Deutsches Institut für Bautechnik

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

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European Technical Assessment

ETA-06/0009 of 2 June 2017

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	Binderholz Brettsperrholz BBS
Product family to which the construction product belongs	Solid wood slab element to be used as a structural element in buildings
Manufacturer	Binderholz Bausysteme GmbH Zillertalstraße 39 6263 FÜGEN ÖSTERREICH
Manufacturing plant	W01, W02, W03, W04
This European Technical Assessment contains	26 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-06/0009 issued on 7 April 2016

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Specific Part

1 Technical description of the product

"*Binderholz Brettsperrholz BBS*" are plane timber building components which are made of at least three layers of softwood boards. Adjacent layers are glued together with an angle of 90°. The cross section of the elements is symmetric[1].

The components and the system setup of the elements are given in Annex 1. The building elements are plane.

Two adjacent layers may be oriented with parallel grain direction if a symmetric and crosswise blocked structure is guaranteed.

Not load-bearing outer layers are permissible.

Single board layers (maximum 50% of the cross section) may be replaced by one- and multilayer solid wood panels. The solid wood panels shall be suitable for structural use.

The elements can be produced with a width up to 3.5 m and a length up to 22 m as *Großformat* and with a width up to 1.25 m und a length up to 5 m as *Systemformat.*

The building components in *Systemformat* with a width up to 1.25 m are connected in the plant in longitudinal direction by large finger jointing in accordance with EN 14080 to a length of up to 24 m.

The cross laminated timber elements are manufactured using the automated manufacturing process in accordance with the technical documentation and inspection.

The layers are 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 is used.

Only boards which are planed on both sides of the outer layer are used. The boards may be connected by finger joints in longitudinal direction according to EN 14080. There are no butt joints.

The single boards of the layers in longitudinal direction may be glued at narrow side. The maximum width of the gap is given in Annex 2.

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.

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

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

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

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

Members shall be provided with an effective protection for the solid wood slab elements in service.

[1] For regulations on deviations from symmetry see Annex 2

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 5.

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

Design

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

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

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

Elements which are directly exposed to the weather shall be provided with an effective protection for the cross laminated timber element during assembling and service.

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

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 board layers, for the finger joint connection of the individual boards and for the large finger joint connection an adhesive which meet the requirements of EN 301 shall be used. Alternatively a one component polyurethane adhesive which meets the requirements of EN 15425 and EN 14080, annex B.2 considering annex B.1, may be used.

Regarding the applicable type of adhesive national regulations apply.[2]

Details on the adhesives and the bonding process 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

[2] In Germany adhesives of the type I are to be used.

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. The chemical composition of the adhesives for gluing the board layers, the finger joint connection of the individual boards and the universal finger joint connection has to be in compliance with the chemical composition deposited at the Technical Assessment Body (DIBt).
Formaldehyde emission	The manufactured cross-laminated timber and the used wood based panels comply which EN 13986 of formaldehyde class E1.
Wood preservatives or flame retardants	Wood preservatives and flame retardants are not subject of the ETA.
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	no performance assessed
Impact sound insulation	no performance assessed
Sound absorption	no performance assessed

3.6 Energy economy and heat retention (BWR 6)

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

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

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

The system to be applied is: 1

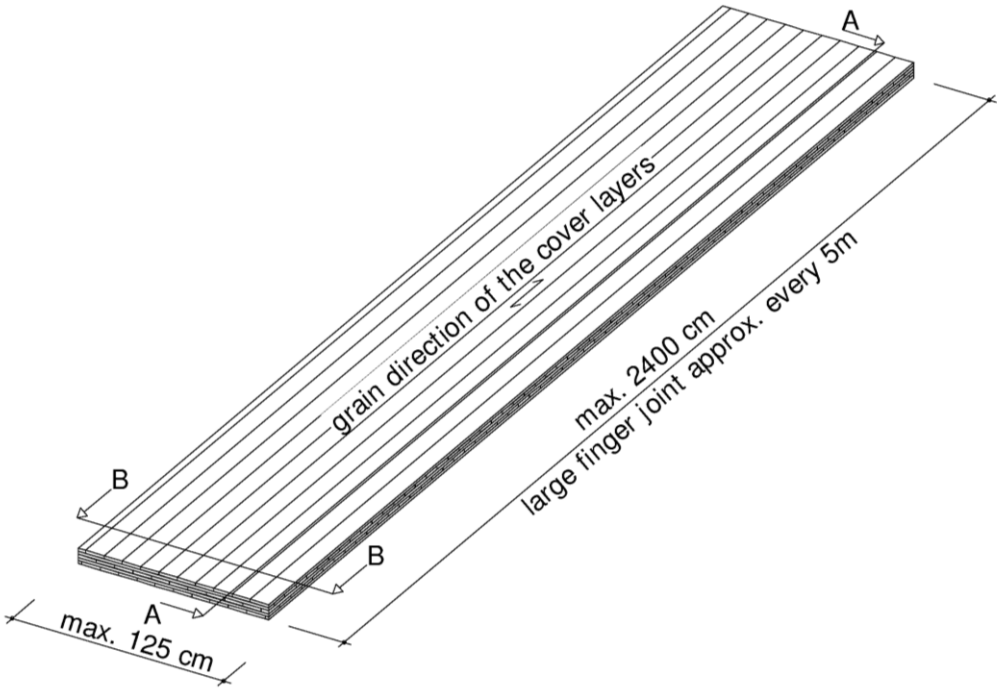
5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

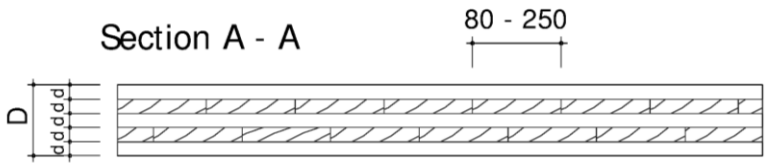
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

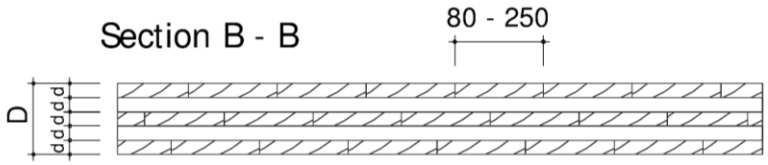
Issued in Berlin on 2 June 2017 by Deutsches Institut für Bautechnik

BD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Deniz







d= board thickness (18mm - 45mm)
D= element thickness (54mm - 350mm)

Binderholz Brettsperrholz BBS	Annex 1
Structure of cross laminated timber element "Systemformat"	

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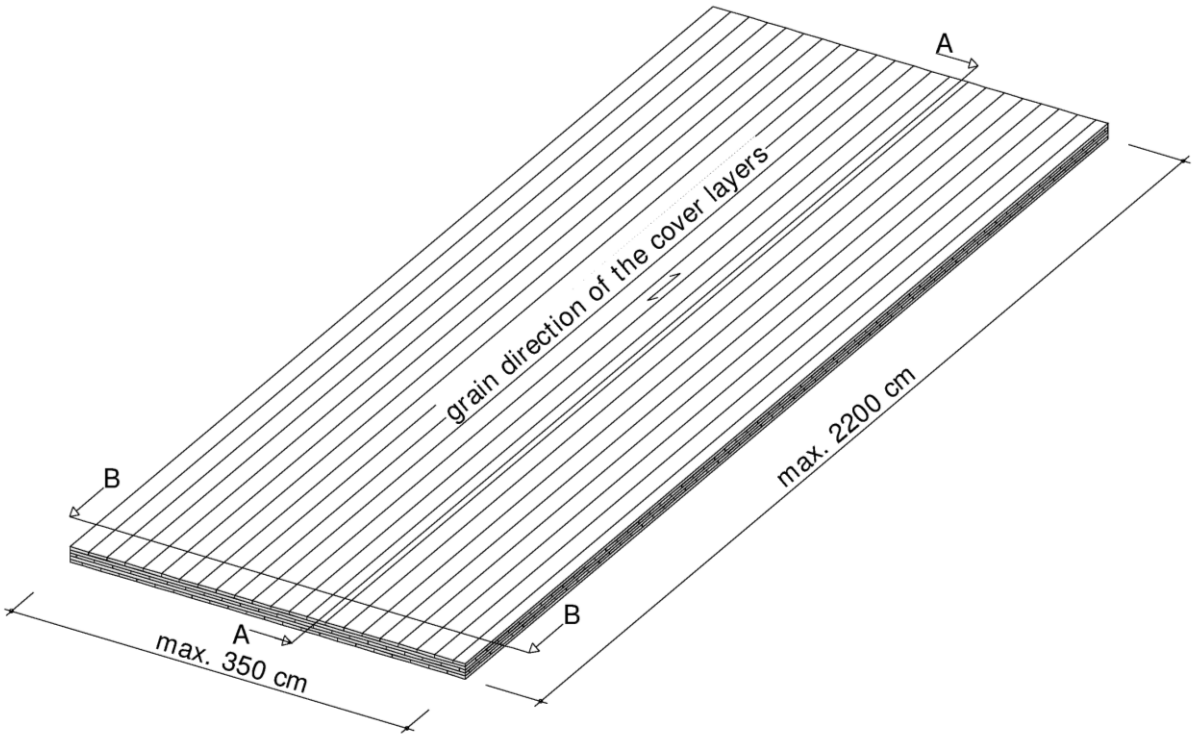

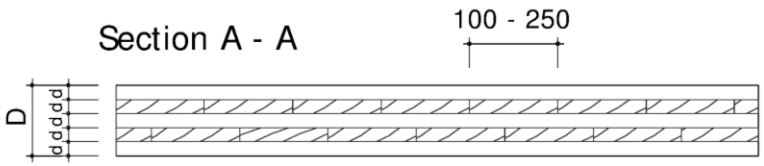

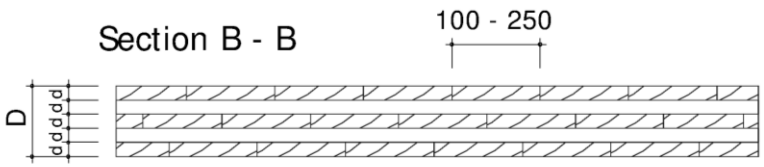

d= board thickness (17mm - 45mm)
D= element thickness (51mm - 315mm)

Binderholz Brettsperrholz BBS	Annex 1
Structure of cross laminated timber element "Großformat"	

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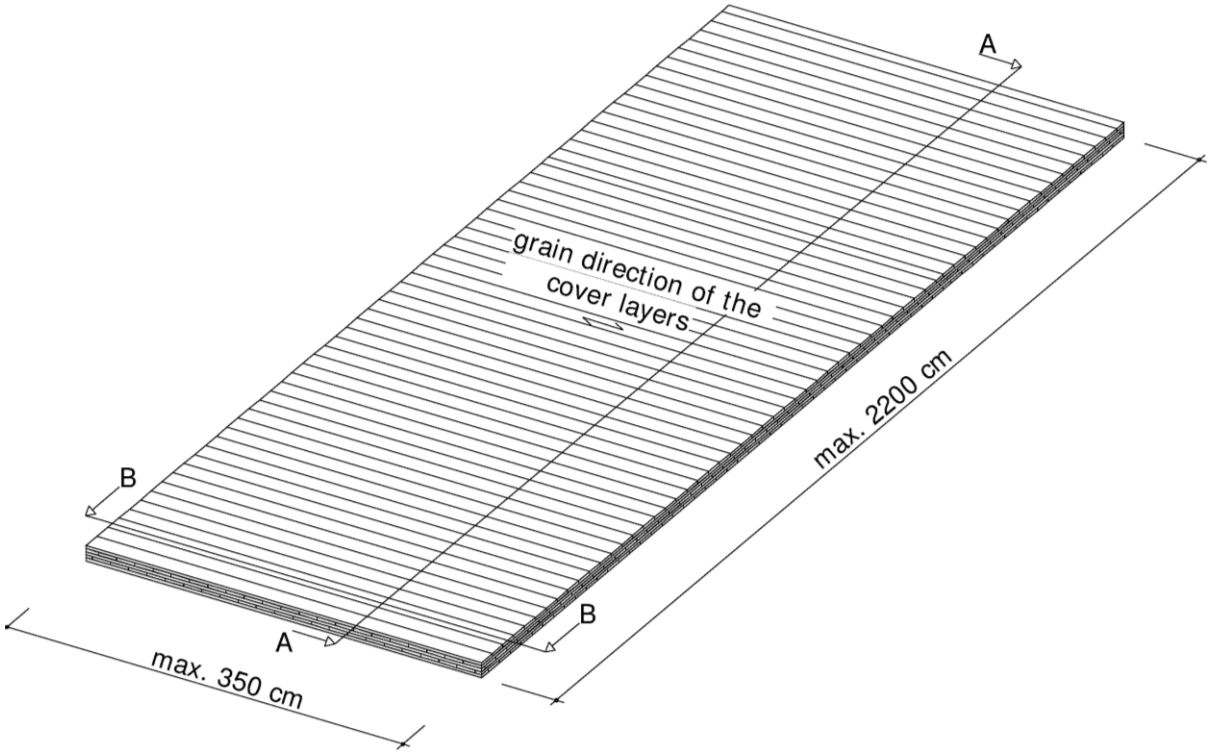

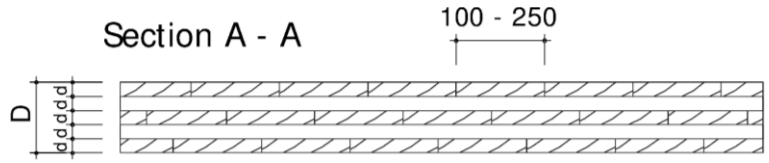

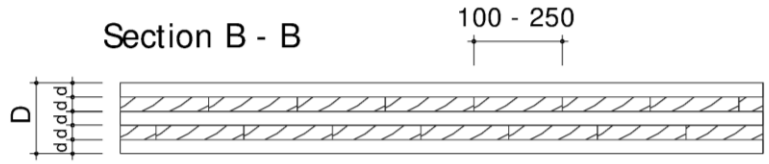

d= board thickness (17mm - 45mm)
D= element thickness (51mm - 315mm)

Binderholz Brettsperrholz BBS	Annex 1
Structure of cross laminated timber element "Großformat DQ"	

Table 1: Dimensions and specifications of the elements

Binderholz Brettsperrholz BBS "Systemformat"	
Characteristic	**Specification**
Cross laminated timber element	
Thickness	54 to 350 mm
Tolerance in thickness	± 1 mm
Width	≤ 1.25 m
Tolerance in width	± 2 mm
Length	≤ 5 m
Tolerance in length (relating to a max. length up to 5 m)	± 2 mm
Length of the element with large finger joint	≤ 24 m
Number of layers	3 ≤ n ≤ 9
maximum number of consecutive layers having the same grain direction	≤ 2
maximum width of gap between the boards of a layer	4 mm
Large finger joints	according to EN 14080
Layup	Symmetric layup [1)]
Boards	
Material	softwood
Strength class according to EN 338 Cover layers / longitudinal layers (having the same grain direction as cover layers) Cross layer (having the a grain direction perpendicular to the cover layer)	 ≥ 90 % C24; < 10 % C16 [2)] ≥ 30 % C24; < 70 % C16 [3)]
Thickness	18 to 45 mm
Width	80 to 250 mm
Ratio width to thickness of the cross-layers	≥ 4:1
Moisture of wood according to EN 13183-2	10 ± 2 % 12 ± 2 % Within one cross laminated timber element only one of the specified moisture ranges shall be applied.
Finger joints	according to EN 14080
Wood based panels	
Material	Solid wood panels according to EN 13986
Thickness	12 to 60 mm
Joints	Joints perpendicular to the longitudinal direction are not allowed. Joints parallel to the longitudinal direction shall be taken into account in the design.

Binderholz Brettsperrholz BBS	Annex 2
Dimensions and specifications of the cross laminated timber	

Table 1 (continued)

***Binderholz Brettsperrholz BBS* "*Großformat*" and "*Großformat DQ*"**	
Characteristic	**Specification**
Cross laminated timber element	
Thickness	51 to 315 mm
Tolerance in thickness	± 1 mm
Width	≤ 3.5 m
Tolerance in width	± 2 mm
Length	≤ 22 m
Tolerance in length (relating to a max. length up to 22 m)	± 2 mm
Number of layers	$3 \leq n \leq 7$
maximum number of consecutive layers having the same grain direction	≤ 2
maximum width of gaps between the boards of a layer	4 mm
Layup	Symmetric layup [1)]
Boards	
Material	softwood
Strength class according to EN 338 Cover layers / longitudinal layers (having the same grain direction as cover layers) Cross layers (having the grain direction perpendicular to the cover layers)	≥ 90 % C24; < 10 % C16 [2)]
Thickness	17 to 45 mm
Width	100 to 250 mm
Ratio width to thickness of the cross-layers	≥ 4:1
Moisture of wood according to EN 13183-2	10 ± 2 % 12 ± 2 % Within one cross laminated timber element only one of the specified moisture ranges shall be applied.
Finger joints	according EN 14080 mechanical resistance
Wood based panels	
Material	Solid wood panels according to EN 13986
Thickness	12 to 60 mm
Joints	Joints perpendicular to the longitudinal direction are not allowed. Joints parallel to the longitudinal direction shall be taken into account in the design.

Binderholz Brettsperrholz BBS	Annex 2
Dimensions and specifications of the cross laminated timber	

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Table 1 (continued)

[1] Deviations from symmetric layup:
- The layup (cross-section) of the element is symmetric with respect to the centre layer.
- When using boards of different strength classes the deviations of the elastic centre of gravity from the geometric centre may be disregarded.
- The layup may also be considered as symmetrical when a thick top layer is substituted by two thinner fibre-parallel layers with approximately the same overall thickness.
- Layers acc. to EN 13986 arranged in addition to the symmetric layup shall be disregarded in design.
- Deviations from symmetry caused by load bearing multi-layered solid wood panels acc. to EN 13986 have to be considered if necessary.

[2] The proportion of wood of grade C16 may be disregarded by way of calculation.
[3] The proportion of wood of grade C24 shall be disregarded by way of calculation.

Binderholz Brettsperrholz BBS	Annex 2
Dimensions and specifications of the cross laminated timber	

Table 2: Essential requirements of the multilayered timber elements

BWR	Requirement	Verification method	Class / Use category / Value
1	**Mechanical resistance and stability**		
	For the calculation of the individual layers the characteristic strength and stiffness values of softwood of the corresponding strength classes acc. to EN 338 shall be used taking into consideration the definitions in Annex 2. In addition the following values apply:		
	Mechanical actions in plane of cross laminated timber	Modulus of elasticity parallel to the grain of the boards	$E_{0,mean}$ 12.000 N/mm²
	Mechanical actions perpendicular to the plane of cross laminated timber	Modulus of elasticity parallel to the grain of the boards	$E_{0,mean}$ 12.000 N/mm²
		Rolling shear strength "Systemformat" "Großformat" and "Großformat DQ" (5%-fractile)	$f_{v,9090,k}$ 1.0 N/mm²
		Rolling shear modulus (mean value)	$G_{9090,mean}$ 50 N/mm²
	In case of connecting the elements by large finger joints the characteristic bending strength is to reduce by 25 %. In case of tensile stresses in the panel plane the characteristic tensile strength is to reduce by 30 %. For references regarding the calculation see annex 4. National regulations might have to be followed.		
	Creep and duration of load	according to EN 1995-1-1	
	Dimensional stability	Moisture content during use shall not change to such extent that adverse deformations can occur.	
	In-service environment	EN 1995-1-1	1 and 2
	Bond integrity	EAD 130005-00-0304	Passed
2	**Safety in case of fire**		
	Reaction to fire		
	Timber elements except for floorings	Commission Decision 2005/610/EC	Euroclass D-s2, d0
	Resistance to fire		
	Charring rate	EN 1995-1-2	0.7 mm/min
3	**Hygiene, health and the environment**		
	Water vapour permeability μ	EN ISO 10456	20 to 50
	Content of dangerous substances	EAD 130005-00-0304	See clause 3

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Table 2 (continued)

4	**Safety in use**		
	Impact resistance	Soft body resistance is assumed to be fulfilled for walls with a minimum of 3 layers and minimum thickness of 60 mm.	
5	**Protection against noise**		
	Airbourne sound insulation	no performance assessed	
	Impact sound insulation	no performance assessed	
	Sound absorption	no performance assessed	
6	**Energy economy and heat retention**		
	Thermal conductivity λ	EN ISO 10456	0,12 W/(m^2 · K)
	Air tightness	no performance assessed	
	Thermal inertia c_p	EN ISO 10456	1.600 J/(kg · K)

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1 Recommendations for the design of the elements

1.1 General

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

The determination of the distribution of stresses and internal forces must consider the influence of shear deformations of the cross layers. In Annex 6 advice is given on how to perform the calculation of the elements.

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

1.2 Characteristic values

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

The deformations caused by shear forces may be calculated by using the element thickness D irrespective of the given layup and a global shear modulus of G = 60 N/mm² for 3-layer elements and of G = 80 N/mm² for elements with 5 layers or more.

1.3 Mechanical actions perpendicular to the element`s plane

1.3.1 Bending and shear

For the calculation of the characteristic values of the element according to Annex 6, only the boards, which are oriented parallel to the span direction, may be considered.

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

$$k_\ell = \min \begin{cases} 1 + 0.025\,n \\ 1.1 \end{cases}$$

where n = number of adjacent boards

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.

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

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.

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1.4.1 Shear

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

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

where

D element thickness (see Annex 1)

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

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

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

1.4.2 Tension and compression

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

1.5 Buckling

For buckling the 5%-quantile values of the modulus of elasticity may be set to 5/6 of the corresponding mean value: $E_{0.05} = 5/6\ E_{0,mean}$

The imperfection factor β_c may be set to $\beta_c = 0.1$ as for glued laminated timber.

Binderholz Brettsperrholz BBS	Annex 4
Design considerations	

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:

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

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

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

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

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

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

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

Shear design is in the governing plane:

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

Notation:

h_{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]

Binderholz Brettsperrholz BBS	Annex 4
Design considerations	

2 Recommendations for the design of the fasteners

2.1 General

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

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

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

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

The grain direction of the cover layers governs the minimum spacings of the fasteners as well as the embedding strength is.

For the design of the fasteners the values acc. to Table 3 shall be assumed:

Table 3: Density values

purpose of use	symbol	Systemformat Großformat Großformat DQ
self-weight BBS	$\gamma_{G,k}$	4,5 kN/m^3
calculation of the connection stiffness of - screws, nails and staples - bolts and dowels in the wide face - split ring, shear plate and toothed-plate connectors in the wide face - split ring and shear plate connectors in the narrow face	ρ_{mean}	420 kg/m^3
calculation of load carrying capacity - screws, nails and staples - split ring, shear plate and toothed-plate connectors in the wide face	ρ_k	350 kg/m^3
- bolts and dowels in the wide face - split ring and shear plate connectors in the narrow face		385 kg/m^3

2.2 Connections with dowels and bolts

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

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

where

d fastener diameter in mm

α angle between force and grain direction of the cover layer

The grain direction of the cover layers is taken into account for the calculation of the embedding strength.

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

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

For dowels with a diameter of ≥ 10 mm in the wide faces, $n_{ef} = n$ may be assumed.

2.3 Nails

General

The minimum diameter for nails in Binderholz Brettsperrholz BBS Systemformat und Binderholz Brettsperrholz BBS Großformat is 2.8 mm.

Laterally loaded nails - wide faces

The characteristic load-carrying capacity of laterally loaded nails in the wide faces is to be determined according to EN 1995-1-1. The embedding strength shall be calculated with the characteristic density of the boards of the outer layer.

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

Laterally loaded nails - narrow faces

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

Axially loaded nails

Only threaded nails with a characteristic withdrawal parameter of $f_{ax,k} \geq 50 \cdot 10^{-6} \cdot \rho_k^2$ and a characteristic pull through parameter $f_{head,k} \geq 100 \cdot 10^{-6} \cdot \rho_k^2$ may be used (ρ_k = characteristic density in kg/m^3; max. 500 kg/m^3).

The design may be carried out as for nails in solid timber according to DIN EN 1995-1-1.

Axially loaded nails in the narrow faces may only be used when they are not placed in end grain.

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2.4 Screws

General

The outer thread diameter shall be used as the relevant diameter d of the screw. Penetration lengths lef < 4 · d should not be considered as load-carrying.

Laterally loaded screws - wide faces

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

The minimum diameter for screws in the wide faces of Binderholz Brettsperrholz is 4.0 mm.

The embedding strength may be determined as for nails in solid timber according to DIN EN 1995-1-1 where the characteristic density of the cover layers is to be used.

For self-tapping screws arranged at an angle α of 30° ≤ *α* < 90° with respect to the direction of grain of the cover layer the embedding strength shall be calculated as follows:

$$f_{h,\alpha,k} = \frac{0.082 \cdot \rho_k \cdot d^{-0.3}}{2.5 \cdot \cos^2 \alpha + \sin^2 \alpha}$$ in N/mm² without predrilled holes

$$f_{h,\alpha,k} = \frac{0.082 \cdot \rho_k \cdot (1 - 0{,}01 \cdot d)}{2.5 \cdot \cos^2 \alpha + \sin^2 \alpha}$$ in N/mm² with predrilled holes

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

Laterally loaded screws - narrow faces

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

The minimum diameter for screws in the narrow faces of Binderholz Brettsperrholz is 8.0 mm.

Regardless of the arrangement of the screw in the narrow face (e.g. for angles between screw axis and grain direction of 0° ≤ *α* < 90°), the characteristic value of the embedding strength, when using screws without predrilling, shall be calculated as follows:

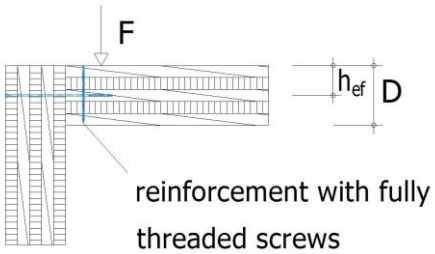
$$f_{h,k} = 20 \cdot d^{-0,5}$$ in N/mm²

where

d nominal diameter of the screw in mm

The effective number of screws n_{ef} may be set as for bolts in solid timber according to DIN EN 1995-1-1.

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



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Axially loaded screws (pull-out)

The minimum value of the angle α between the screw axis and the grain direction is to be observed in accordance with the European Technical Approval or Assessment of the screw used.

The characteristic load-carrying capacity of an axially loaded screw is:

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

where

$F_{ax,i,Rk}$ characteristic withdrawal capacity for screws acc. to the European Technical Approval or Assessment in the board layer i depending on the characteristic density, the angle between the screw axis and grain direction, and the length of the threaded area of the screw in the board layer i

n number of board layers

Screws oriented parallel to the wide face of the cross laminated timber should be completely arranged within one board layer. The outer diameter of the threaded part should not exceed the thickness of the board layer the screw is arranged in.

The characteristic pull-through strength of the screw head is to be determined as for solid timber, depending on the characteristic density of the corresponding layer in the head area of the screw.

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Axially loaded screws (compressive capacity)

The characteristic value of the compressive load carrying capacity of a fully thread screw embedded in timber is the minimum of the axial resistance against pushing-in and the buckling resistance of the screw:

$$F_{ax,c,Rk} = \min \begin{cases} F_{ax,Rk} \\ \kappa_c \cdot N_{pl,k} \end{cases} \quad \text{in N}$$

where

$F_{ax,Rk}$ characteristic axial withdrawal capacity (see Axially loaded screws (pull-out))

$$\kappa_c = \begin{cases} 1 & \text{for } \bar{\lambda}_k \le 0{,}2 \\ \dfrac{1}{1/\left(k + \sqrt{\left(k^2 - \bar{\lambda}_k^2\right)}\right)} & \text{for } \bar{\lambda}_k > 0{,}2 \end{cases}$$

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

$$\bar{\lambda}_k = \sqrt{\frac{N_{pl,k}}{N_{ki,k}}}$$

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

d_2 = inner thread diameter of the screw in mm

$f_{y,k}$ = characteristic yield strength in N/mm^2 acc. to the European Technical Approval or Assessment of the screw

$N_{ki,k}$ = $\sqrt{c_h\, E_S\, I_S}$ = characteristic elastic buckling load in N

c_h = $\left(0.19 + 0.012\, d\right) \rho_k \left(\dfrac{90° + \alpha}{180°}\right)$ = elastic foundation coefficient of the screw in N/mm2 for the most unfavorable combination of α and ρ_k

ρ_k = characteristic density of a board layer

α = angle between screw axis and grain direction of a board layer

$E_S \cdot I_S$ = $210{,}000\, \pi \dfrac{d_2^4}{64}$ = bending stiffness of the inner thread diameter cross-section of the screw in Nmm^2

2.5 Split ring, shear plate and toothed-plate connectors

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

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

3. Minimum spacings of fasteners

3.1 Minimum spacings of fasteners in the wide faces

Minimum spacings – parallel and perpenticular to grain

Edge and end distances

loaded end $a_{3,t}$ unloaded end $a_{3,c}$ unloaded edge $a_{4,c}$ loaded edge $a_{4,t}$

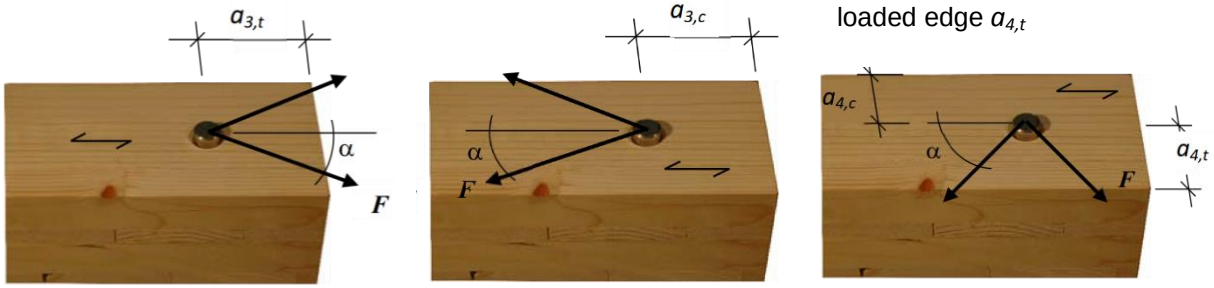

Table 4a: Minimum spacings of fasteners in the wide faces

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

3.2 Minimum spacings, minimum thicknesses, minimum layer thicknesses und minimum penetration lengths of fasteners in the narrow faces

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

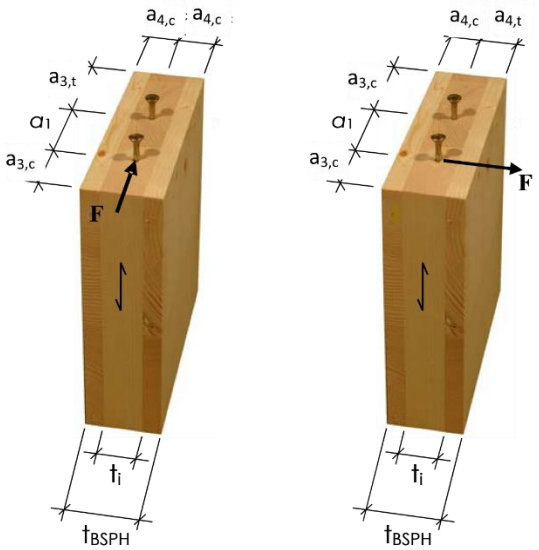

Table 4b: Minimum spacings of fasteners in the narrow faces

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

Table 4c: Requirements for fasteners in the narrow faces of cross laminated timber

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

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Reference documents

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

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

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

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

EN 338:2016, Structural timber – Strength classes

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

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