Deutsches Institut für Bautechnik

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Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment

ETA-10/0241 of 29 June 2018

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	Leno Cross Laminated Timber
Product family to which the construction product belongs	Solid wood slab elements to be used as structural elements in buildings
Manufacturer	ZÜBLIN Timber GmbH Industriestraße 2 86551 Aichach DEUTSCHLAND
Manufacturing plant	ZÜBLIN Timber GmbH Industriestraße 2 86551 Aichach DEUTSCHLAND
This European Technical Assessment contains	24 pages including 6 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 130005-00-0304
This version replaces	ETA-10/0241 issued on 28 June 2013

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Specific Part

1 Technical description of the product

Leno Cross Laminated Timber elements are plane solid wood slab elements made of at least three crosswise glued softwood boards. Adjacent layers of the softwood boards are arranged perpendicular (angle of 90°) to each other. The cross-section of the solid wood slabs shall be symmetrically or nearly symmetrically.

The principle structure of the solid wood slab is shown in annex 2.

A maximum of three adjacent layers may be arranged in the same direction as long as a nearly symmetric cross-section with cross layering remains.

The elements are plane. They may be slightly bent (see Tab. A.2.1) as long as the bending does not influence the characteristics of the elements as described in this European Technical Assessment.

Single layers of the elements may be replaced by one-layer solid wood panels according to EN 13986 or laminated veneer lumber panels according to EN 14374 and the information deposited with Deutsches Institut für Bautechnik. As cover layer a Fineline-layer (layer of laminated veneer lumber standing upright) may be used on or both sides, see annex 2.

The maximum thickness of the Fineline cover layer is 40 mm and the maximum width of the lamellas 220 mm. The maximum thickness of layers of softwood or one-layer-solid wood panels is 40 mm, the maximum thickness of the laminated veneer lumber panels is 45 mm.

The products may be covered with gypsum boards or gypsum fibreboards according to EN 520 and/or EN 15283-2 on one or both sides. These panels must not be used for calculation of the elements.

A specification of the composition of the solid wood slabs and of the boards to be used is given in annex 2.

Boards are visually or machine strength graded. Only technically dried wood is used.

Only boards, which are planed on both sides, are used. The boards may be connected by finger joints according to EN 385 in longitudinal direction. There are no butt joints. For the fingerjointing of Fineline lamellas the data deposited with Deutsches Institut für Bautechnik must also be observed.

The elements may be connected by universal finger joints according to EN 14080.

The boards within a layer may either be glued together or be without glue on their adjacent surfaces. The maximum width of gaps is given in annex 2.

The boards may be grooved with notches of approx. 2.5 mm width in intervals of 40 to 80 mm. In the case of three-layer elements notches with a width of 20 mm or 40 mm may be arranged in accordance with annex 2. The distance between the notches and between notch and edge is between 40 m and 80 mm. The remaining thickness of the boards in the area of the notches is between 4 mm and 7 mm. If the distance of the notches from the edge and between each other is about 40 mm, the remaining thickness of the boards in the area of notches may be half of the board thickness.

The adhesive for gluing the layers, the finger joints of the individual boards and the universal finger joints meets the requirements for the "Type I" adhesive according to EN 301 which passed the tests according to EN 302-1 to EN 302-4. Alternatively a PU-adhesive fulfilling the requirements of EN 14080, Annex C, may be used. For the classification EN 15425 applies. This also applies for solid wood panels, laminated veneer lumber and Fineline layers being part of the product.

The adhesive used and the manufacturing process must be conform to the information deposited with Deutsches Institut für Bautechnik.

The application of wood preservatives and flame retardants is not subject of the ETA.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The elements are intended to be used as load-bearing and/or stiffening or not load-bearing wall, ceiling/floor, roof and special construction components for timber structures. For the taking up and transmitting of loads they may be stressed both perpendicular to the element plane and in the element plane.

The performances given in Section 3 are only valid if the solid wood slab elements are used in compliance with the specifications and conditions given in Annex 2 to 5.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the solid wood slab element of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

3.1 Mechanical resistance and stability [1)] (BWR 1)

Essential characteristic	Performance
Bending [2)]	Annex 3
Tension and compression [2)]	Annex 3
Shear [2)]	Annex 3
Embedment strength	Annex 3
Creep and duration of the load	Annex 3
Dimensional stability	Annex 3
In-service environment	Annex 3
Bond integrity	Annex 3

[1)] This characteristic also relates to BWR 4.

[2)] Load bearing capacity and stiffness regarding mechanical actions perpendicular to and in plane of the solid wood slab element.

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Annex 3
Resistance to fire	Annex 3

3.3 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content, emission and/or release of dangerous substances	
Substance/s classified as EU-cat. Carc. 1A and/or 1B [a)]	no performance assessed
Substance/s classified as EU-cat. Muta. 1A and/or 1B [a)]	
Substance/s classified as EU-cat. Acute Tox. 1, 2 and/or 3; Repr. 1A and/or 1B; STOT SE 1 and/or STOT RE 1 [a)]	
Formaldehyde emission	Formaldehyde class E1 in accordance with EN 13986
Wood preservatives and flame retardants	Wood preservatives and flame retardants are not subject of the ETA
Water vapour permeability - Water vapour transmission	Annex 3

[a)] in accordance with Regulation (EC) No 1272/2008

3.4 Safety and accessibility in use (BWR 4)

Essential characteristic	Performance
Impact resistance	Annex 3

3.5 Protection against noise (BWR 5)

Essential characteristic	Performance
Airborne sound insulation	no performance assessed
Impact sound insulation	no performance assessed
Sound absorption	no performance assessed

3.6 Energy economy and heat retention (BWR 6)

Essential characteristic	Performance
Thermal conductivity	Annex 3
Air permeability	no performance assessed
Thermal inertia	Annex 3

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with EAD No. 130005-00-0304 the applicable European legal act is: 1997/176/EC amended by 2001/596/EC

The system to be applied is: 1

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 29 June 2018 by Deutsches Institut für Bautechnik

BD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Deniz

Deutsches Institut für Bautechnik DIBt

Annex 1 Specifications of intended use

A.1.1 Intended Use and Loading

The elements are intended to be used as load-bearing and/or stiffening or not load-bearing wall, ceiling/floor, roof and special construction components for timber structures. For the taking up and transmitting of loads they may be stressed both perpendicular to the element plane and in the element plane.

The solid wood slab element shall be subjected to static and quasi-static actions only.

The solid wood slab element is intended to be used in service classes 1 and 2 according to EN 1995-1-1.

A.1.2 Design

The suitability of the solid wood slab elements for the specified purpose is given under the following conditions:

- Design of the solid wood slab elements is carried out under the responsibility of an engineer experienced in such products.
- Design of the works accounts for the protection of the solid wood slab elements.
- The solid wood slab elements are installed correctly.

The design of the solid wood slab element can be performed according to EN 1995-1-1, taking into account Annexes 2 to 5 of the European Technical Assessment.

A.1.3 Packaging, transport, storage

The solid wood slab elements shall be protected during transport and storage against any damage and detrimental moisture effects. The manufacturer's instructions for packaging, transport and storage shall be observed.

A.1.4 Installation provisions

EN 1995-1-1 in conjunction with the respective national annex applies for the installation.

The manufacturer shall prepare assembling instructions in which the product-specific characteristics and important measures to be taken into consideration for assembling are described. The assembling instructions shall be available at every construction site.

The assembling of the solid wood slab elements according to this European Technical Assessment shall be carried out by appropriately qualified personnel.

The product shall only be installed in structures where they are protected from wetting, weathering and moisture.

The safety-at-work and health protection regulations have to be observed.

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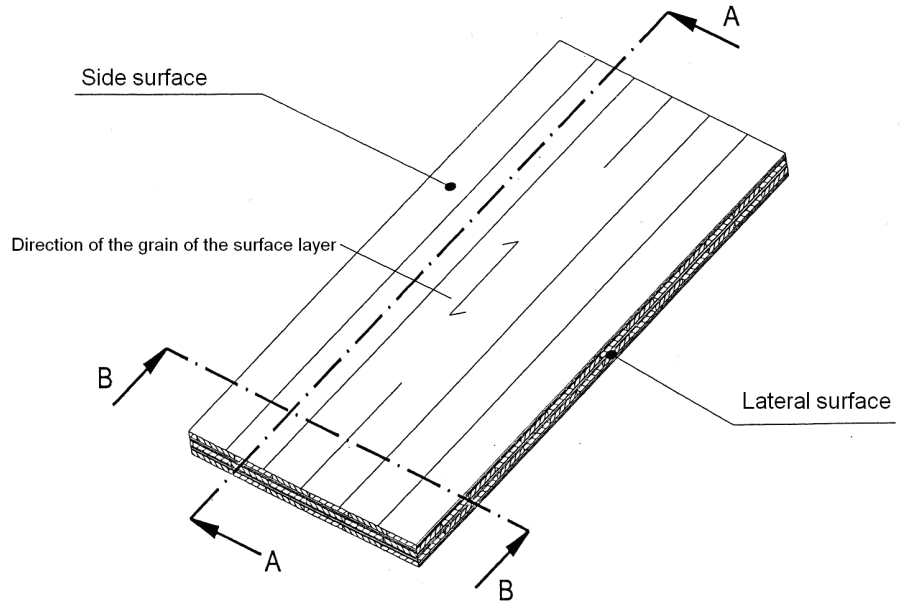
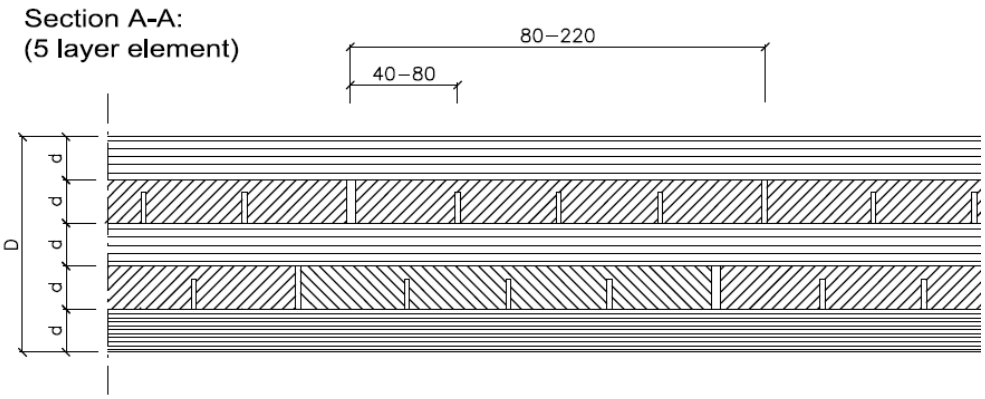
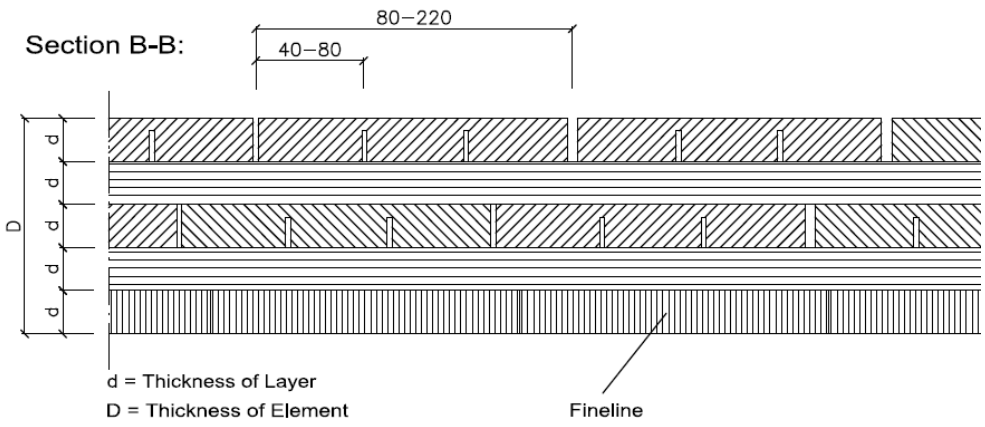
Annex 2 Construction of the wood slab elements "Leno Cross Laminated Timber" (example)







Leno Cross Laminated Timber	Annex 2
Construction of the elements	

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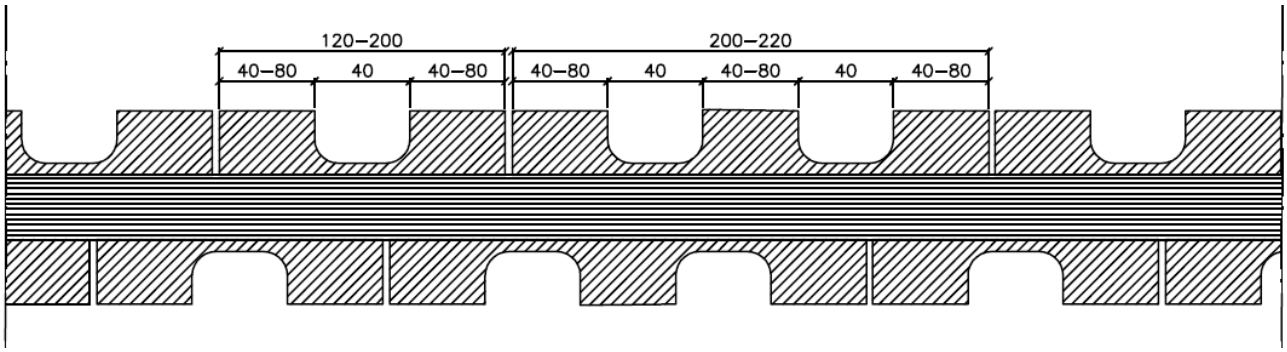
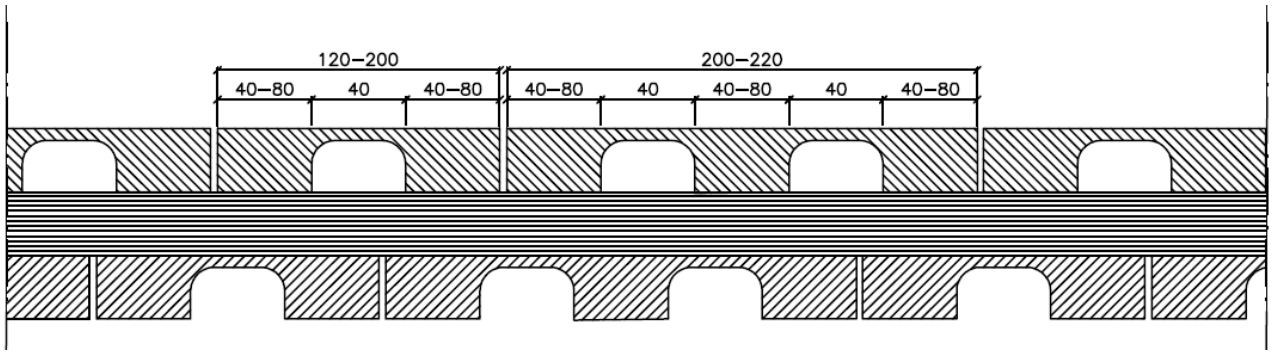
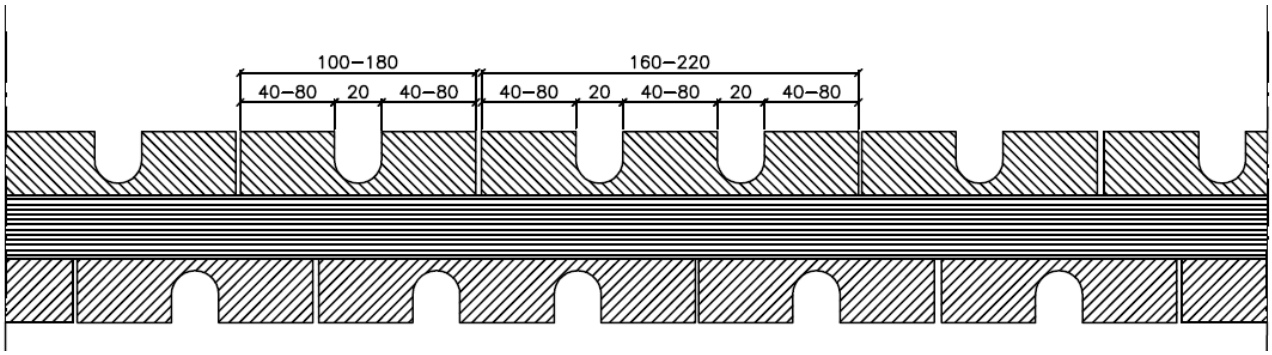
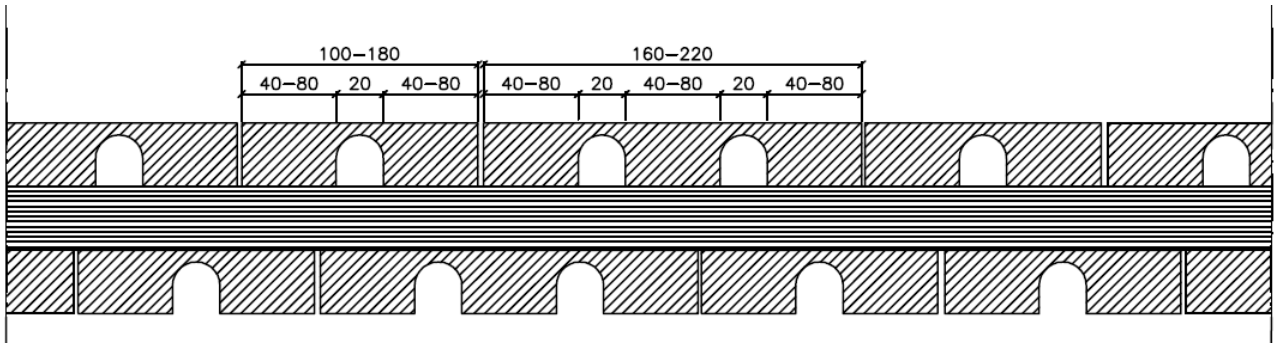
Assembly of the three layer elements with notches









Leno Cross Laminated Timber	Annex 2
Construction of the elements	

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Fineline layer

Leno Cross Laminated Timber

Construction of the elements

Annex 2

Table A.2.1: Dimensions and specifications of the elements

Characteristic	Specification
Cross laminated timber element	
Thickness	30 to 300 mm
Width	≤ 4.8 m
Length	≤ 30 m
Number of layers	≥ 3
maximum number of consecutive layers having the same grain direction	≤ 3
maximum width of gap between the boards of a layer	6 mm
Layup	Symmetric layup [1)]
Boards	
Material	Softwood (spruce, pine)
Strength class according to EN 338	≥ C16 [2)]
Thickness	10 to 40 mm [3)]
Width	80 to 220 mm
Ratio width to thickness of the cross-layers	≥ 4:1
Moisture of wood according to EN 13183-2	12 ± 2 %
Finger joints	according to EN 14080

1) In the case of deviances from symmetry, the distance between the stresses neutral line and the geometrical middle of the cross section shall not be more than is a maximum of 1/10 of the element thickness of the element.

2) Within each layer a maximum of 30% of the boards may belong to the next lower strength class without that being considered in the calculation. The following combinations are possible:

100 % C 16;
70 % C24 / 30 % C16;
70 % C30 / 30 % C24;
70 % C35 / 30 % C30 und
70 % C40 / 30 % C35.

In deviation to the above in the following cases only a maximum of 10% of the boards of the next lower strength class may be used:

- In the upper and lower surface layer of elements or element parts with cross sections with only one parallel oriented layer and a remaining width of less than 1.0 m.
- In the upper and lower surface layer of elements or element parts with cross sections with only two parallel oriented layers and a remaining width of less than 0.5 m.
- In the respectively outer cross layers of elements or element parts, which are under bending stress perpendicular to the longitudinal direction of the surface layers and have a remaining width (measured in the direction of the grain of the surface layer) of less than 1.0m.
- In the horizontal layers in the field of of door or window lintels of wall elements.

These rules also apply for cross sections where certain layers are replaced by layers of wood based panels (laminated veneer lumber, solid wood panels).

3) The elements might be bent as follows depending on the thickness of the layers:

Thickness of the layer ≤ 12 mm	bending radius R ≥ 250·d,
Thickness of the layer > 12 to ≤ 17 mm	bending radius R ≥ 350·d,
Thickness of the layer > 17 to ≤ 22 mm	bending radius R ≥ 420·d,
Thickness of the layer > 22 to ≤ 27 mm	bending radius R ≥ 500·d,

with R = bending radius of a single board and d = thickness of a single board of a bended layer.

Leno Cross Laminated Timber	Annex 2
Dimensions and specifications of the cross laminated timber	

Annex 3 Essential requirements of the solid wood slab

Table A.3.1: Essential requirements of the solid wood sl**ab**

BWR	Requirement	Verification method	Class / Use category / Value
1	**Mechanical resistance and stability**		
	For the calculation of the individual layers the characteristic strength and stiffness values of softwood of the corresponding strength classes acc. to EN 338 and EN 14081-1 (for LS 15) shall be used taking into consideration the definitions in Annex 2. In addition the following values apply:		
	Mechanical actions in plane of cross laminated timber	Shear strength (5%-fractile)	$f_{v,k}$	see Annex 4, clause A.4.1.4.1
	Mechanical actions perpendicular to the plane of cross laminated timber	Rolling shear strength (5%-fractile)	$f_{v,9090,k}$	0.70 N/mm²
		Rolling shear modulus (mean value)	$G_{9090,mean}$	50 N/mm²
	For layers of one layered solid wood panels, which do not include notches, as characteristic rolling shear strength $f_{v,9090,k}$ = 1.25 N/mm² can be assumed. If elements are connected by universal finger joints according to EN 387, the characteristic values for bending, tension and compression shall be reduced by 40% in field of the universal finger joint. For the characteristic values of solid wood panels and structural laminated veneer lumber the rules of the associated European standard apply. For Fineline surface layers the characteristic values for softwood lamellas of the strength class C35 apply. National regulations might have to be followed. For references regarding the calculation see annexes 4 and 5.		
	Creep and duration of load	according to EN 1995-1-1	
	Dimensional stability	Moisture content during use shall not change to such extent that adverse deformations can occur.	
	Durability of timber In-service environment	EN 1995-1-1	1 and 2
	Bond integrity	EAD 130005-00-0304	Passed
2	**Safety in case of fire**		
	Reaction to fire		
	Timber elements except for floorings	Commission Decision 2005/610/EC	Euroclass D-s2, d0
	Resistance to fire		
	Charring rate	EN 1995-1-2 EN 13501-2	0.7 mm/min
3	**Hygiene, health and the environment**		
	Water vapour permeability μ	EN ISO 10456	20 (wet) to 50 (dry)
	Content of dangerous substances	EAD 130005-00-0304	See clause 3.3

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4	**Safety in use**		
	Impact resistance	Soft body resistance is assumed to be fulfilled for walls with a minimum of 3 layers and minimum thickness of 60 mm.	
5	**Protection against noise**		
	Airbourne sound insulation	no performance assessed	
	Impact sound insulation	no performance assessed	
	Sound absorption	no performance assessed	
6	**Energy economy and heat retention**		
	Thermal conductivity λ	EN ISO 10456	0.12 W/(m^2 · K)
	Air permeability	no performance assessed	
	Thermal inertia c_p	EN ISO 10456	1600 J/(kg · K)

Leno Cross Laminated Timber	Annex 3
Essential requirements of the cross laminated timber	

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Annex 4 Design considerations

A.4.1 Recommendations for the design of the elements

A.4.1.1 General

Design, calculation and realization may be performed according to EN 1995-1-1 taking into account the following provisions. For the calculation according to EN 1995-1-1 national regulations may have to be followed.

The determination of the distribution of stresses and internal forces must consider the influence of shear deformations of the cross layers. In Annex 4 advice is given on how to perform the calculation of the elements.

If using panels as cover, the deformation of the covers might have to be taken into account. These cover layers may not be used for calculation of the bearing capacity of the cross laminated timber elements.

For the calculations regarding rolling shear, bending stresses and buckling of elements with three layers and large notches the remaining cross-section can be considered with:

for notches of 20 mm B ·0.75

for notches of 40 mm B ·0.60

with

B = width of a board without notches.

National regulations may apply for the calculation of fasteners.

A.4.1.2 Characteristic values

The characteristic strength and stiffness values can be taken from Annex 2 and 3. In addition the following applies:

The deformations caused by shear forces may be calculated by using the element thickness D irrespective of the given layup and a global shear modulus of G = 60 N/mm².

A.4.1.3 Mechanical actions perpendicular to the element`s plane

A.4.1.3.1 Bending and shear

For the calculation of the characteristic values of the element according to Annex 4, only the boards, which are oriented parallel to the span direction, may be considered.

A.4.1.3.2 Tension and compression

The behaviour in bearing and deformation against compression perpendicular to the element's plane can be calculated according to EN 1995-1-1 using the strength and stiffness values given in chapter A.4.1.2.

Tension loads perpendicular to plane of the element should be avoided.

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A.4.1.4 Mechanical actions in plane of the element

For loads in plane of the element only layers can be taken into account, where the direction of the grain is parallel to the stresses occurring from external loads.

A.4.1.4.1 Shear

Shear stresses may be calculated with the gross cross section. These shear stresses are to be compared with an effective characteristic shear strength $f_{v,k}$ according to the following equation:

$$f_{v,k} = \min \begin{cases} 3.5 \\ 8.0 \dfrac{D_{net}}{D} \\ 2.5 \dfrac{(n-1)\left(a^2+b^2\right)}{6\,D\,b} \end{cases} \quad \text{in N/mm}^2$$

where

D element thickness (see Annex 2)

D_{net} total thickness of longitudinal or cross layers within the element; the smaller value applies

n number of layers within the element, adjacent layers with parallel lamellae shall be considered as one layer and

a, b width of the boards in the longitudinal or cross layers, where b > a.
(If a and b is unknown, the minimum value must be applied for a and b.)

A.4.1.4.2 Tension and compression

The load-bearing and deformation behaviour in the element plane can be calculated according to EN 1995-1-1 using the strength and stiffness values given in chapter A.4.1.2.

A.4.1.4.3 Buckling

For the calculation of buckling the instability factor for glued laminated timber GL24c acc. to EN 1995-1-1 might be taken into account. The calculation shall be performed with the geometry of the cross section as is.

A.4.2 Design according to the theory of flexible bonded beams

The calculation of elements with up to five layers can be performed using the theory of flexible bonded beams as described in EN 1995-1-1.

To consider deformations due to shear the factor s_i/K_i according to the standard is substituted by the factor $\bar{h}_i/(G_R \cdot b)$.

The effective moment of inertia is calculated by:

$$I_{ef} = \sum_{i=1}^{3} (I_i \cdot + \gamma_i \cdot A_i \cdot a_i^2) \qquad \text{where} \quad A_i = b_i \cdot h_i; \qquad I_i = \frac{b_i \cdot h_i^3}{12}$$

$$\gamma_1 = \frac{1}{1 + \frac{\pi^2 \cdot E_0 \cdot A_1 \cdot \bar{h}_1}{G_R \cdot b \cdot l^2}}; \qquad \gamma_2 = 1; \qquad \gamma_3 = \frac{1}{1 + \frac{\pi^2 \cdot E_0 \cdot A_3 \cdot \bar{h}_2}{G_R \cdot b \cdot l^2}}$$

$$a_1 = \left(\frac{h_1}{2} + \bar{h}_1 + \frac{h_2}{2}\right) - a_2; \qquad a_3 = \left(\frac{h_2}{2} + \bar{h}_2 + \frac{h_3}{2}\right) + a_2$$

$$a_2 = \frac{\gamma_1 \cdot A_1 \cdot \left(\frac{h_1}{2} + \bar{h}_1 + \frac{h_2}{2}\right) - \gamma_3 \cdot A_3 \cdot \left(\frac{h_2}{2} + \bar{h}_2 + \frac{h_3}{2}\right)}{\sum_{i=1}^{3} (\gamma_i \cdot A_i)}$$

The bending stress in the centre of the boards may be disregarded.

The governing bending stress in the outermost fibre of the boards:

$$\sigma_{m,r,i,d} = \pm \frac{M_d}{I_{ef}} \cdot \left(\gamma_i \cdot a_i + \frac{h_i}{2}\right) \le f_{m,d}$$

Shear design is in the governing plane:

$$\tau_{v,d} = \frac{V_d \cdot \gamma_i \cdot S_i}{I_{ef} \cdot b} \le f_{R,d}$$

Notation:

h_i = thickness of the layer i parallel to the direction of load transfer [mm]

$\bar{h}_i$ = thickness of the layer i perpendicular to the direction of load transfer [mm]

b = width of the element [mm]

n = number of layers

l = span width [mm]

I_{ef} = effective moment of inertia [mm^4]

G_R = rolling shear modulus [N/mm²]

E_0 = modulus of elasticity parallel to the grain of the boards [N/mm²]

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Annex 5 Fasteners

A.5 Recommendations for the design of the fasteners

A.5.1 General

The determination of characteristic values of the load-bearing capacity of fasteners in the element shall be carried out according to EN 1995-1-1 or acc. to an European Technical Approval or Assessment which has been granted for the relevant fastener as for softwood or for glued laminated timber. For the calculation according to European regulations national provisions may apply.

Wide faces are the surfaces of the element parallel to the plane of the element consisting of the surface of the outer layers.

Narrow faces are the lateral and the cross grain board surfaces perpendicular to the plane of the element.

Only fasteners according to EN 1995-1-1 or a European Technical Approval or Assessment or according to national regulations may be used.

Fasteners in the lateral surfaces of wood based panels used as cover layers are not allowed.

If the position of the fasteners in the narrow faces is not clearly defined (end grain, gaps between the single boards, etc.), then the most unfavourable case is to be assumed.

The grain direction of the cover layers governs the minimum spacings of the fasteners as well as the embedding strength is.For the minimum spacings, minimum thicknesses, minimum layer thicknesses and minimum penetration length of fasteners, see Annex 5.6.

The rules for the design of fasteners stated below are applicable to areas without notches according to annex 2. The edge distances to notches have to be observed.

Additional please note the following:

A.5.2 Nails

The nails must be at least 4.0 mm in diameter.

Wide faces

The characteristic load-carrying capacity of laterally loaded nails in the wide faces is to be determined according to EN 1995-1-1. The embedment strength may be calculated with the density of the top layer of boards. Decisive for the minimum spacing is the direction of the grain of the cover layers.

The effective number of nails n_{ef} may be set equal to the actual number n.

Narrow faces

Nails in the narrow faces of the elements shall not be considered as load-bearing.

Axially loaded screws (pull-out)

Only grooved nails with a characteristic value of the point side withdrawal strength $f_{ax,k} \geq 50 \cdot 10^{-6} \cdot \rho_k^2$ and a characteristic value of the head side pull-through strength $f_{head,k} \geq 100 \cdot 10^{-6} \cdot \rho_k^2$ might be employed for axial loading (ρ_k = characteristic density in kg/m³; max. 500 kg/m³). The nails must at least go through three layers. The characteristic axial withdrawal strength can under these circumstances be assumed to:

$$F_{ax,Rk} = 14 \cdot d^{0,6} \cdot l_{ef} \cdot k_d \quad \text{in N}$$

with

d	diameter of the nail in mm,
l_{ef}	profiled nail length in the element at the head of the nail,
k_d	coefficient; k_d = 0.8 for d < 6 mm, k_d = 1 for d ≥ 6 mm

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Fasteners	

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A.5.3 Screws

As decisive diameter of the screws the outer diameter of the thread applies. Screws loaded perpendicular to their axis in the wide faces should have a diameter of at least 4 mm, screws in the narrow faces of at least 8 mm, if the edge of a board is not considered construction edge. Penetration depth l_{ef} < 4d may not be taken into account. The rope effect may be taken into account for shear loaded screws. Screws in the cross grain of lateral surfaces may only be subject to short or very short term loads.

For wood screws with a diameter of $d \leq 8$ mm pre-drilling is not required. If a pre-drilling is required, it has to be done with $0.7 \cdot d$ in the lateral surfaces.

Wide faces

The load direction must be perpendicular to the screw axis and parallel to the wide face of the cross laminated timber.

The characteristic load bearing capacity of laterally loaded screws in the wide faces can be calculated according to EN 1995-1-1. The regulations for wood screw connections in solid timber shall be used. As density the characteristic value of the wood of the cover layer shall be used. In case the penetration depth of the screw is at least as large as the thickness of the three outer layers, the characteristic density can be assumed with ρ_k = 400 kg/m³.

The angle between direction of the force and direction of the grain might have to taken into account.

For angles between $45° \leq \alpha \leq 90°$ between the screw axis and the direction of the grain of the cover layer, the characteristic values for α = 90° can be assumed if only the dimension perpendicular to the wide faces is taken into account as the penetration depth.

Narrow faces

The load direction must be perpendicular to the screw axis and parallel to the narrow face of the cross laminated timber.

Irrespective of the arrangement of a screw in the narrow face (which means under angles $0° \leq \alpha \leq 90°$ between screw axis and direction of the grain) the characteristic value of the embedment strength can be assumed to:

$$f_{h,k} = 20 \cdot d^{-0.5} \quad \text{in N/mm²}$$

with

d nominal diameter of the screw in mm,

The factor n_{ef} shall be calculated as for solid timber acc. to EN 1995-1-1.

If a component of the force is oriented perpendicular to the wide face, there is the risk of a failure due to tension perpendicular to the grain. In case the ratio a/h is not over 0.7, a calculation due to tension perpendicular to the grain is advised. For ratios $0.5 \leq a/h < 0.7$ and $a_1 \leq 2t$ the characteristic load bearing capacity of a screw due to tension perpendicular to the grain can be assumed to:

$$F_{v,90,Rk} = 4.4 \cdot (l_{ef} \cdot t)^{0.8} \quad \text{in N}$$

with

l_{ef} penetration depth of the fastener, maximum 12d

t Thickness of the cross laminated timber under transverse tension loads

a_1 see pictures in annex 5

The degree of permanent and semipermanent loads shall not exceed 50% of the whole load in this case.

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Fasteners	

Withdrawal (pull-out), wide and narrow faces

For withdrawal forces of screws in the wide and narrow faces the following applies:

The minimum value of the angle α between the axis of the screw and the direction of the grain stated in the European Technical approval or assessment of the screw shall be observed.

The characteristic load-carrying capacity of an axially loaded screw (pull-out) can be assumed to:

$$F_{ax,Rk} = k_d \cdot \sum_{i=1}^{n} F_{ax,i,Rk} \quad \text{in N}$$

with

$F_{ax,i,Rk}$ characteristic value of the withdrawal strength of the screw according to European Technical approval or assessment in the board layer i depending on the characteristic density, the angle between axis of the screw and direction of the grain and the length of the thread area of the screw in the board layer i

n number of the board layers taken into account

k_d coefficient; k_d = 0.8 for d < 6 mm, k_d = 1 for d ≥ 6 mm

The characteristic pull through resistance shall be calculated as for solid timber elements with the characteristic density of the associated layer in the area of the head of the screw.

For screws that penetrate at least three board layers and have at least a penetration depth of 4d, the following characteristic load-carrying capacity of an axially loaded screw (pull-out) can be assumed:

$$F_{ax,Rk} = \frac{31 \cdot d^{0.8} \cdot l_{ef}^{0.9} \cdot k_d}{1.5 \cdot \cos^2 \alpha + \sin^2 \alpha} \quad \text{in N}$$

with

α angle between axis of the screw and direction of the grain; the smallest value is decisive

l_{ef} thread length in the cross laminated timber

d diameter of the screw in mm

k_d coefficient; k_d = 0.8 for d < 6 mm, k_d = 1 for d ≥ 6 mm

Withdrawal (pushing in), wide and narrow faces

For loads pushing the screws in the wide and narrow faces the following applies:

The minimum value of the angle α between the axis of the screw and the direction of the grain stated in the European Technical approval or assessment of the screw shall be observed. The characteristic value of the load-cattying capacity of a fully threaded screw under compression loads may be calculated as the $F_{ki,Rk}$ with:

$$F_{ki,Rk} = \kappa_c \cdot N_{pl,k} \quad \text{in N}$$

with:

$$\kappa_c = \begin{cases} 1 & \text{für } \overline{\lambda_k} \le 0.2 \\ \dfrac{1}{k + \sqrt{k^2 - \overline{\lambda_k}^2}} & \text{für } \overline{\lambda_k} > 0.2 \end{cases}$$

$$k = 0.5 \cdot \left[1 + 0.49\left(\overline{\lambda_k} - 0.2\right) + \overline{\lambda_k}^2\right]$$

$$\overline{\lambda_k} = \sqrt{\frac{N_{pl,k}}{N_{ki,k}}}$$

$$N_{pl,k} = \pi \cdot \frac{d_2^2}{4} \cdot f_{y,k} \quad \text{in N}$$

with

d_2 = core diameter of the screw in mm

$f_{y,k}$ = yield limit in N/mm² according to the European Technical approval or assessment of the screw

$N_{ki,k}$ = $\sqrt{c_h \cdot E_s \cdot I_s}$ = elastic critical buckling load in N

c_h = $\left(0.019 + 0.012 \cdot d\right) \cdot \rho_k \cdot \left(\dfrac{90° + \alpha}{180°}\right)$ = bedding factor in N/mm²; the most unfavourable combination of α und ρ_k is decisive

ρ_k = characteristic density of a board layer

α = Angle between axis of the screw and direction of the grain

$E_s * I_s = \dfrac{210000 \cdot \pi \cdot d_2^4}{64}$ Nmm² = bending stiffness of the core section of the screw

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A.5.4 Split ring, shear plate and toothed-plate connectors

Wide faces

The characteristic load-carrying capacity of split ring, shear plate and toothed-plate connectors in the wide faces of cross laminated timber may be calculated according to EN 1995-1-1 for an angle between force and grain direction of $\alpha = 0°$ regardless of the actual angle between the force and grain direction of the cover layers.

When inserting in the wide faces a minimum layer thickness of 20 mm must be maintained.

Narrow faces

For split ring and shear plate connectors in the narrow faces of the cross laminated timber the regulations for connections with split ring connectors in the end grain of timber members may be applied.

A.5.5 Connections with dowels and bolts

Wide faces

The characteristic load-carrying capacity of dowelled or bolted connections in the wide faces is to be determined with the embedding strength according to the following equation:

$$f_{h,\alpha,k} = \frac{32 \cdot (1 - 0.015 \cdot d)}{1.1 \cdot \sin^2 \alpha + \cos^2 \alpha} \quad \text{in N/mm}^2$$

with

d fastener diameter in mm

α angle between force and grain direction of the cover layer

Decisive for the calculation of the embedding strength is the grain direction of the cover layers.

For dowels and bolts connections with a diameter ≥ 10 mm, $n_{ef} = n$ may be assumed.

Narrow faces

The characteristic load-carrying capacity of dowelled or bolted connections in the narrow faces is to be determined with the embedding strength according to the following equation:

$$f_{h,k} = 9 \cdot (1 - 0.017 \cdot d) \quad \text{in N/mm}^2$$

with

d fastener diameter in mm

Note: For actions perpendicular to the plane of the cross laminated timber the possibility of splitting caused by the tension force component perpendicular to the grain, shall be taken into account. Connections with ratios $h_{ef}/D \leq 0.7$ should be reinforced with fully threaded screws.

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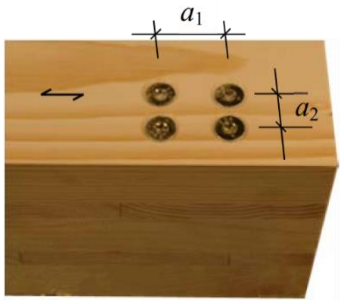
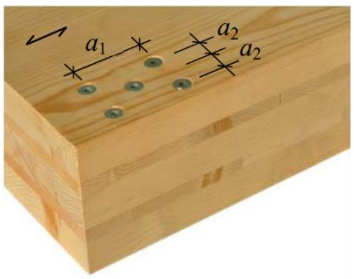
Fasteners	

A.5.6 Minimum spacings of fasteners

A.5.6.1 Minimum spacings of fasteners in the wide faces

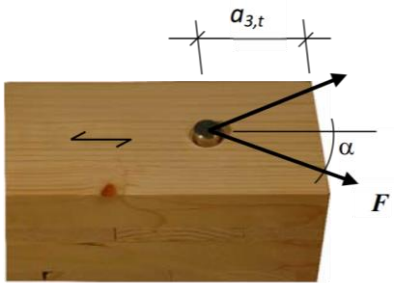
Minimum spacings – parallel and perpenticular to grain



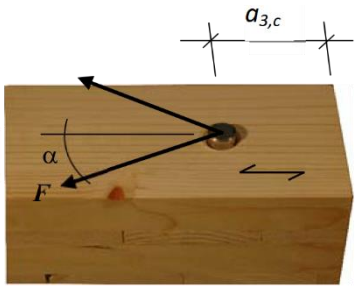


Edge and end distances

loaded end $a_{3,t}$



unloaded end $a_{3,c}$



unloaded edge $a_{4,c}$
loaded edge $a_{4,t}$

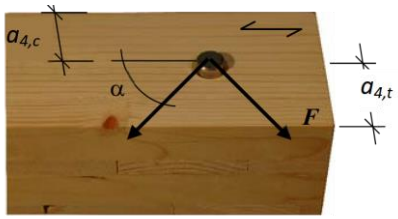


Table A.5.1: Minimum spacings of fasteners in the wide faces

fastener	a_1	a_2	$a_{3,t}$	$a_{3,c}$	$a_{4,t}$	$a_{4,c}$
screws [1)]	4·d	2.5·d	6·d	6·d	6·d	2.5·d
nails	(3+3·cosα)·d	3·d	(7+3·cosα)·d	6·d	(3+4·sinα)·d	3·d
dowels	(3+2·cosα)·d	3·d	5·d	4·d·sinα min. 3·d	3·d	3·d
bolts	(3+2·cosα)·d min. 4·d	4·d	5·d	min. 4·d	3·d	3·d
α angle between force and grain direction of the cover layer 1) self-tapping screws						

A.5.6.2 Minimum spacings, minimum thicknesses, minimum layer thicknesses und minimum penetration lengths of fasteners in the narrow faces

The minimum spacings in the narrow faces are independent of the angle between fastener axis and grain direction.

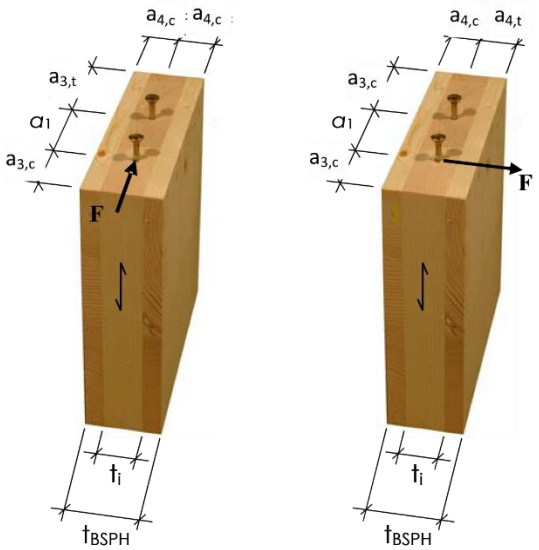


Table A.5.2: Minimum spacings of fasteners in the narrow faces

	a_1	a_2	$a_{3,t}$	$a_{3,c}$	$a_{4,t}$	$a_{4,c}$
screws [1)]	10·d	3·d	12·d	7·d	6·d	5·d
dowels	4·d	3·d	5·d	3·d	5·d	3·d
bolts	4·d	4·d	5·d	4·d	5·d	3·d
[1)] self-tapping screws						

Table A.5.3: Requirements for fasteners in the narrow faces of cross laminated timber

fastener	Minimum thickness of the cross laminated timber	Minimum thickness of the relevant layer	Minimum penetration length of the fastener t_1 oder t_2 *)
	t_{BSPH} in mm	t_i in mm	in mm
Screws [1)]	10·d	d > 8 mm: 3·d d ≤ 8 mm: 2·d	10·d
Dowels bolts	6·d	d	5·d
*) t_1 Minimum penetration length of the fastener in side members (member to be connected) t_2 Minimum penetration length of the fastener in middle members (cross laminated timber element) [1)] self-tapping screws			

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Annex A.6 Reference documents

EAD 130005-00-0304, European Assessment Document for “Solid wood slab element to be used as a structural element in buildings”, Edition March 2015

EN 13986:2014 + A1:2015, Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking

EN 14374:2005, Timber structures – Structural laminated veneer lumber - Requirements

EN 520:2009, Gypsum plasterboards – Definitions requirements and test methods

EN 15283-2:2009, Gypsum boards with fibrous reinforcement – Definitions requirements and test methods – Part 2: Gypsum fibre boards

EN 14080:2013, Timber structures - Glued laminated timber and glued solid timber - Requirements

EN 301:2013, Adhesives, phenolic and aminoplastic, for load-bearing timber structures

EN 302-1 bis 4, Adhesives for load bearing timber structures – test methods – Part 1 to 4

EN 15425:2008, Adhesives - One component polyurethane for load bearing timber structures - Classification and performance requirements

EN 1995-1-1:2004 + A1:2008 + A2:2014, Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings

EN 338:2016, Structural timber – Strength classes

EN 13183-2:2002, Moisture content of a piece of sawn timber – Part 2: Estimation by electrical resistance method

EN 387:2002, Glued laminated timber – Large finger joints – Performance requirements and minimum production requirements

EN 1995-1-2:2004 + AC:2009, Eurocode 5 - Design of timber structures - Part 1-2: General - Structural fire design

EN ISO 10456:2007 + AC:2009, Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values