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

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European technical approval ETA-06/0138

English translation, the original version is in German

Handelsbezeichnung *Trade name*	**KLH-Massivholzplatten** *KLH solid wood slabs*
Zulassungsinhaber *Holder of approval*	**KLH Massivholz GmbH 8842 Katsch an der Mur 202 Österreich**
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	**Massive plattenförmige Holzbauelemente für tragende Bauteile in Bauwerken** *Solid wood slab element to be used as structural elements in buildings*
Geltungsdauer vom *Validity from*	**10.09.2012**
bis zum *to*	**09.09.2017**
Herstellwerk *Manufacturing plant*	**KLH Massivholz GmbH 8842 Katsch an der Mur 202 Österreich**
Diese Europäische technische Zulassung umfasst *This European technical approval contains*	**43 Seiten einschließlich 7 Anhängen** *43 Pages including 7 Annexes*
Diese Europäische Technische Zulassung ersetzt *This European Technical Approval replaces*	**ETA-06/0138 mit Geltungsdauer vom 01.07.2011 bis zum 30.06.2016** *ETA-06/0138 with validity from 01.07.2011 to 30.06.2016*

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I LEGAL BASES AND GENERAL CONDITIONS

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

1. Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1] – Construction Products Directive (CPD) –, amended by the Council Directive 93/68/EEC of 22 July 1993[2], and Regulation (EC) 1882/2003 of the European Parliament and of the Council of 29 September 2003[3];

2. *dem Gesetz vom 20. März 2001 über das Inverkehrbringen und die Verwendbarkeit von Bauprodukten (Steiermärkisches Bauproduktegesetz 2000), LGBl. Nr. 50/2001, in der Fassung LGBl. Nr. 85/2005 und LGBl. Nr. 13/2010*;

   the law from 20 March 2001 concerning putting on the market and use of construction products (Styrian construction products law 2000), LGBl. № 50/2001, amended by LGBl. № 85/2005, and LGBl. № 13/2010;

3. Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex of Commission Decision 94/23/EC[4];

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

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

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

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

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

[1] Official Journal of the European Communities № L 40, 11.02.1989, page 12
[2] Official Journal of the European Communities № L 220, 30.08.1993, page 1
[3] Official Journal of the European Union № L 284, 31.10.2003, page 1
[4] Official Journal of the European Communities № L 17, 20.01.1994, page 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of product and intended use

1.1 Definition of product

The European technical approval (ETA) applies to a product, the

KLH solid wood slabs,

made of softwood boards, laminated boards or wood-based panels which are bonded together in order to form solid wood slab elements. Adjacent layers of the softwood boards are arranged perpendicular (angle of 90 °) to each other and cross sections of the solid wood slabs are symmetrically. The following extensions are considered.

– 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 have to be considered.

The principle structure of the solid wood slab is shown in Annex 1, Figure 1 and Figure 2. Surfaces are planed.

The application of wood preservatives and flame retardants is not subject to the European technical approval.

1.1.1 Wood

Wood species is European spruce or equivalent softwood.

1.1.2 Wood-based panels

Wood-based panels are in accordance with EN 13986 or a European technical approval.

1.2 Intended use

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

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

The solid wood slab is intended to be used in service classes 1 and 2 according to EN 1995-1-1[5]. Members which are directly exposed to the weather shall be provided with an effective protection for the solid wood slab element in service.

The provisions made in the European technical approval are based on an assumed intended working life of the solid wood slab of 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the manufacturer or the Approval Body, but are regarded only as a means for selecting the appropriate product in relation to the expected, economically reasonable working life of the construction works.

[5] Reference documents are listed in Annex 6.

2 Characteristics of product and methods of verification

2.1 Characteristics of product

2.1.1 General

The solid wood slabs and their boards correspond to the information given in the Annexes 1 to 3. The material characteristics, dimensions and tolerances of the solid wood slabs not indicated in these Annexes are given in the technical documentation[6] of the European technical approval.

2.1.2 Boards, wood based panels

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

If wood based panels are used, these shall conform to EN 13986 or a European technical approval.

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. They are supplied in supporting quality and CE-marked.

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

2.1.3 Butt joints within layers of solid wood panels

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

2.1.4 Adhesive

The adhesive for bonding the solid wood slabs and the finger joints of the individual boards is a PU adhesive and shall conform to EN 15425.

2.1.5 Hygiene, health and the environment

A manufacturer's declaration to this effect has been submitted.

The product does not contain dangerous substances specified in EOTA TR 034, dated March 2012. A manufacturer's declaration to this effect has been submitted.

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

2.1.6 Identification

The European technical approval for the solid wood slab is issued on the basis of agreed data, deposited with Österreichisches Institut für Bautechnik, which identifies the solid wood slab that has been assessed and judged. Changes of materials, of composition or characteristics, or to the production process, which could result in this deposited data being incorrect, should be immediately notified to Österreichisches Institut für Bautechnik before the changes are introduced. Österreichisches Institut für Bautechnik will decide whether or not such changes affect the European technical approval, and, if so, whether further assessment or alterations to the European technical approval are considered necessary.

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[6] The technical documentation of the European technical approval is deposited at Österreichisches Institut für Bautechnik and, in so far as is relevant to the tasks of the approved body involved in the attestation of conformity procedure, is handed over to the approved body.

2.2 Methods of verification

The assessment of the fitness of the solid wood slab for the intended use in relation to the requirements for mechanical resistance and stability, for safety in case of fire, for hygiene, health and the environment, for protection against noise, for energy economy and heat retention, as well as for durability in the sense of the Essential Requirements 1, 2, 3, 5 and 6 of Council Directive 89/106/EEC has been made according to the CUAP for "*Solid wood slab element to be used as a structural element in buildings*", Edition June 2005, ETA request № 03.04/06.

3 Evaluation of conformity and CE marking

3.1 System of conformity attestation

The system of conformity attestation applied to this product shall be that laid down in the Council Directive 89/106/EEC of 21 December 1988, Annex III (2) (i), referred to as System 1. This system provides for.

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

(a) Tasks for the manufacturer

- (1) Factory production control;
- (2) Further testing of samples taken at the factory by the manufacturer in accordance with a prescribed test plan[7].

(b) Tasks for the approved body

- (3) Initial type testing of the product;
- (4) Initial inspection of the factory and of factory production control;
- (5) Continuous surveillance, assessment and approval of factory production control.

3.2 Responsibilities

3.2.1 Tasks for the manufacturer; factory production control

At the manufacturing plant the manufacturer has implemented and continuously maintains a factory production control system. All the elements, requirements and provisions adopted by the manufacturer are documented in a systematic manner in the form of written policies and procedures. The factory production control system ensures that the product is in conformity with the European technical approval.

The manufacturer shall only use raw materials supplied with the relevant inspection documents as laid down in the prescribed test plan. The incoming raw materials shall be subject to controls and tests by the manufacturer before acceptance. Check of incoming materials shall include control of inspection documents presented by the manufacturer of the raw materials (comparison with nominal values) by verifying the dimensions and determining the material properties.

The frequency of controls and tests conducted during production and on the assembled solid wood slab is laid down in the prescribed test plan, taking account of the automated manufacturing process of the solid wood slab.

The results of factory production control are recorded and evaluated. The records include at least:

– Designation of the product, basic materials and components;

[7] The prescribed test plan has been deposited at Österreichisches Institut für Bautechnik and is handed over only to the approved body involved in the conformity attestation procedure. The prescribed test plan is also referred to as control plan.

- Type of control or testing;
- Date of manufacture of the product and date of testing of the product or basic materials or components;
- Results of control and testing and, if appropriate, comparison with requirements;
- Name and signature of person responsible for factory production control.

The records shall be kept at least for five years and they shall be presented to the approved body involved in continuous surveillance. On request they shall be presented to Österreichisches Institut für Bautechnik.

3.2.2 Tasks for the approved body

3.2.2.1 Initial type testing of the product

For initial type testing, the results of the tests performed as part of the assessment for the European technical approval may be used unless there are changes in the production line or plant. In the case of changes, the necessary initial type-testing shall be agreed between Österreichisches Institut für Bautechnik and the approved body involved.

3.2.2.2 Initial inspection of factory and of factory production control

The approved body shall ascertain that, in accordance with the prescribed test plan, the factory, in particular personnel and equipment, and the factory production control are suitable to ensure a continuous and orderly manufacturing of the solid wood slab according to the specifications mentioned in Section II as well as in the Annexes of the European technical approval.

3.2.2.3 Continuous surveillance

The approved body shall visit the factory at least once a year for routine inspection. It shall be verified that the system of factory production control and the specified manufacturing process are maintained, taking account of the prescribed test plan. On demand the results of continuous surveillance shall be made available by the approved body to Österreichisches Institut für Bautechnik. Where the provisions of the European technical approval and the prescribed test plan are no longer fulfilled, the certificate of conformity shall be withdrawn.

3.3 CE marking

The CE marking shall be affixed on the accompanying commercial documents. The symbol “CE” shall be followed by the identification number of the certification body and shall be accompanied by the additional information:

- Name or identifying mark and address of the manufacturer;
- Number of the certificate of conformity;
- Last two digits of the year in which the CE marking was affixed;
- Number of the European technical approval;
- Species of wood used;
- Type of wood-based panels used including reference to the respective CE marking, if relevant;
- Number and orientation of layers;
- Number of layers of wood-based panels, if relevant;
- Nominal thickness of the solid wood slab.

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

4.1 Manufacturing

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

Single and double layers of planed boards shall be bonded together to the required thickness of the solid wood slabs. Individual boards shall be joined in longitudinal direction by means of finger joints according to EN 385, there shall be no butt joints.

Adhesive shall be applied on one faces of each board. The edges of the boards need not to be bonded. Pressure shall be at or above 0,6 N/mm^2.

4.2 Installation

4.2.1 Design of solid wood slab elements

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

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

– Design of the solid wood slab elements is carried under the responsibility of an engineer experienced in solid wood slab elements.

– Design of the works shall account for the protection of the solid wood slab elements in service.

– The solid wood slab elements are installed correctly.

Design of the solid wood slab elements may be according to EN 1995-1-1 and EN 1995-1-2, taking into account the Annexes 2 to 6 of the European technical approval. Standards and regulations in force at the place of use shall be considered.

4.2.2 Installation of solid wood slab elements

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

Solid wood slab element installation shall be carried out by appropriately qualified personnel under the supervision of the person responsible for technical matters on site. An assembly plan shall be prepared for each structure, which contains the sequence in which the solid wood slab element shall be installed and the designation of the individual solid wood slab elements. The assembly plan shall be available at the construction site.

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

5 Recommendations for the manufacturer

5.1 General

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

5.2 Recommendations on packaging, transport and storage

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

5.3 Recommendations for use, maintenance and repair of the works

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.

On behalf of Österreichisches Institut für Bautechnik

The original document is signed by:

Rainer Mikulits

Managing Director

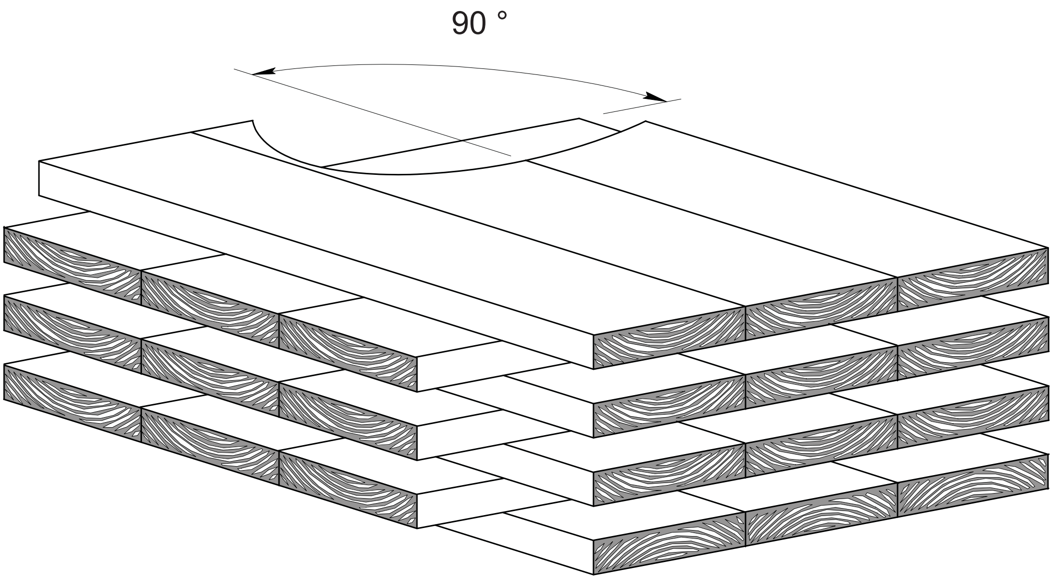

Figure 1: Principle structure of the solid wood slab

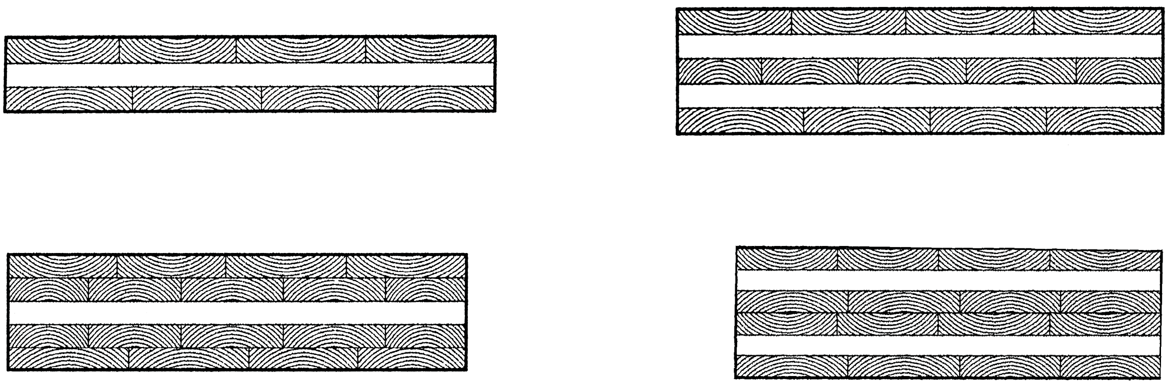

Figure 2: Typical examples of the structure of the solid wood slab

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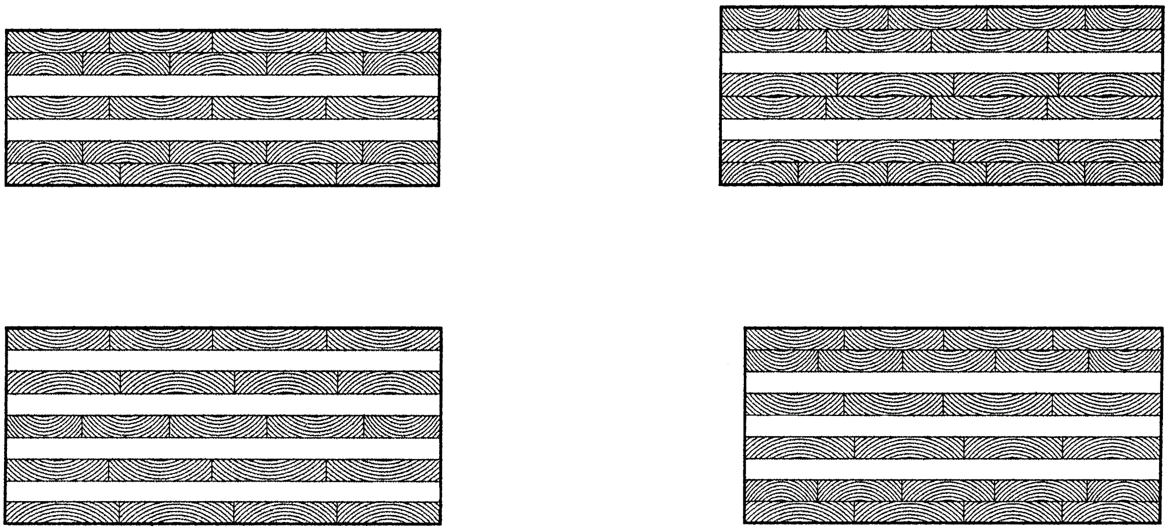

Figure 3: Typical examples of the structure of the solid wood slab

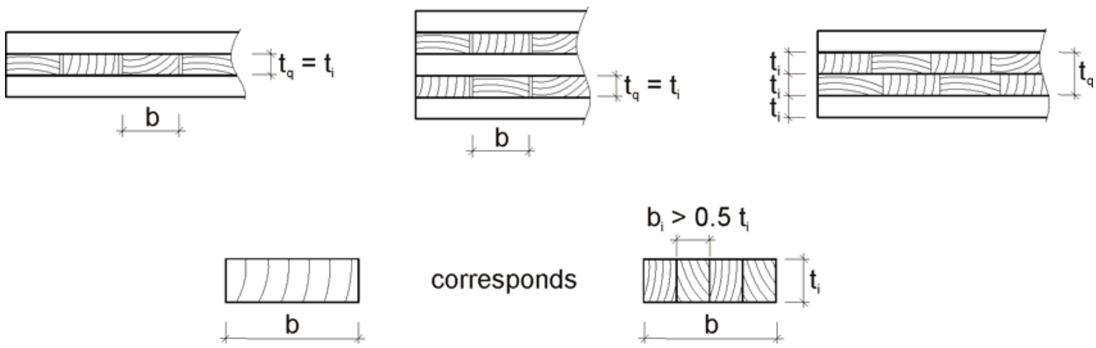

Figure 4: Typical dimensions of cross section of KLH solid wood slab lamellas

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.

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Table 1: Dimensions and specifications

Characteristic		Dimension / Specification
Solid wood slab element		
Thickness	mm	57 to 300
Width	m	≤ 2.98
Length	m	≤ 16.50
Number of layers	—	3 to 16
Maximum width of joints between boards within one layer: regions with fasteners to be applied elsewhere	 mm mm	 3 6
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	%	12 ± 2
Finger joints	—	EN 385

1) Laminated boards with single lamellas b_i and $t_i \leq 45$ 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.

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Characteristic data of the solid wood slab	of European technical approval ETA-06/0138

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Table 2: Product characteristics of the solid wood slab

ER	Requirement	Verification method	Class / Use category / Numeric value
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 $E_{0, mean}$ – perpendicular to the grain of the boards $E_{90, mean}$	Annex 4 CUAP 03.04/06, 4.1.1.1 EN 338	12 000 MPa 370 MPa
	Shear modulus 3) – parallel to the grain of the boards $G_{0,mean}$ – perpendicular to the grain of the boards, rolling shear modulus $G_{90, mean}$	EN 338 CUAP 03.04/06, 4.1.1.1	690 MPa 50 MPa
	Bending strength – parallel to the grain of the boards $f_{m, k}$	Annex 4 CUAP 03.04/06, 4.1.1.1	24 MPa
	Tensile strength – perpendicular to the grain of the boards $f_{t, 90, k}$	EN 1194, reduced	0.12 MPa
	Compressive strength – perpendicular to the grain of the boards $f_{c, 90, k}$	EN 1194	2.7 MPa
	Shear strength – parallel to the grain of the boards $f_{v, k}$ – perpendicular to the grain of the boards (rolling shear strength) $f_{v, R, k}$	EN 1194 Annex 4 CUAP 03.04/06, 4.1.1.3	2.7 MPa 0.8 to 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 CUAP 03.04/06, 4.1.2.1	12 000 MPa
	Shear modulus 3) – parallel to the grain of the boards $G_{0,mean}$ 1)	A_{net}, Annex 4 CUAP 03.04/06, 4.1.2.3	500 MPa 1)
	Bending strength – parallel to the grain of the boards $f_{m, k}$	W_{net}, Annex 4 CUAP 03.04/06, 4.1.2.1	24 MPa

ER	Requirement	Verification method	Class / Use category / Numeric value
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 1194	16.5 MPa
	Compressive strength		
	– parallel to the grain of the boards $f_{c,0,k}$	EN 1194	24 MPa
	– concentrated, parallel to the grain of the boards $f_{c,0,k}$	CUAP 03.04/06, 4.1.2.2	$k_{c,0}$ Annex 4, 2.4
	Shear strength		
	– regardless of loading direction, per glue line $f_{v,K,k}$	Annex 4 – Shear flow	90 N/mm
	– parallel to the grain of the boards $f_{v,k}$	Annex 4 – Shear stress	3.9 to 8.4 MPa
	3. Other mechanical actions		
	Creep and duration of load	EN 1995-1-1	Service class 1 and 2
	Deformation factor k_{def}	EN 1995-1-1	Equivalent to GLT
	Modification factor k_{mod}	EN 1995-1-1	Equivalent to GLT
	Dimensional stability Moisture content during service shall not change to such an extend that adverse deformation will occur.		
	Fasteners	Annex 5	Service class 1 and 2
	Dimensional tolerance		
	– Shrinkage perpendicular to the plane of the solid wood slab	0.24 % in thickness per % moisture variation	
	– Shrinkage in plane of the solid wood slab	0.01 % in length per % moisture variation	

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 $\frac{5}{6}$.

ER	Requirement	Verification method	Class / Use category / Numeric value
2	**Reaction to fire**		
	Solid wood panels excluding floorings (ρ_{mean} = 420 kg/m³)	Commission Decision 2003/43/EC	Euroclass D-s2, d0
	Floorings of solid wood panels		Euroclass D_{FL}-s1
	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 10456	25 to 50
5	**Protection against noise**		
	Airborne sound insulation – Plain wall, thickness of 94 mm – Plain wall, thickness of 145 mm	EN 12354-1	 approximately 33 dB approximately 37 dB
	Impact sound insulation	No performance determined	
	Sound absorption	No performance determined	
6	**Energy economy and heat retention**		
	Thermal conductivity, λ	EN ISO 10456	0.13 W/(m · K)
	Air tightness	No performance determined	
	Thermal inertia, specific heat, c_p	EN ISO 10456	1 600 J/(kg · K)
—	**Durability**		
	Durability of timber Service classes	EN 1995-1-1	1 and 2

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Product characteristics of the solid wood slab	of European technical approval ETA-06/0138

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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.

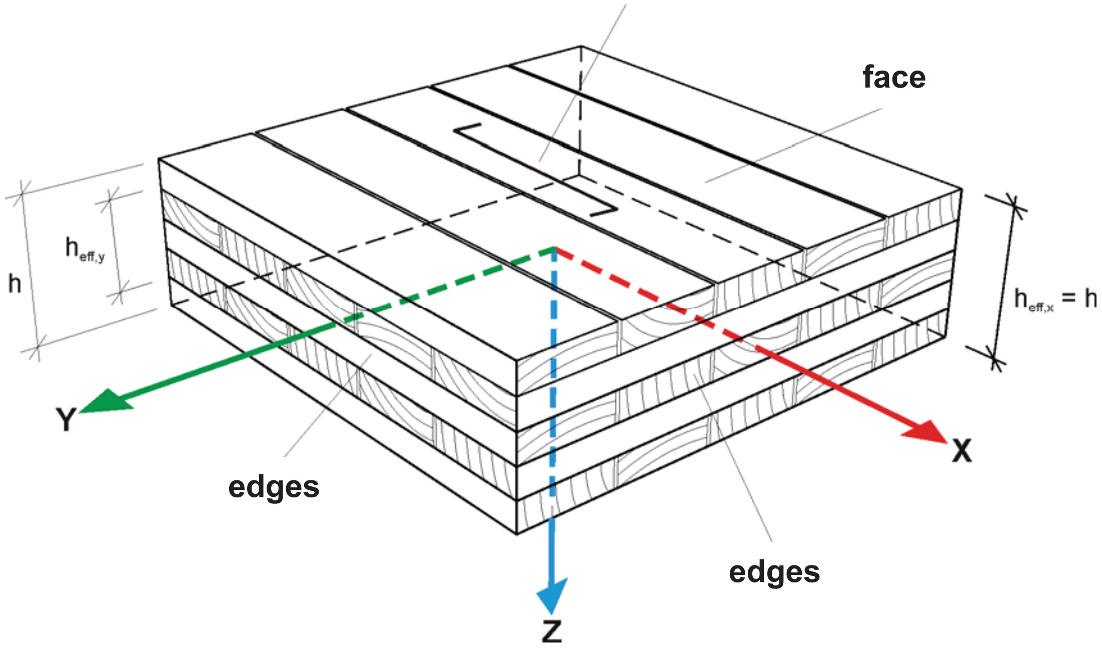

Figure 5: Main directions regarding mechanical actions perpendicular to the solid wood slab

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

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.

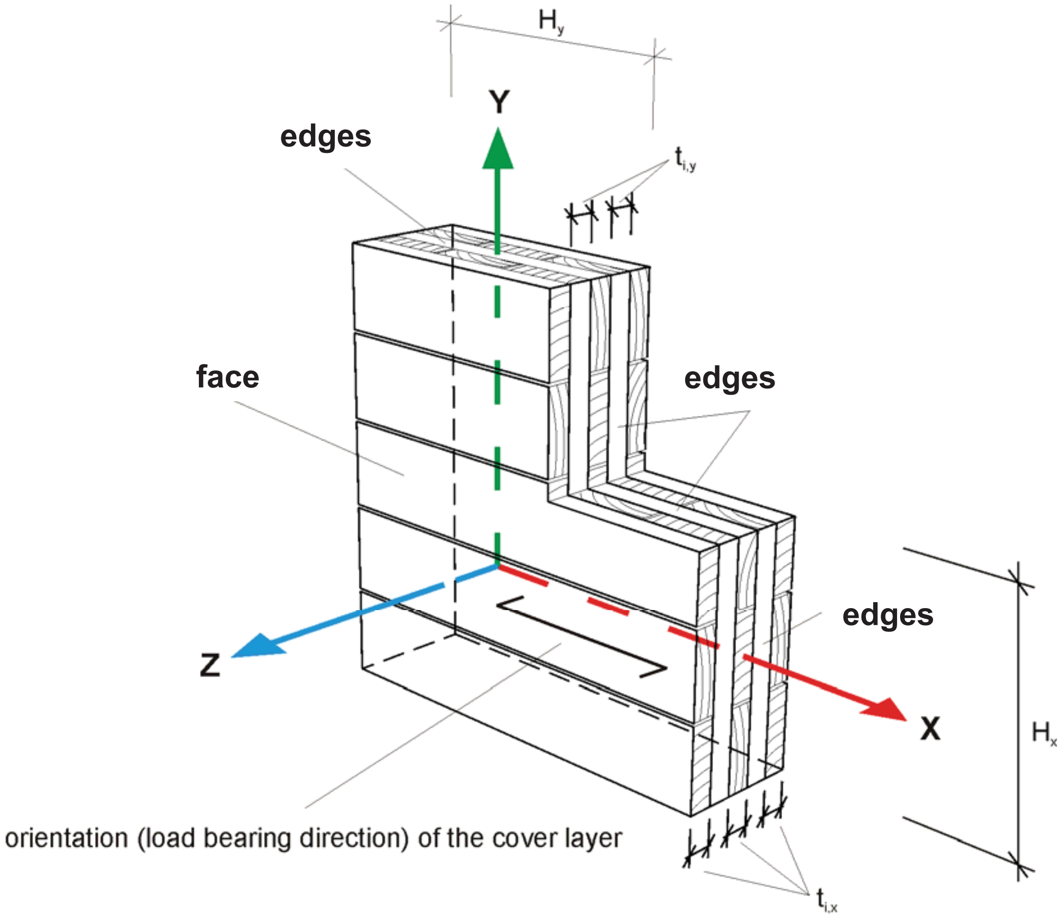

Figure 6: Main directions regarding mechanical actions in plane of the solid wood slab

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

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.

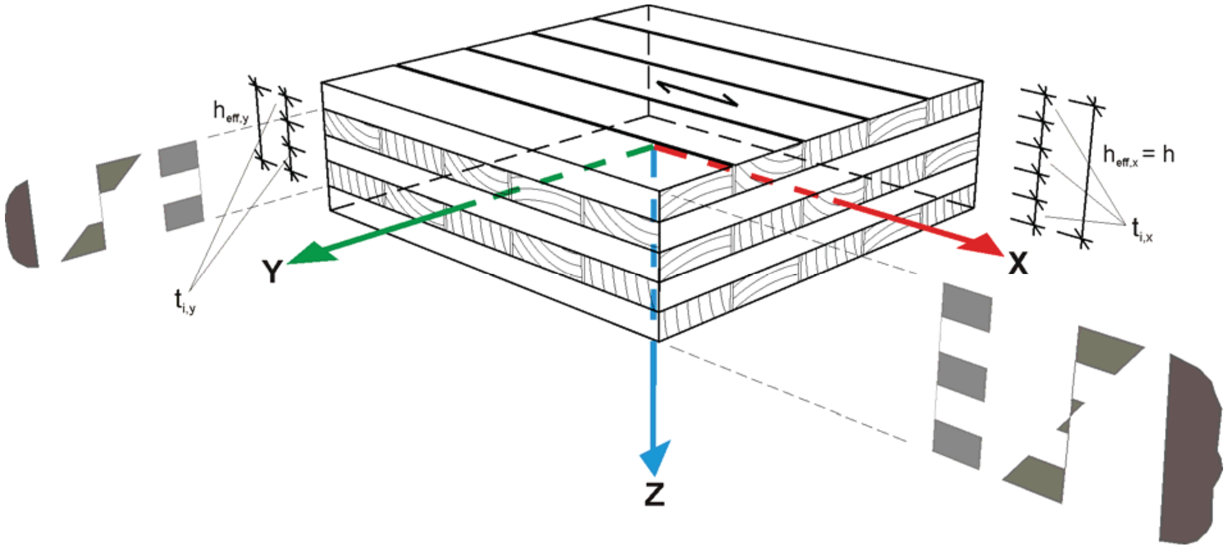

Figure 7: Normal and shear stresses

2 Calculation of stiffness properties

2.1 Short-term deformation

The deformation behaviour of KLH-solid wood slab 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

$E_{0,\ mean}$ .... 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 is employed, also referred to as γ-method. Therein the expression $\frac{s_i}{k_i}$ shall be substituted by $\frac{t_q}{G_{90,\ mean} \cdot b}$.

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 deflection constant 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 solid wood slabs; this estimation is conservative.

2.1.3 Longitudinal stiffness

Longitudinal 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 $\frac{L}{H} \geq 4$

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 solid wood slabs 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. For members sensitive to deformations, e.g. cantilever slabs supported on two adjacent edges only, the torsional stiffness shall be reduced within the model to 40 %.

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.

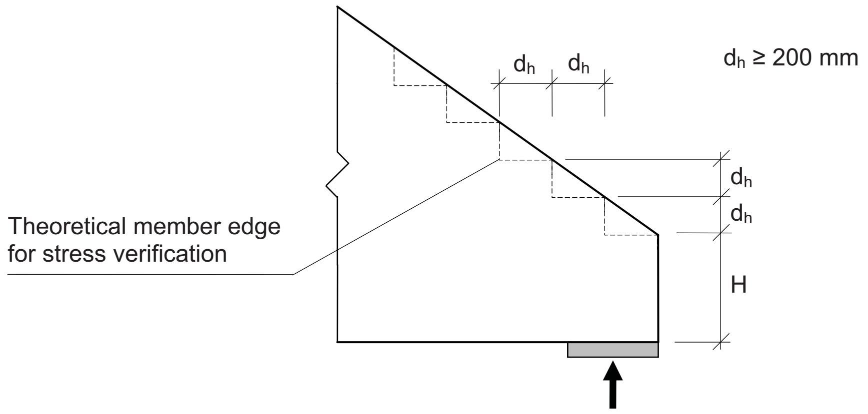

Figure 8: Modelling of an inclined edge by step shaped modelling

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.

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 solid wood slabs

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:

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

$\sigma_{t,0,d}$ 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.

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 $\frac{L}{400}$ 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 $a \leq \frac{H}{2}$ or $a \leq 500$ mm (the smaller value is decisive)

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

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 $A_{net,y}$.

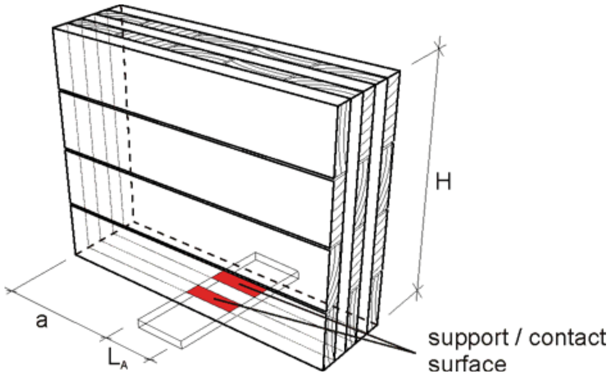

Figure 9: Geometry of load introduction

The capacity of the adjacent members (e.g. timber, concrete, or masonry) shall be verified. The distribution of stresses shall be determined taking into account 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.

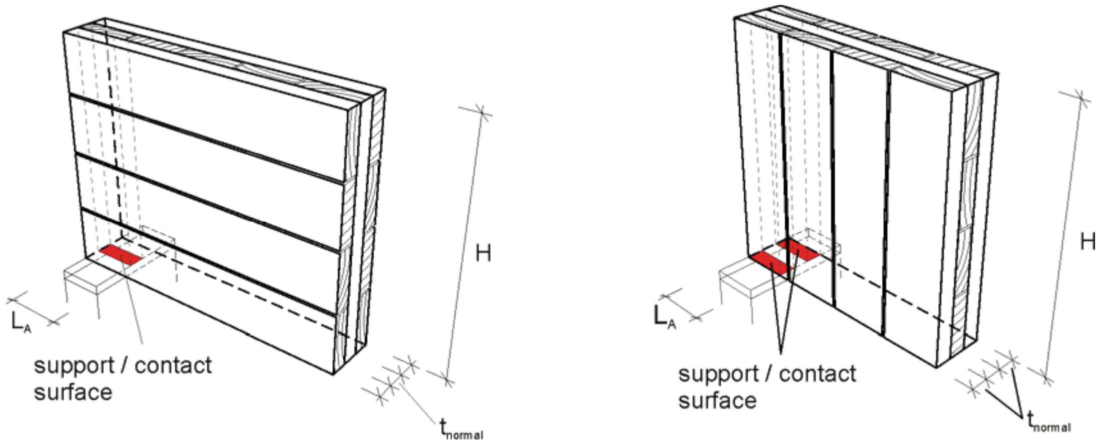

Figure 10: Bearing width and contact area

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The contact areas of two KLH solid wood slabs 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 solid wood slab to timber, steel, or concrete. In the case of contact to the edge of a KLH solid wood slab, 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.

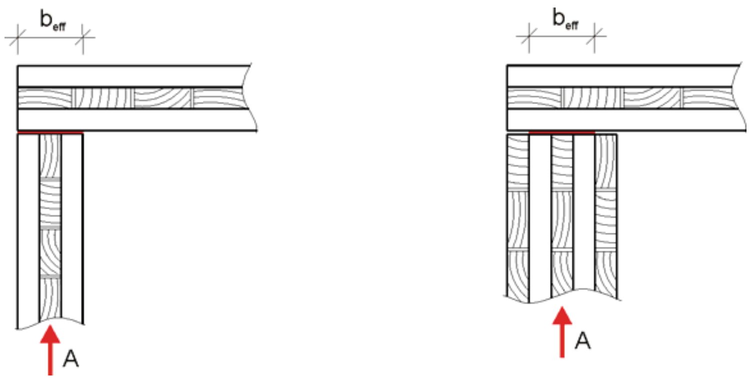

Figure 11: Effective bearing width for determination of contact area

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.

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 $\frac{L}{h} > 10$, 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 $\frac{L}{h} \geq 4$.

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, characteristic values according to Table 4

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

Table 4: Characteristic values of rolling shear strength

Thickness of the cross layer	Ratio $\frac{\text{width of board}}{\text{thickness of board}}$	characteristic rolling shear strength
t_q	—	$f_{v,R,k}$
mm		MPa
$t_q \leq 45$ mm	$\geq 4:1$	1.2
	$\geq 2.3:1$	
$t_q > 45$ mm	$\geq 2.3:1$	0.8

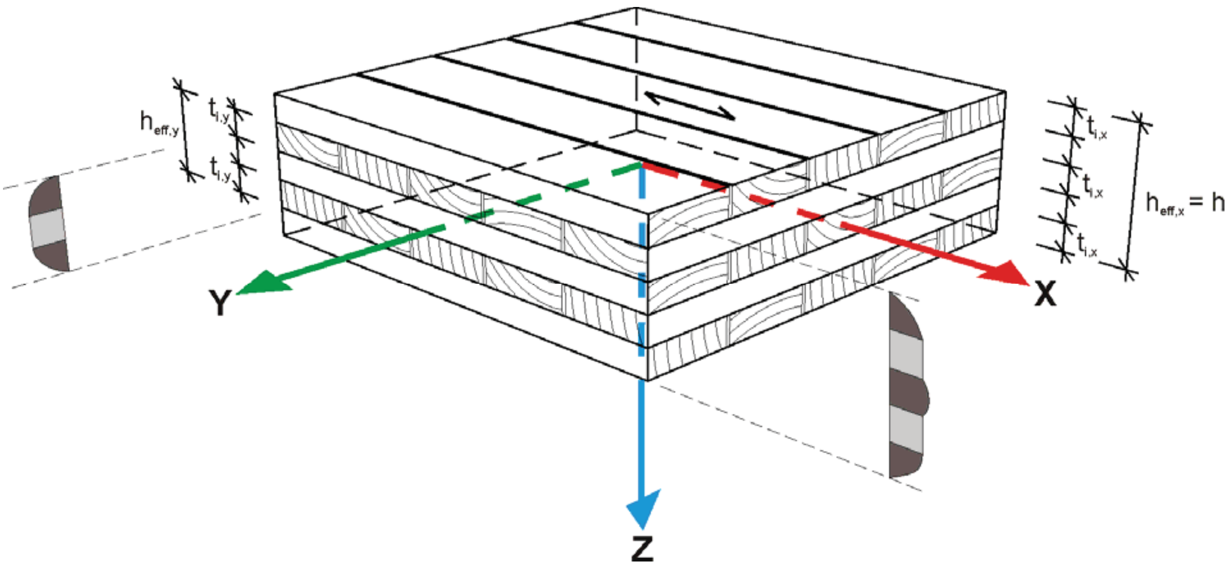

Figure 12: Shear stresses resulting from actions perpendicular to the plane of the solid wood slab

Figure 13: Effective height for calculation of shear stresses

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 2 is applicable.

The design shear stress is calculated with

$$\tau_{v, d} = \frac{V_d \cdot S_{net}}{I_{net} \cdot b}$$

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

The characteristic value of rolling shear strength in a single or a multiple span slab shall be reduced to 0.8 MPa for the proportions of the shear force resulting from a concentrated load acting in the central third of the span. Interim values may be calculated by linear interpolation according to Figure 14.

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

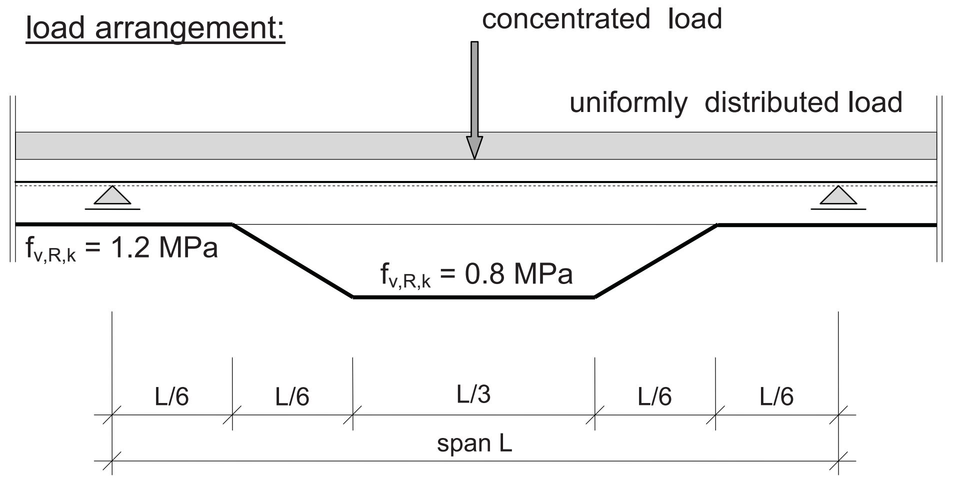

Figure 14: Characteristic values for rolling shear strength for shear forces resulting from concentrated load close to mid-span

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 15 and Figure 16. The notch factor k_v shall be determined according to EN 1995-1-1, with k_n = 4.7 for KLH solid wood slabs. The notch inclination i shall be taken to zero in any case.

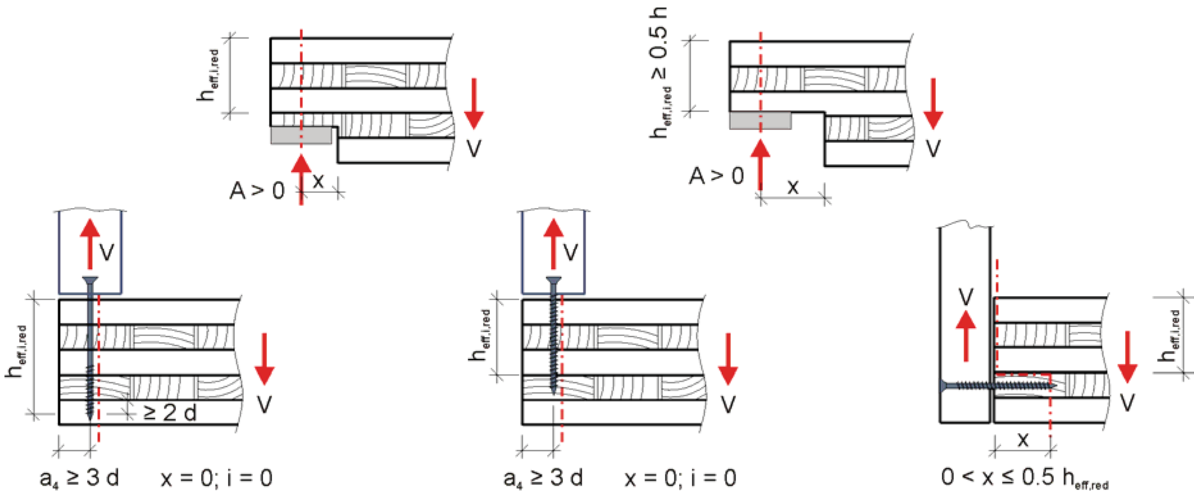

Figure 15: Reduced height, h_{eff}, to account for notches

Examples of typical notches, including notches from connections with fasteners, are given in Figure 15. 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.

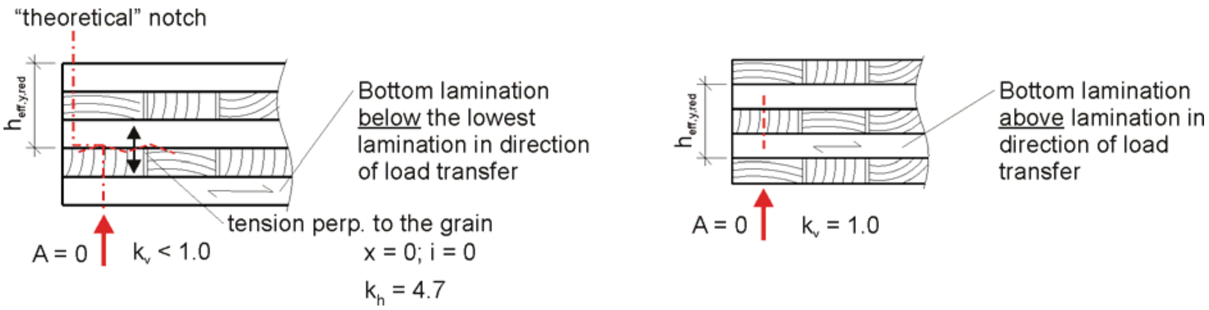

Figure 16: Left – partly supported edge – edge perpendicular to the cover layers
Right – partly supported edge – edge parallel to the cover layers

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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 $2 \cdot d$. 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 $e = 0{,}5 \cdot h$ away from the edge of the supporting member may be applied, see Figure 17. 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 18.

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 17.

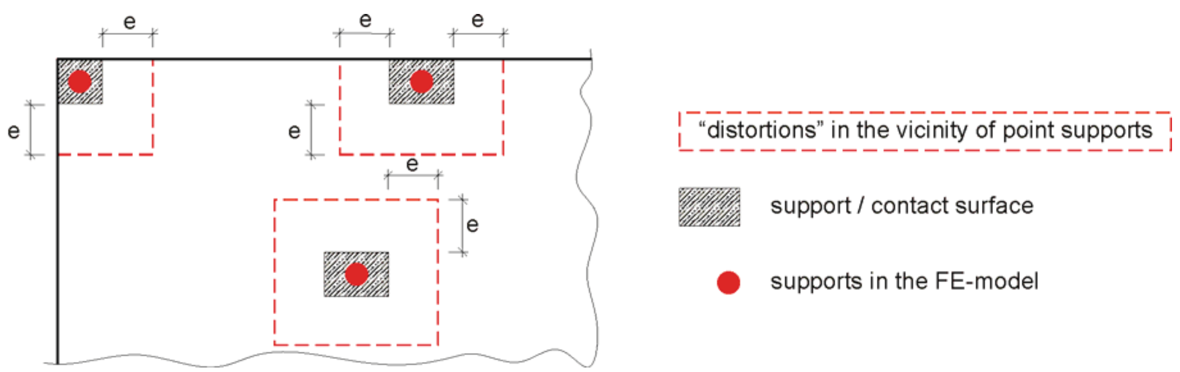


Figure 17: Relevant cross section for calculation of shear stresses close to point supports or concentrated loads

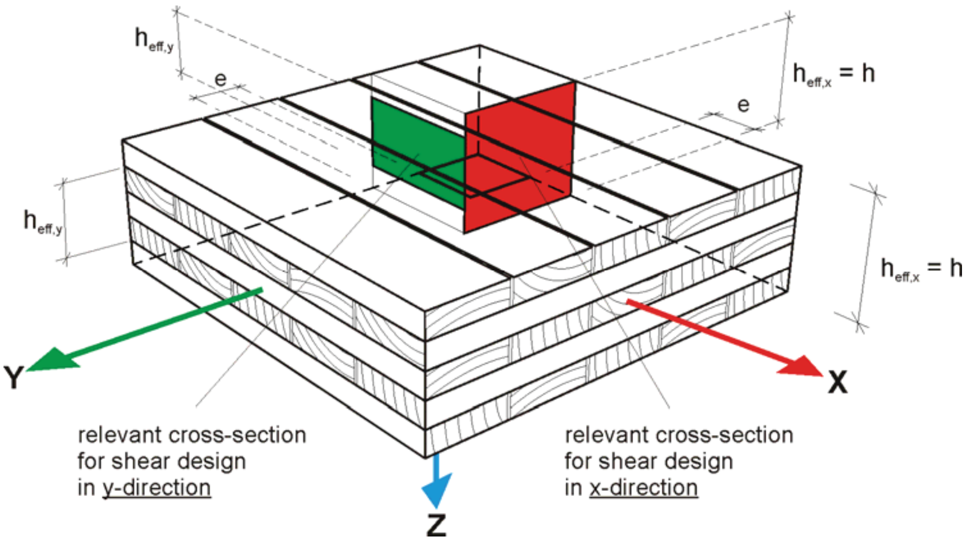


Figure 18: Relevant cross sections for shear stress verification – example of a point support at a corner

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.

$$t_{v,d} = \frac{n_{xy,d} \cdot 1}{L_K}$$

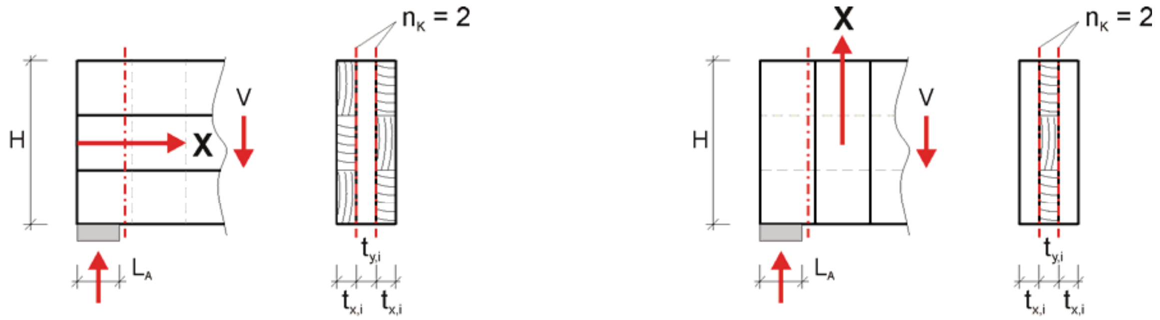
L_K .... total glue line length between adjacent, crosswise arranged layers, where $L_K = n_K \cdot H$

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 gluelines between adjacent, crosswise arranged layers in the respective cross section

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



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 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 $\frac{L}{H} < 4$, 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

Table 5: Characteristic values of shear strength – shear in plane of the slab

Thickness of layer t	mm	19 [2)]	34	45
Characteristic value of shear strength $f_{v,k}$ [1)]	MPa	8.4 [2)]	5.5	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 5 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 20: 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 $\frac{L}{H} \geq 4$ and a depth of $H \leq 800$ 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.

4 Structural fire design

4.1 Performance R – load bearing capacity

Structural fire design of KLH solid wood slabs 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 the KLH solid wood slab 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 4.

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, $0° \leq \alpha \leq 90°$

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

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

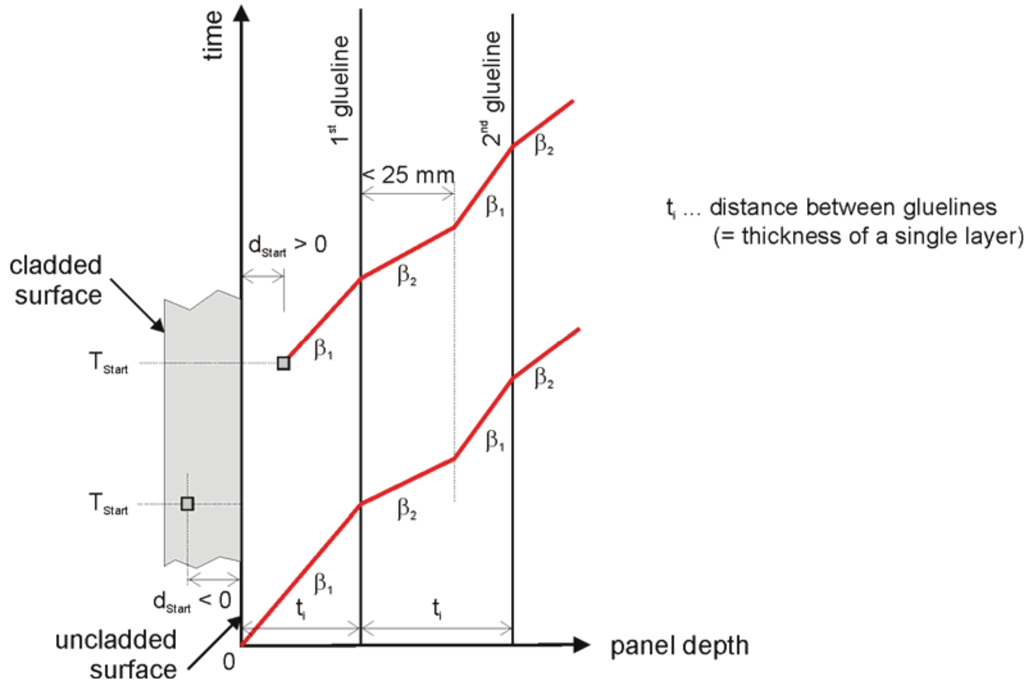


Figure 21: Charring behaviour with and without cladding

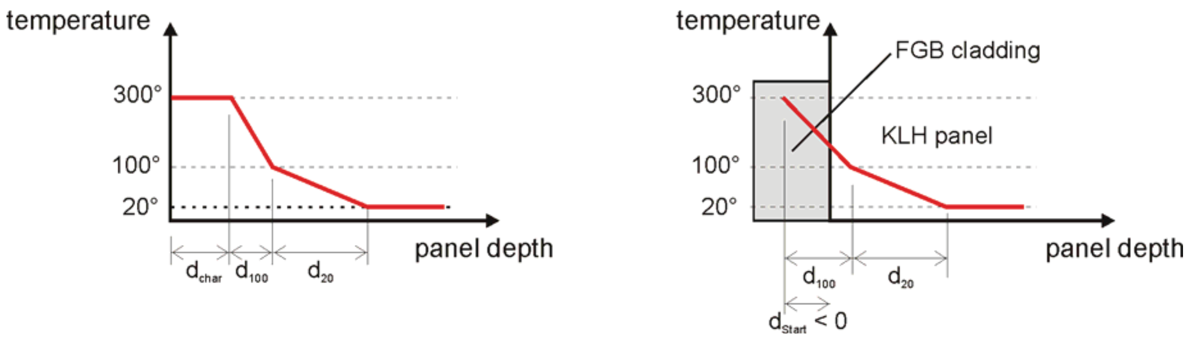


Figure 22: Temperature profiles for non cladded and cladded KLH solid wood slabs

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4.1.1 Parameters for structural fire design

Table 6 is applicable for fire exposure up of 120 minutes for cladded KLH solid wood slabs. For non cladded KLH solid wood slabs the time of fire exposure may exceed 120 minutes.

Table 6: Charring rates and depth of elevated temperatures for KLH solid wood slabs

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
α > 75 °	none	0		0.55 / 0.65	0.80 / 0.90	15	25	0	T > 0
α > 75 °	1 × 15 FGB 4)	-12	-6	-	-	25	25	30	T = 30
		11	16	0.55 / 0.65	0.80 / 0.90	15	25	60	T ≥ 60
α > 75 °	2 × 15 FGB 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
α > 75 °	2 × 18 FGB 4)	-30	-25	-	-	25	35	30	T = 30
		-20	-15	-	-	25	35	60	T = 60
		-10	-5	-	-	25	35	90	T = 90
		10	5	-	-	25	35	120	T = 120
α ≤ 75 °	none	0		0.65 / 0.75	1.00 / 1.10	15	25	0	T > 0
α ≤ 75 °	1 × 15 FGB 4)	-12	-6	-	-	25	25	30	T = 30
		30	34	0.65 / 0.75 5)	1.00 / 1.10	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) **F**ireproof **G**ypsum **B**oard
5) Following the initial value T_0 the charring rate a_2 shall be applied until the next glue line is reached

For KLH solid wood slabs 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.

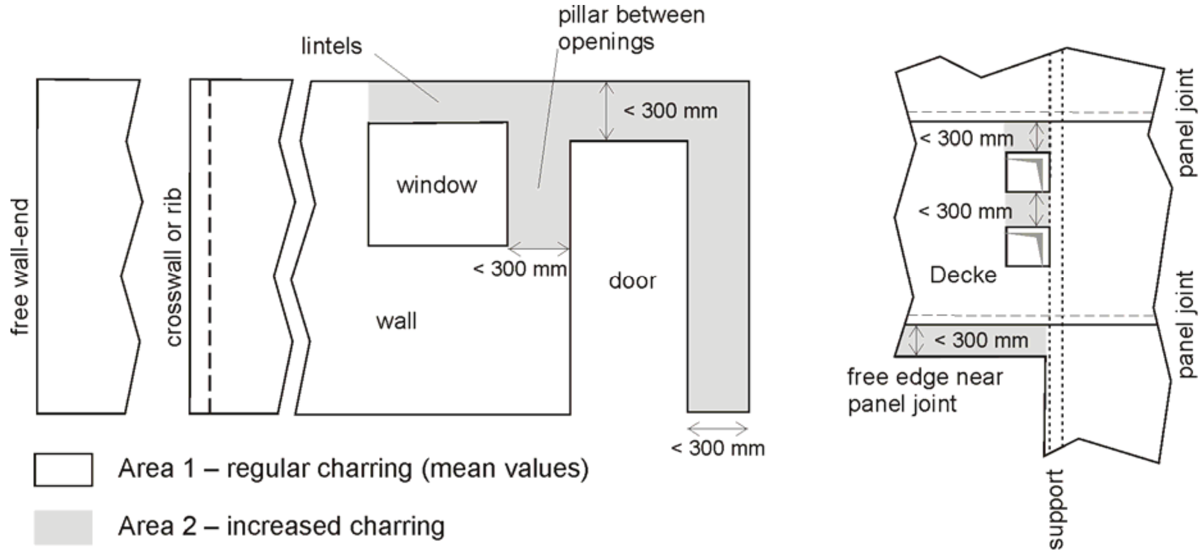

Figure 23: Definition of regions for application of regular and increased charring rates

4.1.2 Local charring at corners, grooves, etc.

The depth of the 300 °C isotherme may be assumed according to Figure 24. Grooves with a cross section ≤ (20 / 20) mm may be disregarded. Grooves smaller than 80 mm shall be considered as shown in Figure 24.

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.

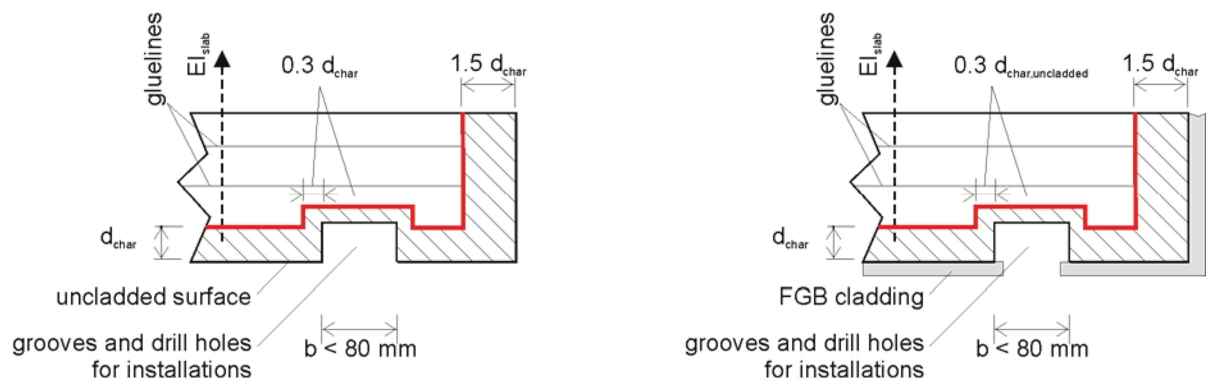

Figure 24: Charring at a groove and at an edge of a wall

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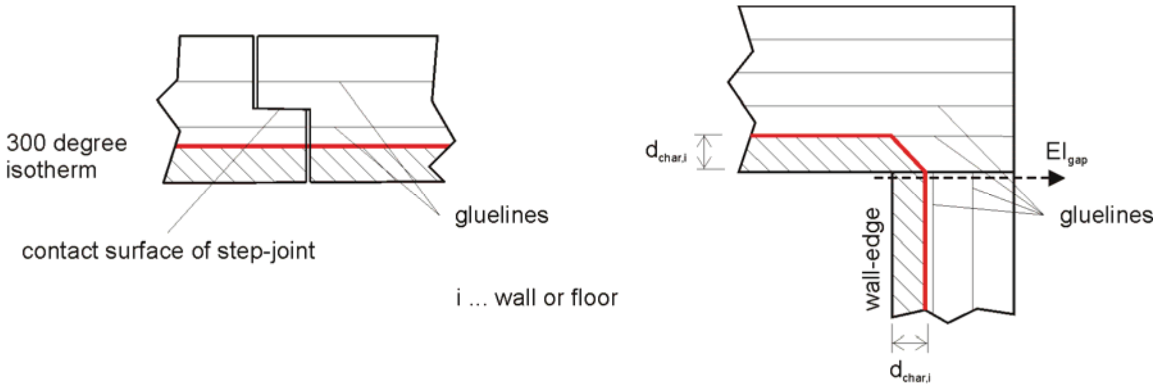

Figure 25: Charring behaviour in the vicinity of a step-joint or an inside corner

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 does not exceed 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 not exceeding 250 mm.

Fasteners

The determination of the load bearing capacities of the fasteners in KLH solid wood slabs shall be carried out according to EN 1995-1-1 and/or the European technical approval 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 European technical approval 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 ETA holder shall be observed.

Wood screws

- <u>Laterally loaded screws</u> 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 cross 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.
- <u>Axially loaded screws</u> shall have a minimum diameter of 4 mm. Axially loaded screws driven in cross 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 cross grain shall be reduced by 25 %.

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 solid wood slabs. The minimum nominal diameter should be 5 mm. The requirements of the European technical approval 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.

Reference documents

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