Deutsches Institut für Bautechnik

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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-11/0189 of 7 April 2016

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	Derix X-LAM
Product family to which the construction product belongs	Solid wood slab element to be used as a structural element in buildings
Manufacturer	W. u. J. Derix GmbH & Co. Dam 63 41372 Niederkrüchten DEUTSCHLAND
Manufacturing plant	W. u. J. Derix GmbH & Co. Dam 63 41372 Niederkrüchten DEUTSCHLAND Poppensieker & Derix GmbH & Co. KG Industriestraße 24 49492 Westerkappeln DEUTSCHLAND
This European Technical Assessment contains	22 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	European Assessment Document (EAD) 130005-00-0304
This version replaces	ETA-11/0189 issued on 3 January 2013

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Specific Part

1 Technical description of the product

Derix X-LAM is a cross laminated timber element made of softwood consisting of an odd number of 3 layers up to 11 layers. The lay-up of the cross laminated timber shall be symmetrical to its centre plane. The elements are plane.

Individual layers consist of parallel oriented lamellae made of strength graded boards or wood based panels. Wood based panel layers may be bonded to layers made of softwood lamellae or solid wood panels perpendicular (angle of 90°) to each other. The overall thickness of the layers consisting of wood based panels may not exceed 50 % of the element thickness.

In elements with at least five layers, two adjacent layers may be oriented with parallel grain direction. With the exception of the solid wood panels according to EN 13986[1] it is not allowed to arrange wood based panels in two adjacent layers.

The components and the system setup of the product are given in Annex 1, Figure 1 and Figure 2.

The application of chemical substances (wood preservatives and flame retardants) is not subject of the European technical assessment.

Wood species are spruce, fir, pine, larch and Douglas fir. For layers consisting of wood based panels oriented strand boards (OSB), plywood, laminated veneer lumber (LVL), and single-layered solid wood panels in each case according to EN 13986 and laminated veneer lumber (LVL) according to EN 14374[2] or a European technical assessment may be used.

Manufacturing

The cross laminated timber elements are manufactured in accordance with the provisions of this European technical assessment using the automated manufacturing process in accordance with the technical documentation.

The layers shall be bonded together to the required thickness of the cross laminated timber.

Specifications of the used boards are given in Annex 2. Boards are visually or machine strength graded. Only technically dried wood shall be used.

The boards may be connected by finger joints in longitudinal direction according to EN 14080[3]. There shall be no butt joints. Wood-based panels may not be connected in longitudinal direction. Joints parallel to the longitudinal direction shall be taken into account.

Only wood based panels, which fulfil the requirements for the given service classes according to EN 1995-1-1[4], shall be used. Only wood based panels which can be assigned to formaldehyde class E1 according to EN 13986 shall be used.

The solid wood slab elements correspond to the specifications given in Annexes 1 to 3 of this European technical assessment. The material characteristics, dimensions and tolerances of the solid wood slab elements not indicated in these Annexes are given in the technical documentation of the European technical assessment.

1	EN 13986:2004+A1:2015	Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
2	EN 14374:2004	Timber structures - Structural laminated veneer lumber - Requirements
3	EN 14080:2013	Timber structures - Glued laminated timber and glued solid timber - Requirements
4	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

Design

The European Technical Assessment only applies to the manufacture and use of solid wood slab elements. Verification of stability of the building while using the solid wood slab elements is not subject of the European Technical Assessment.

The following conditions shall be observed:

- Design of the solid wood slab elements is carried out under the responsibility of an engineer experienced in such products.
- 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 solid wood slab element can be performed according to EN 1995-1-1, taking into account of Annexes 2 to 6 of the European Technical Assessment. Standards and regulations valid in the place of use shall be considered.

Packaging, transport, storage, maintenance and repair

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.

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.

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.

Solid wood slab elements shall be protected against detrimental change of moisture. The safety-at-work and health protection regulations have to be observed.

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

The solid wood slab element is intended to be used as a structural or non-structural element in buildings and timber structures. The solid wood slab 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.

Members which are directly exposed to the weather shall be provided with an effective protection for the solid wood slab element in service.

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 1 to 6.

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.

For gluing the layers among each other to form a solid wood slab element as well as the finger joints of the individual boards an adhesive type I according to EN 301[5] is to be used. Specifications are deposited with Deutsches Institut für Bautechnik.

3.2 Safety in case of fire (BWR 2)

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

[5] EN 301:2013 Adhesives, phenolic and aminoplastic, for load-bearing timber structures - Classification and performance requirements

3.3 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content of dangerous substances	The manufacturer has submitted a written declaration to the Technical Assessment Body (DIBt) that no dangerous substances > 0.1 wt. % are used in the product assessed by the present ETA. Only wood based panels which can be assigned to formaldehyde class E1 according to EN 13986 shall be used. The use of wood preservatives and flame retardants is excluded. The chemical composition of the adhesives for gluing the cross laminated timber among each other and the wood-based panels as well as the finger joints of the individual boards has to be in compliance with the chemical composition deposited at the Technical Assessment Body (DIBt).
Release scenarios regarding BWR 3	IA 1, IA 2
Water vapour permeability – Water vapour transmission	Annex 3

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	Annex 3
Impact sound insulation	Annex 3
Sound absorption	Annex 3

3.6 Energy economy and heat retention (BWR 6)

Essential characteristic	Performance
Thermal conductivity	Annex 3
Air permeability	Annex 3
Thermal inertia	Annex 3

3.7 Sustainable use of natural resources (BWR 7)

The performance of this product in terms of sustainable use of natural resources has not been investigated.

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 7 April 2016 by Deutsches Institut für Bautechnik

Andreas Kummerow
p.p. Head of Department

beglaubigt:
Deniz

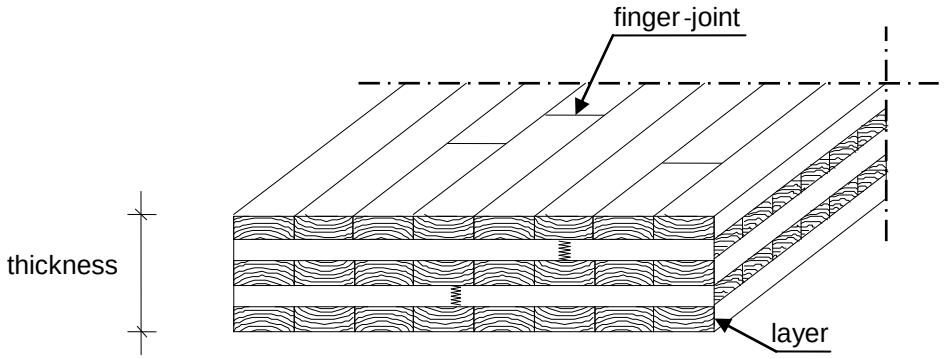

Figure 1: Principle structure of the cross laminated timber element (five layers)

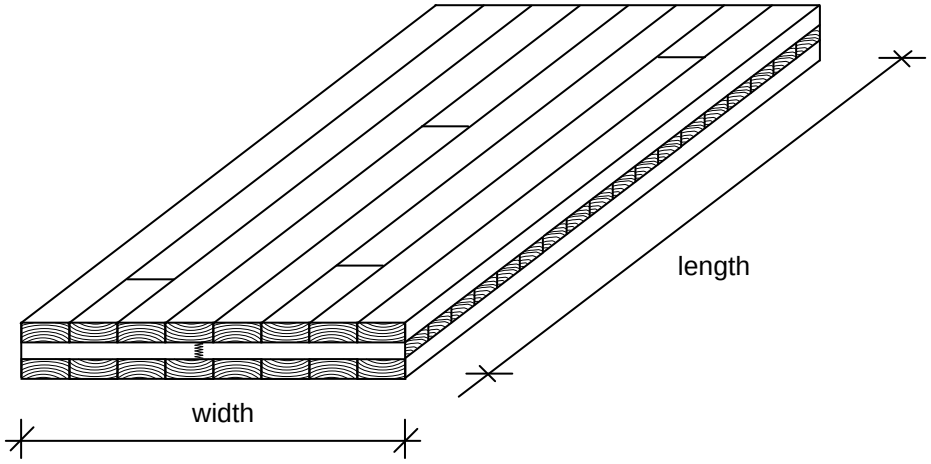

Figure 2: Cross laminated timber element (three layers)

Derix X-LAM	Annex 1
Structure of cross laminated timber	

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Table 1: Dimensions and specifications of the elements

Characteristic	Dimensions and specifications
Cross laminated timber element	
Thickness	60 to 400 mm
Tolerance in thickness	± 2 mm if thickness ≤ 200 mm ± 3 mm if thickness > 200 mm
Width	≤ 3.50 m
Length	≤ 18.00 m
Number of layers	3 ≤ n ≤ 11
Number of consecutive layers having the same grain direction	≤ 2 for n ≥ 5
Maximum width of gaps between adjacent boards in longitudinal layers in cross layers	 3 mm 6 mm
Boards	
Material	Spruce, fir, pine, larch and Douglas fir
Strength class according to EN 338[1] resp EN 14081-1[2]	≥ C16 *)
Surface	planed or grinded
Thickness in longitudinal layers in cross layers	 15 to 45 mm 15 to 40 mm
Width	80 to 260 mm
Ratio width to thickness of the cross-layers	≥ 4:1
Moisture of wood according to EN 13183-2[3]	8 ± 2; 9 ± 2, 10 ± 2; 11± 2, 12 ± 2 (in %) Within one cross laminated timber element only one of the specified moisture ranges shall be applied.
Finger joints	EN 14080
Wood based panels	
Material	OSB, plywood, LVL and single-layered solid wood panels according to EN 13986 or ETA and LVL according to EN 14374 or ETA
Thickness	15 to 45 mm
Joints	Wood-based panels may not be connected in longitudinal direction. Joints parallel to the longitudinal direction shall be taken into account.
*) In each layer 10 % of a lower strength class may be used.	

1	EN 338:2009	Timber structures - Strength classes
2	EN 14081-1:2005+A1:2011	Timber structures. Strength graded structural timber with rectangular cross section. General requirements
3	EN 13183-2:2002	Moisture content of a piece of sawn timber - Part 2: Estimation by electrical resistance method

Derix X-LAM	Annex 2
Dimensions and specifications of the cross laminated timber	

Table 2: Essential requirements of the cross laminated timber

BWR	Requirement	Verification method	Class / Use category / Value
1	**Mechanical resistance and stability**		
	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. Wood based-panels shall fulfil the requirements given in EN 13986, EN 14374 or in a ETA and the technical class shall be declared. In addition the following values apply:		
	Panel shear strength	Shear strength for the calculation with the gross cross section (5% fractile)	$f_{v,k}$ as given in Table 3 or in Annex 3
	Bending strength	Rolling shear strength (5% fractile)	$f_{R,k}$ 1.0 N/mm²
		Rolling shear modulus (mean value)	$G_{R,mean}$ 50 N/mm²
	For references regarding the calculation see Annexes 4 to 6. National regulations might have to be followed.		
	Use of fasteners	according to EN 1995-1-1, for further details see Annex 5	
	Creep and duration of load	according to EN 1995-1-1	
	Dimensional stability	Moisture content during use shall not change to such an extent that adverse deformations can occur.	
	In-service environment	EN 1995-1-1	1 and 2
	Bond integrity	EAD 130005-00-0304	Passed
2	**Behaviour in case of fire**		
	Reaction to fire		
	Solid wood panels except for floorings	Commission Decision 2005/610/EC	Euroclass D-s2, d0
	Floorings		Euroclass D_{fl}-s1
	Resistance to fire		
	Charring rate only applies for tightly butted boards	EN 1995-1-2[4]	β_0 = 0.65 mm/min β_n = 0.7 mm/min
3	**Hygiene, health and the environment**		
	Water vapour resistance factor μ	no performance assessed	
	Content of dangerous substances	EAD 130005-00-0340	See clause 3
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 insul.	No performance assessed	
	Impact sound insulation	No performance assessed	
	Sound absorption	No performance assessed	
6	**Energy economy and heat retention**		
	Thermal conductivity λ	No performance assessed	
	Air tightness	No performance assessed	
	Thermal inertia c_p	No performance assessed	

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

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Table 3: Characteristic shear strength $f_{v,k}$ calculated with the gross cross section (for mechanical actions in plane of the cross laminated timber)

Element Thickness in mm	Number of layers	Thickness of individual layers in mm (written in **bold** characters for longitudinal layers)											$f_{v,k}$ [1)] in N/mm²
63	3	21	**21**	21									2.5
85	3	32	**21**	32									1.9
96	3	32	**32**	32									1.9
112	3	40	**32**	40									1.7
105	5	21	**21**	21	**21**	21							3.0
147	5	35	**21**	35	**21**	35							2.2
162	5	40	**21**	40	**21**	40							2.1
184	5	40	**32**	40	**32**	40							2.0
63	3	**21**	21	**21**									2.5
85	3	**32**	21	**32**									1.9
96	3	**32**	32	**32**									1.9
101	3	**40**	21	**40**									1.7
112	3	**40**	32	**40**									1.7
120	3	**40**	40	**40**									1.8
105	5	**21**	21	**21**	21	**21**							3.0
138	5	**32**	21	**32**	21	**32**							2.3
162	5	**40**	21	**40**	21	**40**							2.1
184	5	**40**	32	**40**	32	**40**							2.0
200	5	**40**	40	**40**	40	**40**							2.1
147	7	**21**	21	**21**	21	**21**	21	**21**					3.3
191	7	**32**	21	**32**	21	**32**	21	**32**					2.5
213	7	**32**	32	**32**	21	**32**	32	**32**					2.5
223	7	**40**	21	**40**	21	**40**	21	**40**					2.2
234	7	**40**	21	**40**	32	**40**	21	**40**					2.2
256	7	**40**	32	**40**	32	**40**	32	**40**					2.2
280	7	**40**	40	**40**	40	**40**	40	**40**					2.3
244	9	**32**	21	**32**	21	**32**	21	**32**	21	**32**			2.7
260	9	**40**	21	**32**	21	**32**	21	**32**	21	**40**			2.3
284	9	**40**	21	**40**	21	**40**	21	**40**	21	**40**			2.3
288	9	**32**	32	**32**	32	**32**	32	**32**	32	**32**			2.6
304	9	**40**	32	**32**	32	**32**	32	**32**	32	**40**			2.2

Derix X-LAM

Essential requirements of the cross laminated timber

Annex 3

Table 3 (continued)

Element Thickness in mm	Number of layers	Thickness of individual layers in mm (written in **bold** characters for longitudinal layers)											$f_{v,k}$ [1)] in N/mm²
320	9	**40**	32	**40**	32	**32**	32	**40**	32	**40**			2.3
328	9	**40**	32	**40**	32	**40**	32	**40**	32	**40**			2.3
360	9	**40**	40	**40**	40	**40**	40	**40**	40	**40**			2.4
378	11	**40**	21	**40**	32	**40**	32	**40**	32	**40**	21	**40**	2.4
400	11	**40**	32	**40**	32	**40**	32	**40**	32	**40**	32	**40**	2.4
224	7	**32**	**32**	32	**32**	32	**32**	**32**					1.7
218	7	**40**	**32**	21	**32**	21	**32**	**40**					1.3
234	7	**40**	**40**	21	**32**	21	**40**	**40**					1.3
256	7	**40**	**40**	32	**32**	32	**40**	**40**					1.4
264	7	**40**	**40**	32	**40**	32	**40**	**40**					1.4
272	7	**40**	**40**	40	**32**	40	**40**	**40**					1.5
280	7	**40**	**40**	40	**40**	40	**40**	**40**					1.5
60	3	**20**	20	**20**									2.7
80	3	**30**	20	**30**									2.0
90	3	**30**	30	**30**									2.1
100	3	**40**	20	**40**									1.6
110	3	**40**	30	**40**									1.7
120	3	**40**	40	**40**									1.8
130	5	**30**	20	**30**	20	**30**							2.5
140	5	**40**	20	**20**	20	**40**							2.3
150	5	**30**	30	**30**	30	**30**							2.5
160	5	**40**	20	**40**	20	**40**							2.0
170	5	**40**	30	**30**	30	**40**							2.2
180	5	**40**	30	**40**	30	**40**							2.1
200	5	**40**	40	**40**	40	**40**							2.1
140	7	**20**	20	**20**	20	**20**	20	**20**					3.4
160	7	**30**	20	**20**	20	**20**	20	**30**					3.0
180	7	**30**	20	**30**	20	**30**	20	**30**					2.7
200	7	**30**	30	**30**	20	**30**	30	**30**					2.7
220	7	**40**	20	**40**	20	**40**	20	**40**					2.2

Table 3 (continued)

Element Thickness in mm	Number of layers	Thickness of individual layers in mm (written in **bold** characters for longitudinal layers)											$f_{v,k}$ [1)] in N/mm²
240	7	**40**	20	**40**	40	**40**	20	**40**					2.3
260	7	**40**	30	**40**	40	**40**	30	**40**					2.3
280	7	**40**	40	**40**	40	**40**	40	**40**					2.3
230	9	**30**	20	**30**	20	**30**	20	**30**	20	**30**			2.8
250	9	**40**	20	**30**	20	**30**	20	**30**	20	**40**			2.6
280	9	**40**	20	**40**	20	**40**	20	**40**	20	**40**			2.3
270	9	**30**	30	**30**	30	**30**	30	**30**	30	**30**			2.8
290	9	**40**	30	**30**	30	**30**	30	**30**	30	**40**			2.6
310	9	**40**	30	**40**	30	**30**	30	**40**	30	**40**			2.4
320	9	**40**	30	**40**	30	**40**	30	**40**	30	**40**			2.4
360	9	**40**	40	**40**	40	**40**	40	**40**	40	**40**			2.4
370	11	**40**	20	**40**	30	**40**	30	**40**	30	**40**	20	**40**	2.4
390	11	**40**	30	**40**	30	**40**	30	**40**	30	**40**	30	**40**	2.4
190	7	**30**	**30**	20	**30**	20	**30**	**30**					1.7
210	7	**30**	**30**	30	**30**	30	**30**	**30**					1.8
230	7	**30**	**30**	40	**30**	40	**30**	**30**					1.6
240	7	**40**	**40**	20	**40**	20	**40**	**40**					1.3
260	7	**40**	**40**	30	**40**	30	**40**	**40**					1.4
280	7	**40**	**40**	40	**40**	40	**40**	**40**					1.5
240	9	**30**	**30**	20	**30**	20	**30**	20	**30**	**30**			2.0
270	9	**30**	**30**	30	**30**	30	**30**	30	**30**	**30**			2.1
300	9	**40**	**40**	20	**40**	20	**40**	20	**40**	**40**			1.6
330	9	**40**	**40**	30	**40**	30	**40**	30	**40**	**40**			1.7
360	9	**40**	**40**	40	**40**	40	**40**	40	**40**	**40**			1.8
290	11	**30**	**30**	20	**30**	20	**30**	20	**30**	20	**30**	**30**	2.2
310	11	**30**	**30**	20	**30**	30	**30**	30	**30**	20	**30**	**30**	2.2
360	11	**40**	**40**	20	**40**	20	**40**	20	**40**	20	**40**	**40**	1.8
400	11	**40**	**40**	30	**40**	30	**40**	30	**40**	30	**40**	**40**	1.9
60	3	20	**20**	20									2.7
70	3	20	**30**	20									2.3
80	3	30	**20**	30									2.0
90	3	30	**30**	30									2.1

Table 3 (continued)

Element Thickness in mm	Number of layers	Thickness of individual layers in mm (written in **bold** characters for longitudinal layers)											$f_{v,k}$ [1] in N/mm²
100	3	30	**40**	30									1.9
110	3	40	**30**	40									1.7
120	3	40	**40**	40									1.8
100	5	20	**20**	20	**20**	20							3.2
110	5	20	**20**	30	**20**	20							2.9
120	5	20	**30**	20	**30**	20							2.7
130	5	30	**20**	30	**20**	30							2.5
140	5	30	**30**	20	**30**	30							2.5
150	5	30	**30**	30	**30**	30							2.5
160	5	40	**20**	40	**20**	40							2.0
170	5	30	**40**	30	**40**	30							2.2
180	5	40	**30**	40	**30**	40							2.1
190	5	40	**40**	30	**40**	40							2.1
200	5	40	**40**	40	**40**	40							2.1

[1] Values apply to a minimum board width of
120 mm for a board thickness of 20 or 21 mm
140 mm for a board thickness of 30 or 32 mm
160 mm for a board thickness of 40 mm

For elements with lay-ups differing from those given in Table 3 the shear strength for the calculation with the gross cross section may be calculated by :

$$f_{v,k} = \min \begin{cases} 3.5 \\ 8.0 \cdot \dfrac{h_{net}}{h_{tot}} \\ 2.0 \cdot \dfrac{1}{6 \cdot h_{tot}} \cdot \sum_{i=1}^{n-1} \dfrac{b_i^2 + b_{i+1}^2}{a_i} \end{cases} \quad \text{in N/mm}^2$$

with n = number of layers within the element, neighbouring layers with parallel lamellar shall be considered as one layer

h_{net} = total thickness of longitudinal or cross layers within the element, the smaller value applies

h_{tot} = total thickness of the element (sum of longitudinal and cross layers)

b_i = boardwidth in layer i

b_{i+1} = boardwidth in layer i+1

a_i = max $\{b_i; b_{i+1}\}$

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1 Mechanical actions perpendicular to the plane of the element

Stress distribution within the element shall be calculated taking into account the shear deformation of the cross layers.

For simply supported cross laminated timber elements with up to 5 layers the stress distribution may be calculated according to EN 1995-1-1, Annex B as mechanically jointed beam where the value s_i/K_i is substituted by $\overline{h_i}/(G_R \cdot b)$

with $\overline{h_i}$ = thickness of the cross layer
G_R = 50 N/mm^2 shear modulus of the cross layer
b = width of the cross layer.

(Design according to the theory of flexible bonded beams see Annex 6)

For cross laminated timber with more than 5 layers numerical solutions shall be used offered by computer programs taking into account the shear deformation of the cross layers.

For the design of cross laminated timber the characteristic strength and stiffness values shall be taken from Annex 3.

For the bending design only the stresses at the edges of the boards are decisive.

For the calculation of the cross-section values according Annex 6 the boards and wood-based panels in load-bearing direction may taken into account.

For the verification of the bending strength the design bending strength value of a layer of boards may be multiplied by a system strength factor factor k_ℓ :

$$k_\ell = \min \begin{cases} 1 + 0{,}025 \cdot n \\ 1{,}2 \end{cases}$$

with n = number of boards within a layer

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

2 Mechanical actions in plane of the cross laminated timber

Stress distribution within the element shall be calculated by taking into account only the boards which are oriented in the direction of the actions.

Shear stresses may be calculated with the total thickness of the element.

For the design of cross laminated timber elements made of layers of softwood the characteristic strength and stiffness values of the layers of softwood shall be taken from Annex 3.

For the design of cross laminated timber elements with layers of wood-based panels either the characteristic strength and stiffness values of the layers of softwood shall be used or the corresponding values of the wood-based panels may taken into account.

For the verification of the bending strength the design bending strength value of a layer of boards may be multiplied by a system strength factor factor k_ℓ :

$$k_\ell = \min \begin{cases} 1 + 0{,}025 \cdot n \\ 1{,}2 \end{cases}$$

with n = number of longitudinal layers.

Derix X-LAM	Annex 4
Design of the cross laminated timber	

Deutsches Institut für Bautechnik DIBt

1 General

The design rules given in this section amend the design rules for connections given in EN 1995-1-1.

Plane sides are the surfaces of the element parallel to the plane of the element, narrow sides are the surfaces perpendicular to the plane sides of the element.

The indications of the connectors in the plane sides only apply to outer layer made of softwood. Connectors in the narrow sides of wood-based panel are not permissible.

1.1 Perpendicular to the axis loaded dowel type fasteners

1.1.1 Joints in the plane side of cross laminated timber

Embedding strength:

For nails, self-tapping screws, dowels and bolts in the plane side of cross laminated timber the embedding strength of solid timber may be used, depending on the characteristic density of the laminations of the cross laminated timber and on the angle between force and grain direction of the outer layer.

The following conditions shall be fulfilled:

- Diameter of nails $d \geq 4$ mm
- Outer thread diameter of self-tapping screws $d \geq 6$ mm

Effective number of fasteners:

The effective number of fasteners n_{ef} for outer layers with a thickness ≤ 40 mm shall be taken from equation (1).

$n_{ef} = n$ with n number of fasters within one row (1)

For outer layers with a thickness > 40 mm the effective number of fasteners n_{ef} according to EC 5 (8.3.1.1) shall be used.

Minimum spacings, edge and end distances:

Minimum spacings, edge and end distances and angle α between the force and the grain direction of the outer layers as defined in Figure 4 are given in Table 4.

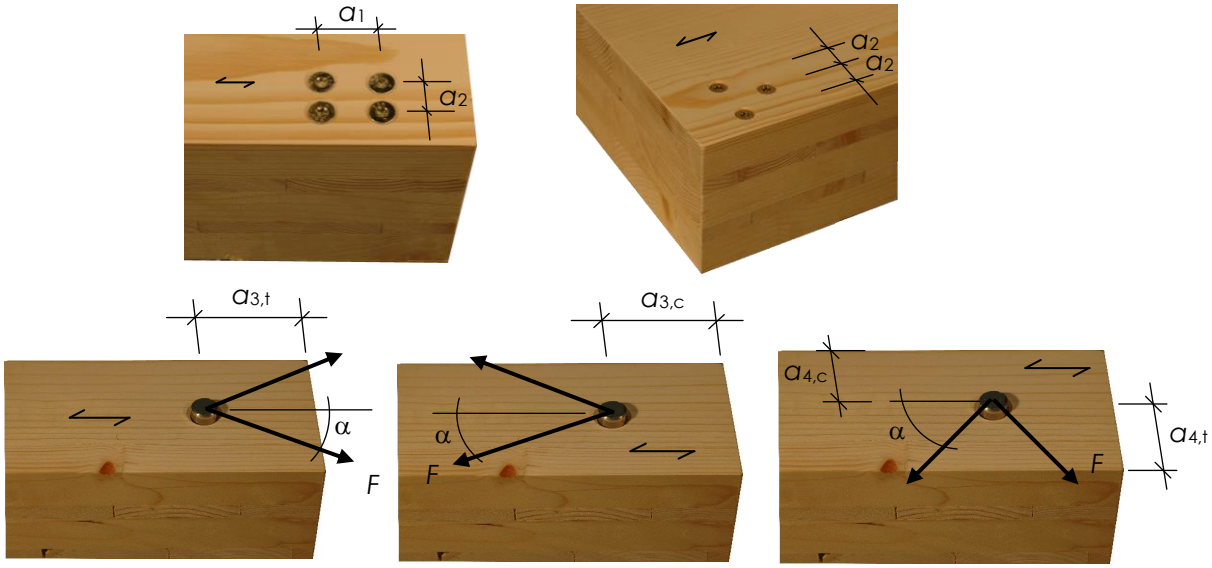

Figure 4: Definitions of minimum spacings, edge and end distances for laterally loaded dowel-type fasteners in the plane side of cross laminated timber

Derix X-LAM	Annex 5
Design of connectors	

Table 4: Definitions of minimum spacings, edge and end distances in the plane side of cross laminated timber elements

	a_1	$a_{3,t}$	$a_{3,c}$	a_2	$a_{4,t}$	$a_{4,c}$
Nails	(3+3 cos α) d	(7+3 cos α) d	6 d	3 d	(3+4 sin α) d	3 d
Self-tapping screws	4 d	6 d	6 d	2.5 d	6 d	2.5 d
Dowels	(3+2 cos α) d	5 d	$\max\begin{cases}4d\cdot\sin\alpha\\3d\end{cases}$	3 d	3 d	3 d
Bolts	$\max\begin{cases}(3+2\cos\alpha)d\\4d\end{cases}$	5 d	4 d	4 d	3 d	3 d

1.1.2 Joints in the narrow side of cross laminated timber

Embedding strength:

The characteristic embedding strength for self-tapping screws with a diameter $d \geq 8$ mm in the narrow sides of cross laminated timber may be calculated according to equation (2).

$$f_{h,k} = 20 d^{-0.5} \quad \text{in N/mm}^2 \qquad (2)$$

Where

d = Nominal diameter of the self-tapping screws in mm

For actions perpendicular to the plane side 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 $h_e/h < 0.7$ should be reinforced with fully threaded screws (see example in Figure 5).

Where

h_e = Loaded edge distance to the most distant fastener

h = Thickness of the cross laminated timber element

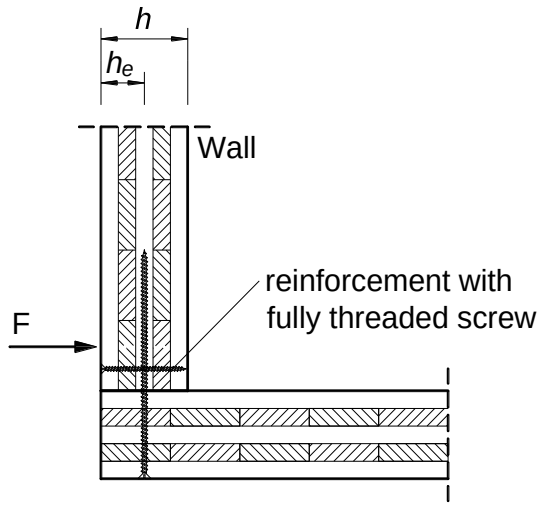

Figure 5: Reinforcement of a cross laminated timber wall with fully threaded screws

Effective number of fasteners:

The effective number of fasteners n_{ef} according to EC 5 (8.3.1.1) shall be used.

Minimum spacings, edge and end distances:

Minimum spacings, edge and end distances as defined in Figure 6 and further requirements for connections with self-tapping screws in the narrow side of cross laminated timber are given in Table 5 and Table 6.

Derix X-LAM	Annex 5
Design of connectors	

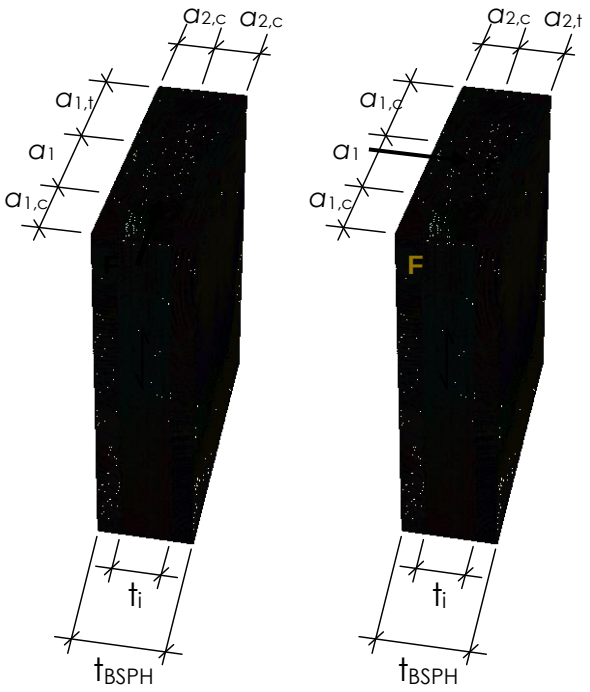

Figure 6: Definitions of minimum spacings, edge and end distances for laterally loaded self-tapping screws in the narrow side of cross laminated timber

Table 5: Definitions of minimum spacings, edge and end distances in the narrow side of cross laminated timber element

	a_1	$a_{3,t}$	$a_{3,c}$	a_2	$a_{4,t}$	$a_{4,c}$
Self-tapping screws	10 d	12 d	7 d	3 d	6 d	3 d

Table 6: Requirements for joints in the narrow side of cross laminated timber

	Minimum thickness of the relevant layer t_i in mm	Minimum thickness of the cross laminated timber t_{BSPH} in mm	Minimum penetration length of the fastener t_1 or t_2 in mm [a)]
Self-tapping screws	d > 8 mm: 3 · d d ≤ 8 mm: 2 · d	10 · d	10 · d

a) t_1 Minimum penetration length of the fastener in side members
t_2 Minimum penetration length of the fastener in middle members

1.2 Axially loaded dowel type fasteners

1.2.1 Threaded nails

The characteristic withdrawal capacity for threaded nails in the plane sides of cross laminated timber may be calculated according equation (3).

$$R_{ax,k} = 14 \cdot d^{0,6} \cdot \ell_{ef} \quad \text{in N} \tag{3}$$

Where

d = Outer diameter of the threaded part

ℓ_{ef} = Penetration length of the threaded part

The following conditions should be fulfilled:

- at least two nails in a connection
- diameter of the threaded part d ≥ 4 mm
- penetration length of the threaded part $\ell_{ef} \geq 8\,d$
- characteristic point side withdrawal parameter $f_{ax,k} \geq 50 \cdot 10^{-6} \cdot \rho_k^2$

  with ρ_k = characteristic value of density (kg/m^3)

1.2.2 Self tapping screws

Withdrawal capacity:

The characteristic withdrawal capacity for self tapping screws in the plane sides or in the narrow sides of cross laminated timber may be calculated according equation (4).

$$R_{ax,k} = \sum_{i=1}^{n} f_{ax,i,k} \cdot \ell_{ef,i} \cdot d \quad \text{in N} \tag{4}$$

Where

d = Outer thread diameter of the screw, with $d \geq 6$ mm for screws in the plane sides of cross laminated timber and $d \geq 8$ mm for screws in the narrow sides of cross laminated timber

$f_{ax,i,k}$ = Characteristic withdrawal parameter of layer i depending on the characteristic density $\rho_{k,i}$ and the angle α_i between screw axis and grain direction of layer i

$\ell_{ef,i}$ = Penetration length of the threaded part in layer i

n = Number of penetrated layers

The following conditions should be fulfilled:

- Penetration length of the threaded part $\ell_{ef,I} \geq 4\ d$

For the design of axially loaded screws in cross laminated timber only threaded parts with an angle $\alpha \geq 30°$ between screw axis and grain direction may be taken into account.
Screws oriented parallel to the plane side of the cross laminated timber should be completely arranged within one layer. The outer diameter of the threaded part should not exceed the thickness of the layer the screw is arranged in.
The characteristic pull-through strength of the screw head for solid timber may be used, depending on the characteristic density of the layer at the head side of the screw.

1.3 Connections with split ring connectors and toothed-plate connectors

The characteristic value of the load-bearing capacity of split ring connectors and toothed-plate connectors in the plane sides of cross laminated timber may be calculated according to EN 1995-1-1.

Split ring connectors and toothed-plate connectors may neither be arranged in the plane sides of wood based panels nor in the narrow sides of Derix Cross Laminated Timber members containing wood-based panels.

For split ring connectors in the narrow sides of cross laminated timber the regulations for connections with split ring connectors in the end grain may be applied.

Toothed-plate connectors in the narrow sides of cross laminated timber shall not be taken into consideration as load-bearing.

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_{tot}	=	thickness of the whole element [mm]
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]

Derix X-LAM	Annex 6
Design according to the theory of flexible bonded beams	