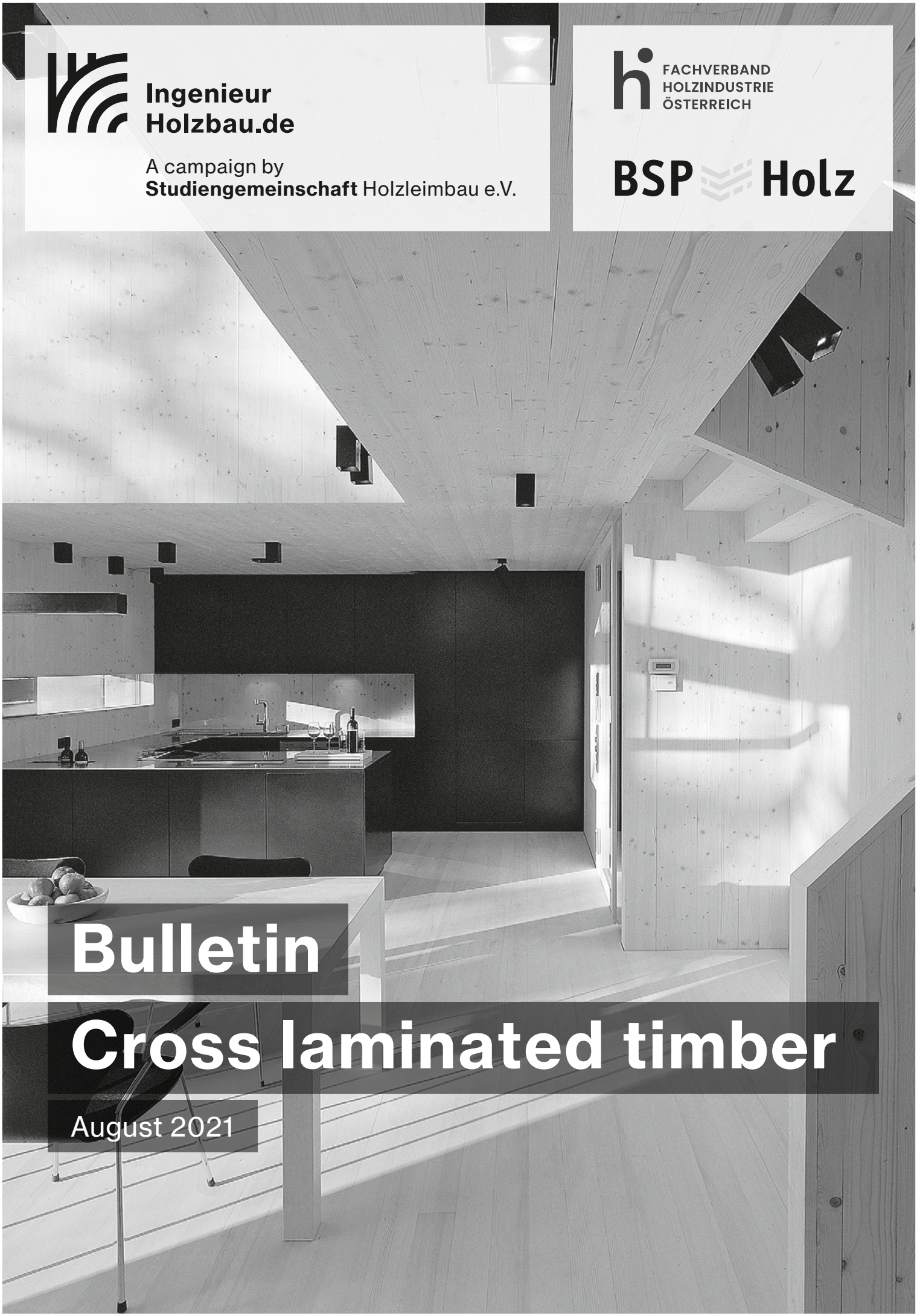

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FACHVERBAND HOLZINDUSTRIE ÖSTERREICH

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Bulletin

Cross laminated timber

August 2021

General
Load-bearing cross laminated timber (X-Lam) components are structurally designed and meticulously manufactured, high-quality construction elements. They are used as large-dimension plates and diaphragms or as beams in service classes 1 or 2 according to DIN EN 1995-1-1: 2010-12.

Cross laminated timber may only be produced in accordance with a German technical approval (abZ) of Deutsches Institut für Bautechnik or a European technical assessment (ETA). A list of current German technical approvals and European technical assessments can be found at www.brettsperrholz.org (filed under Brettsperrholz / gültige Zulassungen).

In the following sections, general material-dependent rules are explained which ensure a long service life and the preservation of appearance. Furthermore, terms important to the determination of the quality of cross laminated timber are explained.

Table 1
Tolerances at a reference moisture content of 12%

Plate thickness	for t ≤ 300 mm for t > 300 mm	± 2 mm ± 3 mm
Plate widths and openings	for b ≤ 3.000 mm for b > 3.000 mm	± 2 mm ± 3 mm
Plate lengths	for ℓ ≤ 3.000 mm for 3.000 < ℓ ≤ 10.000 mm for ℓ > 10.000 mm	± 3 mm ± 4 mm ± 5 mm

Lay-up
Cross laminated timber consists of at least three orthogonally arranged and bonded softwood layers. If there are more than three solid-timber layers, neighbouring layers may be glued with the grain aligned if permitted by the German technical approval or European technical assessment.

The lamellae in each timber layer may be arranged along their narrow sides either with or without gaps. If arranged without gaps, the narrow sides may be edge bonded.

Some German technical approvals and European technical assessments allow the inclusion of layers of derived wood products. The surfaces of X-Lam members may have factory-applied non-load-bearing layers for aesthetic or building physics reasons.

Standard dimensions and tolerances
Cross laminated timber should be requested with thicknesses starting at 60 mm and increasing in 10 mm steps. The tolerances listed in Table 1 apply.

Design
The design is carried out in accordance with EN 1995-1-1:2010-12 (Eurocode 5-1-1, including its national annex), taking into account the requirements of the manufacturer‘s technical approval or ETA.

Cross laminated timber members may be designed carrying load along one or two axes. The load-bearing capacity is determined by considering the static system and load configuration. The specification of properties will not suffice. The cross-sectional lay-up must instead be stated, describing the properties of the layers.

The manufacturers provide design aids for conventional systems and load distributions.

Since strength and stiffness values vary depending on the cross-sectional lay-up and the manufacturer’s production methods, the design of the load-bearing construction and, where applicable, the building physics verification should be checked when products are exchanged.

Verification of fire protection is carried out in reports or assessments of the manufacturer according to the requirements of the respective German technical approvals or European technical assessments.

Further information about design and construction

General
The design of plates, diaphragms and beams made of a layered orthogonal material differs from the design of the linear structural elements commonly found in timber construction.

In the past years, numerous reference books and booklets containing an introduction to the design of cross-laminated timber elements have been published. The following list includes some useful publications on this topic.

Material parameters
The material parameters to use must be taken from
- the respective German technical approval of the Deutsches Institut für Bautechnik (DIBt) or
- the European technical assessment (ETA). To use these parameters for designs executed in Germany, a manufacturer-specific general technical approval issued by DIBt might be required.

Design rules
The following design rules apply for designs executed in Germany:
- the design rules of the respective abZ or ETA, possibly with a linked ETA specific application rules (aBG)
- together with DIN EN 1995-1-1 (Eurocode 5-1-1) and DIN EN 1995-1-1/ NA (National Annex).
- Dederich, L. et al: INFORMATIONSDIENST HOLZ, holzbau handbuch, Reihe 3, Teil 5, Folge 2, Leitdetails für Bauteilanschlüsse in den Gebäudeklassen 4 und 5 https://informationsdienst-holz.de/publikationen/leitdetails-fuer-bauteilanschluesse-gebaeudeklasse-4-und-5
- Many manufacturers provide standard details.
- Further information can also be found in design guides of manufacturers of fasteners and fire protection elements.

Further literature
Detailed design information can be found in:
Augustin, M.; Blaß, H.; Bogensperger, T.; Ebner; Ferk, Heinz J.; Fontana, M.; Frangi, A.; Hamm, P.; Jöbstl, R.; Moosbrugger, T.; Richter, K.; Schickhofer, G.; Thiel, A.; Traetta, G.; Uibel, T.: BSPhandbuch.
Holz-Massivbauweise in Brettsperrholz, 2nd revised edition, 2010 (only available as download)

Wallner-Novak, M.; Koppelhuber, J. and Pock, K.:
Brettsperrholz Bemessung – Grundlagen für Statik und Konstruktion nach Eurocode.
pro Holz Austria, Vienna, Austria, 2013, ISBN 978-3-902320-96-4

Wallner-Novak, M.; Augustin, M., Koppelhuber, J. and Pock, K.:
Brettsperrholz Bemessung – Band II: Anwendungsfälle.
proHolz Austria, Vienna, Austria, 2013, ISBN 978-3-902320-96-4

For fire design, DIN EN 1995-1-2 with DIN EN 1995-1-2/NA must also be considered.

Structural elements/connections
A catalogue of structural elements, including crosslaminated timber elements, and relevant building-physics parameters can be found at www.dataholz.com.
The requirements for fire protection and necessary design verification formats for Germany can be determined by using the fire protection navigator (www.brandschutznavigator.de). Many manufacturers provide product-specific information.

Software
An extensive software package including background documentation can be found at www.cltdesigner.at. Many manufacturers provide productspecific design information.

Strength class
The strength, stiffness, and density parameters of cross laminated timber are generally given as the properties of the individual layers in the European technical assessments or German technical approvals of the manufacturers. The properties given apply to the direction of the grain of the individual layers.

Various mechanical methods can be used to determine the internal forces and stresses in the layers and the deformations of the entire system. System coefficients can be used for the structural verifications of the individual layers parallel to the grain.

Cross laminated timber is generally made of solid-timber layers of strength classes C 24 or T 14 according to DIN EN 338. The strength and stiffness parameters refer to the solid-timber layers with the grain oriented parallel to the direction of the respective stress. The strength, stiffness, and density parameters for cross laminated timber of strength class CL 24 are shown in Table 2. The manufacturer-specific German technical approvals and European technical assessments do not yet allow the declaration of strength class CL 24 instead of the declaration of the list of individual values.

The manufacturer-specific individual values for solid-timber lamellae of strength class C 24 or T 14 can be higher than those of strength class CL 24.

Figure 1 assigns the strength and stiffness parameters listed in Table 2 to the actions.

Table 2
Minimum values of the strength and stiffness parameters of the solid-timber layers of cross laminated timber of strength class CL 24 (in N/mm²) and density parameters (in kg/m³)[1)]

Property [2)]		Symbol	Value
Bending strength [3)]	For out-of-plane bending moments	$f_{m,k}$	24
Tensile strength	In plane	$f_{t,0,k}$	14
	Out of plane	$f_{t,90,k}$	0,12
Compressive strength	In plane	$f_{c,0,k}$	21
	Out of plane	$f_{c,90,k}$	2,50
Shear strength [4)]	Longitudinal	$f_{v,k}$	3,50
	Rolling shear	$f_{r,k}$	0,70
Young's modulus [5)]	In plane	$E_{0,mean}$	11.000
	Out of plane	$E_{90,mean}$	370
Shear modulus [5) 6)]	Out of plane	G_{mean}	650
	Rolling shear	$G_{r,mean}$	50
Density		ρ_k	385

1) For verifications using the net cross section.
2) See Figure 1.
3) For in-plane bending moments, such as those present in the design of columns and cantilevering panels, the characteristic value of the in-plane edgewise bending strength $f_{m,edge,k}$ is required. This value is generally not found in the German technical approval or European technical assessment. According to FprEN 16351:2020, a value of $f_{m,edge,k}$ = 20,5 N/mm² may be used. Any information supplied by the manufacturer must be taken into account.
4) For the verification of the shear strength of the entire cross section or the torsion strength of the glued intersection areas of the lamellae of neighbouring solid-timber layers, further parameters are necessary which generally cannot be declared, based on the German technical approval or European technical assessment. According to FprEN 16351:2020, the shear strength of the entire cross section can be assumed as $f_{v,xy,k}$ or $f_{v,yx,k}$ = 5,50 N/mm². The torsion strength of the intersection areas is given as $f_{tor,node,k}$ = 2,5 N/mm². Any information supplied by the manufacturer must be taken into account.
5) The 5% quantiles of the Young's and shear moduli may be assumed to be 5/6 of the mean values: $E_{05} = E_{mean} \cdot 5/6$ and $G_{05} = G_{mean} \cdot 5/6$
6) The in-plane shear modulus may be assumed to be G_{xy} = 250 N/mm². This parameter is generally not found in the German technical approval or European technical assessment. Any information by the manufacturer must be taken into account.

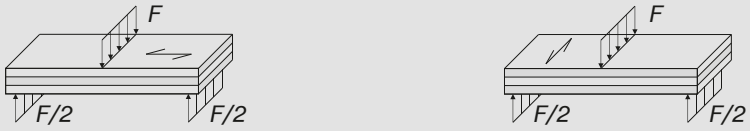
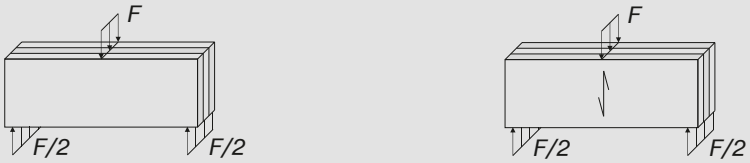
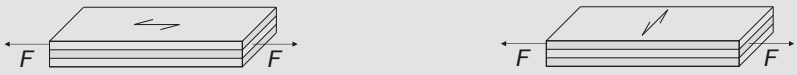
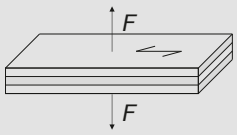
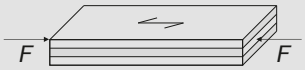
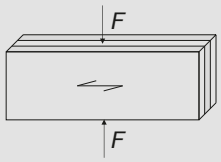
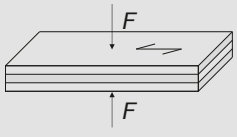
Action	Parameters for the verification of the layers parallel to the grain
	f_m f_v and f_r E_0 G and G_r
	$f_{m,edge}$ $f_{v,xy}$ and $f_{tor,node}$ E_0 G_{xy}
	$f_{t,0}$ $E_{t,0}$
	$f_{t,90}$ E_{90}
 	$f_{c,0}$ $E_{c,0}$
	$f_{c,90}$ $E_{c,90}$

Figure 1
The strength and stiffness parameters listed in Table 2 assigned to actions

Tension perpendicular to the grain
Tension perpendicular to the grain (tension perpendicular to the plane of the panel) must be sustained by orthogonal reinforcement, e.g. by self-drilling fully threaded screws.

Holes, notches, cut-outs, bore holes, and cuts executed on-site, and additional loads
Execution of holes, notches, bore holes, and cuts, as well as changes to the static system and additional loads, must be discussed with the designer of the structure.

Marking
Cross laminated timber components comply with the requirements of the building authorities. Components manufactured in accordance with a German technical approval bear the German conformity mark (Ü-Zeichen) (see Figure 2); those manufactured in accordance with a European technical assessment carry the CE-mark (see Figure 3).

Figure 2
Example of an Ü-Zeichen (Ü mark)

CE

4321

Manufacturer **XY**

XX

NB – **xyz**

ETA xx/yyyy

Cross laminated timber of Class CL24
as load-bearing element
in buildings and timber structures

Strength, stiffness and density properties to be listed as individual values

Embedmendt strength,
k_{mod} and k_{def} according to EN 1995-1-1

Tolerances
for widths and thicknesses up to xx mm ± yy mm
for widths and thicknesses > xx mm ± zz mm

MC **≤ 12%**

α = **5 x 10-6/K**

DC 5

SC 1 oder 2

Area: **xxxxx**
Finger joints: **yyyyy**
Glue line integrity test: **passed**

D-s2, d0

Fire resistance according to Table xx
of Annex **yy** of ETA **xxxx/yyy**

E1

μ = **xx** (dry); μ = **yy** (moist)

Soft body impact resistance test: **passed**

R = **xx** dB

$L'_{n,w}$ = **XX** dB

α = **xx** for yy Hz to zz Hz;
α = **ss** for tt Hz to uu Hz

λ = **0, 12 W/(m/K)**

C ≤ **X** m^3 / [h·m^3/(h Pa)^n]

c_p = **1.600 J/(kg/K)**

< CE-mark pursuant to Directive 93/68/EEC

< Number of the notified body

< Name and address or sign of the manufacturer

< Last two digits of the year in which the CE-mark was first applied

< Number of declaration of performance

< Number of the ETA

< Intended purpose and identifying code of the product type

< Mandated properties

Figure 3
Example of a CE-mark for cross laminated timber according to an ETA based on EAD 130005-00-0304 (manufacturer-specific text in bold)

Wood preservation and wood species
Structural protection of wood should take precedence over preservative treatment. Preservative treatment of wood is uncommon and also not required as per DIN 68800: cross laminated timber is manufactured from kiln-dried timber and only used for service classes (SC) 1 and 2. An attack by wood-destroying fungi is unlikely due to the expected moisture content of the timber being less than 20% (u < 20%). Pursuant to DIN 68800-1: 2011-10, adequate durability against insect attack may be assumed in SC 1 and SC 2, irrespective of species.

Cross laminated timber is generally manufactured from spruce; however, other types of softwood may also be used.

Surface qualities
Cross laminated timber components can be manufactured with varying surface qualities. Three surface qualities are defined in Table 3 (see Page 8). Other, manufacturer-specific definitions of surface quality also exist. The following general criteria apply:
- Additionally, for example for knot sizes, grading requirements apply.
- Glue lines and finger joints are not defects, since they are specific to the product.
- Wood-based panels are generally butt-joined.
- Additional treatment of the surface, such as sanding, brushing, or profiling, can be arranged.
- The desired surface texture of the member must be contractually agreed on and specified in the tender.
- The surfaces of a cross laminated timber member may be supplied with different surface qualities.
- Unless otherwise agreed, industrial quality is provided.

Cracking
Moisture is absorbed mainly by the outer layers of cross laminated timber. The moisture content must gradually approach the moisture expected during later use.

As is the case with all structural solid-timber products, the cracks appearing due to the moisture content of the material progressing towards the equilibrium moisture content of the product at its final location are product-specific and cannot be avoided.

Transport and assembly
Cross laminated timber components should be transported and installed only by experienced, suitably equipped and trained specialist companies. The following should be taken into account:
- The members must be protected from moisture and dirt during transport and until installation. To prevent discolouration and rust marks, the components must be covered when in the vicinity of steel being welded or cut.
- Transport packaging must be removed soon after delivery to reduce the risk of condensation, which leads to blue stains or mildew.
- Members must be stored at an adequate distance from the ground, covered with tarpaulins, and secured against toppling.
- Adequately dimensioned lifting gear and slings must be used for lifting.
- Cross laminated timber members must be accurately aligned. Components must be supported temporarily if necessary.
- Installed members must be kept covered until the final weather protection is in place.
- To prevent rust marks on the timber members, corrosion protection must be applied to steel parts before installation.
- See also Page 9.

Figure 4–6
Application examples of cross laminated timber

Table 3
Surface qualities of the visible area (surface layer made of solid-timber lamellae) of cross laminated timber at a moisture content of 12%

Criterion	Surface quality (non-visible quality)	Surface quality (industrial quality)	Surface quality (room quality)
Wood species	Addition of other species possible	One species; spruce/fir are deemed one wood type	One species; spruce/fir are deemed one wood type
Surface	Smoothed, without further surface treatment	Planed or sanded	Planed or sanded
Gap width [1)]	Maximum 6 mm	Maximum 4 mm	Maximum 2 mm
Knots	No restrictions	Fixed knots permitted; black and missing knots over 30 mm mean diameter must be patched	Fixed knots permitted; black and missing knots over 15 mm mean diameter must be patched
Pitch pockets1 [1)]	Permitted	Permitted	Up to 5 mm × 50 mm or equivalent area permitted; larger areas must be patched
Discolouration [1)]	No restrictions	Up to 20% of the surface area	Up to 5% of the surface area
Insect attack	Worm grooves up to Ø 2 mm permitted	Not permitted	Not permitted
Ingrown bark	Permitted	Permitted	Isolated occurrence permitted
Pith	Permitted	Permitted	Isolated occurrence permitted
Cracks [1)]	Criteria according to strength grading	Criteria according to strength grading	Criteria according to strength grading

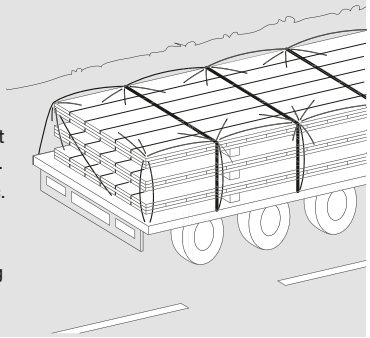
[1)] Condition upon delivery

Important notes for working with cross laminated timber (X-Lam)

Figure 7

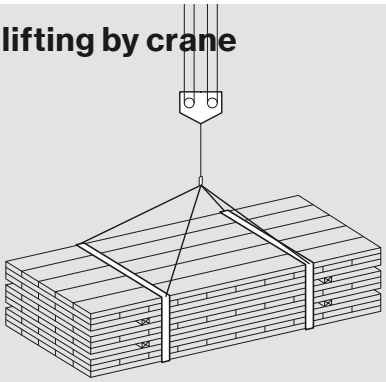
1 Transport and delivery

- The loading sequence should be discussed with the manufacturer if necessary.
- During transport, the members must be protected from moisture and dirt.
- Keep driveways clear to allow traffic.
- If elements are stored on the building site, the ground must be dry and have adequate load-bearing capacity.



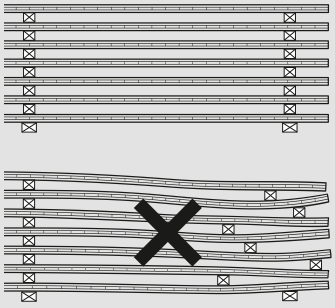
2 Fastening and lifting by crane

- Operation only by trained staff.
- Heed accident prevention regulations.
- Use suitably dimensioned lifting gear and slings according to the installation instructions.
- Before use, check lifting gear, slings, and attachment points for damage.



3 Storage at building site

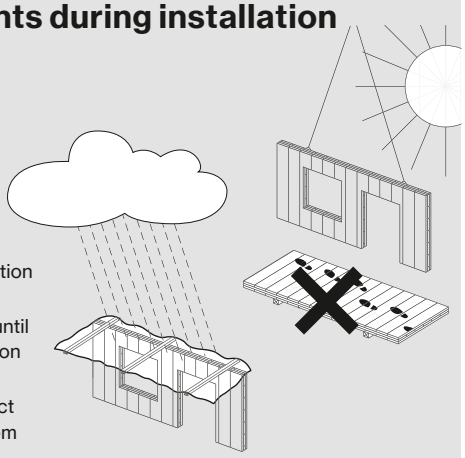
- Use timber spacers.
- When stacking members horizontally, align timber spacers vertically.
- Secure stored members against toppling.
- Remove packaging to prevent condensation.
- Provide adequate ground clearance and tarpaulins to protect members from rain, water spray, and rising damp.
- For extended storage, use additional timber spacers to prevent creep deformations.



4 Components during installation

Install in accordance with installation instructions.

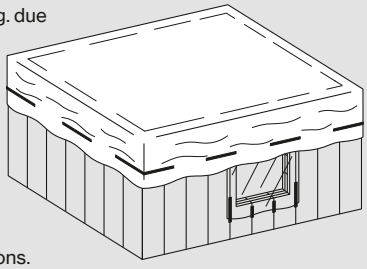
- Avoid detrimental absorption of moisture.
- Keep members covered until the final weather protection is in place.
- Prevent soiling and protect members by covering them if necessary.



5 Protection of installed members

Avoid staining by covering visible surfaces

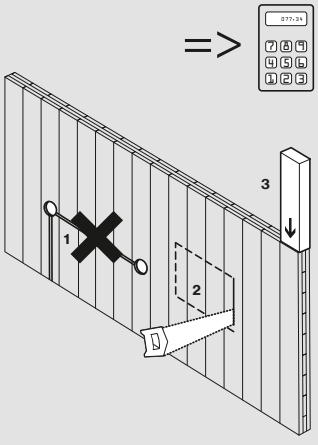
- Ensure adequate ventilation to prevent discolouration due to moisture absorption during construction (e.g. due to screeding or rendering).
- Dry components which have absorbed moisture as soon as possible, but very carefully.
- Tarpaulins should be attached in a way that prevents water accumulation and limits capillary absorption of water in gaps.
- Heed accident prevention regulations.



6 Modifications on-site

Notches (1), holes (2), and additional loads (3)

- The effect of opening holes and recessing on-site on load-carrying capacities must be discussed in advance with the site engineer.
- The capacity for carrying additional static loads must be verified.



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Studiengemeinschaft Holzleimbau e.V.
Heinz-Fangman-Str. 2
D-42287 Wuppertal
+49 (0)202·76 97 27 33 Fax
www.ingenieurholzbau.de
www.brettschichtholz.de
info@brettschichtholz.de

FACHVERBAND HOLZINDUSTRIE ÖSTERREICH

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