance classification normally suitable for use in concealed applications where appearance is not of primary concern. Specific characteristics of this grad are as follows:

- a) Voids appearing on the edges of laminations need not be filled.
- b) Loose knots and knot holes appearing on the outermost layers exposed to view are not filled.
- c) Members are surfaced on outermost layers only and the appearance requirements apply only to these layers.
- d) Occasional misses, low laminations or wane (limited to the solid sawn timber grade) are permitted on the surface layers and are not limited in length.

## Annex C (normative)

### Ply grading

[Table C.1](#) give layer characteristics and [Table C.2](#) provides a standard list of minimum characteristics of the layers according to their location in the final product.

**Table C.1 — Ply characteristics**

	Inner layer	Outer layer	Face	Other
Timber Quality Index	Q <sub>i</sub>	Q <sub>j</sub>	...	...
NOTE Q <sub>i</sub> , Q <sub>j</sub> , ... are given in accordance with <a href="#">Annex B</a> .				

**Table C.2 — Manufacturing characteristic limits in end-product**

Ply <sup>a</sup>	Outer layer (face) 1	Ply 2	Ply 3	...	...	Ply n <sup>b</sup> (back)
Category of defect or characteristic						
(Manufacturing characteristics) dimensions and shape						
Type and quality and location of structural bond lines						
Open joints						
Overlaps						
Blister/Delamination						
Hollow/Imprints/Bumps						
Roughness						
Edge void						
Edge defect (sawing/sanding)						
Repairs						
<sup>a</sup> Plies are numbered from face (1) to back (n). <sup>b</sup> n = total number of plies.						

NOTE Other characteristic could be required and added, if necessary.

## Annex D (normative)

### Production assessment, trade marking and factory production control

#### D.1 Product assessment

##### D.1.1 Qualification testing

Qualification testing shall be performed for all characteristics included in this document for which the manufacturer declares performances:

- at the beginning of the production of a new or modified CLT products (unless a member of the same family), or
- at the beginning of a new or modified method of production (where this may affect the stated properties); or
- they shall be repeated for the appropriate characteristic(s), whenever a change occurs in the CLT product design, in the raw material or in the supplier of the components, or in the production process beyond a family, which would affect significantly one or more of the characteristics.

##### D.1.2 Sample conditioning

CLT panel samples shall be stored in a suitable environment until the adhesive has cured sufficiently to permit evaluation. The CLT samples at the time of mechanical tests shall have an average moisture content of not less than the reference moisture content of the layer minus 4 moisture content percentage points.

##### D.1.3 Bending test methods

Bending tests shall be conducted flatwise (loads are applied perpendicular to the outermost layer of CLT) in accordance with ISO 13910, with a width of not less than 300 mm and an on-centre span more than 21 times the specimen depth. The weight of the CLT panel is permitted to be included in the determination of the bending moment capacity.

##### D.1.4 Bending test requirements

The average bending stiffness ( $EI$ ) and the characteristic bending moment ( $f_b S$ ) determined from qualification tests shall meet or exceed the published characteristic bending stiffness and bending moment adjusted for duration of load effects.

##### D.1.5 Shear test methods

Shear tests shall be conducted flatwise (loads are applied perpendicular to the outermost layer of CLT) in accordance with ISO 13910 using a specimen width of not less than 300 mm and an on-centre span of at least 5 times the specimen depth.

##### D.1.6 Shear test requirements

The characteristic interlaminar shear capacity ( $V_s$ ) determined from qualification tests shall meet or exceed the published characteristic interlaminar shear capacity adjusted for duration of load effects.