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User manual

# X-Lam Designer

# User manual

Version 6.0

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	X-Lam D	esigner
	Version 6	5.10.2
	© holz.bau forschungs Inffeldgasse 24, 80 Tel: +43 (0) 31 Fax: +43 (0) 31 Registered of Register court: Graz Commercial register nu	gmbh 2009 - 2018 10 Graz, Austria 6/873-4606 6/873-4619 ffice: Graz Commercial Court
lodules		
Plate Plate loaded in	Connections	Special
Continuous beam	Internal forces	Compression perpendicular to grain

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## 1 GENERAL

### **1.1** System requirements

- Java SE Runtime Environment (JRE 8) A free version of JRE can be downloaded from <u>http://www.java.com/download/</u>

### **1.2** Design methods

Detailed information about the design methods implemented for CLT can be found in the CLThandbook | Solid timber structures made of cross laminated timber (CLT) | Verifications on the basis of the new European concept for construction standards (only available in German) and the <u>BSP Wiki</u>.

The CLThandbook (ISBN 978-3-85125-109-8; only available in German) can be ordered at <u>lignum@tugraz.at</u>.

### **1.3** Standards and guidelines used

### **1.3.1** Base documents

- DIN EN 1990:2010-12 and ON EN 1990:2003-03 respectively: Basis of structural design
- DIN EN 1991-1-1:2010-12 and ON EN 1991-1-1:2003-03 respectively: Actions on structures
   Part 1-1: General actions – Densities, self-weight, imposed loads for buildings
- **DIN EN 1995-1-1:2010-12 and ON EN 1995-1-1:2009-07 respectively:** Design of timber structures Part 1-1: General - Common rules and rules for buildings
- DIN EN 1995-1-2:2010-12 and ON EN 1995-1-2:2011-09: Design of timber structures Part 1-2: General - Structural fire design

### 1.3.2 National Annexes

- Germany
- Austria
- Sweden
- Netherlands
- France

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### **1.4** Translations

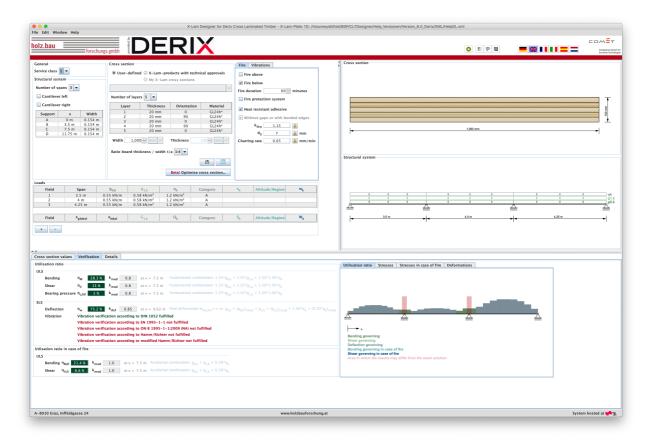
It is specifically stated that the versions of the X-Lam Designer in other languages are translations of the Austrian version. Therefore, any potential dissimilarities with engineering design standards in other countries cannot be ruled out. When differences due to translation are identified, the version in German shall take precedence.

# 2 GENERAL PROGRAM BUILD-UP

### 2.1 Modules

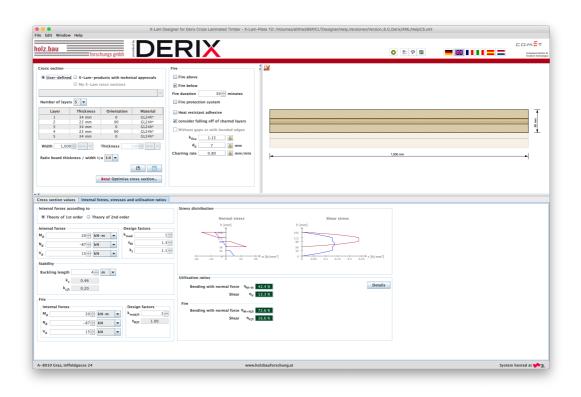
The program "X-Lam Designer" consists of four modules.

The module "CLT-Plate 1D – continuous beam" offers the required verifications for the ultimate limit state (ULS) with respect to bending and shear for permanent and transient loads as well as accidental (fire) design situations, and the verifications for the serviceability limit state with respect to deflection and vibrations according to EN 1990 or EN 1995 for continuous systems such as cross laminated timber plates.

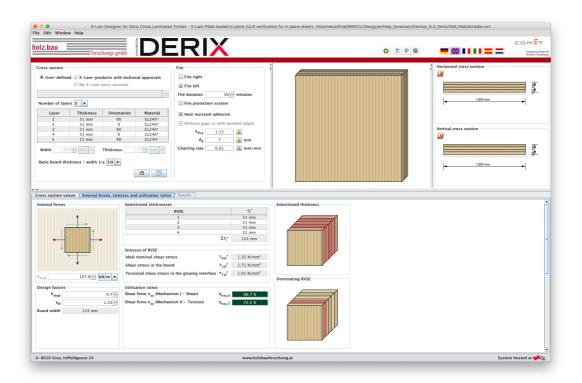


After specifying the internal forces and buckling lengths, the module "CLT-Plate 1D – Internal forces" carries out the required verifications of the ultimate limit state with respect to normal and shear forces for permanent and transient loads as well as accidental design situations.

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The module "CLT-Plate loaded in plane" carries out the required shear stress verifications for a CLT cross-section in the ultimate limit state for permanent and transient loads as well as for accidental design situations based on a given shear force in plane per unit length.



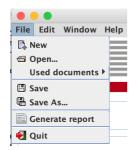
The module "Compression perpendicular to grain" calculates the  $k_{c,90}$ -coefficients for various load situations (point or line load introduction or transmission) and carries out the required verifications.

File Edit Window Help	X-Lam Designer - Compression perpendicular to	
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Cross section User-defined * X-Lam-products with technical approvals U V-Lam cross sections V	Dimensions and type of load introduction         Plate           Plate	
Arrow Minimum load introduction area Acmin 40,000 mm <sup>2</sup>	3	
Effective area         69,325 mm²           Alc3 <sub>max</sub> 69,325 mm²           Jais         271 mm           Wain         256 mm           z         250 mm²           k_00         1.32           k_00 Acuin         52,055 mm²           Utilisation ratio         200 mm²           Compression perpendicular to grain n <sub>c00</sub> 95 %		
A-8010 Graz, Inffeldgasse 24	www.holzbauforschung.at	System hosted at 🚽 🎵

### 2.2 Menu bar

The menu item "File" offers the following selections:

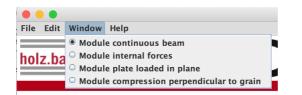
- New: Creates a new project
- Open and Save: Opens or saves a project
- Generate report: Compiles a pdf-format summary of specifications and results
- Quit: Closes the program



In the menu item "Edit", the project information and settings can be entered or changed.

File	Edit	Window	Help
	Р	roject info	rmation
hol	₿I P	references	
			fors

In the menu item "Window", one can move between the two modules.



In the menu item "Help", the user manual as well as further information concerning the X-Lam Designer can be accessed.

File Edit Window	Help
۱ <u>ــــــــــــــــــــــــــــــــــــ</u>	関 X-Lam Designer Help
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#### 2.3 Buttons



A window with settings/preferences will open by clicking on the left button in the first series of buttons, another window with information about the X-Lam Designer will pop up by clicking on the middle, and help information can be accessed by clicking on the right button.

By clicking on one of the buttons in the second series of buttons shown in the following figure, the language can be changed. The current version offers German, English, French, Italian, Spanish and Dutch translations.



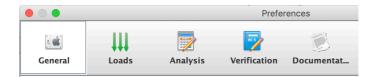
#### 2.4 Settings/Preferences

The settings are divided into the categories:

General



- Loads
- Analysis
- Verification
- Documentation



Within the category General, it can be specified if the single pages of the report (pdf format with security settings) should be also exported as pictures and if so, in which format (png or jpg). Furthermore, by ticking the second box, one can (de)activate the warning notice for the symmetry conditions of the cross-section. The default units of the cross-section properties can be changed by clicking the "Units..." button.

<ul> <li>Show warning info for symmetric condition for layered cross section</li> <li>Export Pdf-report as pictures: Format prg</li> <li>Calculation of plate weight according to ON B 1991-1-1 ▼</li> <li>Coad position         <ul> <li>Plate weight total</li> <li>Permanent loads total</li> <li>Field-by-field</li> <li>Wind total</li> <li>Field-by-field</li> <li>Imposed load category B</li> <li>O.7</li> <li>O</li></ul></li></ul>	Calculate automatically					Un
Calculation of plate weight       according to ON B 1991-1-1         Load position         Plate weight         Total         Imposed loads         Field-by-field         Wind         Total         Wind         Total         Imposed load category A         Imposed load category B         Imposed load category C         Imposed load category D         Imposed load category F         Imposed load category F         Imposed load category G         Imposed load category G         Imposed load category G         Imposed load category F         Imposed load category G         Imposed load category G         Imposed load category H         O       O         Imposed load category H         O       O         Imposed load category H         O       O         Snow loads for regions above 1000 m         Snow loads on structures         O       O         Y       Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously	Show warning info for symmetric cond	tion for layered cross section				
Load position       Permanent loads       Total       Combinations         Permanent loads       Total       Combination factors       according to EN       ▼         Imposed loads       Field-by-field       Imposed load category A       0.7       0.5       0.3         Snow       Field-by-field       Imposed load category B       0.7       0.5       0.3         Wind       Total       Imposed load category C       0.7       0.7       0.6         Imposed load category D       0.7       0.7       0.6       0.8         Imposed load category E       1       0.3       0.8       0.8         Imposed load category F       0.7       0.5       0.3       0.8         Imposed load category F       0.7       0.7       0.6       0.8         Imposed load category F       0.7       0.5       0.3       0.8         Imposed load category G       0.7       0.5       0.3       0.8       0.8         Imposed load category F       0.7       0.5       0.2       0.9       0.9         Snow loads for regions below 1000 m       0.7       0.5       0.2       0.9       0.9         Snow loads for regions above 1000 m       0.7       0.5       0.2	Export Pdf-report as pictures: Format	png				
Load position       Permanent loads       Total       Combinations         Permanent loads       Total       Combination factors       according to EN       ▼         Imposed loads       Field-by-field       Imposed load category A       0.7       0.5       0.3         Snow       Field-by-field       Imposed load category B       0.7       0.5       0.3         Wind       Total       Imposed load category C       0.7       0.7       0.6         Imposed load category D       0.7       0.7       0.6       0.8         Imposed load category E       1       0.3       0.8       0.8         Imposed load category F       0.7       0.5       0.3       0.8         Imposed load category F       0.7       0.7       0.6       0.8         Imposed load category F       0.7       0.5       0.3       0.8         Imposed load category G       0.7       0.5       0.3       0.8       0.8         Imposed load category F       0.7       0.5       0.2       0.9       0.9         Snow loads for regions below 1000 m       0.7       0.5       0.2       0.9       0.9         Snow loads for regions above 1000 m       0.7       0.5       0.2						
Load position       Permanent loads       Total       Combinations         Permanent loads       Total       Combination factors       according to EN       ▼         Imposed loads       Field-by-field       Imposed load category A       0.7       0.5       0.3         Snow       Field-by-field       Imposed load category B       0.7       0.5       0.3         Wind       Total       Imposed load category C       0.7       0.7       0.6         Imposed load category D       0.7       0.7       0.6       0.8         Imposed load category E       1       0.3       0.8       0.8         Imposed load category F       0.7       0.5       0.3       0.8         Imposed load category F       0.7       0.7       0.6       0.8         Imposed load category F       0.7       0.5       0.3       0.8         Imposed load category G       0.7       0.5       0.3       0.8       0.8         Imposed load category F       0.7       0.5       0.2       0.9       0.9         Snow loads for regions below 1000 m       0.7       0.5       0.2       0.9       0.9         Snow loads for regions above 1000 m       0.7       0.5       0.2						
Plate weight       Total       ▼         Permanent loads       Total       ▼         Imposed loads       Field-by-field       ▼         Snow       Field-by-field       ■         Wind       Total       ■         Imposed load category B       0.7       0.5       0.3         Imposed load category C       0.7       0.7       0.6         Imposed load category D       0.7       0.7       0.6         Imposed load category B       0.7       0.7       0.6         Imposed load category C       0.7       0.7       0.6         Imposed load category F       0.7       0.7       0.6         Imposed load category F       0.7       0.7       0.6         Imposed load category G       0.7       0.5       0.3         Imposed load category F       0.7       0.7       0.6         Imposed load category G       0.7       0.5       0.3         Imposed load category F       0.7       0.5       0.3         Imposed load category H       0       0       0         Snow loads for regions below 1000 m       0.5       0.2       0         Snow loads in FIN, IS, N, S       0.6       0.2       0 </th <th>culation of plate weight according to</th> <th>ON B 1991-1-1 ▼</th> <th></th> <th></th> <th></th> <th></th>	culation of plate weight according to	ON B 1991-1-1 ▼				
Permanent loads       Total       Ψ₀       Ψ₁       Ψ₂         Imposed loads       Field-by-field       Imposed load category A       0.7 ○       0.5 ○       0.3 □         Wind       Total       Imposed load category B       0.7 ○       0.5 ○       0.3 □         Imposed load category C       0.7 ○       0.7 ○       0.5 ○       0.3 □         Imposed load category B       0.7 ○       0.7 ○       0.6 □         Imposed load category C       0.7 ○       0.7 ○       0.6 □         Imposed load category C       0.7 ○       0.7 ○       0.6 □         Imposed load category C       0.7 ○       0.7 ○       0.6 □         Imposed load category E       1 ○       0.9 ○       0.8 □         Imposed load category F       0.7 ○       0.7 □       0.6 □         Imposed load category G       0.7 □       0.5 □       0.3 □         Imposed load category H       0 □       0 □       0 □       0 □         Snow loads for regions below 1000 m       0.5 □       0.2 □       0 □         Snow loads in FIN, IS, N, S       0.7 □       0.5 □       0.2 □       0 □         Yind loads on structures       0.6 □       0.2 □       0 □       0 □         Yind loads	ad position	Combinations				
Permanent loads       Total       Ψ0       Ψ1       Ψ2         Imposed loads       Field-by-field       Imposed load category A       0.7       0.5       0.3         Snow       Field-by-field       Imposed load category B       0.7       0.5       0.3         Wind       Total       Imposed load category C       0.7       0.7       0.6       0         Imposed load category D       0.7       0.7       0.7       0.6       0 <th>ate weight Total 🔻</th> <th>Combination factors</th> <th>according</th> <th>to EN</th> <th>-</th> <th></th>	ate weight Total 🔻	Combination factors	according	to EN	-	
Imposed loads       Field-by-field         Snow       Field-by-field         Wind       Total         Imposed load category A       0.7         0.7       0.5         0.7       0.5         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.7       0.7         0.6       0.7         0.7       0.7         0.6       0.7         0.7       0.7         0.6       0.7         0.7       0.5         0.8       0.7         0.7       0.7         0.7       0.5         0.7       0.5         0.7       0.5         0.7       0.5         0.7       0.5         0.7       0.5         0.7       0	rmanent loads					
Snow       Field-by-field         Wind       Total         Imposed load category B       0.7         Imposed load category C       0.7         Imposed load category C       0.7         Imposed load category D       0.7         Imposed load category D       0.7         Imposed load category E       1         Imposed load category F       0.7         Imposed load category G       0.7         Imposed load category G       0.7         Imposed load category H       0         Imposed load so for regions below 1000 m       0.5         Snow loads for regions above 1000 m       0.7         Snow loads on structures       0.6         Mind loads on structures       0.6         Or       0         Or       0         Or       0         Or       0         Or       0         Snow loads for regions above 1000 m       0.7         O.5       0.2         Or       0         Snow loads on structures       0.6         O.7       0.5         O.7       0.5         O.7       0.5         O.7       0.5         O.7<		Imposed load category A	-	-	-	
Show       Frieid=By-frieid         Wind       Total         Imposed load category C       0.7         Imposed load category D       0.7         Imposed load category E       1         Imposed load category F       0.7         Imposed load category G       0.7         Imposed load category G       0.7         Imposed load category G       0.7         Imposed load category H       0         OF       0         Snow loads for regions below 1000 m       0.5         Snow loads for regions above 1000 m       0.7         Snow loads in FIN, IS, N, S       0.7         OF       0         Snow loads on structures       0.6         OF       0         Snow loads on structures       0.6         OF       0         OF       0         OF       0         Snow loads on structures       0.6         OF       0         OF       0         Combinations of distributed and concentrated loads						
Imposed load category D       0.7 and 0.8 and 0.8 and 0.7 and 0.7 and 0.8 and 0.7 and 0.7 and 0.8 and 0.7 and				0.7	0.6	
Imposed load category F       0.7       0.7       0.6         Imposed load category G       0.7       0.5       0.3         Imposed load category H       0       0       0         Snow loads for regions below 1000 m       0.5       0.2       0         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads for regions above 1000 m       0.7       0.5       0.2         Wind loads on structures       0.6       0.2       0         Wind loads on structures       0.6       0.2       0         Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously       0       0         Combinations of distributed and concentrated loads       0       0	ind Total 🔻	Imposed load category D	0.7	0.7	0.6	
Imposed load category G       0.7       0.5       0.3         Imposed load category H       0       0       0         Snow loads for regions below 1000 m       0.5       0.2       0         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads in FIN, IS, N, S       0.7       0.5       0.2         Wind loads on structures       0.6       0.2       0         Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously       0       0         Combinations of distributed and concentrated loads       0       0       0		Imposed load category E	1 -	0.9 *	0.8	
Imposed load category H       0       0       0       0         Snow loads for regions below 1000 m       0.5       0.2       0       0         Snow loads for regions above 1000 m       0.7       0.5       0.2       0         Snow loads in FIN, IS, N, S       0.7       0.5       0.2       0         Wind loads on structures       0.6       0.2       0       0         Wind loads on structures       0.6       0.2       0       0         Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously       0       0       0         Combinations of distributed and concentrated loads       0       0       0       0       0		Imposed load category F	0.7 ÷	0.7	0.6	
Snow loads for regions below 1000 m       0.5       0.2       0         Snow loads for regions above 1000 m       0.7       0.5       0.2         Snow loads in FIN, IS, N, S       0.7       0.5       0.2         Wind loads on structures       0.6       0.2       0         Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously       Combinations of distributed and concentrated loads		Imposed load category G	0.7 +	0.5 🔹	0.3 ÷	
Snow loads for regions above 1000 m 0.7 0.5 0.2 m Snow loads in FIN, IS, N, S 0.7 0.5 0.2 m Wind loads on structures 0.6 0.2 0 0 m Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously Combinations of distributed and concentrated loads		Imposed load category H	0 -	0	0 ÷	
Snow loads in FIN, IS, N, S       0.7       0.5       0.2         Wind loads on structures       0.6       0.2       0         Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously       Combinations of distributed and concentrated loads		Snow loads for regions below 1000 m	0.5 🗧	0.2 🔹	0	
Wind loads on structures       0.6       0.2       0         Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously       0       0         Combinations of distributed and concentrated loads       0       0       0		Snow loads for regions above 1000 m	0.7 +	0.5	0.2 +	
Apply imposed loads on roofs (category H) and snow loads or wind actions together simultaneously Combinations of distributed and concentrated loads		Snow loads in FIN, IS, N, S	0.7 +	0.5	0.2 🗧	
Combinations of distributed and concentrated loads		Wind loads on structures	0.6 ÷	0.2 🔹	0 ÷	
		Apply imposed loads on roofs (cate or wind actions together simultaneous	gory H) an ously	d snow lo	oads	
		Combinations of distributed and conc	entrated l	oads		
$\mathbb{M}$ consider $q_k$ and $Q_k$ as one load group		${\color{red} \rule{0.5ex}{2.5ex} \hspace{0.5ex} \mathbb{P}}$ Consider $\textbf{q}_k$ and $\textbf{Q}_k$ as one load groups of the second s	oup			
$\checkmark$ Consider $w_k$ and $W_k$ as one load group		$\blacktriangleright$ Consider $\mathbf{w}_k$ and $\mathbf{W}_k$ as one load groups of the second sec	oup			
$\checkmark$ Consider s <sub>k</sub> and S <sub>k</sub> as one load group		$\checkmark$ Consider s <sub>k</sub> and S <sub>k</sub> as one load gro	up			

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The settings regarding the type of calculation for the dead load, as well as the type of load position can be configured within the category Loads. The load combinations can be also adjusted here. As for the combination factors, they can be chosen according to EN or NA, but can be also user-defined. Furthermore, an option is offered here to simultaneously apply either snow load or wind actions together with the imposed load on roofs (category H). For the automatic generation of load combinations, it is also necessary to define whether the distributed and single loads should be considered as a one load group. This is due to differences which arise in combinations where the leading actions come from variable loads.

The method of analysis can be chosen within the category Analysis. Currently, two approaches are provided: (i) shear analogy method and (ii) Timoshenko beam theory. The number of calculation points of the field can be specified in two ways: either by specifying the number of subdivisions of the fields or by specifying the maximum size of the subdivisions. When selecting the latter one, it needs to be further chosen between the height of the plate (element size according to selected cross-section) and a fixed element size.

Furthermore, here you can specify whether the modulus of elasticity  $E_{90}$  should be ignored in the calculation.

System		
Method of analysis	Timoshenko 🔻	
Subdivision of the fields	$\bigcirc$ Number of subdivisions	10 -
	maximum size of elements	plate thickness
		○ 0.15 → m
Cross section		
⊭ ignore E <sub>90</sub>		

It is also necessary to specify whether the National Annex should be considered in verification and if so, which one. Furthermore, partial safety factors for the ULS verification need to be specified by selecting either EN, NA or user-defined from a drop-down list.

Verifica	Verifications according to EN 1995-1-1				
🖌 Consider National Annex		ex	ON B 1995-1-1/NA:2009-07	-	
ULS v	erification				
Part	ial safety factors —				
ac	cording to NA 🔻				
YM	1.25				
YM	fi 1.00				
YG	1.35				
YQ	1.50				

The deformation factors (values according to either TU Graz, EN, NA or userdefined), as well as the limit values for deformation need to specified in the "Deformations" tab within the subsection regarding the SLS verification. By ticking the first box, the weight of the plate  $g_0$  will not be considered in calculation of

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instantaneous deformation  $w_{inst}$  at t=0. Furthermore, here can be also specified whether the Base Document should be taken into account in deformation analysis or not. Likewise, here is also given an option to neglect short cantilevers in deformation analysis.

SLS verification				
Deformations Vibration				
$\Box$ Ignore X-Lam plate weight (g <sub>0</sub> ) in calculating instantaneous deformation w <sub>inst</sub> at t=0				
Take into account the Base Document				
Ignore short cantilevers	I/Imax 0.1 ×			
Deformation factor	Limit values for deformation			
k <sub>def</sub> -values corresponding to TU Graz 💌	Limit values according to EN 1995-1-1			
NK 1 0.85	Instantaneous deformation $w_{inst} t = 0: 1/300$			
NK 2 1.1	Final deformation $w_{fin} t = \infty$ : 1/ 150			
	Final deformation $w_{net,fin} t = \infty$ : 1/ 250			
	Limit values according to ON B 1995-1-1/NA:2009-07			
	Characteristic combination $t = 0: 1/300$			
	Characteristic combination $t = \infty$ : I/ 200 $\frac{1}{2}$			
	Quasi-permanent combination: I/ 250*			

Additional verifications of vibration can be activated in the Vibration tab. In addition to verification according to Eurocode 5, other implemented analysis include: the simplified verification according to DIN ( $w_{perm} \le 6$  mm), the verification according to suggestion of Hamm/Richter given in the BSPhandbuch, as well as its modified form. Furthermore, here is offered an option to include or neglect the shear deformation in calculations of the natural frequency and/or the deformation w(1kN) or w(2kN) at the stiffness criterion.

SLS verification	
Deformations     Vibration     Additional verfifiactions	
✓ Verification according to DIN	
<ul> <li>✓ Verification according to Hamm/Richter</li> <li>✓ Verification according to modified Hamm/Richter</li> </ul>	
Include shear deformation	
✓ in calculations of natural frquency	
✓ at stiffness criterion	

In the Documentation settings, one can choose whether, and if so, which detailed results should be included in the pdf report as an appendix.

Include detailed results as appen
 Fire
 Combinations
 Internal forces
 Deformations

Supporting forces

Verifications

### 2.5 Information

The information window includes the contact address, the terms of use, and a button for feedback.

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X-Lai	m Designer
v	/ersion 6.10.2
Tool for calculation and design of c	cross laminated timber elements based on the Eurocode
DE	
Inffeldgasse Tel:+4 Fax:+4 Regis Register cour	schungs gmbh 2009 – 2018 24, 8010 Graz, Austria 3(0) 316/873-4606 3(0) 316/873-4619 3(0) 316/873-4619 I: Gaz Commercial Court gister number: FN 232682f
Terms of use Feedback	To producer-independent version

### 2.6 Project information

Project information can be entered by clicking on "Edit | Project information". Here, a project name and a description of the component to be examined can be inserted. Furthermore, the name of the author or a person in charge can be included. The date of creation, the date of the latest change in the project, as well as the storage location are created automatically.



### X-Lam Designer for Derix Cross Laminated Timber

User manual

00	Project information
Project number	
Project name	Projekt
Structural element	t
Description	
Author	
Created:	April 20, 2010 8:30:30 PM CEST
Modified:	April 20, 2010 8:33:05 PM CEST
Storage location:	/Users/alithiel/Desktop/Desktop/BspHelp1_1_1.xml
	OK Cancel

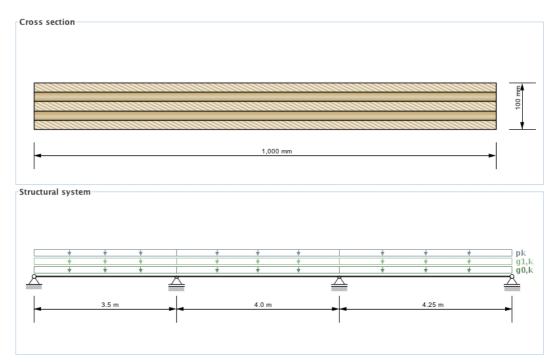
## 3 MODULE "CLT-PLATE 1D – CONTINUOUS BEAM"

### 3.1 Input information

The input information entry is divided into several fields as follows:

- General: General information on the project and on the component to be examined
- Structural system: Description of the structural system
- Cross section: Description of the cross section
- Loads: Specification of the loads
- Fire / Vibration: Specification of parameters concerning structural fire design and vibrations

A graphical representation of the input data is shown on the right side. This offers the possibility for a fast check of the input data.



### 3.1.1 General

The input field "General" defines the service class. It is only allowed to use CLT elements in areas of service class 1 and 2.

User manual

General					
Service class	1	Ŧ			

- Service class 1 (interior service condition) is in general consistent with a common utilisation of living spaces.
- Service class 2 (protected exterior service condition) is generally used for open but roofed structures.

### 3.1.2 Structural system

In the current version a continuous beam with a maximum of 7 spans including a cantilever on the left and right side can be analysed. The supporting width and span of field (via x-value in the table) can be defined within this input field.

Structural	itructural system				
Number o	Number of fields 3 💌				
Cantil	ever left				
Cantil	Cantilever right				
Support	Support x Width				
A	0 m	0.06 m			
В	3.5 m	0.06 m			
C	7.5 m	0.06 m			
D	D 11.75 m 0.06 m				

### 3.1.3 Cross section

Cross section —				
🔵 User-define	ed 🖲 X-Lam-pro	ducts with techn	ical approvals	
	🔘 My X-Lam	cross sections		
X-100/5s			-	
Number of laye	Number of layers 5 💌			
Layer	Thickness	Orientation	Material	
1	20 mm	90	C24-DERIX-ETA	
2	20 mm	0	C24-DERIX-ETA	
3	20 mm	90	C24-DERIX-ETA	
4	20 mm	0	C24-DERIX-ETA	
5	20 mm	90	C24-DERIX-ETA	
Width 1,00	Width 1,000 mm v Thickness 100 mm v			
Ratio board thi	ckness / width t,	/a 1:4 💌		
		Beta! Optimise	cross section	

The cross section can be defined by the user or by choosing a typical cross section of a proprietary CLT product. There is also the possibility to save own CLT cross sections in a library. The elements are subdivided by the number of layers.

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If a user-defined cross section is entered, the thickness and orientation of each layer can be changed. Furthermore, the material can be changed for all layers. The thickness of each layer has to be within the range of 6.0 mm to 45 mm. In the case of proprietary CLT products, the strength class of lumber and the orientation can be changed. If the orientation is changed, the whole cross section is rotated.

The width of the CLT plate strips can be also defined in this field. The default value is set to 1 m. The thickness of the CLT plate is calculated automatically based on the thickness of the single layers.

### 3.1.3.1 My CLT cross sections

By clicking the button the current cross section can be stored in the library and be retrieved by selecting "My CLT cross sections" later on.

The library can be displayed with the button

Saved cross sections				
Test 1	Project name Test 1			
Test 2 Test 3	Layer	Thickness	Orientation	Material
lest 5	1	23 mm	0	GL24h*
	2	20 mm	90	GL24h*
	3	40 mm	0	GL24h*
	4	20 mm	90	GL24h*
	5	23 mm	0	GL24h*
		1.000 mm		→ The second se
	-	1.000 mm		

- The edit mode can be entered by clicking on . Currently, only the name of the stored cross section can be changed.
- With the changes are saved.
- With be chosen cross section in the sidebar can be removed from the library.
- With erross sections from a csv file can be imported.
- With the cross sections from the library can be exported to a csv file.

### 3.1.4 Loads

The loads are divided into the dead load (weight of the plate)  $(g_{0,k})$ , permanent loads  $(g_{1,k})$ , imposed load  $(q_k)$ , snow load  $(s_k)$  and wind load  $(w_k)$ . This classification

is necessary to automatically carry out calculations for different load case combinations.

The plate weight is calculated automatically. The calculation method can be selected in the settings/preferences window. The default calculation method is based on the arithmetic average of density ( $\rho_{mean}$ ) of the chosen material. However, the unit weight may also be calculated using:

- calculation in accordance with ON B 1991-1-1. A unit weight of 5.5 kN/m<sup>3</sup> is assumed in the calculation.
- a user-defined density: Calculation based on a user-defined density

When entering the imposed loads, one of the following categories has to be chosen:

- A: Areas for domestic and residential activities
- B: Office areas
- C: Areas where people may congregate (with the exception of areas defined under category A, B and D)
- D: Shopping areas -
- E: Areas for storage and industrial activities
- F: Traffic and parking areas for light-duty vehicles
- G: Traffic and parking areas for medium-duty vehicles -
- H: Roofs

When entering the snow load, the country code or an altitude above sea level where the structure will be located has to be specified:

- < 1000 m
- > 1000 m
- FIN (Finland), IS (Iceland), N (Norway), S (Sweden)

The span of each field can also be modified in the table of distributed loads.

Concentrated loads can be entered in the second table. The position can be defined whether by the local or global x-coordinate.

Field	Span	g <sub>0,k</sub>	g <sub>1,k</sub>	q <sub>k</sub>	Category	s <sub>k</sub>	Altitude/Region	w <sub>k</sub>
1	3.5 m	0.55 kN/m	0.58 kN/m <sup>2</sup>	1.2 kN/m <sup>2</sup>	A			
2	4 m	0.55 kN/m	0.58 kN/m <sup>2</sup>	1.2 kN/m <sup>2</sup>	A			
3	4.25 m	0.55 kN/m	0.58 kN/m <sup>2</sup>	1.2 kN/m <sup>2</sup>	A			
Field	x <sub>global</sub>	x <sub>lokal</sub>	G <sub>1,k</sub>	Q <sub>k</sub>	Category	s <sub>k</sub>	Altitude/Region	W <sub>k</sub>

User manual

### 3.1.5 Fire

By choosing "Fire above" and/or "Fire below" in the tab "Fire" a structural fire design has to be carried out. The "Fire duration" is specified in minutes and can be increased (or decreased) by increments of 30 minutes by pressing the up (or down) arrows, or defined by entering a specific duration between 0 minutes and 240 minutes in the allotted box. By ticking the box next to "Fire protection" a layer of fire protection is added to the plate, but the effective protection time of the protection layer needs to be defined.

Fire Vibrati	ons			
🗌 Fire above				
🖌 Fire below				
Fire duration	60 -	minutes		
✓ Fire protect	tion			
above	0	minutes		
below	20	minutes		
🗌 Heat resist	ant adhesive			
🔲 Without ga	Without gaps or with bonded edges			
k <sub>fire</sub>	1.15			
d <sub>0</sub>	7	mm		
Charring rate	0.80	mm/min		

For a user-defined cross section, options are given for specifying heat resistant adhesives, presence of grooves, and whether the layers are edge-glued. For proprietary CLT products both values are set automatically and they cannot be changed.

The values  $k_{fire}$  (conversion factor 20%-quantiles) and  $d_0$  (layer thickness to take into consideration the influence of temperature exposure) as well as the charring rate (dependent on the option edge glued or without groove) are pre-set and cannot be changed.

### 3.1.6 Vibrations

Fire V	ibrations		
🖌 Vibra	tion verifica	tion	
✓ Vibrati adjace	tions affect ent spans	ing	
ζ	3	%	
	ideration of d (concrete ess		
✓ scree	d (concrete		
✓ scree stiffn	d (concrete ess	topping)	
✓ scree stiffn d	d (concrete ess 6.0	topping)	
✓ scree stiffn d E EJ <sub>screed</sub>	d (concrete ess 6.0 21,000.0 270.8	topping) ] cm ] N/mm <sup>2</sup> kNm <sup>2</sup> /r	n
✓ scree stiffn d E	6.0 21,000.0	topping) cm N/mm²	

The tab "Vibrations" allows for vibration verification.

For the vibration verification the following specifications are of importance:

- Vibrations affecting adjacent span: Is it detrimental if vibrations are transferred to neighboring fields?
- Modal damping factor  $\zeta$
- Consideration of the screed (concrete topping) stiffness: Is the stiffness of the screed (concrete topping) taken into consideration?
  - Thickness of the screed (concrete topping)
  - Modulus of elasticity of the screed (concrete topping)
- support (2-sided or 4-sided)
- room width b perpendicular to the load carrying direction

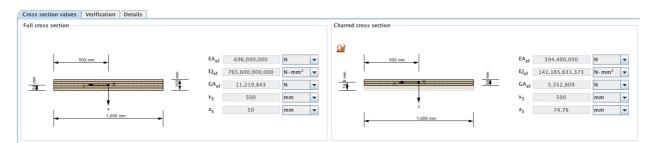
The effective width  $b_w$  of the chosen cross section used by the stiffness criteria will be specified.

### 3.2 Results and output

Load combinations are compiled based on the input loads entered in the "Loads" field. The respective  $k_{mod}$ - and  $k_{def}$ -values can be determined automatically based on the classification of loads (plate weight, wind load, etc.).

### 3.2.1 Cross section values

Output values generated in the tab "Cross section values" field include the effective stiffness, the position of the centre of mass for the full cross section and also for the charred cross section in case of structural fire design.



### **3.2.2** Summary of the results

A summary of the verifications can be retrieved via the tab "Verifications". The utilisation ratios for various limit states are colour-coded indicating if the verification is fulfilled (green) or not fulfilled (red). The locations of the maximum utilisation ratio and the governing combinations are compiled in the same way.

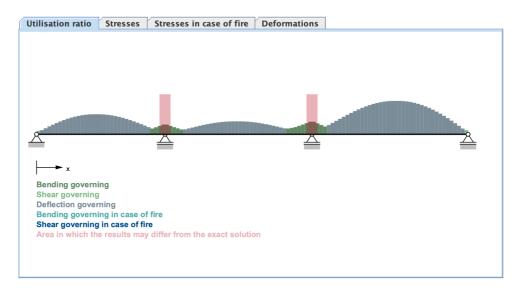
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Cross section valu	ies Verification Details
Utilisation ratio	
ULS	
Bending	$\eta_{M}$ 28.3 % $k_{mod}$ 0.8 at x = 7.5 m Fundamental combination: 1.35* $g_{0,k}$ + 1.35* $g_{1,k}$ + 1.50*1.00* $q_{k}$
Shear	$\eta_V$ 13 % $k_{mod}$ 0.8 at x = 7.5 m Fundamental combination: $1.35^*g_{0,k} + 1.35^*g_{1,k} + 1.50^*1.00^*q_k$
Bearing pres	sure $\eta_{c,90}$ 5 % $k_{mod}$ 0.8 at x = 7.5 m Fundamental combination: $1.35*g_{0,k} + 1.35*g_{1,k} + 1.50*1.00*q_k$
SLS	
Deflection	$\mathbf{n}_{\mathbf{w}} = 75.2 \times \mathbf{k}_{\mathbf{def}} = 0.85  \text{at } \mathbf{x} = 9.62 \text{ m}  \text{Final deformation } \mathbf{w}_{\text{net,fin}} \mathbf{t} = \infty : \mathbf{g}_{0,k} + (\mathbf{g}_{0,k})_{\text{creep}} + \mathbf{g}_{1,k} + (\mathbf{g}_{1,k})_{\text{creep}} + 1.00^{\circ} \mathbf{q}_{k} + (0.30^{\circ} \mathbf{q}_{k})_{\text{creef}} + \mathbf{g}_{1,k} + \mathbf{g}$
Vibration	Vibration verification according to DIN 1052 fulfilled
	Vibration verification according to EN 1995-1-1 not fulfilled
	Vibration verification according to ON B 1995-1-1:2009 (NA) not fulfilled
	Vibration verification according to Hamm/Richter not fulfilled
	Vibration verification according to modified Hamm/Richter not fulfilled
Utlisation ratio in	case of fire
ULS	
Bending N <sub>M</sub>	fi 21.4 % $k_{mod}$ 1.0 at x = 7.5 m Accidental combination: $g_{0,k} + g_{1,k} + 0.30^* q_k$

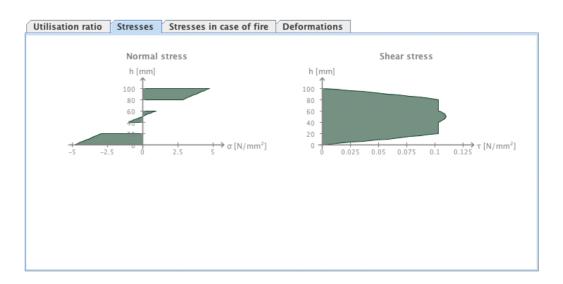
The tab "Utilisation" shows the distribution of the governing utilisation ratios along the beam. Areas in which the results may differ from the exact solution are marked here.



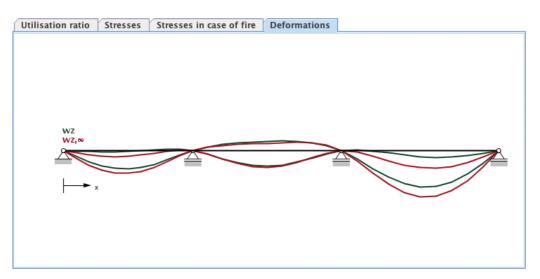
The tab "Stresses" shows the governing stresses resulting from the ULS verification. If a structural fire design was carried out, the governing stresses in case of fire are shown in the tab "Stresses in case of fire".

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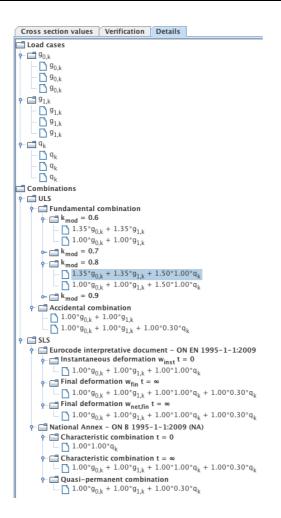
The tab "Deformations" shows the deformed system or the envelope given by the minimum and maximum deformation resulting from the governing SLS verification.



#### 3.2.3 **Detailed results**

The detailed results can be retrieved in the tab "Details". The "tree" on the left side offers the possibility to choose the respective load case or combination.

User manual

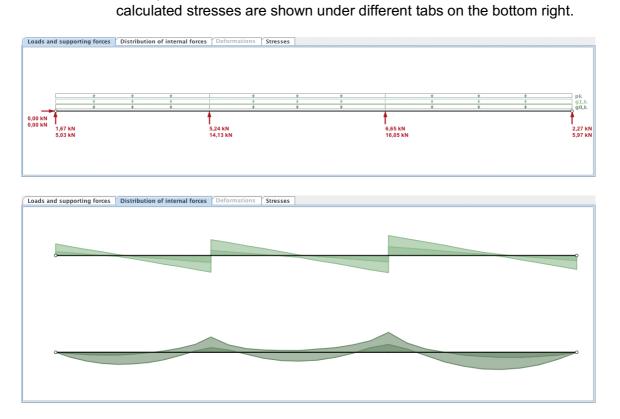


The results of this choice (internal forces, deformations) are then shown for each of the calculation sections of each field (ten sections / field) in the table on the top right.

Field	x	M <sub>max</sub>	М	v	M <sub>min</sub>	М	v	V <sub>max</sub>	М	v	V <sub>min</sub>	М	v
1	0.0 m		-0.00 kN·m	4.59 kN		-0.00 kN·m	2.11 kN		-0.00 kN·m	5.03 kN		-0.00 kN·m	1.67 kN
1	0.35 m		1.56 kN·m	3.87 kN		0.49 kN·m	1.13 kN		1.56 kN·m	3.87 kN		0.49 kN·m	1.13 kN
1	0.7 m		2.71 kN·m	2.70 kN		0.79 kN·m	0.60 kN		2.71 kN·m	2.70 kN		0.79 kN·m	0.60 kN
1	1.05 m		3.45 kN⋅m	1.54 kN		0.91 kN·m	0.06 kN		3.45 kN⋅m	1.54 kN		0.91 kN·m	0.06 kN
1	1.4 m		3.79 kN⋅m	0.38 kN		0.84 kN·m	-0.47 kN		3.79 kN·m	0.38 kN		0.84 kN·m	-0.47 kN
1	1.75 m		3.71 kN⋅m	-0.79 kN		0.58 kN·m	-1.00 kN		1.63 kN·m	-0.40 kN		2.66 kN-m	-1.39 kN
1	2.1 m		3.23 kN⋅m	-1.95 kN		0.13 kN·m	-1.54 kN		1.40 kN·m	-0.94 kN		1.97 kN·m	-2.55 kN
1	2.45 m		2.35 kN·m	-3.12 kN		-0.50 kN·m	-2.07 kN		0.98 kN·m	-1.47 kN		0.87 kN·m	-3.72 kN
1	2.8 m		1.05 kN·m	-4.28 kN		-1.32 kN·m	-2.61 kN		0.37 kN·m	-2.00 kN		-0.63 kN·m	-4.88 kN
1	3.15 m		-0.43 kN·m	-2.54 kN		-2.54 kN·m	-6.05 kN		-0.43 kN·m	-2.54 kN		-2.54 kN·m	-6.05 kN
1	3.5 m		-1.41 kN·m	-3.07 kN		-4.86 kN·m	-7.21 kN		-1.41 kN·m	-3.07 kN		-4.86 kN·m	-7.21 kN
2	3.5 m		-1.41 kN⋅m	2.16 kN		-4.86 kN·m	6.92 kN		-4.86 kN·m	6.92 kN		-1.41 kN·m	2.16 kN
2	3.9 m		-0.67 kN·m	1.55 kN		-2.36 kN·m	5.59 kN		-2.36 kN·m	5.59 kN		-0.67 kN·m	1.55 kN
2	4.3 m		0.63 kN·m	3.15 kN		-1.19 kN·m	2.05 kN		-0.40 kN·m	4.26 kN		-0.17 kN·m	0.94 kN
2	4.7 m		1.89 kN·m	2.51 kN		-0.76 kN·m	0.75 kN		1.04 kN·m	2.93 kN		0.09 kN·m	0.33 kN
2	5.1 m		2.63 kN·m	1.18 kN		-0.58 kN·m	0.14 kN		1.94 kN·m	1.60 kN		0.10 kN·m	-0.28 kN
2	5.5 m		2.83 kN·m	-0.15 kN		-0.65 kN·m	-0.47 kN		2.32 kN·m	0.26 kN		-0.13 kN·m	-0.89 kN
2	5.9 m		2.51 kN·m	-1.48 kN		-0.96 kN·m	-1.08 kN		0.14 kN·m	-0.39 kN		1.41 kN·m	-2.17 kN
2	6.3 m		1.65 kN·m	-2.81 kN		-1.51 kN·m	-1.69 kN		-0.14 kN·m	-1.00 kN		0.28 kN·m	-3.50 kN
2	6.7 m		0.26 kN·m	-4.14 kN		-2.31 kN·m	-2.30 kN		-0.66 kN·m	-1.61 kN		-1.39 kN·m	-4.83 kN
2	7.1 m		-1.43 kN·m	-2.22 kN		-3.59 kN·m	-6.16 kN		-1.43 kN·m	-2.22 kN		-3.59 kN·m	-6.16 kN
2	7.5 m		-2.44 kN·m	-2.83 kN		-6.32 kN·m	-7.49 kN		-2.44 kN·m	-2.83 kN		-6.32 kN·m	-7.49 kN
3	7.5 m		-2.44 kN·m	3.82 kN		-6.32 kN·m	8.55 kN		-6.32 kN·m	8.55 kN		-2.44 kN·m	3.82 kN
3	7.925 m		-0.96 kN·m	3.17 kN		-2.98 kN·m	7.14 kN		-2.98 kN·m	7.14 kN		-0.96 kN·m	3.17 kN
3	8.35 m		1.09 kN·m	5.33 kN		-1.09 kN·m	2.91 kN		-0.25 kN·m	5.73 kN		0.25 kN-m	2.52 kN
3	8.775 m		3.06 kN·m	3.92 kN		0.01 kN·m	2.27 kN		1.88 kN·m	4.31 kN		1.19 kN·m	1.87 kN
3	9.2 m		4.42 kN·m	2.51 kN		0.84 kN·m	1.62 kN		3.42 kN⋅m	2.90 kN		1.84 kN·m	1.22 kN
3	9.625 m		5.19 kN·m	1.09 kN		1.38 kN·m	0.97 kN		4.35 kN⋅m	1.49 kN		2.22 kN·m	0.57 kN
3	10.05 m		5.35 kN·m	-0.32 kN		1.66 kN·m	0.32 kN		1.66 kN⋅m	0.32 kN		5.35 kN·m	-0.32 kN
3	10.475 m		4.92 kN·m	-1.73 kN		1.66 kN·m	-0.33 kN		1.66 kN·m	-0.33 kN		4.92 kN·m	-1.73 kN
3	10.9 m		3.88 kN·m	-3.15 kN		1.38 kN·m	-0.98 kN		1.38 kN·m	-0.98 kN		3.88 kN·m	-3.15 kN
3	11.325 m		2.24 kN·m	-4.56 kN		0.83 kN·m	-1.62 kN		0.83 kN·m	-1.62 kN		2.24 kN·m	-4.56 kN
3	11.75 m		0.00 kN·m	-5.97 kN		0.00 kN·m	-2.27 kN		0.00 kN·m	-2.27 kN		0.00 kN·m	-5.97 kN



By choosing the desired calculation section in the table, the loads and supporting forces, the distribution of internal forces and the deformations as well as the



tress distribution			<u> </u>	
	Normal stress		Shear stre	55
	h [mm]	h (n	nml	
	1	1	↑	
		100 -		
_	80	80 -		
	40	60 - 40 -		
	20	40 - 20 -		
-5 -2.5		N/mm <sup>2</sup> ] 0 -		.015 0.02 τ [N/mm <sup>2</sup> ]
-5 -2.5	0 2.5 5	(	ο <sup>0</sup> 0.005 0.01 0	.015 0.02
tresses and utilisat	ion ratios of single layers-			
cresses and accusa	and fution of shighe layers			
4 max				
/ max				
<b>1 max</b> Layer	σ <sub>M</sub>	η <sub>M</sub>	τ <sub>V</sub>	η <sub>V</sub>
Layer # 1	3.931 N/mm <sup>2</sup>	23.3 %	0.013 N/mm <sup>2</sup>	0.7 %
Layer # 1 # 2	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup>	23.3 % 0.0 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 %
Layer # 1 # 2 # 3	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 %
Layer # 1 # 2 # 3 # 4	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 %
Layer # 1 # 2 # 3	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 %
Layer # 1 # 2 # 3 # 4	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 %
Layer # 1 # 2 # 3 # 4	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 %
Layer # 1 # 2 # 3 # 4 # 5	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 %
Layer # 1 # 2 # 3 # 4 # 5	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 %
Layer # 1 # 2 # 3 # 4 # 5	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup> -3.931 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 % 23.3 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 % 0.7 %
Layer # 1 # 2 # 3 # 4 # 5 A min Layer	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup> -3.931 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 % 23.3 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 % 0.7 % 0.7 %
Layer # 1 # 2 # 3 # 4 # 5 # 4 # 5	3.931 N/mm <sup>2</sup> 0.000 N/mm <sup>2</sup> 0.786 N/mm <sup>2</sup> -0.000 N/mm <sup>2</sup> -3.931 N/mm <sup>2</sup>	23.3 % 0.0 % 4.7 % 0.0 % 23.3 % η <sub>M</sub> 6.2 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 % 0.7 % 0.7 %
Layer # 1 # 2 # 3 # 4 # 5 A min Layer # 1 # 2	3.931 N/mm²           0.000 N/mm²           0.786 N/mm²           -0.000 N/mm²           -3.931 N/mm²           1.049 N/mm²           0.000 N/mm²	23.3 % 0.0 % 4.7 % 0.0 % 23.3 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup>	0.7 %           1.7 %           0.7 %           1.7 %           0.7 %           0.7 %           0.6 %           1.5 %
Layer # 1 # 2 # 3 # 4 # 5 // min Layer # 1 # 2 # 3	3.931 N/mm²           0.000 N/mm²           0.786 N/mm²           -0.000 N/mm²           -3.931 N/mm²           1.049 N/mm²           0.000 N/mm²           0.000 N/mm²	23.3 % 0.0 % 4.7 % 0.0 % 23.3 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 % 0.7 % 1.7 % 0.7 %
Layer # 1 # 2 # 3 # 4 # 5 # 4 # 5 # 4 # 1 # 2 # 3 # 4	3.931 N/mm²           0.000 N/mm²           0.786 N/mm²           -0.000 N/mm²           -3.931 N/mm²           1.049 N/mm²           0.210 N/mm²           0.210 N/mm²	23.3 % 0.0 % 4.7 % 0.0 % 23.3 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup>	0.7 %           1.7 %           0.7 %           1.7 %           0.7 %           0.7 %           0.6 %           1.5 %           0.7 %
Layer # 1 # 2 # 3 # 4 # 5 // min Layer # 1 # 2 # 3	3.931 N/mm²           0.000 N/mm²           0.786 N/mm²           -0.000 N/mm²           -3.931 N/mm²           1.049 N/mm²           0.000 N/mm²           0.000 N/mm²	23.3 % 0.0 % 4.7 % 0.0 % 23.3 %	0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.014 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.013 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup> 0.012 N/mm <sup>2</sup>	0.7 % 1.7 % 0.7 % 1.7 % 0.7 % 1.7 % 0.7 %

# 4 MODULE "CLT-PLATE 1D – INTERNAL FORCES"

### 4.1 Input data

The input data include:

- Cross section: Definition of the cross section
- Fire: Specifications concerning structural fire design
- Internal forces: According to the theory (of 1<sup>st</sup> or 2<sup>nd</sup> order) on which the calculations are based on
- Design factors
- Stability: Specifications concerning stability

### 4.1.1 Cross section

See 3.1.3

### 4.1.2 Fire

See 3.1.5

# 4.1.3 Type of calculation, internal forces, design factors and specifications concerning stability

The internal forces and the underlying type of calculation are defined in the tab "Internal forces, stresses and utilisation ratios". Additionally, the design values are specified here.

If the internal forces result from a calculation based on a first order analysis a substitute buckling length has to be stated in case of a negative normal force ("problem of stability"). Based on this buckling length and the respective cross section the required buckling factor  $k_c$  needed for the verification is calculated automatically.

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Internal forces acc	ording to order  〇 Theory of 2nd c	order
Internal forces	20 _ kN⋅m ▼	Design factors
N <sub>d</sub>	-100 kN 15 kN KN	$Y_{M}$ 1,25 $$
Stability Buckling length k <sub>c</sub>	5 <u>↓</u> m ▼ 0.32	
k <sub>c,fi</sub>	0.13	
Internal forces M <sub>d</sub> N <sub>d</sub> V <sub>d</sub>	$20^{\uparrow}_{\lor} kN \cdot m \checkmark$ $-100^{\downarrow}_{\lor} kN \checkmark$ $15^{\downarrow}_{\lor} kN \checkmark$	Design factors k <sub>mod,fi</sub> <u>1</u> $\stackrel{\wedge}{}$ Y <sub>M,fi</sub> 1.00

### 4.2 Results and output

### 4.2.1 Cross section values

See 3.2.1

### 4.2.2 Summary of the results

Normal stress	Shear stress
h [mm] 146 112 90 56 34 0 0 10 20 $\sigma$ [N/mm <sup>2</sup> ]	h [mm] 146 12 90 56 34 0 0,05 0,1 0,15 0,2 0,25 T [N/mm]
h normal force η <sub>M+N</sub> 46.8 %	Detail
Shear $\eta_{V,fi}$ 16.6 %	
	h normal force $\eta_{M+N}$ 46.8% Shear $\eta_V$ 12.8%

The stress distributions and the governing utilisation ratios are shown in the tab "Internal forces, stresses and utilisation ratios".

### 4.2.3 Detailed results

Stresses and utilisation ratios of the single layers are shown when clicking on the "Details" button.

Layer		η <sub>M</sub>	σ <sub>N</sub>	η <sub>N</sub>	σ <sub>M+N</sub>	η <sub>M+N</sub>	τ <sub>V</sub>	$\eta_V$
# 1	6.545 N/mm <sup>2</sup>	31.0 %	-0.980 N/mm <sup>2</sup>	15.8 %	5.565 N/mm <sup>2</sup>	46.8 %	0.128 N/mm <sup>2</sup>	5.3 %
# 2	0.000 N/mm <sup>2</sup>	0.0 %	-0.000 N/mm <sup>2</sup>	0.0 %	0.000 N/mm <sup>2</sup>	0.0 %	0.128 N/mm <sup>2</sup>	12.8 %
# 3	1.524 N/mm <sup>2</sup>	7.2 %	-0.980 N/mm <sup>2</sup>	15.8 %	0.544 N/mm <sup>2</sup>	23.0 %	0.138 N/mm <sup>2</sup>	5.7 %
# 4	-0.000 N/mm <sup>2</sup>	0.0 %	-0.000 N/mm <sup>2</sup>	0.0 %	-0.000 N/mm <sup>2</sup>	0.0 %	0.128 N/mm <sup>2</sup>	12.8 %
# 5	-6.545 N/mm <sup>2</sup>	31.0 %	-0.980 N/mm <sup>2</sup>	15.8 %	-7.525 N/mm <sup>2</sup>	46.8 %	0.128 N/mm <sup>2</sup>	5.3 %
Layer	σ <sub>M</sub>	η <sub>M</sub>	σ <sub>N</sub>	η <sub>N</sub>	σ <sub>M+N</sub>	η <sub>M+N</sub>	τ <sub>V</sub>	η <sub>ν</sub>
# 3	15.034 N/mm <sup>2</sup>	49.5 %	-1.471 N/mm <sup>2</sup>	39.6 %	13.564 N/mm <sup>2</sup>	89.1 %	0.239 N/mm <sup>2</sup>	6.9 %
# 4	-0.000 N/mm <sup>2</sup>	0.0 %	-0.000 N/mm <sup>2</sup>	0.0 %	-0.000 N/mm <sup>2</sup>	0.0 %	0.239 N/mm <sup>2</sup>	16.6 %
# 5	-15.034 N/mm <sup>2</sup>	49.5 %	-1.471 N/mm <sup>2</sup>	39.6 %	-16.505 N/mm <sup>2</sup>	89.1 %	0.239 N/mm <sup>2</sup>	6.9 %

# 5 MODULE "CLT-PLATE LOADED IN PLANE"

### 5.1 Input information

The input information entry is divided into several fields as follows:

- Definition of the cross section
- Information concerning structural fire design
- Internal force variables
- Design factors

### 5.1.1 Cross section

### See Fehler! Verweisquelle konnte nicht gefunden werden.

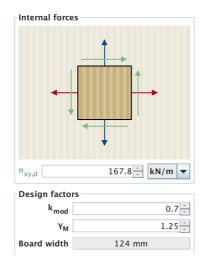
In this module it is not possible to change the cross sectional width.

### 5.1.2 Fire

See Fehler! Verweisquelle konnte nicht gefunden werden.

Fire left / right instead of fire above and below.

### 5.1.3 Internal forces and design factors



In the tab "internal forces, stresses and utilization ratio" it is possible to define the shear force in plane per unit length nxy,d, as well as the design factors. The design method is based on a board width which is chosen when defining the cross section.

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### 5.2 Results and output

### 5.2.1 Cross section values

The effective stiffnesses of a plate loaded in plane are given in the tab "cross section values for the full cross section and in case of structural fire design for the charred cross section.

The small differences between the extensional stiffnesses  $D_x$  and  $D_y$  and the effective extensional stiffness  $EA_{ef}$  in the module CLT-plate 1D result from the negligence of the extensional stiffness of the cross layers in this module.



### 5.2.2 Summary of the results

The calculated substituted thicknesses, stresses as well as utilization ratios of the two mechanisms (Mechanism I – shear and Mechanism II – torsion) are given in the tab "internal forces, stresses and utilization ratios".

Substituted thicknesses			Substituted thickness
RVSE		t <sub>i</sub> *	
1		31 mm	
2		31 mm	
3		31 mm	
4		31 mm	
	∑t <sub>i</sub> *	124 mm	
Stresses of RVSE			
Ideal nominal shear stress	- *	1.25 N/mm <sup>2</sup>	
ideal nominal snear stress	τ <sub>0,d</sub> *	1.35 N/mm <sup>2</sup>	
Shear stress in the board	τ <sub>v,d</sub> *	2.71 N/mm <sup>2</sup>	
Torsional shear stress in the glueing interface	τ <sub>τ,d</sub> *	1.01 N/mm <sup>2</sup>	
			Dominating RVSE
Utilisation ratios			
Shear force n <sub>xy</sub> (Mechanism I – Shear)	η <sub>nxy,V</sub>	96.7 %	
Shear force n <sub>xv</sub> (Mechanism II - Torsion)	η <sub>nxy,T</sub>	72.5 %	
xy	-11Xy,1		

Furthermore, the utilization ratios, that were calculated based on ETA-11/0189 are given.

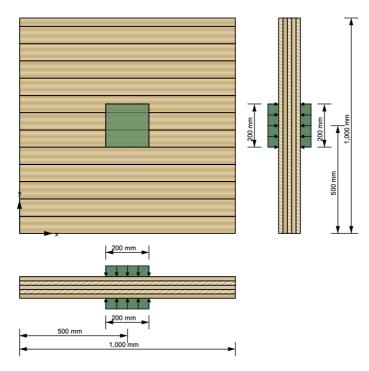
# 6 MODULE " COMPRESSION PERPENDICULAR TO GRAIN"

### 6.1 Input information

The input is divided into:

- definitions of the cross section
- definitions of the plate dimensions
- input of the loads
- type of load configuration
- calculation options

An option for a quick control of the input data is offered by a graphical representation shown on the right side.



### 6.1.1 Cross-section

See Fehler! Verweisquelle konnte nicht gefunden werden.

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### 6.1.2 Plate dimensions and gap execution

The plate is specified with its dimensions in x and y direction. The plate length is defined with dimension in x direction and the plate width with dimension in y direction.

Plate	
Length	1,000 - mm
Width	1,000 <u>*</u> mm
🔲 not s	side bonded or cracks in top layers expected
Gaps	s or cracks > 1 mm

In addition to plate dimensions, the analysis also considers the way the lamellas are joined into individual layers. Regarding to the joining of the outer layers, one should differ:

- side gluing of lamellas,
- assembly without adhesive where lamellas are placed side by side without the sheduled gaps or the expected occurence of cracks and
- possible occurrence of gaps or cracks wider than 1 mm.

### 6.1.3 Load data and design factors

The applied force  $F_{c,90}$  (design value) in [N], as well as the design factors can be specified here.

Loads	to induce and design factors
F <sub>c,90</sub>	100,000 <u>*</u> N
k <sub>mod</sub>	1 *
Υ <sub>M</sub>	1.25

### 6.1.4 Load configuration

The load situation is described by specifying the load introduction above and below. Thereby, one can define if the load is even applied, and if so, if it is applied locally or continuously (over entire surface).

If the load is applied locally, it needs to be defined by entering the dimensions of the load surface (length  $I_{1,2}$  in direction x and width  $w_{1,2}$  in direction y) and the position. The position is defined as the distance between the center of a load surface and the origin of the coordinate system (lower left corner of the plate). Currently, centers of the top and the bottom load surface are coupled and cannot be moved relative to each other.

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Load i	ntroduction above	Load	introduction below
🔾 no	ne	0 n	one
() co	ntinuous	Continuous	
Ioc	al	Iocal	
$I_1$	200 🔹 mm	I <sub>2</sub>	200 📩 mm
$w_1$	200 🕺 mm	w <sub>2</sub>	200 - mm
e <sub>l,1</sub>	500 🗧 mm	e <sub>l,2</sub>	500 – mm
e <sub>w,1</sub>	500 - mm	e <sub>w,2</sub>	500 - mm

### 6.1.5 Calculation options

In the calculation options, the load distribution angles for longitudinal layers  $\alpha_0$  and cross layers  $\alpha_{90}$  can be changed, and for one-sided load introduction, it can be specified, in which depth (=  $k_{ls} \cdot t_{CLT}$ ) the effective area is to be determined.

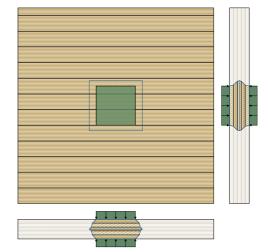
Options		
Load distribution angle	α <sub>0</sub>	45 ÷
	α <sub>90</sub>	15 ÷ °
Height factor for one-sided load introduction	k <sub>ls</sub>	0.4 🗧

### 6.2 Results and Output

The minimum load introduction area  $A_{c,min}$  describes the reference area in order to get the effective area  $A_{ef,max}$  by multiplying with the factor  $k_{c,90}$ . For different load introduction areas on each side it is the intersection of these two areas.

The utilisation ratio for compression perpendicular to grain is indicated by  $\eta_{c,90}$  in [%] and the figure shows the assumed load distribution (blue line).

Minimum load introduction area	
A <sub>c,min</sub>	40,000 mm <sup>2</sup>
Effective area	
A(z) <sub>max</sub>	69,325 mm <sup>2</sup>
l <sub>dis</sub>	271 mm
w <sub>dis</sub>	256 mm
z	50 mm
k <sub>c,90</sub>	1.32
k <sub>c,90</sub> *A <sub>c,min</sub>	52,659 mm²
Utilisation ratios	
Compression perpendicular to grain $\eta_{c,90}$	95 %



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# 7 CONTACT

- Address: holz.bau forschungs gmbh Inffeldgasse 24 8010 Graz Austria
- Internet: <u>www.cltdesigner.at</u> <u>www.cltdesigner.com</u>
- E-Mail: <u>cltdesigner@tugraz.at</u>