Designated according to The Construction Products (Amendment etc.) (EU Exit) Regulations 2020

UK Technical Assessment	**UKTA-0836-22/0028 of 16/02/2022**
Technical Assessment Body issuing the UK Technical Assessment:	British Board of Agrément
Trade name of the construction product:	KLH® - CLT[(1)] (1) Henceforth noted throughout as KLH-CLT
Product family to which the construction product belongs:	Area Code 13 Structural timber products / elements and ancillaries Solid wood slab elements to be used as structural elements in buildings
Manufacturer:	KLH Massivholz GmbH Gewerbestraße 4 8842 Teufenbach-Katsch Austria
Manufacturing plant(s):	KLH Massivholz GmbH Gewerbestraße 4 8842 Teufenbach-Katsch Austria KLH Massivholz Wiesenau GmbH Wiesenau 2 9462 Bad St. Leonhard Austria
This UK Technical Assessment contains:	49 pages including 8 Annexes
This UK Technical Assessment is issued in accordance with The Construction Products (Amendment etc.) (EU Exit) Regulations 2020 on the basis of:	UKAD 130005-00-0304: Solid wood slab element to be used as a structural element in buildings

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1. Technical description of the product

1.1. General

This UK Technical Assessment (UKTA) applies to the cross laminated timber KLH-CLT.

KLH-CLT is manufactured from softwood boards, laminated boards or wood-based panels, which are bonded together to form cross laminated solid wood slab elements. The adjacent layers of the softwood boards are arranged perpendicular to each other (see Annex 1, Figure 1).

The surfaces are planed with the principal structure of the cross laminated timber shown in Annex 1, Figures 1 to 3.

The solid wood slab elements consist of between three and eighteen adjacent layers, which are arranged perpendicular to each other. The thickness and orientation of individual layers are symmetrically assembled.

The following factors apply:

- 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. Adjacent layers of solid wood panels are permissible.
- No load-bearing function is assigned to wood-based panels, other than solid wood panels. These are only used for providing the surfaces of the solid wood slabs.
- Multiple consecutive board layers may be arranged in the same direction if their overall thickness does not exceed 90 mm.
- For solid wood slabs with distinctive asymmetric cross sections, the effects of asymmetry must be considered.

KLH-CLT and the boards for its manufacturing correspond to the specifications given in Annexes 1 and 2. The material characteristics, dimensions, and tolerances of KLH-CLT, not indicated in these Annexes, are given in the UKTA technical file.

The application of wood preservatives and flame retardants is not included within this UKTA.

1.2. Components

1.2.1 Boards

The specification of the boards is given in Annex 2, Table 1. Boards are visually or machine strength graded. Only kiln-dried wood shall be used.

The wood species are European spruce or equivalent softwood.

1.2.2 Adhesive

The adhesive for bonding of the cross laminated timber and the finger joints of the individual boards shall conform to EN 15425.

1.2.3 Wood-based panels

Wood-based panels are in accordance with EN 13986.

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.

Laminated boards are exclusively used in cross layers.

Butt joints within one layer of solid wood panels are to be statically regarded as a joint without transfer of tension or compression forces.

Wood-based panels other than solid wood panels are only used for providing the surfaces of the solid wood slab elements without a load bearing function.

2. Specification of the intended use(s) in accordance with the applicable UK Assessment Document (hereinafter UKAD)

2.1. Intended use

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

The solid wood slab elements shall be subjected to static and quasi-static actions (not relevant for fatigue e.g., low cycle alternating stress due to person induced vibrations, wind and seismic loads and less highly frequented heavy traffic) only.

The solid wood slab elements are 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.

2.2. General assumptions

The solid wood slab elements are manufactured in accordance with the provisions of the UK Technical Assessment using the automated manufacturing process as identified in the inspection of the manufacturing plant by the BBA and laid down in the technical file.

The manufacturer shall ensure that the requirements in accordance with sections 1, 2 and 3 as well as with the Annexes of this UK Technical Assessment are made known to those who are concerned with design and execution of the works.

Single and double layers of planed boards shall be bonded together to the required thickness of the cross laminated timber. The individual boards shall be jointed in longitudinal direction by means of finger joints according to EN 14080; there shall be no butt joints.

Adhesive shall be applied on one face of each board. The edges of the boards need not be bonded. The applied pressure shall be at least 0.6 N/mm².

Design

The UK Technical Assessment only applies to the manufacture and use of cross laminated timber. Verification of stability of the works including application of loads on the cross laminated timber is not subject to this UK Technical Assessment.

The following conditions shall be observed:

- Design of cross laminated timber members is the responsibility of an engineer experienced in such products.
- Design of the works shall account for the protection of the cross laminated timber in service.
- The cross laminated timber members are installed correctly.

Cross laminated timber members elements should be designed according to EN 1995-1-1 and EN 1995-1-2, taking into account Annexes 2 to 7 of this UK Technical Assessment. Standards and regulations in force at the place of use shall also be considered.

Packaging, transport, storage, maintenance, replacement and repair

The manufacturer is responsible for the appropriate measures and should advise on transport, storage, maintenance, replacement and repair of the product.

Installation

The product must be installed according to the manufacturer’s instructions, or, in absence of such instructions, according to conventional good building practice.

2.3. Assumed working life

The provisions made in the UK Technical Assessment are based on an assumed intended working life of KLH-CLT of 50 years, provided that the cross laminated timber elements are subject to appropriate installation, use and maintenance (see section 2.2). These provisions are based upon the current state of the art and the available knowledge and experience.

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by the Technical Assessment Body but are regarded only as a means for choosing the appropriate 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 (BWR 1)[(1)]

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

(1) These characteristics also relate to basic requirement for construction works 4.

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

3.2. Safety in case of fire (BWR 2)

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

3.3. Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Content, emission and/or release of dangerous substances	No dangerous substances are used as per UKAD 130005-00-0304
Water vapour permeability – Water vapour transmission	See Annex 3

3.4. Safety and accessibility (BWR 4)

Essential characteristic	Performance
Impact resistance	See Annex 3

3.5. Protection against noise (BWR 5)

Essential characteristic	Performance
Airborne sound insulation	See Annex 3
Impact sound insulation	See Annex 3
Sound absorption	No performance assessed

3.6. Energy economy and heat retention (BWR 6)

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

3.7. Sustainable use of natural resources (BWR 7)

No performance was investigated.

4. Assessment and verification of constancy of performance (hereinafter AVCP) system applied

4.1. System of assessment and verification of constancy of performance

According to UKAD No. 130005-00-0304 and Annex V of the Construction Products Regulation (Regulation (EU) 305/2011 as brought into UK law and amended, the system of assessment and verification of constancy of performance 1 applies.

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

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with the British Board of Agrément and made available to the UK Approved Bodies involved in the conformity attestation process.

5.1. UKCA marking for the product/ system must contain the following information:

- Identification number of the Approved Body
- Name/address of the manufacturer of the product/ system
- Marking with intention of clarification of intended use
- Date of marking
- Number of certificate of constancy of performance
- UKTA number.

On behalf of the British Board of Agrément	
Date of Issue: 16 February 2022	**Hardy Giesler** Chief Executive

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ANNEXES

Those annexes apply to the product described in the main body of the UK Technical Assessment.

ANNEX 1 STRUCTURE OF KLH-CLT

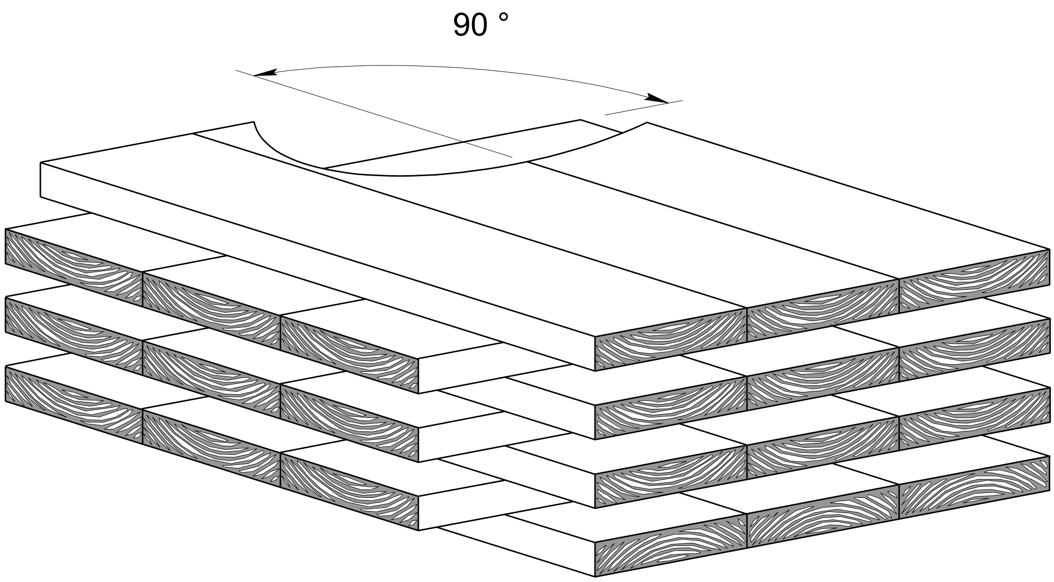

Figure 1: Principle structure of KLH-CLT

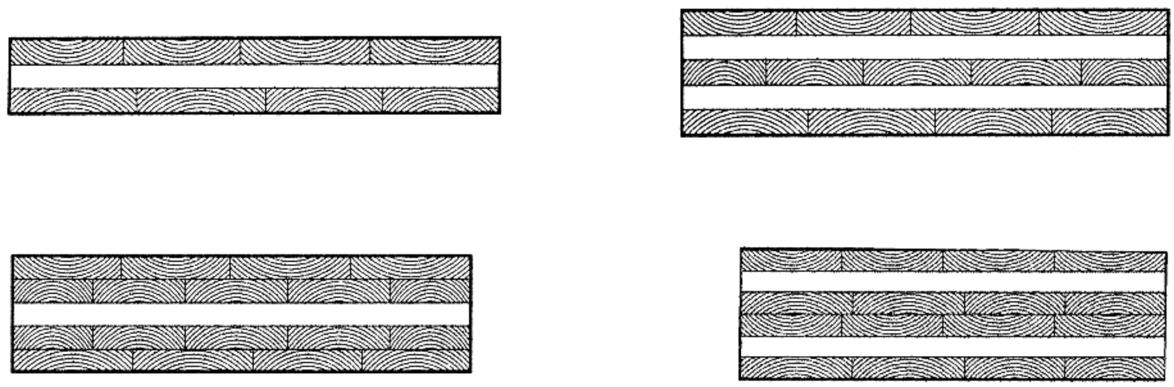

Figure 2: Typical examples of the structure of KLH-CLT

KLH-CLT	Annex 1
Structure of KLH-CLT	

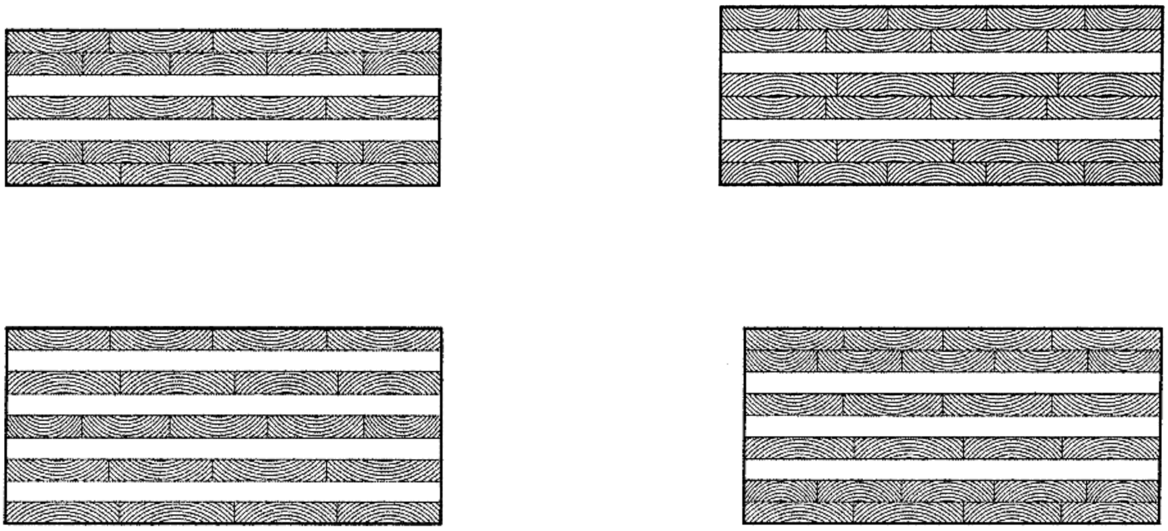

Figure 3: Typical examples of the structure of KLH-CLT

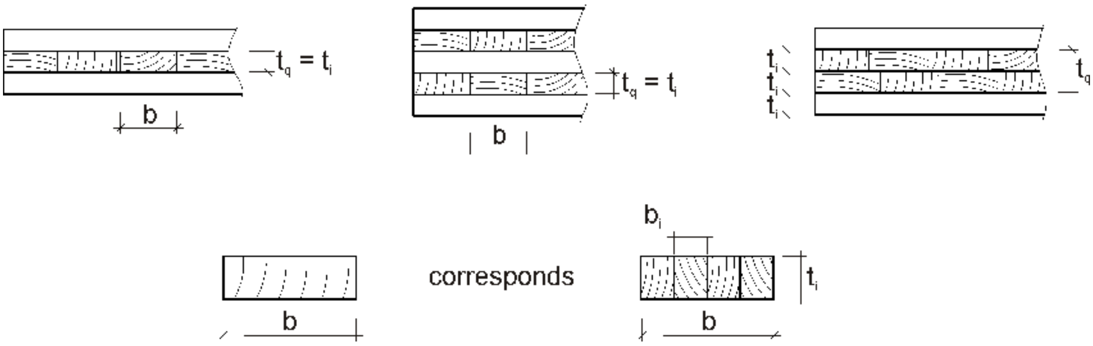

Figure 4: Typical dimensions of cross section of KLH-CLT lamellas

Where

b....................... Width of a single board, solid wood or laminated board

b_i .... Partial cross section of single board or single lamella of laminated boards

t_i .... Thickness of single layer

t_q .... Thickness of single or multiple layer in cross direction, $t_q \leq 90$ mm

Laminated boards are bonded with an adhesive suitable for structural applications.

KLH-CLT	**Annex 1**
Structure of KLH-CLT	

ANNEX 2 CHARACTERISTIC DATA OF KLH-CLT

Table 1: Dimensions and specifications

Item		Dimension / Specification
Solid wood slab element		
Thickness	mm	57 to 360
Width	m	≤ 3.50
Length	m	≤ 16.50
Number of layers	—	3 to 18
Maximum value of joint width between boards within one layer:	mm mm	3 max. 5 % ≤ 6
Density ρ_k	kg/m³	1,1 x $\rho_{l,k}$ = 385
Board [1]		
Surface	—	planed
Thickness, planed dimension	mm	10 to 45
Width [1]	mm	44 to 298
Ratio width to thickness	—	≥ 2.3 : 1 [2] ≥ 4 : 1 [3]
Boards shall be graded with suitable visual and/or machine procedures to be able to assign them to the strength classes according to EN 338.	—	≤ 10 % C16 ≥ 90 % C24 [4]
Moisture of wood according to EN 13183-2	%	Delivery: 12 ± 2 Production: 6 to 15 %, within one member of cross laminated timber the moisture content shall not differ by more than 5 %
Finger joints	—	EN 14080

1) Laminated boards with single lamellas b_i and t_i ≤ 45 mm according to Figure 4, are considered as boards.

2) Minimum ratio for layers oriented in cross direction (stressed on rolling shear).

3) In general

4) For the whole product as well as each single layer.

KLH-CLT	**Annex 2**
Characteristic data of KLH-CLT	

ANNEX 3 PRODUCT CHARACTERISTICS OF KLH-CLT

Table 2: Product characteristics of KLH-CLT

BWR	Essential characteristic	Assessment method	Level / Class / Description
1	**Mechanical resistance and stability**		
	1. Mechanical actions perpendicular to the solid wood slab		
	Modulus of elasticity [3)]		
	– parallel to the grain of the boards $E_{0,\ mean}$	Annex 4 UKAD 130005-00-0304, 2.2.1.1	12 000 MPa
	– perpendicular to the grain of the boards $E_{90,\ mean}$	EN 338, increased	450 MPa
	Shear modulus [3)]		
	– parallel to the grain of the boards $G_{0,mean}$	EN 338	690 MPa
	– perpendicular to the grain of the boards, rolling shear modulus $G_{90,\ mean}$	I_{eff}, γ-method UKAD 130005-00-0304, 2.2.1.1	50 MPa
	Bending strength		
	– parallel to the grain of the boards $f_{m,\ k}$	Annex 4 UKAD 130005-00-0304, 2.2.1.1	24 MPa
	Tensile strength		
	– perpendicular to the grain of the boards $f_{t,\ 90,\ k}$	EN 338, reduced	0.12 MPa
	Compressive strength		
	– perpendicular to the grain of the boards $f_{c,\ 90,\ k}$	EN 338	2.7 MPa
	Shear strength		
	– parallel to the grain of the boards $f_{v,\ k}$	EN 338	2.7 MPa
	– perpendicular to the grain of the boards (rolling shear strength) $f_{v,\ R,\ k}$	Annex 4 UKAD 130005-00-0304, 2.2.1.3	1.2 MPa
	2. Mechanical actions in plane of the solid wood slab		
	Modulus of elasticity [3)]		
	– parallel to the grain of the boards $E_{0,\ mean}$	A_{net}, I_{net}, Annex 4 UKAD 130005-00-0304, 2.2.1.1	12 000 MPa
	Shear modulus [3)]		
	– parallel to the grain of the boards $G_{0,mean}$ [1)]	A_{net}, Annex 4 UKAD 130005-00-0304, 2.2.1.3	500 MPa [1)]
	Bending strength		
	– parallel to the grain of the boards $f_{m,\ k}$	W_{net}, Annex 4 UKAD 130005-00-0304, 2.2.1.1	24 MPa

KLH-CLT	**Annex 3**
Product characteristics of KLH-CLT	

BWR	Essential characteristic	Assessment method	Level / Class / Description
1	**2. Mechanical actions in plane of the solid wood slab**		
	Tensile strength [2] – parallel to the grain of the boards $f_{t, 0, k}$	EN 338	16.5 MPa
	Compressive strength – parallel to the grain of the boards $f_{c, 0, k}$ – concentrated, parallel to the grain of the boards $f_{c, 0, k}$	EN 338 UKAD 130005-00-0304, 2.2.1.2	24 MPa $k_{c,0}$ Annex 4, 3.5
	Shear strength – regardless of loading direction, per glue line $f_{v,K,k}$ – parallel to the grain of the boards $f_{v, k}$	Annex 4 – Shear flow Annex 4 – Shear stress	90 N/mm 3.9 to 8.4 MPa
	3. Other mechanical actions		
	Creep and duration of load	k_{mod} and k_{def} according to EN 1995-1-1 for glued laminated timber	
	Dimensional stability Moisture content during service shall not change to such an extent that adverse deformation will occur.		
	– Shrinkage perpendicular to the plane of the solid wood slab – Shrinkage in plane of the solid wood slab	0.24 % in thickness per % moisture variation 0.02 % in length per % moisture variation	
	Fasteners	Annex 7	
	In-service environment		
	Durability of timber Service classes	EN 1995-1-1	 1 and 2
	Bond integrity	UKAD 130005-00-0304	Pass

[1] This value is applicable for 2 dimensional structures, orthotropic plates. For a simplified beam analysis, this value shall be reduced to 50 %.

[2] In case of a non-uniform stress distribution, the characteristic bending strength may be applied.

[3] For determination of the 5 %-fractile values of the stiffness properties the mean values may be multiplied by 5/6.

KLH-CLT	Annex 3
Product characteristics of KLH-CLT	

BWR	Essential characteristic	Assessment method	Level / Class / Description
2	**Reaction to fire**		
	Glued laminated timber products	Commission Decision 2005/610/EC	Mean density of wood ≥ 380 kg/m^3 Euroclass D-s2, d0
	Resistance to fire		
	Charring rate	EN 1995-1-2	Obtained test data according to Annex 5
3	**Hygiene, health and environment**		
	Vapour permeability, μ, including joints within the layers	EN ISO 12572	300 (dry) to 46 (wet)
4	**Safety and accessibility 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**		
	Airborne sound insulation	EN 10140-2	Annex 6
	Impact sound insulation	EN 10140-3	Annex 6
6	**Energy economy and heat retention**		
	Thermal conductivity, λ	EN ISO 10456	0.12 W/(m · K)
	Air permeability	EN 12114	Class 4 acc. to EN 12207
	Thermal inertia, specific heat, c_p	EN ISO 10456	1 600 J/(kg · K)

KLH-CLT	Annex 3
Product characteristics of KLH-CLT	

ANNEX 4 DESIGN CONSIDERATIONS FOR KLH PLATE STRUCTURES

Design considerations for KLH plate structures

1 General definitions and terminology

1.1 Mechanical actions perpendicular to the solid wood slab

Along the two main directions of the solid wood slab, the two main structural directions are defined. See Figure 5 for mechanical actions perpendicular to the solid wood slab.

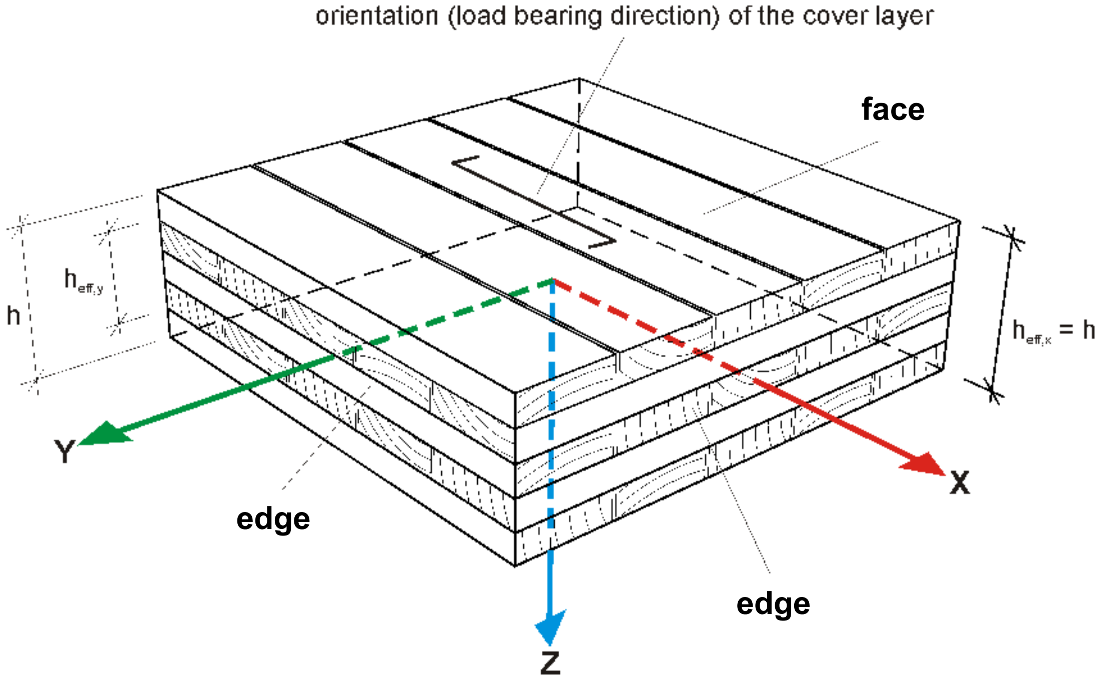

Figure 5: Main directions regarding mechanical actions perpendicular to the solid wood slab

Where

h ....gross thickness of the solid wood slab

$h_{eff,\,x}$, $h_{eff,\,y}$.........effective height of the cross-section in main structural direction x or y

x ....direction parallel to the orientation of the cover layer

y ....direction perpendicular to the orientation of the cover layer

KLH-CLT	Annex 4
Design considerations	

1.2 Mechanical actions in plane of the solid wood slab

Along the two main directions of the solid wood slab, the two main structural directions are defined. See Figure 6 for mechanical actions in plane of the solid wood slab.

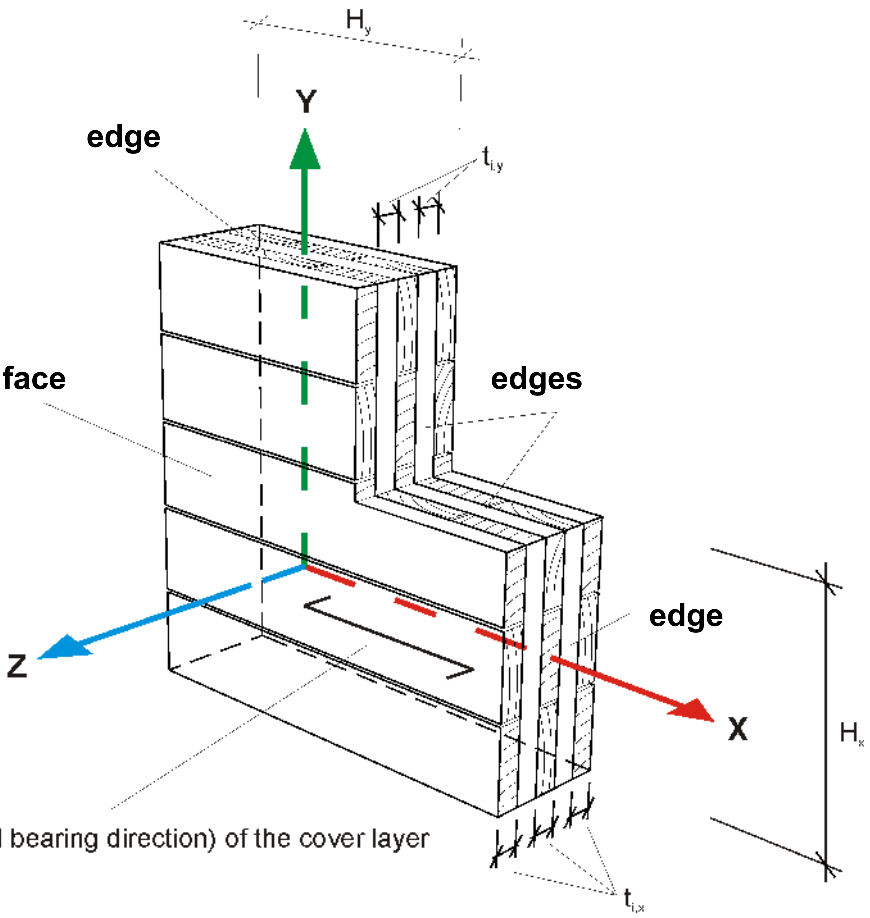

Figure 6: Main directions regarding mechanical actions in plane of the solid wood slab

Where

H_x, H_y ....height of the cross section in the respective structural direction without consideration of joints between adjacent boards

$t_{i,x}$, $t_{i,y}$ ....thickness of the single layers in the respective structural direction

KLH-CLT	Annex 4
Design considerations	

1.3 Normal stress and shear stress in the two main directions of the solid wood slab

Normal stresses and shear stresses resulting from mechanical actions perpendicular to the solid wood slab and normal stresses resulting from mechanical actions in plane of the solid wood slab are shown in Figure 7.

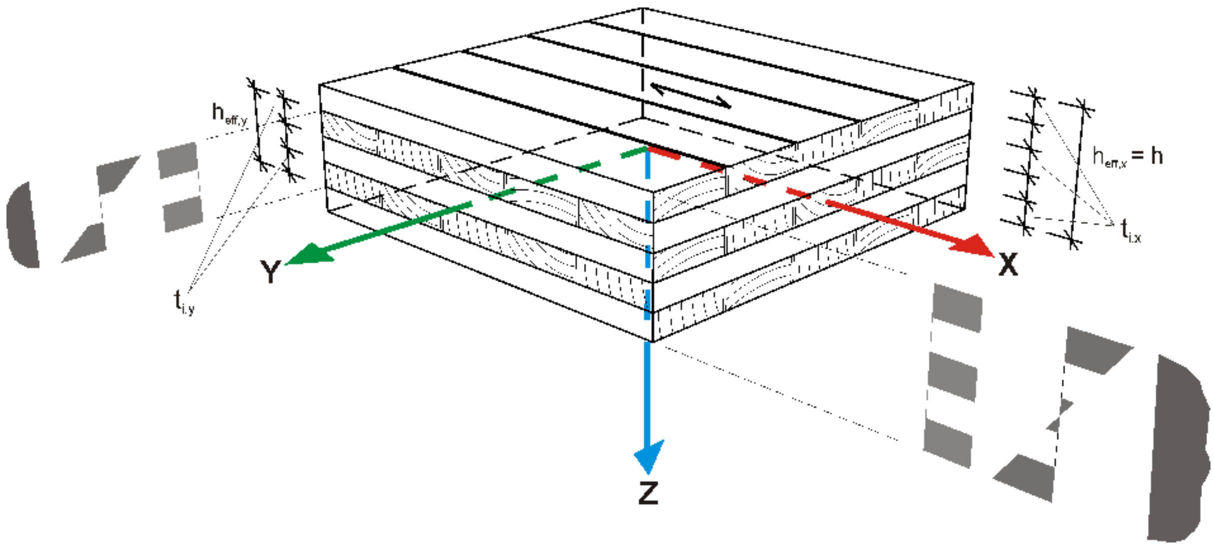

Figure 7: Normal and shear stresses

2 Calculation of stiffness properties

2.1 Short-term deformation

The deformation behaviour of KLH-CLT members can be considered by applying the following stiffnesses. Member forces and moments based on these stiffnesses shall be used for ultimate limit state design.

For actions perpendicular to the solid wood slab shear deformations of the layers perpendicular to the respective structural direction have to be considered.

Serviceability limit state design may be performed in accordance with EN 1995-1-1.

2.1.1 Bending stiffness

For calculation of the deformation due to pure bending, w_{net}, the net cross section, I_{net}, can be applied without shear deformations. I.e. layers oriented perpendicular to the considered main structural direction shall not be taken into account, i.e. $E_{90,\ mean}$ = 0 MPa and without shear deformation.

Where

I_{net}....................moment of inertia of the net cross section for the structural direction concerned

KLH-CLT	Annex 4
Design considerations	

$E_{0,\ mean}$ .... modulus of elasticity of the layers in the structural direction concerned

$E_{90,\ mean}$ .... modulus of elasticity of the layers perpendicular to the concerned structural direction, normally $E_{90,\ mean} = 0$ MPa

2.1.2 Shear deformations

The shear deformations of the perpendicular layers may be taken into account by application of a global shear modulus. This global shear modulus shall be determined for every cross section either by tests or by calculation. For calculation Annex B of EN 1995-1-1 can be applied, also referred to as γ-method. Therein the expression s_i/k_i shall be substituted by t_q / ($G_{90,\ mean} \cdot b$).

Where

t_q .... thickness of the respective cross layers

b .... width of the considered strip of the solid wood slab

$G_{90,\ mean}$ .... rolling shear modulus

The shear deformation results from the equation

$w_v = w_{eff} - w_{net}$

Where

w_{net} .... deformation due to bending by application of I_{net}, pure bending deformation

w_{eff} .... deformation due to bending by application of I_{eff}, bending- and shear deformation

w_v .... shear deformation, thus the global shear modulus can be calculated taking into account a shear factor for the rectangular cross section of 1.2

The global shear modulus is determined with the effective cross section including cross layers according to Figure 7, i.e. $A_{eff,\ x} = b \cdot h_{eff,\ x}$ or $A_{eff,\ y} = b \cdot h_{eff,\ y}$

NOTE For the structural direction perpendicular to the cover layers, the cover layers are disregarded for calculation of the effective cross section.

Where

$A_{eff,\ x}$, $A_{eff,\ y}$ cross sectional area of the layers in the structural direction concerned, including cross layers

b width of the considered strip of the solid wood slab

The global shear modulus, depending on the cross section and on the structural direction, accounting for shear deformation of the cross layers, can be taken to 60 MPa for all types of KLH-CLT; this simplification is conservative.

KLH-CLT	Annex 4
Design considerations	

2.1.3 Extensional stiffness

The extensional stiffness to determine deformations in plane of the solid wood slab shall be calculated with the net cross section of the layers in the considered structural direction, $A_{net, x}$, $A_{net, y}$. I.e. layers oriented perpendicular to the considered structural direction shall not be taken into account, $E_{90, mean}$ = 0 MPa.

$A_{net, x}$, $A_{net, y}$ net cross sectional area of the layers in the structural direction concerned, without cross layers

2.1.4 Shear stiffness in plane of the solid wood slab

Shear stiffness to determine deformations in plane of the solid wood slab can be calculated with the net cross section of the layers in the considered structural direction, $A_{net, x}$, $A_{net, y}$.

In a simplified beam analysis, the shear modulus for the layers in the concerned structural direction shall be taken to G_{LL} = 250 MPa for all configurations.

2.1.5 Bending stiffness for beams in plane of the solid wood slab

The bending stiffness for beams to determine deformations in plane of the solid wood slab should be applied only for a ratio $L/H \geq 4$

The bending stiffness in the considered structural direction, $E \cdot I_{net, z, x}$, $E \cdot I_{net, z, y}$ can be calculated with the net cross section of the layers in the considered main structural direction. I.e. layers oriented perpendicular to the considered main structural direction shall not be taken into account, $E_{90, mean}$ = 0 MPa.

2.1.6 Recommendations on Finite-Element-Analysis

Finite-Element-Analysis is a suitable means for design of KLH-CLT if the following items are considered.

Slabs loaded either perpendicular to the plane or in plane of the solid wood slab with a clearly separated structural behaviour, can be considered as orthotropic plate. However, the torsional stiffness shall be limited within the model to 50 % of the total torsional stiffness of the orthotropic plate.

NOTE Suitable means for modelling of orthotropic plates are varying thicknesses or varying moduli of elasticity in the two main structural directions of the solid wood slab.

If combined structural behaviour, perpendicular to the plane and in the plane of the solid wood slab, is to be considered, care should be taken to adequately consider the stiffness according to the Clauses above.

In case the stiffness perpendicular to the structural direction is of unfavourable influence, this effect shall be considered. In all other cases floors and walls may be analysed as uniaxial plate strips.

NOTE Inclined edges above supports shall be carefully considered. Step shaped modelling according to Figure 8 is recommended.

KLH-CLT	**Annex 4**
Design considerations	

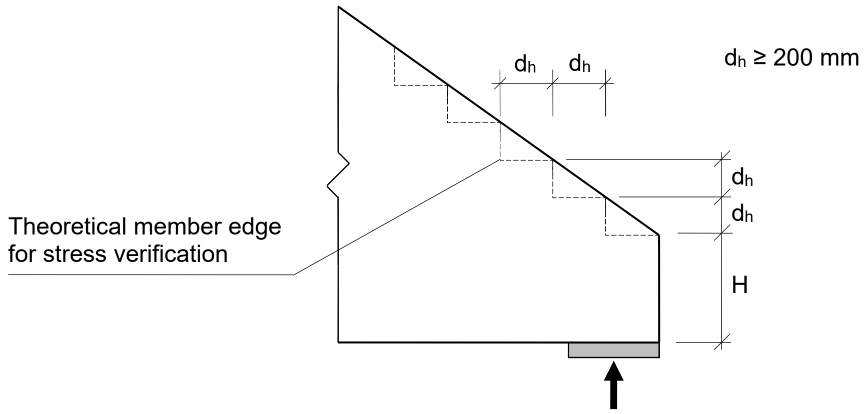

Figure 8: Modelling of an inclined edge by step shaped modelling

2.2 Long-term deformation

All long-term deformations, bending, axial force and shear shall be multiplied by the factors k_{def} given in Annex 3.

KLH-CLT	Annex 4
Design considerations	

3 Ultimate limit state design

3.1 General

Production related constraints, e.g., single boards cut longitudinal in cut outs for openings or the contribution of several layers to the load bearing capacity, should be considered by the system strength factor k_{sys}. Strength characteristics shall be reduced for small members or if only a single layer is loaded in plane of the solid wood slab. They may be increased in case of a larger member or several layers contribute together to the load bearing capacity.

Table 3: System strength factor k_{sys} for KLH-CLT

Loading perpendicular to the solid wood slab	Loading in plane of the solid wood slab	System strength factor
Member width	Number of layers	
b	n	k_{sys}
b ≤ 20 cm	n = 1	0.90
20 cm < b ≤ 100 cm	2 ≤ n < 5	1.00
100 cm < b ≤ 160 cm	5 ≤ n < 8	1.05
b > 160 cm	n ≥ 8	1.10
n .....number of layers along the concerned structural direction – actions in plane of the solid wood slab		

3.2 Tension along the grain – actions in plane of the solid wood slab

Only layers with a structural direction parallel to the stresses shall be considered. The following expression shall be satisfied:

$\sigma_{t,90,d} \leq f_{t,0,d} \cdot k_{sys}$

$\sigma_{t,90,d}$ shall be determined with $A_{net,x}$ or $A_{net,y}$.

For solid wood slabs loaded in plane and with varying tension stresses, the varying parts may be verified against the characteristic bending strength, $f_{m,k}$.

3.3 Tension perpendicular to the grain – actions perpendicular to the plane of the solid wood slab

Tension perpendicular to the grain should be avoided and should be transferred with fasteners.

NOTE Tension perpendicular to the grain for actions in plane of the solid wood slab may be disregarded.

KLH-CLT	Annex 4
Design considerations	

Only short term tension forces, e.g. wind loads, shall be applied perpendicular to the solid wood slab. The following expression shall be satisfied:

$\sigma_{t,90,d} \leq k_{vol} \cdot f_{t,90,d}$

The volume factor k_{vol} may be considered in analogy to glued laminated timber according to EN 1995-1-1, taking into account the penetration of the fasteners. Three dimensional effects, spreading of loads, may be taken into account for $\sigma_{t,90,d}$.

3.4 Compression along the grain – action in plane of the solid wood slab

Only layers with structural direction parallel to the stresses shall be considered. The following expression shall be satisfied:

$\sigma_{c,0,d} \leq f_{c,0,d} \cdot k_{sys}$

$\sigma_{c,0,d}$ shall be determined with $A_{net,x}$ or $A_{net,y}$.

The stability of members may be accounted for with a second order linear elastic analysis. Shear deformation shall be taken into account. The analysis and verification shall be performed using the 5 %-fractile values of the stiffness properties $E_{0.05}$ and $G_{0.05}$. The value for the initial deflection of a member shall be L/400 and covers long term deformations.

The stability of columns subjected to compression should be verified in accordance with EN 1995-1-1. Shear deformation shall be taken into account in the calculation of the slenderness ratio. The imperfection factor β_c may be taken to 0.1 and the factor for redistribution of bending stresses k_m should be taken equal to unity.

The stability of at least 300 mm wide solid wood slabs loaded in plane with non-uniform compression stresses, may be verified with the stress value in a distance of 100 mm from the edge of the member. This takes into account the stabilising effect within plate structures.

In addition to stability for members with low slenderness ratio stresses shall be verified.

For members small in width, stability in plane of the solid wood slab shall be taken into consideration.

3.5 Contact compression along the grain – actions in plane of the solid wood slab

The following expression shall be satisfied for contact compression stresses:

$\sigma_{c,0,d} \leq f_{c,0,d} \cdot k_{c,0}$

$\sigma_{c,0,d}$ shall be determined with $A_{net,x}$ or $A_{net,y}$. For layers of board or wood-based panels, except OSB and LVL, the value for $k_{c,0}$ can be taken to

$k_{c,0} \leq 1.5$ ....for support or load introduction in a distance $a \leq H/2$ or $a \leq 500$ mm (the smaller value is decisive)

$k_{c,0} \leq 1.9$ ....for support or load introduction in a distance $a > H/2$ or $a > 500$ mm (the smaller value is decisive)

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Where

a ....distance from the edge of a concentrated load to the closest end of the member in mm, see Figure 9

H ....member height in mm

$k_{c,0}$ greater than 1.3 is only applicable for end grain to steel contact. In slabs with more than one cover layers, a maximum thickness of 45 mm of the cover layer shall be considered in calculating $A_{net,x}$ or $A_{net,y}$.

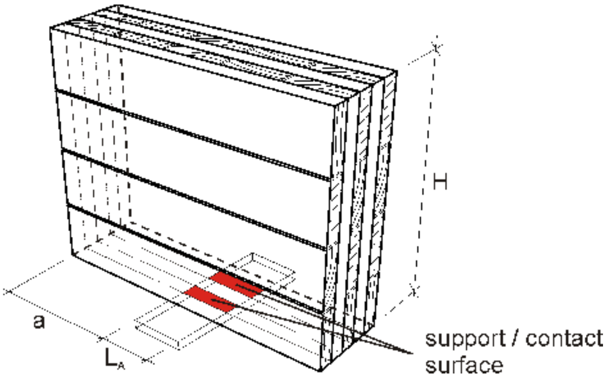

Figure 9: Geometry of load introduction

The capacity of the adjacent members (e.g., timber, concrete, or masonry) shall be verified. The distribution of stresses shall be determined considering the slab rotation and the compliance of the adjacent member.

The minimum bearing length L_A shall be 50 mm. For determination of the contact areas only layers with end grain perpendicular to the contact areas shall be considered, t_{normal} according to Figure 10.

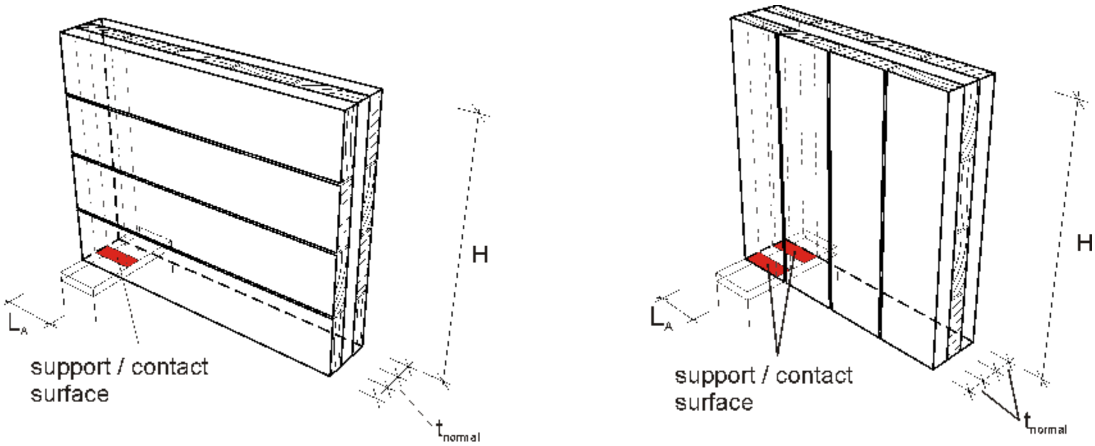

Figure 10: Bearing width and contact area

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The contact areas of two KLH-CLT members in direct contact at their edges are the end grain to end grain contact areas only. If a rigid load distribution plate is placed between the two solid wood slabs, the full end grain contact areas of both solid wood slabs, i.e. $A_{net,\,x}$ or $A_{net,\,y}$, can be taken.

3.6 Compression perpendicular to the grain

The following expression shall be satisfied:

$\sigma_{c,\,90,\,d} \leq f_{c,\,90,\,d} \cdot k_{c,\,90}$

$\sigma_{c,\,90,\,d}$ may be determined with $A_{c,\,90}$ and $k_{c,\,90}$ should be taken to

$k_{c,\,90} = 2.2$ .... for support or load introduction at the end of the member

$k_{c,\,90} = 3.0$ .... for contact areas with very small rotations, e.g. internal supports of continuous slabs with constant spans

The determination of the contact areas $A_{c,\,90}$ shall take into account:

$A_{c,\,90}$ is the contact surface of KLH-CLT to timber, steel, or concrete. In the case of contact to the edge of a KLH-CLT, e.g. contact from wall to floor, $A_{c,\,90}$ should be calculated with the effective width, $b_{eff,\,x}$ or $b_{eff,\,y}$, to $A_{eff,\,x}$ or $A_{eff,\,y}$, see Figure 11. For verification the complete contact area may be taken into account, assuming a uniform stress distribution. Rotations of the members at the contact area may be neglected.

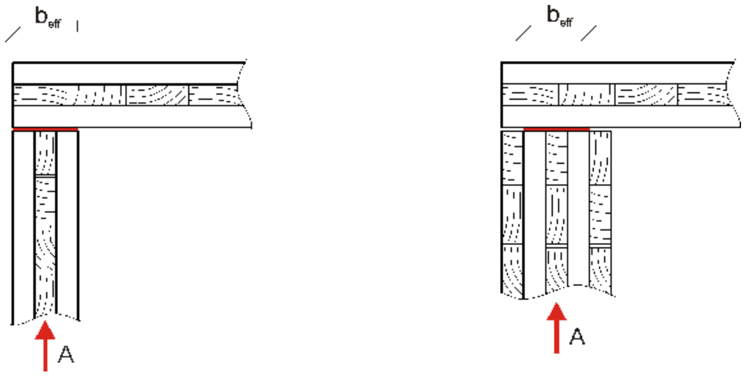

Figure 11: Effective bearing width for determination of contact area

3.7 Compression at an angle to the grain

The design compressive strength $f_{c,\,\alpha,\,d}$ at an angle α to the grain shall be determined in accordance with EN 1995-1-1.

The angle to the grain is to be considered in determining the contact areas. For a wide angle α, the cross layers may be taken into account. Thereby it shall be verified that the load can be uniformly transferred.

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3.8 Bending perpendicular to the plane of the solid wood slab

Shear deformation shall be considered in determining bending stresses. The following expression shall be satisfied:

$\sigma_{m,d} \leq f_{m,d} \cdot k_{sys}$

In a simplified stress analysis for members with a slenderness ratio L/h > 10, and by neglecting shear deformations, the design stresses shall not exceed a percentage η_M of the design strength.

$\eta_M \leq 90$ %........... within in the span

$\eta_M \leq 70$ %........... close to supports and concentrated loads

More accurate methods for the determination of stresses take into account the shear deformation and are e.g.: Finite-Element-Analysis, the shear-analogy-method, or other specific correction methods.

Superposition of bending stresses resulting from bending in both structural directions is not required, since in both structural directions different layers are stressed. Twisting moments, m_{xy}, resulting from two-dimensional analysis need not to be verified.

3.9 Bending in plane of the solid wood slab

The technical bending theory may be applied to beams with a slenderness ratio of $L/h \geq 4$. The following expression shall be satisfied:

$\sigma_{m,d} \leq f_{m,d} \cdot k_{sys}$

$\sigma_{m,d}$ may be determined by application of $W_{net,z,x}$ or $W_{net,z,y}$.

$W_{net,z,x}$, $W_{net,z,y}$.............section modulus of the layers in the structural direction parallel to the span

Superposition of bending stresses resulting from bending in both structural directions is not required, since in both structural directions different layers are stressed.

3.10 Superposition of normal stresses

Normal stresses in the same layer and of the same structural direction resulting from different actions shall be added for verification, see Figure 7.

3.11 Shear perpendicular to the plane of the solid wood slab

The crack factor k_{cr} according to EN 1995-1-1 is to be taken equal to unity. The following expression shall be satisfied:

$\tau_{v,d} \leq f_{v,R,d} \cdot k_v$

$f_{v,R,d}$ ....design rolling shear strength

k_v ....factor taking into account notches or areas with similar failure modes, see Annex 4, Clause 3.12

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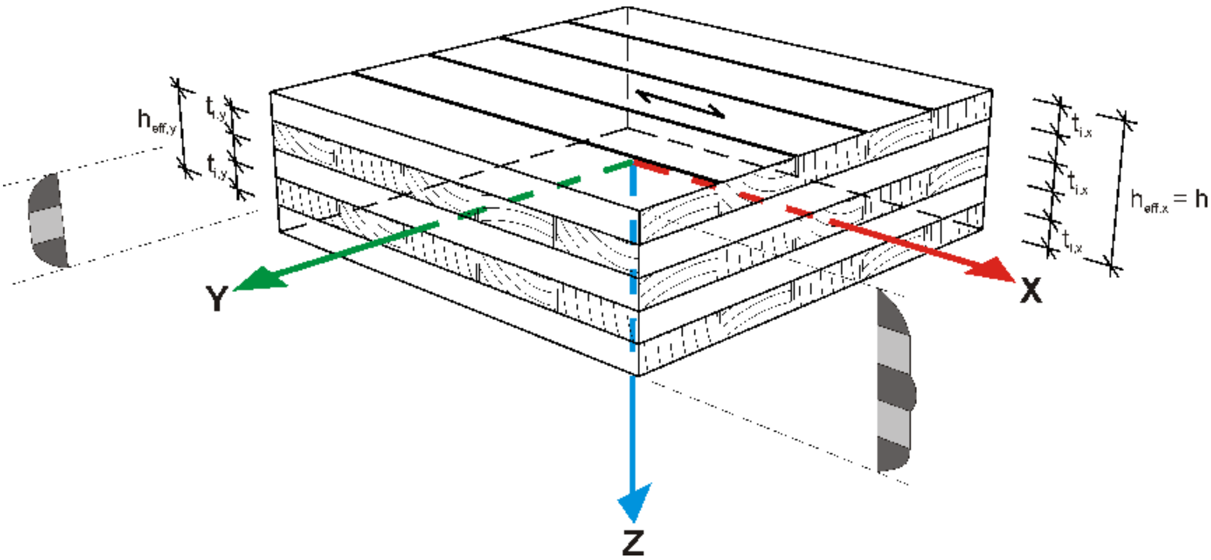

Figure 12: Shear stresses resulting from actions perpendicular to the plane of the solid wood slab

Figure 13: Effective height for calculation of shear stresses

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Shear stresses can be determined by application of I_{net} and S_{net}, not taking into account shear deformation. In general, layers with orientation perpendicular to the structural direction concerned, rolling shear strength $f_{v, R}$, are governing.

NOTE If the effective cross section, h_{eff}, comprises only one layer, the shear strength f_v according to Table 3 is applicable.

The design shear stress is calculated with

$\tau_{v, d} = (V_d \times S_{net}) / (I_{net} \times b)$

Where

S_{net} ....static moment of the respective part of the net cross section

I_{net}.....................moment of inertia of the net cross section

S_{net} and I_{net} are calculated by disregarding the layers perpendicular to the structural direction concerned, i.e. $E_{90, mean} = 0$ MPa

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3.12 Shear perpendicular to the plane of the solid wood slab – Notches

To take account for notches or support details similar to notches, e.g., edges subjected to shear forces at a partly unsupported edge, the effective cross section $h_{eff, red}$ shall be determined according to Figure 14 and Figure 15. The notch factor k_v shall be determined according to EN 1995-1-1, with k_n = 4.7 for KLH-CLT. The notch inclination i shall be taken to zero in any case.

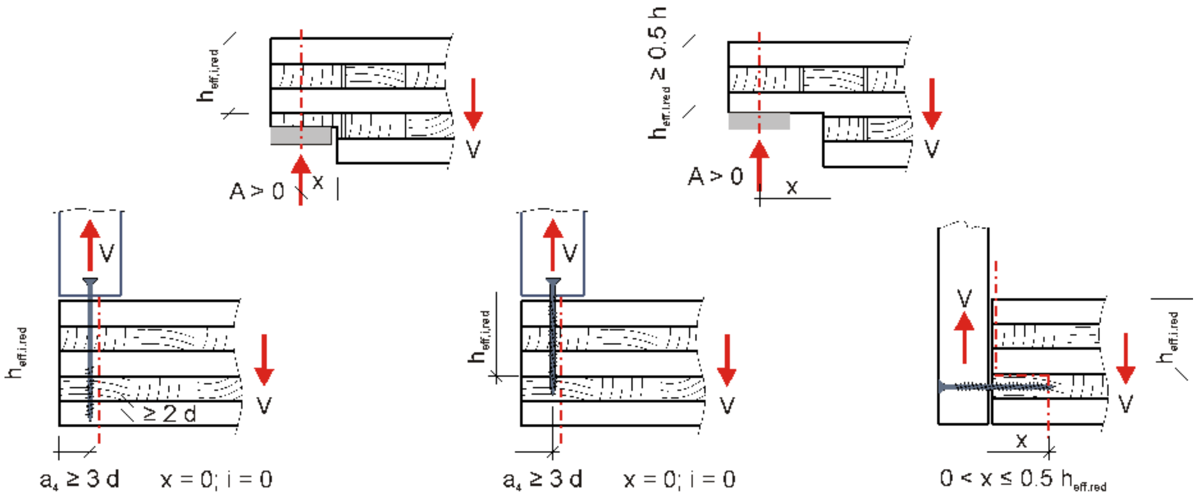

Figure 14: Reduced height, h_{eff}, to account for notches

Examples of typical notches, including notches from connections with fasteners, are given in Figure 14. In connections with wood screws, the width of the cross section shall be taken as the centre spacing of the screws, however not large than $h_{eff, i, red}$.

Edges which are supported only in part shall be considered by a notch.

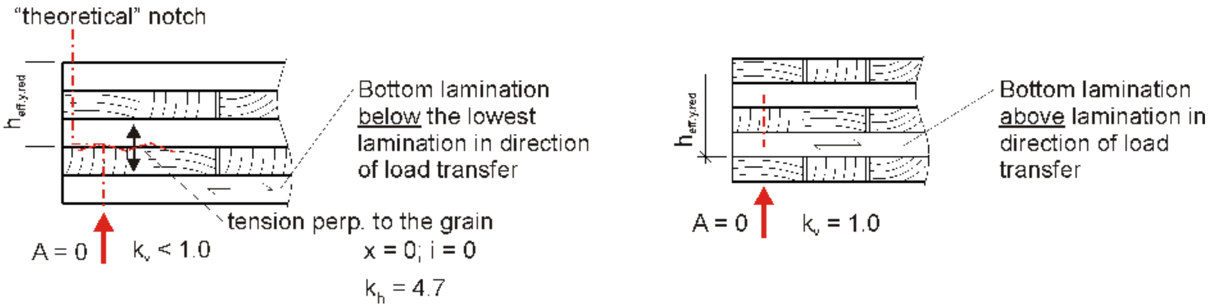

Figure 15: Left – partly supported edge – edge perpendicular to the cover layers
Right – partly supported edge – edge parallel to the cover layers

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Design considerations	

Shear forces of unsupported edges close to point supports may be determined in a distance e, see Annex 3, Clause 3.13, away from the support.

In reinforcements perpendicular to the grain, e.g., by fully threaded self-tapping screws, the total shear force is to be covered by the reinforcement elements. The screws shall extend down to layers below $h_{eff, red}$, with a minimum pointside penetration in the layer of 2 · d. The part of the cross section between the point of the screw and the surface of the solid wood slab shall be verified as a notch.

Where,

d ....nominal diameter of the wood screw

3.13 Shear perpendicular to the plane of the solid wood slab – Point supports

For solid wood slabs stressed in both structural directions, different stiffness for these two directions shall be considered.

Point supports and linear supports may be modelled as points and lines. This inherent gives close to that point or line distorted results. For shear stress verification the stresses in a distance of e = 0,5 · h away from the edge of the supporting member may be applied, see Figure 16. A uniform distribution of shear stresses may be assumed in each cross section. The total reaction force at the support may be distributed proportional to the shear areas in the two structural directions, see Figure 17.

Reductions in the cross-sectional area, e.g. holes, or drill holes, shall be taken into account if they are within the distance e, see Figure 16.

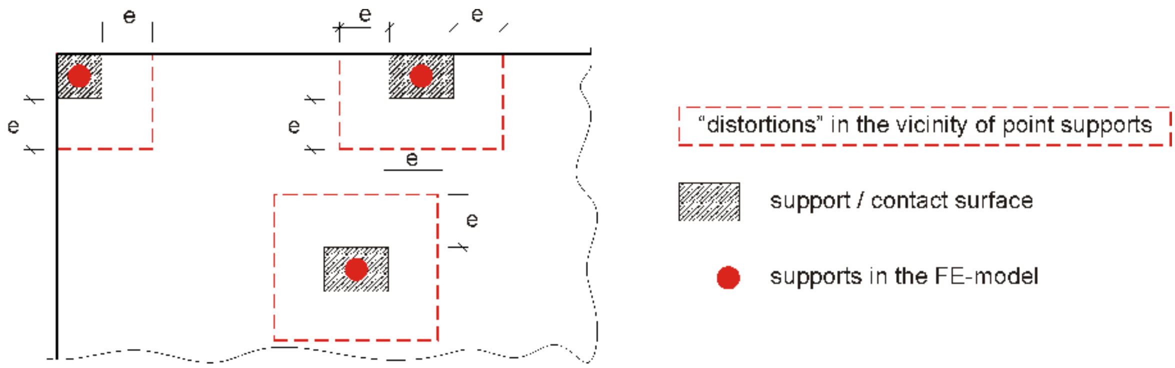

Figure 16: Relevant cross section for calculation of shear stresses close to point supports or concentrated loads

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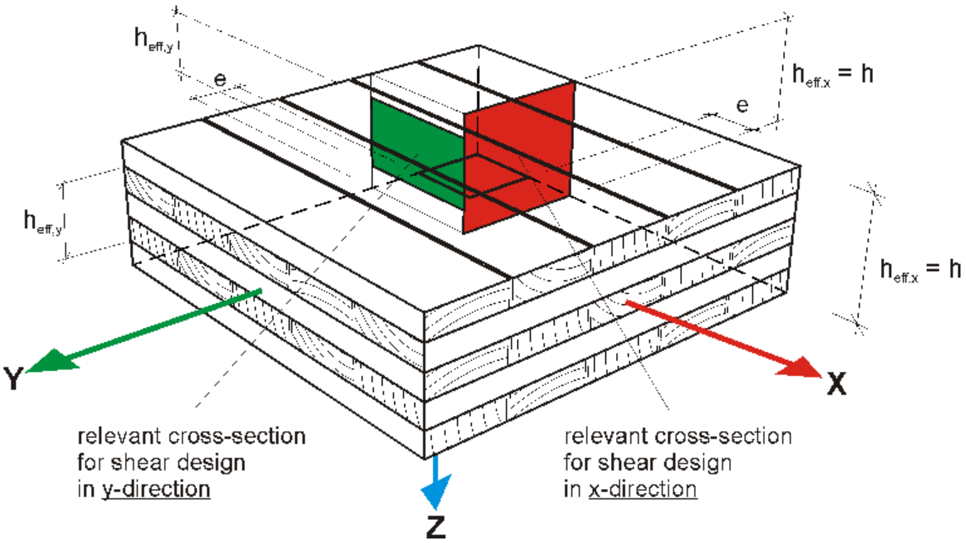

Figure 17: Relevant cross sections for shear stress verification – example of a point support at a corner

3.14 Shear in plane of the solid wood slab

Shear forces in plane of the solid wood slab are to be transferred to a large extent in the contact areas between the crosswise arranged layers. These glue lines are parallel to the direction of the force and hence a reduction of the shear force is not to be applied, i.e., the full shear force has to be taken for verification.

3.14.1 Slabs with general loading situation – verification of shear flow

For in plane shear forces without distinctive loading direction the following expression shall be satisfied:

$t_{v,d} \leq f_{v,K,d}$

The design shear flow $t_{v,d}$ may be determined by application of L_K.

$t_{v,d} = n_{xy,d} \times 1 / L_K$

L_K ....total glue line length between adjacent, crosswise arranged layers, where $L_K = n_K \times H$

H ....design-relevant member height in mm

$n_{xy,d}$ ....design shear force per unit of length resulting from e.g. an Finite-Element-Analysis

n_K ....number of glue lines between adjacent, crosswise arranged layers in the respective cross section

Normally H is to be taken to unity and $t_{v,d} = n_{xy,d} / n_K$ applies.

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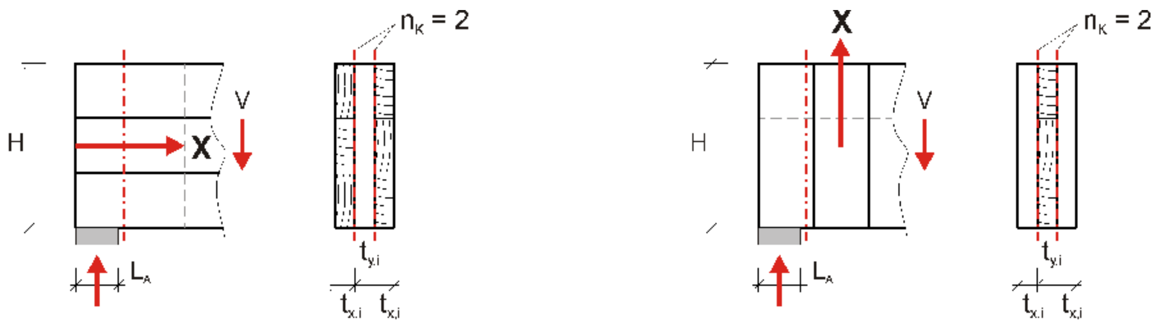

Finite Element Analysis:
- Verification in a section at the edge of the support
- In general, results of an FEA refer to 1 m unit length (H = 1.00 m)

Figure 18: Verification of shear forces in plane of the solid wood slab – shear flow

NOTE Design shear forces, as a result of a Finite-Element-Analysis, are related to a specific unit of length, e.g. kN/m, so H shall be in relation to this length.

3.14.2 Solid wood slabs as beam – verification of shear stress

Members or parts of members with a distinctive loading direction, even for L/H < 4, may be verified by shear stress analysis. A distinctive loading direction can be assumed if the layers perpendicular to this direction are nearly unloaded or if their main purpose is the coupling of the adjacent layers. This is applicable for most beam-like members, e.g. lintels above doors and windows, or columns between windows.

The following expression shall be satisfied:

$$\tau_{v,d} \leq f_{v,d}$$

The design shear stress $\tau_{v,d}$ may be determined by application of $A_{net,x}$ or $A_{net,y}$.

$$\tau_{v,d} = \begin{cases} \dfrac{n_{xy,d} \cdot 1}{A_{net,x}} \\ \text{or} \\ \dfrac{n_{xy,d} \cdot 1}{A_{net,y}} \end{cases}$$

Where

$A_{net,x}$, $A_{net,y}$.......cross sectional area of the layers parallel to the concerned structural direction, without cross layers

$f_{v,d}$ ....design value of shear strength parallel to the concerned structural direction, depending on the thickness of the layer

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Table 4: Characteristic values of shear strength – shear in plane of the slab

Thickness of layer t	mm	19 [2]	20	30	40	45
Characteristic value of shear strength $f_{v,k}$ [1]	MPa	8.4 [2]	8.2	6.2	4.6	3.9

[1] Interim values may be calculated by linear interpolation.

[2] Shear strength values > 8.4 MPa are not applicable, e.g., for laminations with t < 19 mm

The characteristic values of shear strength according to Table 4 may be increased by 25 % for inner layers. When cover layers and inner layers are stressed simultaneously, 25 % higher shear forces shall be assigned to the inner layers. In cover layers with a thickness greater than 45 mm, a maximum thickness of 45 mm shall be taken for stress calculation.

Finite Element Analysis:
- Verification in a section at the edge of the support
- In general, results of an FEA refer to 1 m unit length (H = 1.00 m)

Figure 19: Verification of shear in plane of the slab – shear stress

3.14.3 Simplified verification for beams

Members or parts of members with a distinctive loading direction and with L/H ≥ 4 and a height of H ≤ 800 mm may be verified by applying the technical beam theory. The cross section may be calculated with the layers parallel to this direction, disregarding the joints between the single boards and longitudinal cut boards. In the case of a rectangular cross section, the shear stresses may be calculated according to the following equation.

$$\tau_{v,d} = \begin{cases} \dfrac{1.5 \cdot V_d}{A_{net,x}} \\ \text{or} \\ \dfrac{1.5 \cdot V_d}{A_{net,y}} \end{cases}$$

Where

V_d ....design shear force

$A_{net,x}$, $A_{net,y}$.......cross sectional area of the layers parallel to the concerned structural direction, without cross layers

3.15 Combined shear stresses

Shear stresses resulting from actions in plane of the solid wood panel and perpendicular to the solid wood slab shall be combined by linear superposition, as these stresses are effective in the glue lines between the layers.

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4 Structural fire design

4.1 Performance R – load bearing capacity

Structural fire design of KLH-CLT shall be by applying the charring depth and the reduced strength and stiffness parameters for the part of the cross section which is influenced by elevated temperatures. For verification, a method with reduced cross sections considering the structure of KLH-CLT shall be applied according to EN 1995-1-2. Strength and stiffness parameters for the part of the cross section which is influenced by elevated temperatures can be either taken from Annex B of EN 1995-1-2, by application of test results or by analogy to e.g., glued laminated timber.

The temperature profiles, 300 °C isotherm, and depths of elevated temperatures within the cross section are given in Table 5.

NOTE For members or parts of members subjected to compression, a non-linear relationship, elastic-plastic, may be applied. It can be assumed, that tensile stresses in sections with a temperature > 200 °C lead to local failure and the stresses are redistributed to sections with temperatures ≤ 200 °C.

Where,

d_{char} ....charring depth; distance between the outer surface of the original member and the 300 °C isotherm

β_i ....charring rate of the considered layer i in mm/min

d_{Start} ....initial value for the determination of the 300 °C isotherm, char line

T_{Start} ....time corresponding to d_{Start}

T_i ....time of fire exposure of the considered layer

T_{ges} ....total time of fire exposure

α.......................inclination of the member with respect to the horizontal, $0° \leq \alpha \leq 90°$

$$T_{ges} = T_{Start} + \Sigma\, T_i$$

$$d_{char} = d_{Start} + \Sigma\, (T_i \cdot \beta_i)$$

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Structural fire design	

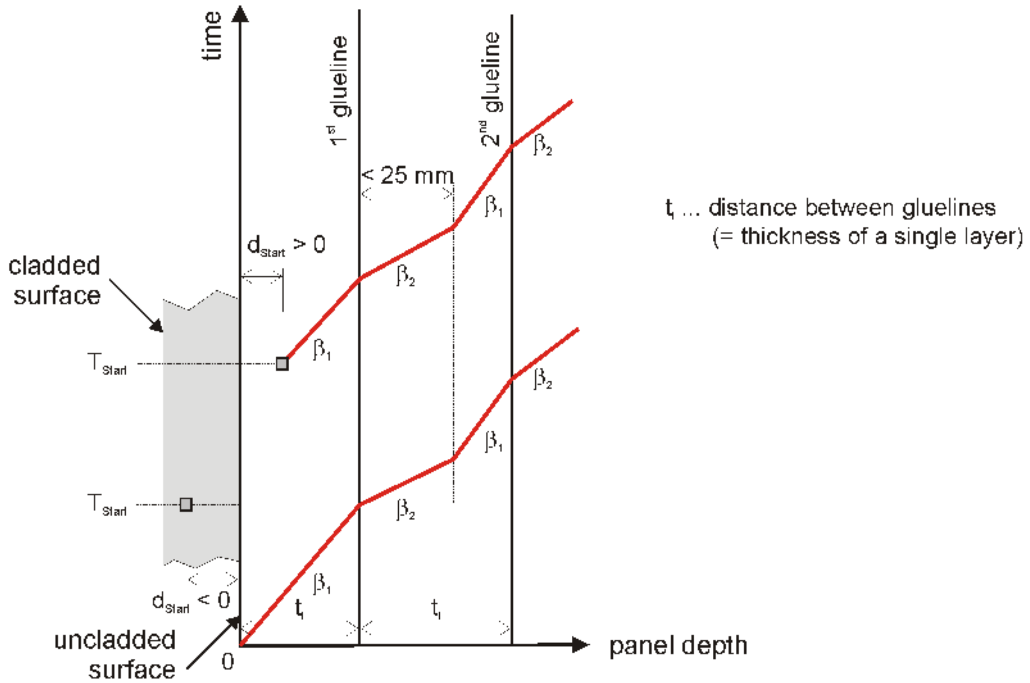

Figure 20: Charring behaviour with and without cladding

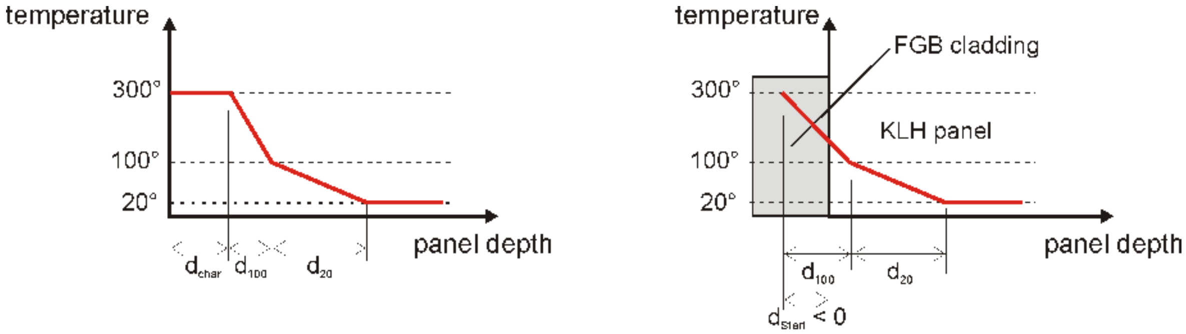

Figure 21: Temperature profiles for non-cladded and cladded KLH-CLT

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Structural fire design	

4.1.1 Parameters for structural fire design

Table 5 is applicable for fire exposure up of 120 minutes for cladded KLH-CLT. For non-cladded KLH-CLT the time of fire exposure may exceed 120 minutes.

Table 5: Charring rates and depth of elevated temperatures for KLH-CLT

Inclination α	Cladding System KLH	d_{Start} [1)]		β_1 [2), 1)]	β_2 [3), 1)]	d_{100}	d_{20}	T_{Start}	Time of exposure
		mm		mm/min	mm/min	mm	mm	min	min
$\alpha > 75°$	none	0		0.55 / 0.65	0.80 / 0.90	15	25	0	T > 0
	1 x 12,5 FGB/GF [4)]	-3	4	0.55 / 0.65	0.80 / 0.90	25	25	30	T = 30
		15	22			15	25	60	T ≥ 60
	1 × 15 FGB/GF [4)]	-12	-6			25	25	30	T = 30
		11	16			15	25	60	T ≥ 60
	2 × 15 FGB/GF [4)]	-35	-25			25	35	30	T = 30
		-15	-10			25	35	60	T = 60
		0	5			25	35	90	T = 90
		8	13			25	35	120	T = 120
	2 × 18 FGB/GF [4)]	-30	-25			25	35	30	T = 30
		-20	-15			25	35	60	T = 60
		-10	-5			25	35	90	T = 90
		5	10			25	35	120	T = 120
	VS70 with 1 x 15 FGB/GF [4)]	-25	-19			20	35	30	T = 30
		0	6			20	30	60	T = 60
		17	23			15	25	90	T ≥ 90
$\alpha \leq 75°$	none	0		0.65 / 0.75	1.00 / 1.10	15	25	0	T > 0
	1 × 15 FGB/GF [4)]	-12	-6	0.65 / 0.75 [5)]	1.00 / 1.10	25	25	30	T = 30
		30	34			15	25	60	T ≥ 60

1) 1st value = global, mean value – 2nd value = local, increased value for a solid wood slabs with width b < 300 mm
2) regular charring rate within one single layer
3) increased charring rate after the failure / drop off of one layer
4) Fireproof Gypsum Board or gypsum fibre boards with a density ≥ 1 000 kg/m³
5) Following the initial value T_0 the charring rate a_2 shall be applied until the next glue line is reached

For KLH-CLT with fire exposure on both sides, the temperature profiles may be determined independently for each side. The temperatures shall be added where temperature profiles are overlapping with temperatures above 20 °C.

KLH-CLT	Annex 5
Structural fire design	

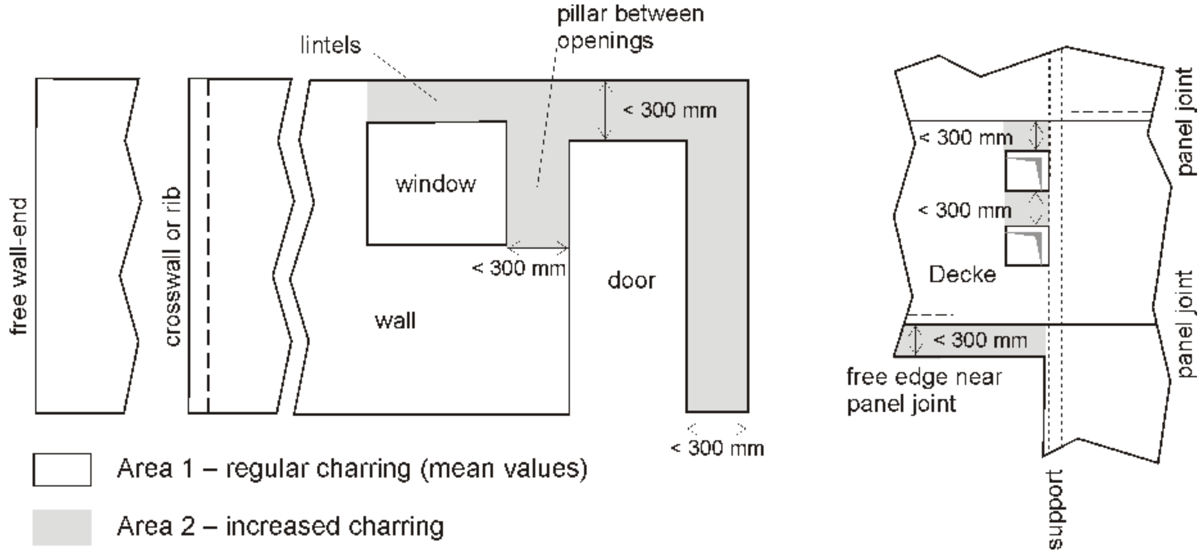

Figure 22: Definition of regions for application of regular and increased charring rates

4.1.2 Local charring at corners, grooves, etc.

The depth of the 300 °C isotherm may be assumed according to Figure 23. Grooves with a cross section ≤ (20 / 20) mm may be disregarded. Grooves smaller than 80 mm shall be considered as shown in Figure 23.

To account for the increased charring at edges, the charring rate at the edges of solid wood slabs shall be taken to 1,5 times the rate at the face.

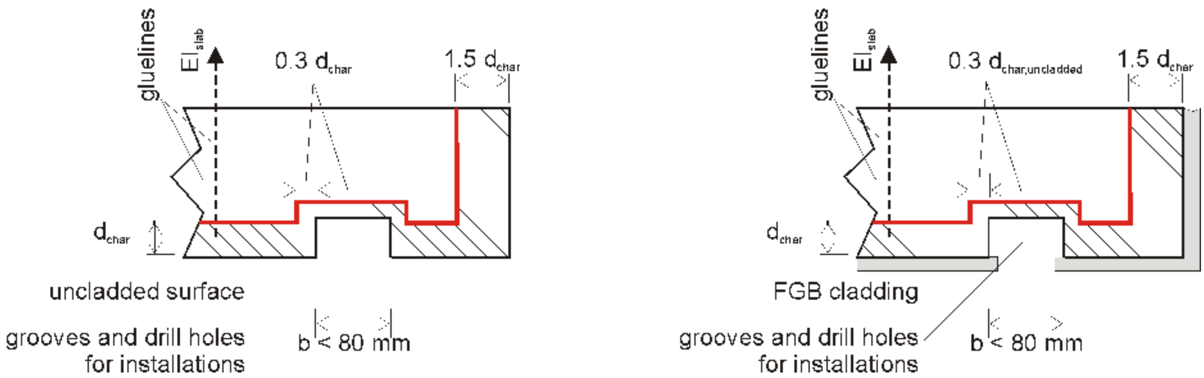

Figure 23: Charring at a groove and at an edge of a wall

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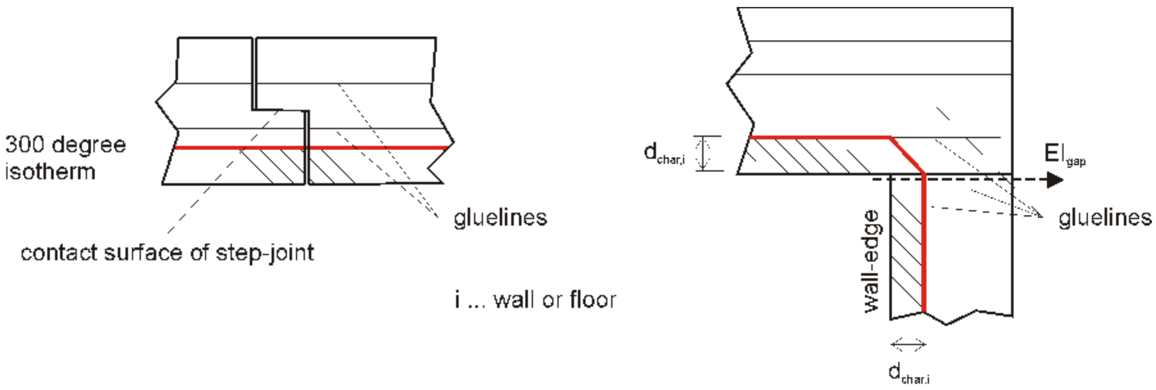


Figure 24: Charring behaviour in the vicinity of a step-joint or an inside corner

4.1.3 Connections

The capacity of connections may be assumed as unchanged if the complete fastener is exposed to temperatures < 200 °C. Edge distances are measured from the char line if the forces are parallel to the char line. Forces perpendicular to the char line relate to the 200 °C isotherm as the edge of the member.

4.2 Performances E and I – integrity and insulation

The performances E and I, penetration of hot gases through the member and limited temperatures on the unexposed side, may be regarded as acceptable under the following conditions:

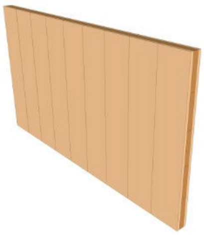
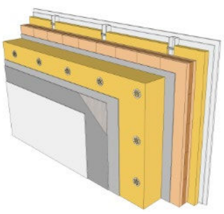
- The residual cross section comprises at least one cover layer and one glue line and
- the distance between glue line and 300 °C isotherm is greater than 15 mm.

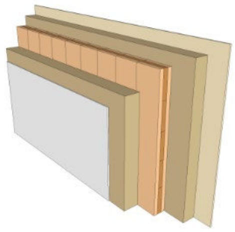
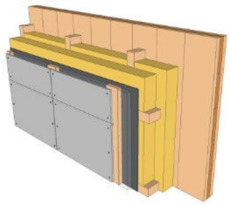
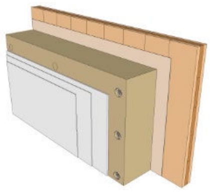
The use of sealing tapes is not required if the following is fulfilled:

- The surface temperature on the unexposed side is determined with the above given temperature profiles and does not exceed 120 °C.
- This is also applicable to butt-joints in corners of two solid wood slabs, if the maximum centre spacing of the screws is 250 mm.
- The temperature in the contact surface of step joints, with the contact surfaces parallel to the face of the solid wood slab, shall be not exceed 150 °C. The step joint shall be connected with wood screws with a maximum centre spacing of 250 mm.

ANNEX 6 EXAMPLES FOR AIRBORNE AND IMPACT SOUND INSULATION

Examples for airborne and impact sound insulation

№	Wall elements		
KLH12.04	158 mm	5s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 41 (-1; -4) dB** 
KLH12.03	128 mm	5s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 37 (-1; -3) dB** 
KLH12.02	94 mm	3s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 36 (-1; -3) dB** 
KLH12.01	72 mm	3s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 32 (-1; -3) dB** 
AW15.01	12.5 mm 50 mm 94 mm 3 mm 200 mm 6 mm 2 mm	Gypsum plasterboard, 680 kg/m³ Light weight C-profiles mounted on connectors including 40 mm mineral wool, 15 kg/m³ 3s KLH-CLT, 470 kg/m³ Adhesive mortar / compensation layer Stone wool rendering panel, 110 kg/m³ Rendering including glass fibre reinforcement Finishing coat	**$R_w(C; C_{tr})$ = 46 (-5; -12) dB** 

№	Wall elements		
AW14.07a	6 mm 100 mm 94 mm 120 mm 8 mm	Clay rendering Wood fibre board, 140 kg/m³ 3s KLH-CLT, 470 kg/m³ Wood fibre board, 140 kg/m³ Rendering system	**$R_w(C; C_{tr})$ = 45 (-3; -8) dB** 
AW14.05	94 mm 100 mm 100 mm 30 mm 12 mm	3s KLH-CLT, 470 kg/m³ Wooden battens, horizontal, 470 kg/m³ including 100 mm stone wool rendering panel, 115 kg/m³ Wooden battens, vertical, 470 kg/m³ including 100 mm stone wool rendering panel, 115 kg/m³ PE-foil Wooden battens, vertical, 470 kg/m³ Cement bonded particle board, 1350 kg/m³	**$R_w(C; C_{tr})$ = 53 (-2; -7) dB** 
AW14.01	94 mm 3 mm 200 mm 5 mm 2 mm	3s KLH-CLT, 470 kg/m³ Adhesive mortar / compensation layer Thermal insulation of hemp, 100 kg/m³ Adhesive mortar / compensation layer including glass fibre reinforcement Finishing coat	**$R_w(C; C_{tr})$ = 54 (-2; -7) dB** 
AW13.04	10 mm 94 mm 100 mm 100 mm 30 mm 19 mm	Gypsum plasterboard, 680 kg/m³ 3s KLH-CLT, 470 kg/m³ Wooden battens, vertical, 470 kg/m³ including 100 mm stone wool clamping plate, 30 kg/m³ Wooden battens, horizontal, 470 kg/m³ including 100 mm stone wool clamping plate, 30 kg/m³ PE-foil Wooden battens, vertical, 470 kg/m³ Shuttering, 500 kg/m³	**$R_w(C; C_{tr})$ = 44 (-1; -5) dB** 
AW12.05	25 mm 50 mm 35 mm 94 mm 280 mm 3 mm 3 mm	2 x Gypsum plasterboard, 680 kg/m³ Acoustical mounting including 50 mm mineral wool, 25 kg/m³ Air layer 3s KLH-CLT, 470 kg/m³ Adhesive mortar / compensation layer EPS, 25 kg/m³ Adhesive mortar / compensation layer including glass fibre reinforcement Finishing coat	**$R_w(C; C_{tr})$ = 57 (-4; -10) dB** 

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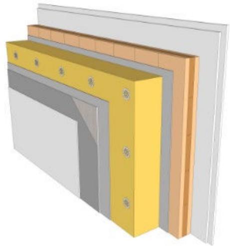
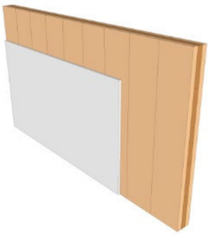
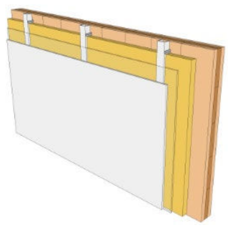
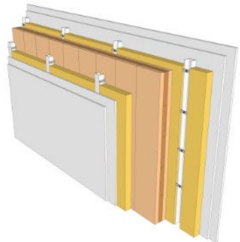
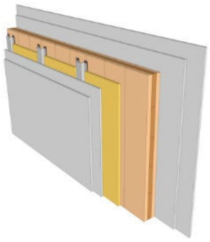
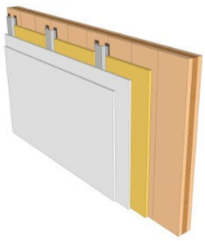
Annex 6

№	Wall elements		
AW12.01	94 mm 100 mm 100 mm 30 mm 30 mm 30 mm	3s KLH-CLT, 470 kg/m³ Wooden battens, vertical, 470 kg/m³ including 100 mm stone wool clamping plate, 30 kg/m³ Wooden battens, horizontal, 470 kg/m³ including 100 mm stone wool clamping plate, 30 kg/m³ PE-foil Wooden battens, vertical, 470 kg/m³ Wooden battens, horizontal, 470 kg/m³ Shuttering, 470 kg/m³	**$R_w(C; C_{tr})$ = 46 (-1; -5) dB** 
AW11.01	25 mm 94 mm 3 mm 180 mm 4 mm 3.5 mm 1.5 mm	2 x Gypsum plasterboard, 900 kg/m³ 3s KLH-CLT, 470 kg/m³ Adhesive mortar / compensation layer Stone wool rendering panel, 110 kg/m³ Adhesive mortar / compensation layer Rendering including glass fibre reinforcement Finishing coat	**$R_w(C; C_{tr})$ = 43 (-3; -8) dB** 
IW12.03	94 mm 25 mm	3s KLH-CLT, 470 kg/m³ 2 x Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 39 (-1; -4) dB** 
IW12.02	94 mm 12.5 mm	3s KLH-CLT, 470 kg/m³ Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 37 (-1; -3) dB** 
TW15.01	94 mm 50 mm 12.5 mm	3s KLH-CLT, 470 kg/m³ Light weight C-profiles mounted on connectors including 40 mm mineral wool, 15 kg/m³ Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 47 (-3; -8) dB** 

KLH-CLT

Protection against noise

Annex 6

№	Wall elements		
TW14.03a	94 mm 20 mm 6 mm	3s KLH-CLT, 470 kg/m³ Wood fibre board, 110 kg/m³ Clay finish	**$R_w(C; C_{tr})$ = 43 (-3; -8) dB** 
TW14.01	25 mm 50 mm 94 mm 50 mm 25 mm	2 x Gypsum plasterboard, 1000 kg/m³ Acoustical mounting including 40 mm glass wool, 15 kg/m³ 3s KLH-CLT, 470 kg/m³ Acoustical mounting including 40 mm glass wool, 15 kg/m³ 2 x Gypsum plasterboard, 1000 kg/m³	**$R_w(C; C_{tr})$ = 67 (-7; -15) dB** 
TW13.14	23 mm 27 mm 94 mm 27 mm 23 mm	Quartz sand panel, 1200 kg/m³ Acoustical mounting including 15 mm mineral wool, 110 kg/m³ 3s KLH-CLT, 470 kg/m³ Acoustical mounting including 15 mm mineral wool, 110 kg/m³ Quartz sand panel, 1200 kg/m³	**$R_w(C; C_{tr})$ = 64 (-8; -17) dB** 
TW13.10	30 mm 94 mm 20 mm 30 mm	2 x Gypsum fibreboard, 1150 kg/m³ 3s KLH-CLT, 470 kg/m³ Acoustical mounting including 20 mm glass wool, 40 kg/m³ 2 x Gypsum fibreboard, 1150 kg/m³	**$R_w(C; C_{tr})$ = 57 (-3; -9) dB** 
TW13.09	94 mm 20 mm 25 mm	3s KLH-CLT, 470 kg/m³ Acoustical mounting including 20 mm glass wool, 40 kg/m³ 2 x Gypsum plasterboard, 900 kg/m³	**$R_w(C; C_{tr})$ = 50 (-3; -10) dB** 

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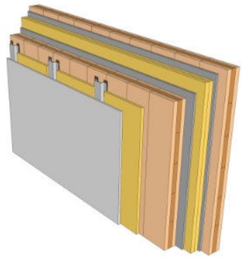
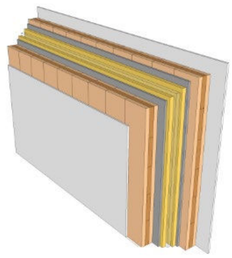
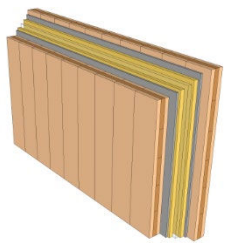
№	Wall elements		
TW12.06	25 mm 50 mm 35 mm 94 mm 35 mm 50 mm 25 mm	2 x Gypsum plasterboard, 680 kg/m³ Lightweight C-profiles including 50 mm stone wool, 22 kg/m³ Air layer 3s KLH-CLT, 470 kg/m³ Air layer Lightweight C-profiles including 50 mm stone wool, 22 kg/m³ 2 x Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 71 (-7; -14) dB** 
TW12.02	94 mm 35 mm 50 mm 25 mm	3s KLH-CLT, 470 kg/m³ Air layer Lightweight C-profiles including 50 mm stone wool, 22 kg/m³ 2 x Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 61 (-3; -9) dB** 
WTW16.05	12.5 mm 20 mm 94 mm 15 mm 30 mm 30 mm 15 mm 94 mm	Gypsum fibreboard, 1150 kg/m³ Acoustical mounting including 15 mm mineral wool, 110 kg/m³ 3s KLH-CLT, 470 kg/m³ Cement bonded sandwich panel, 1000 kg/m³ Fleece laminated glass wool, 40 kg/m³ Fleece laminated glass wool, 40 kg/m³ Cement-bonded sandwich panel, 1000 kg/m³ 3s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 64 (-5; -12) dB** 
WTW16.03	12.5 mm 94 mm 15 mm 30 mm 10 mm 30 mm 15 mm 94 mm 12.5 mm	Gypsum plasterboard, 680 kg/m³ 3s KLH-CLT, 470 kg/m³ Cement-bonded sandwich panel, 1000 kg/m³ Fleece laminated glass wool, 40 kg/m³ Air layer Fleece laminated glass wool, 40 kg/m³ Cement-bonded sandwich panel, 1000 kg/m³ 3s KLH-CLT, 470 kg/m³ Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 65 (-2; -8) dB** 
WTW16.02	94 mm 15 mm 30 mm 30 mm 30 mm 15 mm 94 mm	3s KLH-CLT, 470 kg/m³ Cement-bonded sandwich panel, 1000 kg/m³ Fleece laminated glass wool, 40 kg/m³ Air layer Fleece laminated glass wool, 40 kg/m³ Cement-bonded sandwich panel, 1000 kg/m³ 3s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 66 (-4; -8) dB** 

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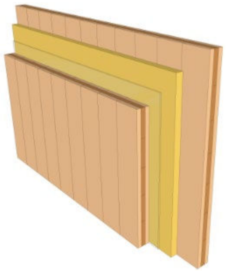
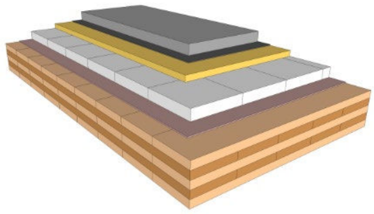
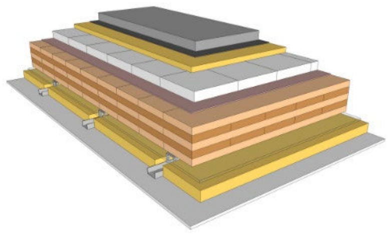
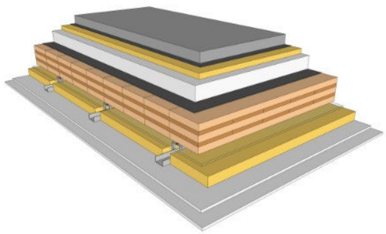
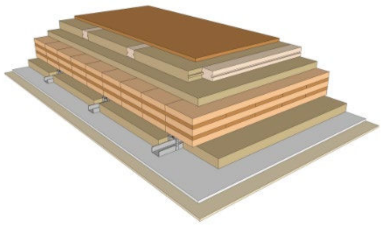
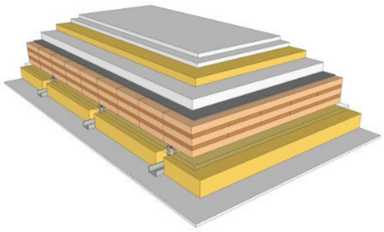
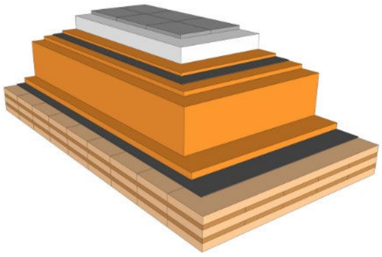
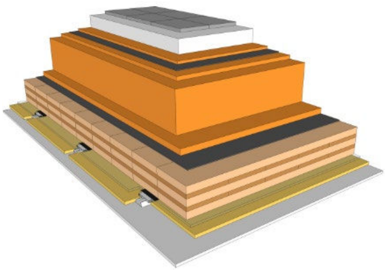
№	Wall elements		
TW12.01	94 mm 50 mm 10 mm 94 mm	3s KLH-CLT, 470 kg/m³ Mineral wool, 25 kg/m³ Air layer 3s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 60 (-4; -8) dB** 

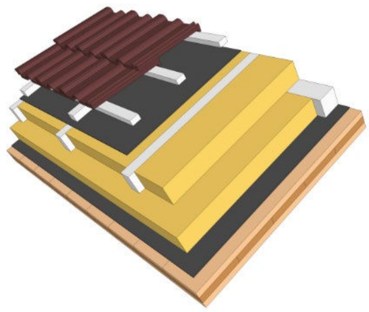
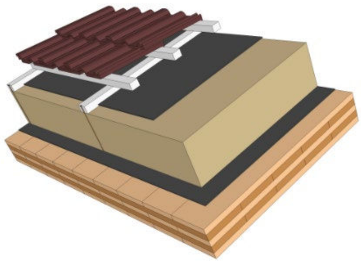
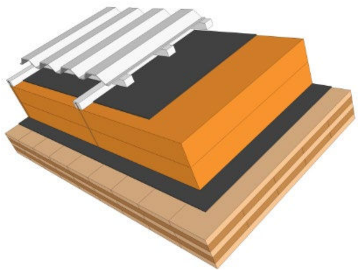
№	Floor elements		
GD15.02	60 mm 30 mm 50 mm 5 mm 145 mm	Cement screed, 2200 kg/m³ Separating layer Impact sound insulation board, 110 kg/m3, s' ≤ 7 MN/m³ Concrete layer, 2000 kg/m³ Acoustic layer, s' ≤ 115 MN/m³ 5s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 60 (-1; -3) dB** **$L_{n,w}(C_I)$ = 43 (1) dB** 
GD15.01	60 mm 30 mm 50 mm 5 mm 145 mm 60 mm 12.5 mm	Cement screed, 2200 kg/m³ Separating layer Impact sound insulation board, 110 kg/m3, s' ≤ 7 MN/m³ Concrete layer, 2000 kg/m³ Acoustic layer, s' ≤ 115 MN/m³ 5s KLH-CLT, 470 kg/m³ Acoustical mounting including 50 mm glass wool, 15 kg/m³ Gypsum plasterboard, 1000 kg/m³	**$R_w(C; C_{tr})$ = 75 (-2; -6) dB** **$L_{n,w}(C_I)$ = 36 (5) dB** 
GD14.08	60 mm 30 mm 80 mm 145 mm 60 mm 25 mm	Cement screed, 2200 kg/m³ Separating layer Impact sound insulation board, 110 kg/m³, s' ≤ 7 MN/m³ Bonded EPS granulate, 135 kg/m³ Trickle protection 5s KLH-CLT, 470 kg/m³ Acoustical mounting including 50 mm glass wool, 15 kg/m³ 2 x Gypsum plasterboard, 1000 kg/m³	**$R_w(C; C_{tr})$ = 74 (-3; -10) dB** **$L_{n,w}(C_I)$ = 44 (4) dB** 

KLH-CLT	**Annex 6**
Protection against noise	

№	Floor elements		
GD14.05	60 mm 40 mm 60 mm 145 mm 60 mm 12.5 mm 6 mm	Wood flooring, 470 kg/m³ Wood fibre board, 140 kg/m³ Wood fibre board, 140 kg/m³ 5s KLH-CLT, 470 kg/m³ Acoustical mounting including 50 mm wood fibre board, 50 kg/m³ Gypsum plasterboard, 1200 kg/m³ Clay finish	**$R_w(C; C_{tr})$ = 71 (-5; -13) dB** **$L_{n,w}(C_I)$ = 48 (5) dB** 
GD14.03	46 mm 40 mm 50 mm 145 mm 100 mm 12.5 mm	2 x Gypsum fibreboard dry screed element, 1250 kg/m³ Impact sound insulation board, 110 kg/m³, s' ≤ 20 MN/m³ Ballast weight, 1600 kg/m³ Separating layer 5s KLH-CLT, 470 kg/m³ Acoustical mounting including 80 mm glass wool, 15 kg/m³ Gypsum plasterboard, 1000 kg/m³	**$R_w(C; C_{tr})$ = 70 (-3; -10) dB** **$L_{n,w}(C_I)$ = 41 (2) dB** 

№	Roof elements		
DT14.02	35 mm 50 mm 20 mm 20 mm 200 mm 20 mm 145 mm	Concrete layer, 2200 kg/m³ Ballast weight, 1600 kg/m³ XPS, 30 kg/m³ PE-foil Impact sound insulation board, 110 kg/m³, s' ≤ 10 MN/m³ EPS, 30 kg/m³ Wood fibre board, 110 kg/m³ PE-foil 5s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 55 (-2; -6) dB** **$L_{n,w}(C_I)$ = 49 (0) dB** 
DT14.01	35 mm 50 mm 20 mm 20 mm 200 mm 20 mm 145 mm 27 mm 12.5 mm	Concrete layer, 2200 kg/m³ Ballast weight, 1600 kg/m³ XPS, 30 kg/m³ PE-foil Impact sound insulation board, 110 kg/m³, s' ≤ 10 MN/m³ EPS, 30 kg/m³ Wood fibre board, 110 kg/m³ PE-foil 5s KLH-CLT, 470 kg/m³ Acoustical mounting including 15 mm mineral wool, 110 kg/m³ Gypsum plasterboard, 680 kg/m³	**$R_w(C; C_{tr})$ = 64 (-3; -9) dB** **$L_{n,w}(C_I)$ = 45 (2) dB** 

KLH-CLT	**Annex 6**
Protection against noise	

№	Roof elements		
STD12.03	 30 mm 40 mm 100 mm 100 mm 94 mm	Roof covering of roof tiles, 40 kg/m³ Wooden battens, horizontal, 470 kg/m³ Wooden battens, vertical, 470 kg/m³ PE-foil Wooden battens, vertical, 470 kg/m³ including 100 mm stone wool clamping plate, 30 kg/m³ Wooden battens, horizontal, 470 kg/m³ including 100 mm stone wool clamping plate, 30 kg/m³ PE-foil 3s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 53 (-1; -5) dB** 
STD12.02	 30 mm 40 mm 240 mm 158 mm	Roof covering of roof tiles, 40 kg/m³ Wooden battens, horizontal, 470 kg/m³ Wooden battens, vertical, 470 kg/m³ PE-foil Wood fibre board, 160 kg/m³ PE-foil 5s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 50 (-4; -11) dB** 
STD12.01	 30 mm 40 mm 240 mm 158 mm	Roof covering of corrugated sheet, 4 kg/m² Wooden battens, horizontal, 470 kg/m³ Wooden battens, vertical, 470 kg/m³ PE-foil PU insulation, 30 kg/m³ PE-foil 5s KLH-CLT, 470 kg/m³	**$R_w(C; C_{tr})$ = 50 (-3; -8) dB** 

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Protection against noise

Annex 6

ANNEX 7 FASTENERS

Fasteners

The determination of the load bearing capacities of the fasteners in KLH-CLT shall be carried out according to EN 1995-1-1 and/or the UK Technical Assessment which has been granted for the relevant fastener for softwood and/or for glued laminated timber or the wood-based panel used.

Only wood screws and split ring connectors may be employed as load bearing fasteners in the edges of the solid wood slabs.

To all fasteners apply

- Only nails, wood screws, bolts, dowels and connectors according to EN 1995-1-1 and/or a UK Technical Assessment may be used as fasteners, observing the following particularities.
- The edge of the solid wood slab is the edge of the member. As long as the maximum joint width according to Annex 2 is not exceeded individual joints need not to be considered.

Nails

- Nails shall have a diameter of at least 4 mm.
- The load bearing capacity of nails shall be determined according to EN 1995-1-1. Minimum spacing and distances shall be determined following the direction of grain of the surface layer.
- Smooth nails shall not be employed for axially loading. For axially loaded nails the recommendations of the UKTA holder shall be observed.

Wood screws

- Laterally loaded screws shall have a nominal diameter of minimum 4 mm and a nominal diameter of minimum 8 mm if driven in the edges of the solid wood slab.
- The load bearing capacity of laterally loaded screws shall be determined according to EN 1995-1-1. The embedment strength shall be determined according to the direction of grain of the surface layer. If driven in end grain, the embedment strength shall be reduced by 50 %. Minimum spacing and distances shall be determined according to the direction of grain of the surface layer.
- Axially loaded screws shall have a minimum diameter of 4 mm. Axially loaded screws driven in end grain shall have a minimum diameter of 8 mm.
- The load bearing capacity of axially loaded screws shall be determined according to EN 1995-1-1. The load bearing capacity of screws driven in end grain shall be reduced by 25 %.

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Fasteners	

Bolts and dowels

- Bolts and dowels shall have a diameter of at least 10 mm.
- The load bearing capacity of bolts and dowels shall be determined according to EN 1995-1-1. The embedment strength shall be determined following the direction of grain of the surface layer. Minimum spacing and distances for dowels and bolts are
  - 5 · d from the loaded edge and between each other and
  - 3 · d from the unloaded edge.

  This applies regardless to the angle between the direction of force and the direction of grain.
- Self-tapping dowels shall be used only in the face of KLH-CLT. The minimum nominal diameter should be 5 mm. The requirements of the European Technical Assessment for the fastener shall be observed.
- For connections with steel plates as the central member the direction of the nearby layers shall be taken into account.

KLH-CLT	**Annex 7**
Fasteners	

ANNEX 8 REFERENCE DOCUMENTS

Reference documents

UKAD 130005-00-0304, *UK Assessment Document for Solid wood slab element to be used as a structural element in buildings*

EN 338 (04.2016), *Structural timber – Strength classes*

EN 1995-1-1 (11.2004), +AC (06.2006), +A1 (06.2008), +A2 (05.2014), Eurocode 5 – *Design of timber structures* - Part 1-1*: General – Common rules and rules for buildings*

EN 1995-1-2 (11.2004) +AC (06.2006), +AC (03.2009), Eurocode 5 – *Design of timber structures* – Part 1-2: *General – Structural fire design*

EN 10140-2 (09.2010), *Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation*

EN 10140-3 (09.2010) +A1 (06.2015), *Acoustics – Laboratory measurement of sound insulation of building elements – Part 3: Measurement of impact sound insulation*

EN 12114 (03.2000), *Thermal performance of buildings – Air permeability of building components and building elements – Laboratory test method*

EN 12207 (12.2016), *Windows and doors – Air permeability – Classification*

EN 13183-2 (04.2002), *Moisture content of a piece of sawn timber* – Part 2: *Estimation by electrical resistance method*

EN 13986 (04.2015), *Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking*

EN 14080 (06.2013), *Timber structures – Glued laminated timber and glued solid timber – Requirements*

EN 15425 (01.2017), *Adhesives – One component polyurethane for load bearing timber structures – Classification and performance requirements*

EN ISO 10456 (12.2007), +AC (12.2009), *Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values*

EN ISO 12572 (08.2016), *Hygrothermal performance of building materials and products – Determination of water vapour transmission properties – Cup method*

KLH-CLT	**Annex 8**
Reference documents	

British Board of Agrément,
Bucknalls Lane,
Watford,
Hertfordshire
WD25 9BA