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Zulassungsstelle für Bauprodukte und Bauarten
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Authorised and notified according to Article 10 of the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products (89/106/EEC)

Deutsches Institut für Bautechnik

DIBt

Mitglied der EOTA
Member of EOTA

European Technical Approval ETA-10/0241

English translation prepared by DIBt - Original version in German language

Handelsbezeichnung *Trade name*		Leno Brettsperrholz *Leno Cross Laminated Timber*
Zulassungsinhaber *Holder of approval*		Merk Timber GmbH Industriestraße 2 86551 Aichach DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*		Massive plattenförmige Holzbauelemente zur Verwendung als tragende Teile in Bauwerken *Solid wood slab elements to be used as structural elements in buildings*
Geltungsdauer: *Validity:*	vom *from* bis *to*	28 June 2013 28 June 2018
Herstellwerk *Manufacturing plant*		Merk Timber GmbH Industriestraße 2 86551 Aichach DEUTSCHLAND

Diese Zulassung umfasst *This Approval contains*	25 Seiten einschließlich 5 Anhänge *25 pages including 5 annexes*
Diese Zulassung ersetzt *This Approval replaces*	ETA-10/0241 mit Geltungsdauer vom 12.08.2010 bis 12.08.2015 *ETA-10/0241 with validity from 12.08.2010 to 12.08.2015*

I LEGAL BASES AND GENERAL CONDITIONS

1 This European technical approval is issued by Deutsches Institut für Bautechnik in accordance with:

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1], modified by Council Directive 93/68/EEC[2] and Regulation (EC) N° 1882/2003 of the European Parliament and of the Council[3];
- *Gesetz über das In-Verkehr-Bringen von und den freien Warenverkehr mit Bauprodukten zur Umsetzung der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte und anderer Rechtsakte der Europäischen Gemeinschaften (Bauproduktengesetz - BauPG) vom 28. April 1998[4], as amended by Article 2 of the law of 8 November 2011[5];*
- Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex to Commission Decision 94/23/EC[6].

2 Deutsches Institut für Bautechnik is authorized to check whether the provisions of this European technical approval are met. Checking may take place in the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European technical approval and for their fitness for the intended use remains with the holder of the European technical approval.

3 This European technical approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on page 1, or manufacturing plants other than those indicated on page 1 of this European technical approval.

4 This European technical approval may be withdrawn by Deutsches Institut für Bautechnik, in particular pursuant to information by the Commission according to Article 5(1) of Council Directive 89/106/EEC.

5 Reproduction of this European technical approval including transmission by electronic means shall be in full. However, partial reproduction can be made with the written consent of Deutsches Institut für Bautechnik. In this case partial reproduction has to be designated as such. Texts and drawings of advertising brochures shall not contradict or misuse the European technical approval.

6 The European technical approval is issued by the approval body in its official language. This version corresponds fully to the version circulated within EOTA. Translations into other languages have to be designated as such.

1 Official Journal of the European Communities L 40, 11 February 1989, p. 12
2 Official Journal of the European Communities L 220, 30 August 1993, p. 1
3 Official Journal of the European Union L 284, 31 October 2003, p. 25
4 *Bundesgesetzblatt Teil I 1998*, p. 812
5 *Bundesgesetzblatt Teil I 2011*, p. 2178
6 Official Journal of the European Communities L 17, 20 January 1994, p. 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of the products and intended use

1.1 Definition of the construction 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 1. Details, about which configurations are allowed, are given in chapter 2.1.2.

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 can be slightly bent as long as the bending does not influence the characteristics of the elements as described in this European technical approval.

The layers of the elements may be replaced by one-layer solid wood panels or laminated veneer lumber panels. Also as surface layer a Fineline - layer (layer of laminated veneer lumber standing upright) may be used on or both sides, see annex 1.

The thickness of the Fineline surface layer shall not exceed 40 mm, the width of the lamellas has a maximum of 220 mm. The thickness of layers made of softwood or one-layer-solid wood panels shall not exceed 40 mm, the thickness of the laminated veneer lumber panels may be up to 45 mm.

The products may be covered with gypsum boards or gypsum fibreboards on one or both sides. These panels may not be used for calculation of the elements.

The application of chemical substances (wood preservatives and flame-protective agents) is not subject of this European technical approval.

1.2 Intended use

The solid wood slabs are intended to be used as a load-bearing, bracing or non structural element in buildings and timber structures. It shall be subjected to static and quasi static actions only.

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

The provisions made in this European technical approval are based on an assumed working life of the solid wood slabs of 50 years, provided that the conditions laid down in sections 4.2 and 5 for the packaging, transport, storage, installation, use, maintenance, repair are met. 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.

2 Characteristics of the products and methods of verification

2.1 Characteristics of the products

2.1.1 General

The solid wood slab elements and their components correspond to the information given in the annexes 1 to 3 of this European technical approval. Details on the elements are deposited with Deutsches Institut für Bautechnik (DIBt).

2.1.2 Construction of the solid wood slab

A specification of the composition of the solid wood slabs and of the boards to be used is given in the annexes 1 and 2.

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

Only boards, which are planed on both sides shall be used. The boards shall be connected by finger joints according to EN 385[7] in longitudinal direction. Butt joints are not permissible. For the fingerjointing of Fineline lamellas the data deposited with Deutsches Institut für Bautechnik shall be observed.

The elements can be connected by universal finger joints according to EN 387[8].

The boards can be grooved with notches of approx. 2,5 mm width in intervals of 40 to 80 mm. For elements of three layers notches with a width of 20 mm or 40 mm according to annex 2 are allowed. The distance between the notches and between notch and edge must be between 40 m and 80 mm. The remaining thickness of the board in field of the notches must be between 4 mm and 7 mm. If the distance between the notches from the edge and the distance between the notches is about 40 mm, the remaining thickness of the boards in the area of notches may be half of the thickness of the boards.

The individual boards of the crossing layers shall observe a ratio $\geq 4 : 1$ for width of the board : thickness of the board.

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

If structural laminated veneer lumber is used as surface layer or, for elements with three layers, as middle layer, it must fulfil the requirements as stated in EN 14374[9] or a European technical approval and as deposited with Deutsches Institut für Bautechnik.

If solid wood panels are used, they must fulfil the requirements as stated in EN 13986[10] or in a European technical approval.

If gypsum boards or gypsum fibre boards are used as additional layer, they must fulfil the requirements as stated in EN 520[11], EN 15283-2[12] or a European technical approval. The gypsum boards or gypsum fibre boards might not be taken into account for calculation.

The laminated veneer lumber, the solid wood panels, the gypsum plaster boards and gypsum fibre boards are only components of the product "Leno Cross Laminated Timber". They are not regulated independently in this European technical approval. National regulations might have to be followed for their use.

7	EN 385:2001	Finger jointed structural timber - Performance requirements and minimum production requirements
8	EN 387:2001	Glued laminated timber - Large finger joints - Performance requirements and minimum production requirements
9	EN 14374:2004	Timber structures - Structural laminated veneer lumber - Requirements
10	EN 13986:2004	Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
11	EN 520:2004	Gipsplatten - Begriffe, Anforderungen und Prüfverfahren
12	EN 15283-2:2009	Gypsum boards with fibrous reinforcement – Definitions, requirements and test methods – Part 2: Gypsum fibre boards

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

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

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

with

R = bending radius of a single board

D = thickness of a single board of a bended layer.

2.1.3 Adhesive

The adhesive for gluing the layers, the finger joints of the individual boards and the universal finger joints shall be an adhesive "Type I" conform to EN 301[13] which passed the tests according to EN 302-1 to EN 302-4[14]. Alternatively a PU - adhesive fulfilling the requirements of EN 14080[15], Annex C, might be used. For the classification EN 15425[16] 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.

2.2 Mechanical resistance and stability

The specifications regarding mechanical resistance and stability are given in annexes 2 to 5. Design can be carried out according to EN 1995-1-1.

2.3 Behaviour in case of fire

2.3.1 Reaction to fire

In accordance with Commission Decision 2003/43/EC the solid wood slab elements covered by this European technical approval for use as wall, roof, ceiling and special construction components comply with Euroclass D-s2,d0 according to EN 13501-1:2007+A1:2009[17]. For the use as floor construction components they comply with Euroclass D_{FL}-s1. The boundary conditions stated in the commission decision have to be attended for this classification.

The Decision of the European Commission might not apply if additional layers are part of the element, depending on the additional layers used and the boundary conditions affected.

13	EN 301:2006	Adhesives, phenolic and aminoplastic, for load-bearing timber structures - Classification and performance requirements
14	EN 302-1 to -4	Adhesives for load-bearing timber structures - Test methods - Part 1: Determination of bond strength in longitudinal tensile shear strength; 2004 Part 2: Determination of resistance to delamination; 2004 Adhesives for load-bearing timber structures - Test methods - Part 3: Determination of the effect of acid damage to wood fibres by temperature and humidity cycling on the transverse tensile strength; 2004 + A1:2005 Adhesives for load-bearing timber structures - Test methods - Part 4: Determination of the effects of wood shrinkage on the shear strength; 2004
15	EN 14080:2005	Timber structures - Glued laminated timber - Requirements
16	EN 15425:2008	Adhesives - One component polyurethane for load bearing timber structures - Classification and performance requirements
17	EN 13501-1:2007+A1:2009	Fire classification of construction products and building elements - Classification using data from reaction to fire tests

Note:

A European reference fire scenario for façades has not been laid down. In some Member States, the classification of the solid wood slabs according to EN 13501-1:2007+A1:2009[17] might not be sufficient for the use in façades. An additional assessment of the solid wood slabs according to national provisions (e.g. on the basis of a large scale test) might be necessary to comply with Member State regulations, until the existing European classification system has been completed.

2.3.2 Resistance to fire

The resistance to fire performance can be calculated according to EN 1995-1-2 using the charring rate given in annex 3. Occurring asymmetries have to be taken into account. The remaining cross section of a layer might not be thinner than 3 mm.

2.4 Hygiene, health and the environment

A manufacturer's declaration has been submitted that no dangerous substances are used in the product regulated by this European technical approval.

Wood preservatives or flame retardants are not part of this European technical approval.

The class of release of formaldehyde has been determined according to EN 13986 with regard to solid wood panels.

The product Leno Cross Laminated Timber fulfils the classification E1 for assemblies with and without laminated veneer lumber. For assemblies with solid wood panels "no performance determined" applies if no further tests are made.

Note:

In addition to the specific clauses relating to dangerous substances contained in this European technical approval, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Directive, these requirements need also to be complied with, when and where they apply.

2.5 Methods of verification

The assessment of the fitness of the solid wood slab for the intended use in relation to the requirements for mechanical resistance and stability, for safety in case of fire, for hygiene, health and the environment, for protection against noise, for energy economy and heat retention, as well as for durability in the sense of these Essential has been made in compliance with the assessment rules for solid wood slabs agreed upon within EOTA.

3 Evaluation and attestation of conformity and CE marking

3.1 System of attestation of conformity

According to the Decision 97/176/EC of the European Commission[18] for the product family 2/3 system 1 of the attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 1: Certification of the conformity of the product by an approved certification body on the basis of:

(a) Tasks for the manufacturer:

(1) factory production control;

(2) further testing of samples taken at the factory by the manufacturer in accordance with a prescribed test plan;

[18] Official Journal of the European Communities L 73/19 from 03/1997

(b) Tasks for the approved body:

(3) initial type-testing of the product;

(4) initial inspection of factory and of factory production control;

(5) continuous surveillance, assessment and approval of factory production control.

Note: Approved bodies are also referred to as "notified bodies".

3.2 Responsibilities

3.2.1 Tasks for the manufacturer

3.2.1.1 Factory production control

The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. This production control system shall insure that the product is in conformity with this European technical approval.

The manufacturer may only use constituent materials stated in the technical documentation of this European technical approval.

The factory production control shall be in accordance with the control plan which is part of the technical documentation of this European technical approval. The control plan is laid down in the context of the factory production control system operated by the manufacturer and deposited with Deutsches Institut für Bautechnik.[19]

The results of factory production control shall be recorded and evaluated in accordance with the provisions of the control plan.

The records shall include at least:

- description of the product and the materials and components used;
- Type of control or test;
- manufacturing date of the product and date of the test of the product ort he material or component used;
- result of controls or tests and, where applicable, comparison to requirements;
- name and sign of the person responsible for the factory production control.

3.2.1.2 Other tasks for the manufacturer

The manufacturer shall, on the basis of a contract, involve a body which is approved for the tasks referred to in section 3.1 in order to undertake the actions laid down in section 3.2.2 For this purpose, the control plan referred to in sections 3.2.1.1 and 3.2.2 shall be handed over by the manufacturer to the approved body involved.

The manufacturer shall make a declaration of conformity, stating that the construction product is in conformity with the provisions of this European technical approval. The declaration of conformity can only be given if the provisions of this European technical approval are met and the control plan is being followed.

[19] The control plan is a confidential part of the European technical approval and only handed over to the approved body involved in the procedure of attestation of conformity. See section 3.2.2.

3.2.2 Tasks for the approved bodies

The approved body shall perform the

- initial type-testing of the product,
- initial inspection of factory and of factory production control,
- continuous surveillance, assessment and approval of factory production

in accordance with the provisions laid down in the control plan.

The initial inspection of the factory shall include the inspection of the factory plant, the technical equipment and the qualification of the staff.

The approved body shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in a written report.

The approved certification body involved by the manufacturer shall issue an EC certificate of conformity of the product stating the conformity with the provisions of this European technical approval. The certificate of conformity can only be given if the provisions of this European technical approval are met and the control plan is being followed.

In cases where the provisions of the European technical approval and its control plan are no longer fulfilled the certification body shall withdraw the certificate of conformity and inform Deutsches Institut für Bautechnik without delay.

3.3 CE marking

The CE marking shall be affixed on the product itself, a label attached to it, the packaging or the accompanying commercial document.

The letters "CE" shall be followed by the identification number of the approved certification body and shall be accompanied by the following additional information:

- the name and address of the producer (legal entity responsible for the manufacture),
- the last two digits of the year in which the CE marking was affixed,
- the number of the EC certificate of conformity for the product,
- the number of the European technical approval,
- description of the element, showing its intended use,
- species of the wood used,
- number and arrangement of the layers,
- nominal thickness of the element,
- strength class of the wood of each layer,
- class of release of formaldehyde (if required),
- type and classification of the adhesive used.

For the CE - marking of laminated veneer lumber (LVL), Solid wood panels (SWP), gypsum boards and gypsum fibre boards used within the element the regulations provided in the associated European standards or European technical approvals apply. The characteristics of this product parts shall be included in the CE - marking of the product "Leno Cross Laminated Timber" according to this European technical approval.

4 Assumptions under which the fitness of the products for the intended use was favourably assessed

4.1 Manufacturing

The solid wood slabs are manufactured in accordance with the provisions of this European technical approval using the automated manufacturing process as identified in the inspection of the plant by the Deutsches Institut für Bautechnik and laid down in the technical documentation.

The layers shall be glued together to the required thickness of the solid wood slabs.

The adhesive deposited with Deutsches Institut für Bautechnik shall be used for manufacturing. This applies also to laminated veneer lumber planes if they are part of the element.

For elements with three layers and a middle layer of laminated veneer lumber it shall be observed that the boards are arranged vertically and the direction of the grain of the surface layers is arranged horizontally.

The European technical approval is issued for the product on the basis of agreed data/information, deposited with Deutsches Institut für Bautechnik, which identifies the product that has been assessed and judged. Changes to the product or production process, which could result in this deposited data/information being incorrect, should be notified to Deutsches Institut für Bautechnik before the changes are introduced. Deutsches Institut für Bautechnik will decide whether or not such changes affect the approval and consequently the validity of the CE marking on the basis of the approval and if so whether further assessment or alterations to the approval shall be necessary.

4.2 Installation

4.2.1 Design of solid wood slab elements

The European technical approval only applies to the manufacture and use of the solid wood slab. Verification of stability of the works including application of loads on the solid wood slab is not subject of this European technical approval.

Fitness for the intended use of the solid wood slab is given under the following conditions:

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

Design of the load bearing capacity of the elements may be undertaken according to EN 1995-1-1 taking into account the annexes of this European technical approval. Standards and regulations valid in the place of use shall be considered.

4.2.2 Installation of solid wood slab elements

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

Solid wood slab element installation shall be carried out by appropriately qualified personnel under the supervision of the person responsible for technical matters on site.

The elements shall be provided with an effective protection against weather in service.

5 Indications to the manufacturer

The manufacturer shall ensure that the requirements in accordance with the clauses 1, 2 and 4 as well as with the Annexes of this European technical approval are made known to those who are concerned during planning and execution of the works.

5.1 packaging, transport and storage

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

5.2 Use, maintenance, repair

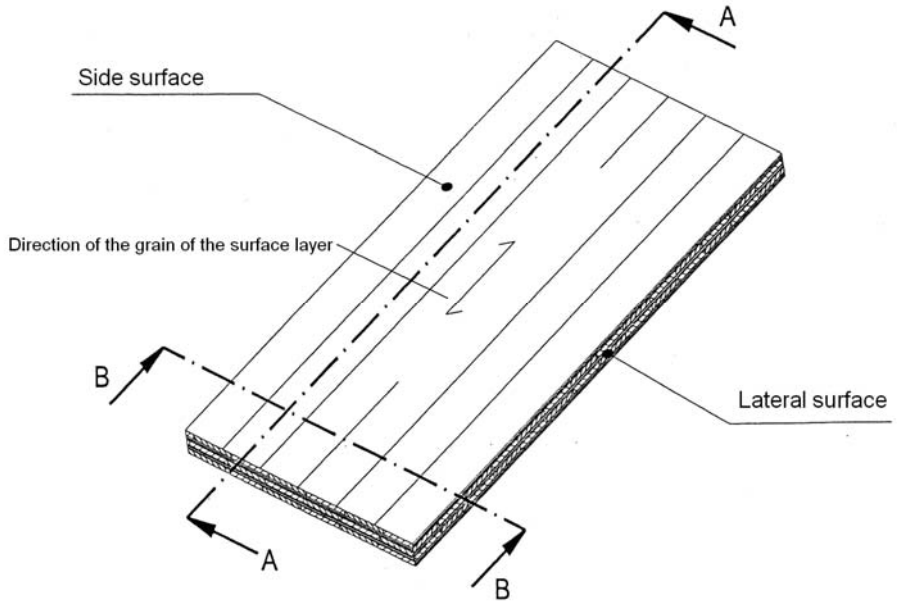
The assessment of the fitness for use is based on the assumption that maintenance is not required during the assumed intended working life. In case of a severe damage of a solid wood slab element immediate actions regarding the mechanical resistance and stability of the works shall be initiated. Should this situation arise replacement of the elements can be necessary.

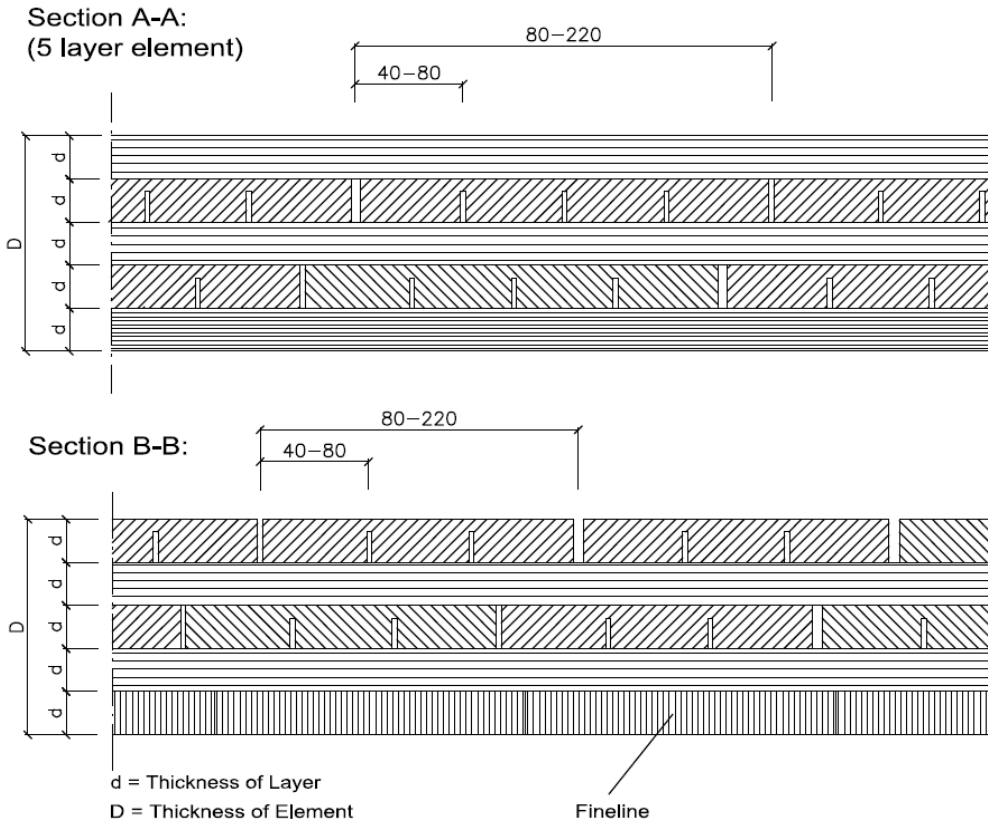
Uwe Bender
Head of Department

beglaubigt:
Christian Warns

Deutsches Institut für Bautechnik DIBt

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





Leno Cross Laminated Timber	
Construction of the elements	Annex 1 Page 1

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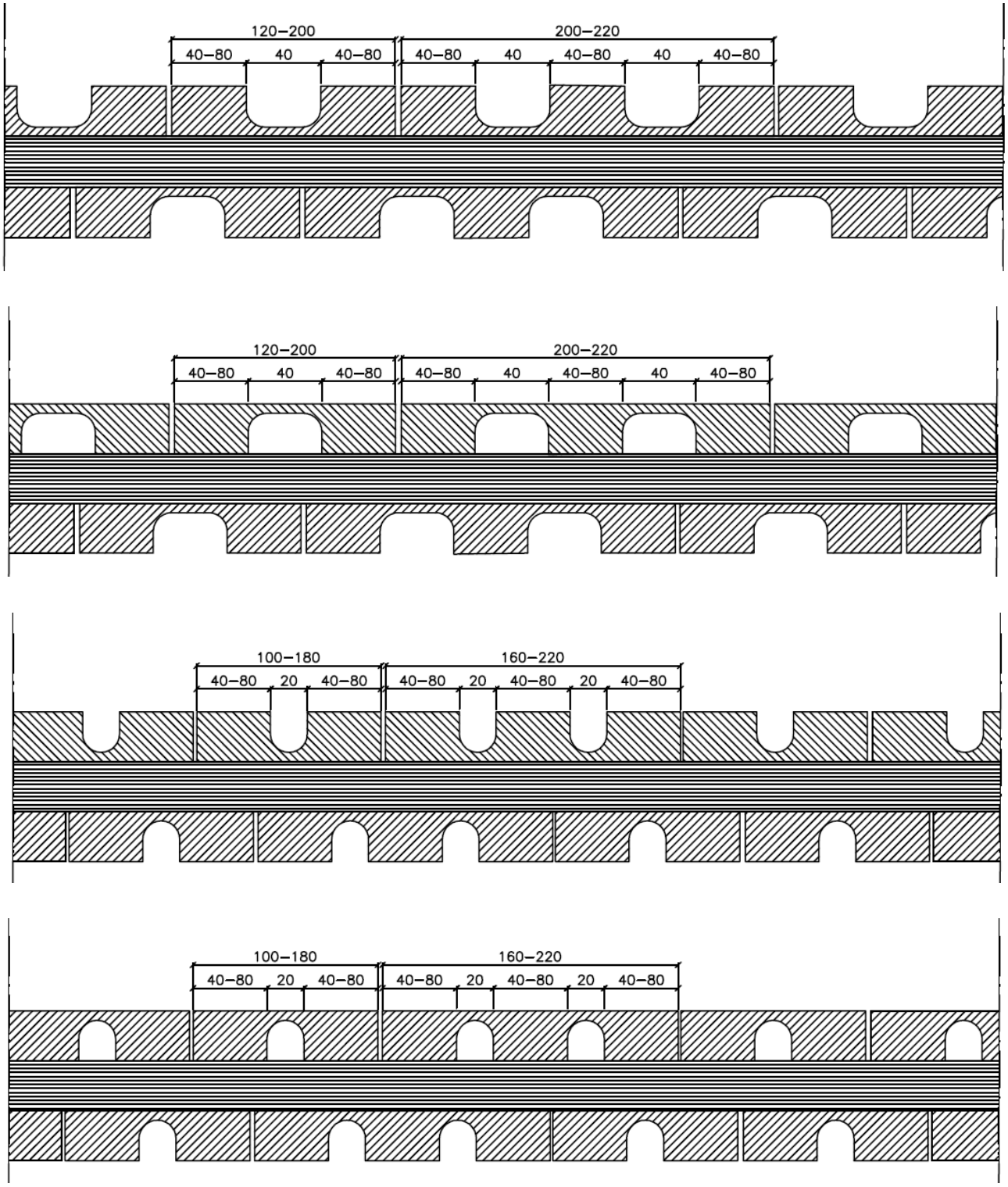
Assembly of the three layer elements with notches



Leno Cross Laminated Timber	Annex 1 Page 2
Construction of the elements	

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Fineline layer

Leno Cross Laminated Timber	Annex 1 Page 3
Construction of the elements	

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Table 1: Dimensions and specifications of the elements

Characteristic	Specification
Elements	
Thickness	30 bis 300 mm
Width	≤ 4,8 m
Length	≤ 30 m
Number of layers	≥ 3
Number of consecutive layers having the same direction	≤ 3
Maximum width of gaps between the boards	6 mm
Boards	
Material	softwood
Strength class according to EN 338 [1]	≥ C16 *
Thickness	10 to 40 mm
Width	80 to 220 mm
Ratio width to thickness of the cross-layers	≥ 4:1
Moisture of wood according to EN 13183-2 [2]	12 ± 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).

[1] EN 338:2009 Timber structures - Strength classes
[2] EN 13183-2:2002 Moisture content of a piece of sawn timber - Part 2: Estimation by electrical resistance method

Leno Cross Laminated Timber	Annex 2
Dimensions and arrangement of the elements	

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Table 2: Essential Requirements of the solid wood slabs

<table>
<tr><th>ER</th><th>Requirement</th><th>Verification method</th><th>Class / Use category / value</th></tr>
<tr><td rowspan="5"></td><td colspan="3">Mechanical resistance and stability</td></tr>
<tr><td rowspan="4">Mechanical actions in plane of the solid wood slab

Mechanical actions perpendicular to the solid wood slab</td><td colspan="2">For the calculation the characteristic strength and stiffness values of softwood according to EN 338 shall be used taking into consideration the definitions in annex 2. In addition the following values apply:
<table>
<tr><th colspan="2" rowspan="2">Characteristic</th><th colspan="2">Thickness of element</th></tr>
<tr><th>≤ 115 mm</th><th>> 115 mm</th></tr>
<tr><td>Rolling shear strength (5% - fractile)</td><td>$f_{R,k}$</td><td>0.85 N/mm²</td><td>0.70 N/mm²</td></tr>
<tr><td>Rolling shear modulus (mean value)</td><td>$G_{R,mean}$</td><td>50 N/mm²</td><td>50 N/mm²</td></tr>
</table>
For layers of one layered solid wood panels, which do not include notches, as characteristic roll shear strength $f_{R,k}$ = 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 or European technical approval 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</td></tr>
<tr><td>Use of fasteners</td><td colspan="2">According to EN 1995-1-1, for further details see annex 4</td></tr>
<tr><td>Creep and duration of load</td><td colspan="2">According to EN 1995-1-1</td></tr>
<tr><td>Dimensional stability</td><td colspan="2">Moisture content during use shall not change to such extent that adverse deformations can occur.</td></tr>
<tr><td rowspan="5">2</td><td colspan="3">Behaviour in case of fire</td></tr>
<tr><td colspan="3">Reaction to fire</td></tr>
<tr><td>Solid wood panels except for floorings</td><td rowspan="2">Commission Decision 2003/43/EC</td><td>Euroclass D-s2,d0</td></tr>
<tr><td>Floorings</td><td>Euroclass D_{fl}-s1</td></tr>
<tr><td colspan="3">Resistance to fire</td></tr>
<tr><td>Charring rate</td><td>EN 1995-1-2</td><td>0,7 mm/min</td></tr>
<tr><td rowspan="3">3</td><td colspan="3">Hygiene, health and the environment</td></tr>
<tr><td>Vapour permeability μ</td><td>EN 12524 [3]</td><td>20 to 50</td></tr>
<tr><td>Release of formaldehyde</td><td>EN 13986 with regard to solid wood panels</td><td>Klasse E1 *</td></tr>
</table>

[3] EN 12524:2000 Building materials and products - Hygrothermal properties - Tabulated design values

Table 2 (continued)

4	**Safety in use**		
	Slipperiness		No performance determined
	Impact resistance		No performance determined
5	**Protection against noise**		
	Airbourne sound insulation		No performance determined
	Impact sound insulation		No performance determined
	Sound absorption		No performance determined
6	**Energy economy and heat retention**		
	Thermal conductivity λ	EN 12524[3]	0.13 W/(m²·K)
	Air tightness		No performance determined
	Thermal inertia c_p	EN 12524[3]	1.600 J/(kg·K)
-	**Durability**		
	Use only in service classes	EN 1995-1-1	1 und 2
* For assemblies with solid wood panels "no performance determined" applies.			

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Recommendations for design and calculation of the elements and fasteners

1 Recommendations for design of the elements

1.1 General

Design, calculation and realization can be done 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. In annex 5 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 elements.

For the calculations regarding rolling shear, bending stresses and buckling of elements with three layers and large notches (see Annex 1, page 11) 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.

1.2 Characteristic values

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

While calculating the part of the deformation due to shear forces, the element's thickness D regardless of the configuration and a shear modulus of G = 60 N/mm² may be used.

1.3 Mechanical actions perpendicular to element plane

1.3.1 Bending and shear

For the calculation of the characteristic values of the element according to annex 5, only the boards, which are oriented parallel to the direction of load, might be considered.

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 1.2 of this annex.

Tension loads perpendicular to the element should be avoided.

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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.

1.4.1 Shear

Shear stresses may be calculated with the brutto cross section A_{Brutto} (with D = thickness of the element and
H = height of the element).

These shear stress shall be compared with an effective characteristic shear value $f_{v,k}$ according to the following formula:

$$f_{v,k} = \min \begin{cases} 3{,}5 \\ 8{,}0 \cdot \frac{D_{net}}{D} \\ 2{,}5 \cdot \frac{(n-1) \cdot (a^2 + b^2)}{6 \cdot D \cdot b} \end{cases} \quad \text{in N/mm}^2$$

with

D thickness of the element (see annex 1)

D_{net} Sum of the longitudinal layers ort he perpendicular layers within the element respectively, the smaller value is decisive

n Number of board layers in the element, adjacent layers with parallel oriented lamellas shall be counted as one layer

a, b width of the boards of the longitudinal or perpendicular layer, b > a shall be observed.

1.4.2 Tension and compression

The behaviour in bearing- and deformation in the element's plane can be calculated according to EN 1995-1-1 using the strength and stiffness values given in chapter 1.2 of this annex.

1.5 Buckling

For the calculation of buckling the instability factor for glued laminated timber might be taken into account. The calculation shall be performed with the geometry of the cross section as is.

2 Recommendations for the design of the fasteners

2.1 General

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

Side surfaces are the surfaces of the element parallel to the plane of the element.

Lateral surfaces are the surfaces perpendicular to the plane of the element, consisting of the lateral surfaces and the cross grain of the boards.

As fasteners nails, wood screws, bolts and dowels, split ring and toothed-plate connectors according to EN 1995-1-1 or a European technical approval or according to national rules may be used.

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

The minimum values for distance and spacing for the fasteners have to be taken from chapter 3 of this annex.

The rules for the design of fasteners stated below are applicable to areas without notches according to annex 1, page 2. The edge distances to notches have to be observed.

2.2 Bolts and dowels

The characteristic value of junctions with bolts and dowels in the side surfaces can be calculated as follows:

$$f_{h,\alpha,k} = \frac{32 \cdot (1 - 0{,}015 \cdot d)}{1.1 \cdot \sin^2 \alpha + \cos^2 \alpha} \text{ in N/mm²}$$

Decisive for the embedment strength is the direction of the grain of the surface layer. For bolts with a diameter ≥ 10 mm $n_{ef} = n$ may be assumed.

The characteristic value of junctions with bolts and dowels in the lateral surfaces can be calculated as follows:

$$f_{h,k} = 9 \cdot (1 - 0.017 \cdot d) \text{ in N/mm²}$$

2.3 Nails

Nails should have a diameter of at leas 4 mm. The characteristic value of the load-bearing capacity of nails in the side surfaces with loads perpendicular to their axis can be calculated according to EN 1995-1-1, the embedment strength may be calculated with the density of the top layer of boards. The rope effect can be taken into account. If the embedment length is as least as large as the thickness of the outer layer, a characteristic density of ρ_k = 400 kg/m³ can be assumed. Decisive for the minimum spacing is the direction of the grain of the surface layer.

Nails in the lateral surfaces might not be taken into consideration as load-bearing.

The characteristic value of the embedment strength, regardless of the angle between direction of the force and direction of the grain, can be assumed to:

$$f_{h,k} = 60 \cdot d^{-0.5} \text{ in N/mm²}$$

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). The nails must at least go through the layers. The characteristic axial withdrawal strength can under these circumstances be assumed to:

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

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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2.4 Screws

As decisive diameter of the screws the outer diameter of the thread applies. Screws loaded perpendicular to their axis in the side surfaces should have a diameter of at least 4 mm, screws in the lateral surfaces 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 ≤ 8 mm pre-drilling is not required. If a pre-drilling is required, it has to be done with 0.7· d in the lateral surfaces.

Shear, side surfaces

The characteristic value of the load bearing capacity of screws in the side surfaces of the board can be calculated according to EN 1995-1-1. The regulations for wood screw connections in softwood shall be used. As density the characteristic value of the wood of the surface 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. The shear force must be oriented in a way that it is perpendicular to the screw and parallel to the side surface layer.

For angles between 45° ≤ α ≤ 90° between the axis of the screw and the direction of the grain of the surface layer, the characteristic values for 90° can be assumed, if the penetration depth is only calculated as the value perpendicular to the side surface.

Shear, lateral surfaces

Unattached to the arrangement of a screw in the lateral surface (which means under angles 0° ≤ α ≤ 90° between axis of the screw and direction of the grain) the characteristic value of the embedment strength can be assumed to:

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

with

d nominal diameter of the screw in mm,

The shear load must be oriented perpendicular to the screw and parallel to the lateral surface of the cross laminated timber. The factor n_{ef} shall be calculated as for softwood. If a component of the force is oriented perpendicular to the side surface, there ist he risk of a failure due to transverse tension. In case the ratio a/h is not over 0.7, a calculation against the failure due to transverse tension is advised. For ratios 0,5 ≤ a/h < 0.7 and a_1≤ 2t the characteristic load bearing capacity of a screw in the verification against transverse tension can be assumed to:

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

Herein mean:

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

t Thickness of the cross laminated timber under Dicke to transverse tension loads

a_1 see pictures in annex 4 and annex 5

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

Withdrawal, side and lateral surfaces

For withdrawal forces against screws in the side or lateral surfaces 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 of the screw shall be observed.

The characteristic withdrawal strength can be assumed to:

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

Herein mean:

$F_{ax,i,Rk}$ characteristic value of the withdrawal strength of the screw according to European Technical approval 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 softwood elements with the characteristic density of the associated layer in the area of the head of the screw.

For screws that go at leas through three layers of boards and have at least an penetration depth of 4d, the following pull thorugh resistance can be assumed:

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

with

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

l_{ef} Lenght of the thread 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

Pushing in of the screws, side or lateral surfaces

For loads pushing the screws in the side or lateral surfaces 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 of the screw shall be observed. The characteristic value of the load bearing capacity of a fully threaded screw under compression loads may be calculated as the $F_{ki,Rk}$ with:

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

with:

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

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

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

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

d_2 = core diameter of the screw in mm

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

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

c_h = $(0.019 + 0.012 \cdot d) \cdot \rho_k \cdot \left(\frac{90° + \alpha}{180°}\right)$ = 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

$E_s * I_s = \frac{210000 \cdot \pi \cdot d_2^4}{64} \text{Nmm}^2$ = bending stiffness of the core section of the screw

2.5 Split ring connectors and toothed-plate connectors

The characteristic value of the load-bearing capacity of split ring connectors in the side surfaces shall be calculated according to EN 1995-1-1 as for an angle between direction of the force and direction of the grain of $\alpha = 0°$.

The characteristic value of the load-bearing capacity of toothed-plate connectors shall be calculated according to EN 1995-1-1 as for an angle between direction of the force and direction of the grain of $\alpha = 0°$, regardless of the actual angle between the direction of the force and the direction of the grain. National regulations shall be observed.

Toothed-plate connectors in the lateral surfaces might not be taken into consideration as load-bearing.

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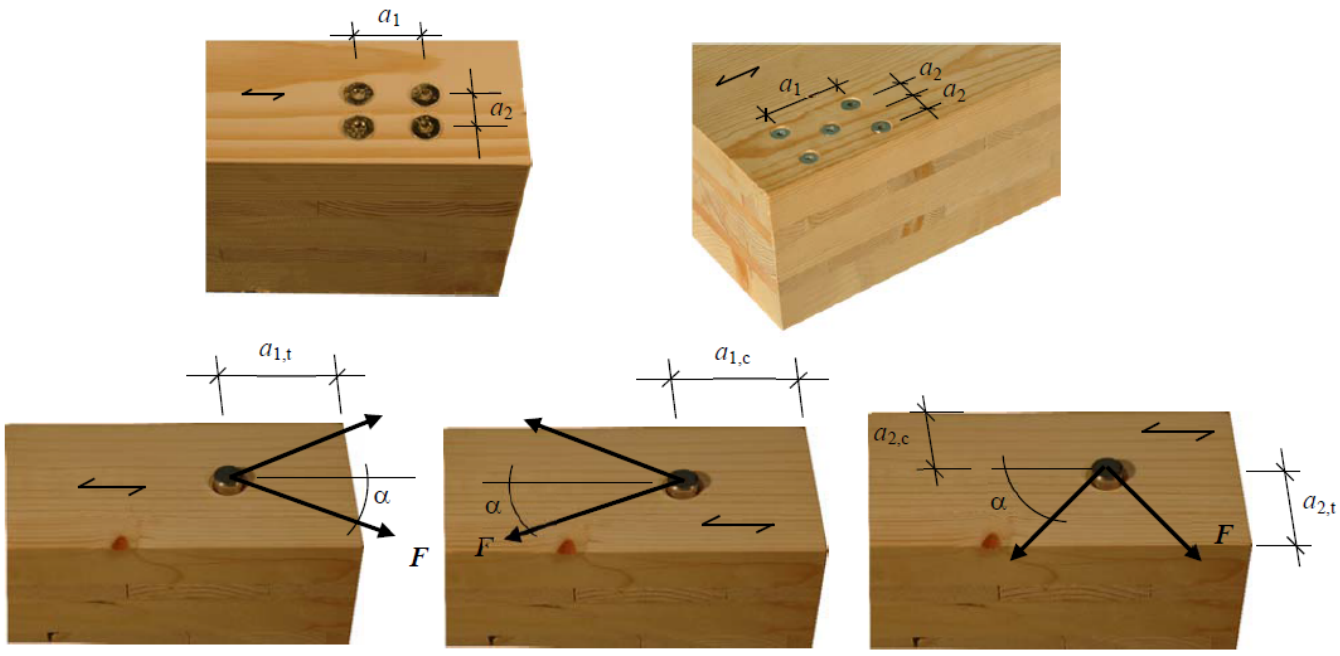
3 Minimum distances for fasteners

3.1 Minimum distances for fasteners in the side surfaces



Fasteners	$a_{1,t}$	$a_{1,c}$	a_1	$a_{2,t}$	$a_{2,c}$	a_2
Screws [1)]	6 ·d	6 ·d	4 ·d	6 ·d	2.5 ·d	2.5 ·d
Nails	(7+3 cosα) ·d	6 ·d	(3+3 cosα) ·d	(3+4 sinα) ·d	3 ·d	3 ·d
dowels	5 ·d	4 · d · sinα	(3+2 cosα) ·d	3 ·d	3 ·d	3 ·d
bolts	5 ·d	4 · d · sinα (min 4 ·d)	(3+2 cosα) ·d (min 4 ·d)	3 ·d	3 ·d	4 ·d

α angle between direction of the force and direction of the grain of the surface layer
[1)] selfdrilling wood screws

Note: in the notation of EN 1995-1-1 the indices slightly differ to the indices shown above:

This ETA	EN 1995-1-1
$a_{1,t}$	$a_{3,t}$
$a_{1,c}$	$a_{3,c}$
$a_{2,t}$	$a_{4,t}$
$a_{2,c}$	$a_{4,c}$

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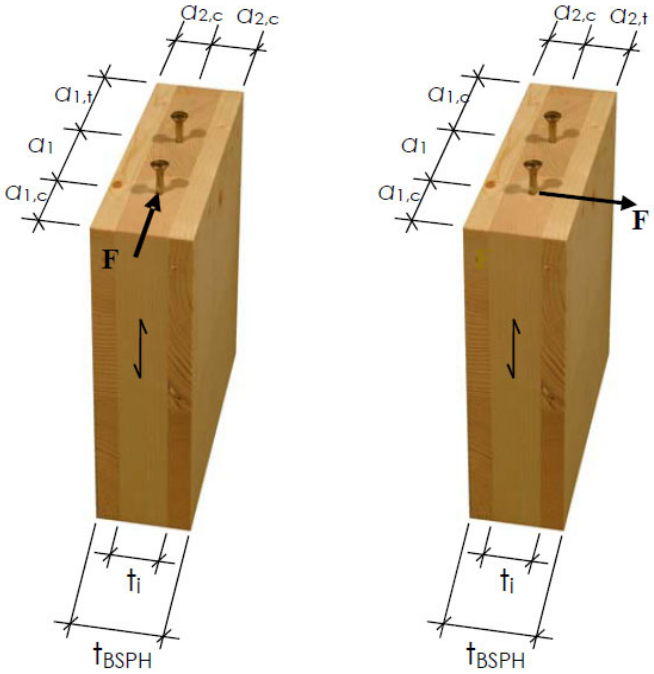
3.2 Minimum distances, minimum thicknesses, minimum board thicknesses and minimum penetration depths for fasteners in the lateral surfaces



	Screws [1]	dowels	bolts
a_1	10 ·d	4 ·d	4 ·d
a_2	3 ·d	3 ·d	4 ·d
$a_{1,t}$	12 ·d	5 ·d	5 ·d
$a_{1,c}$	7 ·d	3 ·d	4 ·d
$a_{2,c}$	5 ·d	3 ·d	3 ·d
[1] selfdrilling wood screws			

Fastener	Minimum thickness of the decisive board layer t_i in mm	Minimum thickness of the cross laminated timber t_{BSPH} in mm	Minimum thickness of the CLT/ minimum penetration legth of the fastener t_1/t_2 in mm
selfdrilling wood screws	d > 8mm: 3 ·d d ≤ 8 mm: 2 ·d	10 ·d	10 ·d
Bolts and dowels	d	6 ·d	5 ·d

For screws with d ≤ 12 mm an edge distance ≥ 42 mm is allowed.
Note: in the notation of EN 1995-1-1 the indices slightly differ to the indices shown above:

This ETA	EN 1995-1-1
$a_{1,t}$	$a_{3,t}$
$a_{1,c}$	$a_{3,c}$
$a_{2,t}$	$a_{4,t}$
$a_{2,c}$	$a_{4,c}$

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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 $\overline{h}_i/(G_R \cdot b)$.
The effective moment of inertia is calculated by:

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

$$\gamma_1 = \frac{1}{1 + \frac{\pi^2 \cdot E_0 \cdot A_1 \cdot \overline{h_1}}{G_R \cdot b \cdot l^2}}; \qquad \gamma_2 = 1; \qquad \gamma_3 = \frac{1}{1 + \frac{\pi^2 \cdot E_0 \cdot A_3 \cdot \overline{h_2}}{G_R \cdot b \cdot l^2}}$$

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

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

The verification of the bending performance is done by determination of the bending stress at the boundary of the boards. The bending stress in the middle of the boards may remain unconsidered.

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

The verification of the shear performance is done by determination of the shear stress in the decisive plane:

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

Legend:

h_i	=	thickness of the layer i parallel to the direction of load transfer [mm]
$\overline{h}_i$	=	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 [Nmm²]
G_R	=	rolling shear modulus [N/mm²]
E_0	=	modulus of elasticity parallel to the grain of the boards [N/mm²]

Leno Cross Laminated Timber	Annex 5
Design according to the theory of flexible bonded beams	