Calculatis
by Stora Enso

User Manual
Version 1.0b
June 2023

storaenso

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1. Get started

Calculatis by Stora Enso is a timber design tool for engineers. Efficient and fully web based, Calculatis allows you to analyse structural elements in our mass timber products, including products from our Sylva™ by Stora Enso range.

Designed for timber construction

Developed to fit the needs of engineers working with wood construction, Calculatis includes design modules for floors, roofs, columns, beams, headers, supports, and connections for structures made from CLT, LVL, glued laminated timber and solid timber. The tool can also conduct hygrothermal (U-value, Glaser Diagram and condensation) and fire design (R, E and I criteria) analysis according to Eurocode and Swiss building code (SIA).

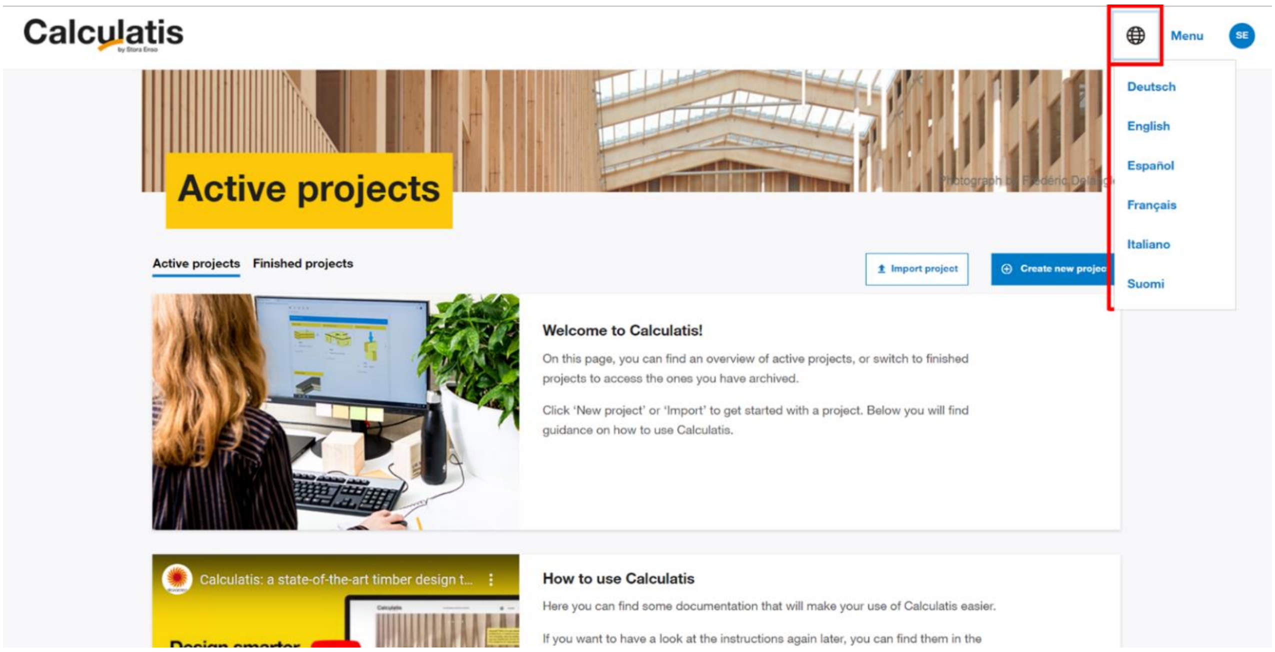
Structural analysis made simple

Calculatis supports all steps of your timber construction project with an efficient workflow and accurate results. With easy and clear parameterization, ready-to-use modules and illustrative reports, the tool helps you save time and access all calculations in one place.

A tool for everyone

Calculatis is free of charge and can be used directly through your web browser, independent of operating system. You can access the tool on desktop, laptop or tablet without the need to install software or save your project files locally. The tool is available in six languages and has over 19 000 users worldwide. Get free access now by signing up on **calculatis.storaenso.com**

1.1. Language settings

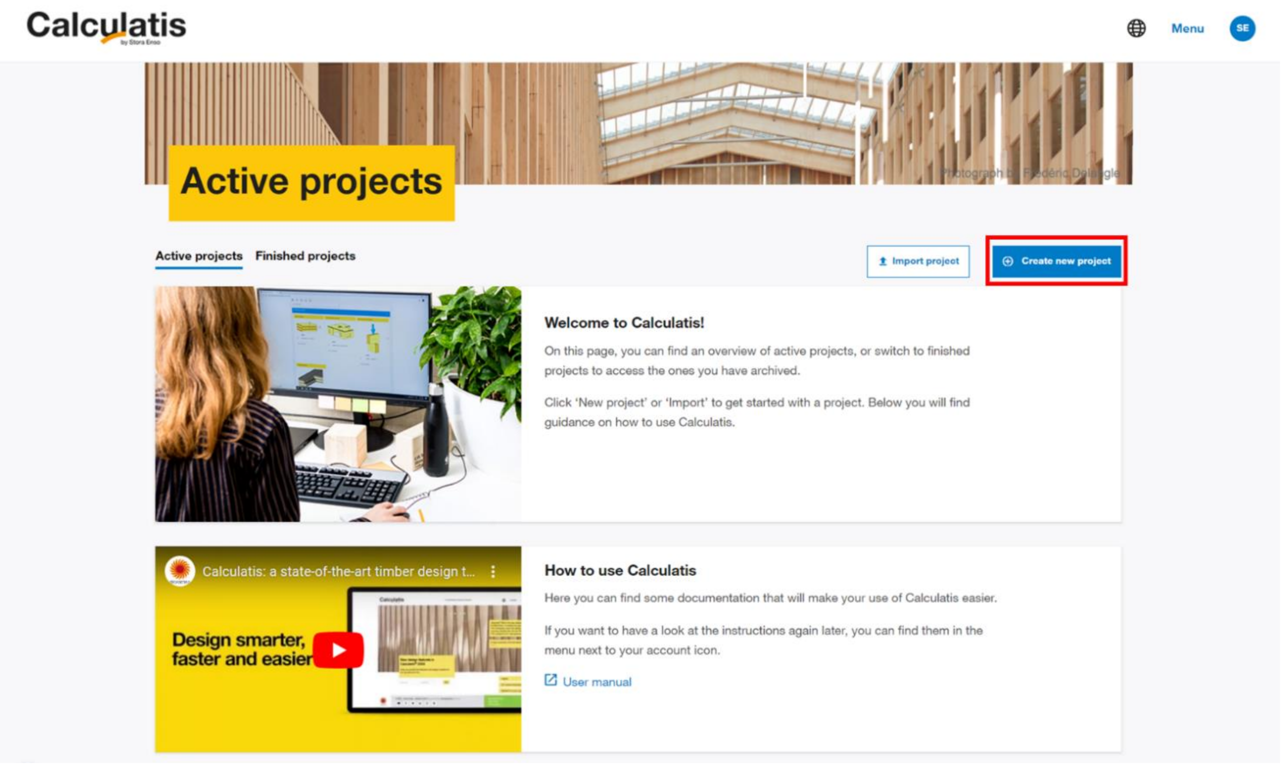


To change the language of the user interface, click on the world icon in the right upper corner. Results will be displayed in the same language as the current operating language. This applies to the PDF-print as well.

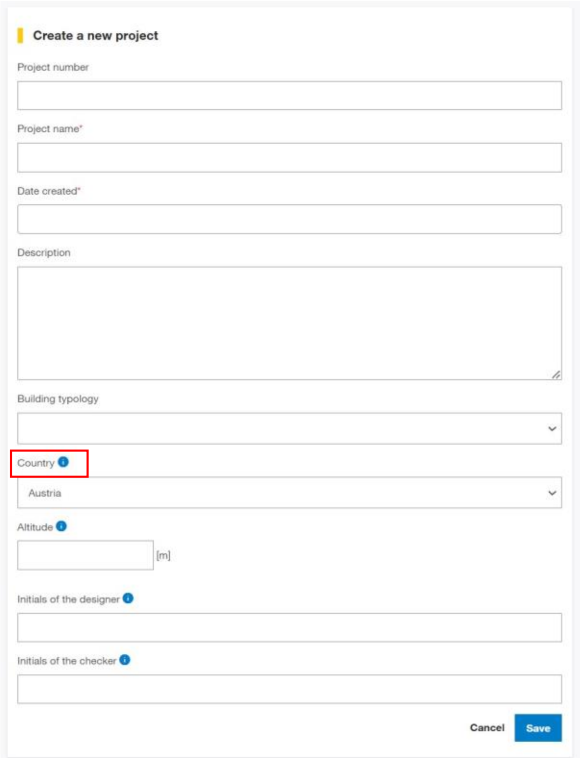
1.2. Create and navigate within a project

Once signed in or logged in, you are in your home screen, where your **active and finished projects** are listed. If you did not create a project yet, the list will be empty. In order to create a project, click on "**+ create new project**".

You can also **import a project**, from another Calculatis account, as a .json file.



Give your project a name and any other information that will help you in future to identify your projects.

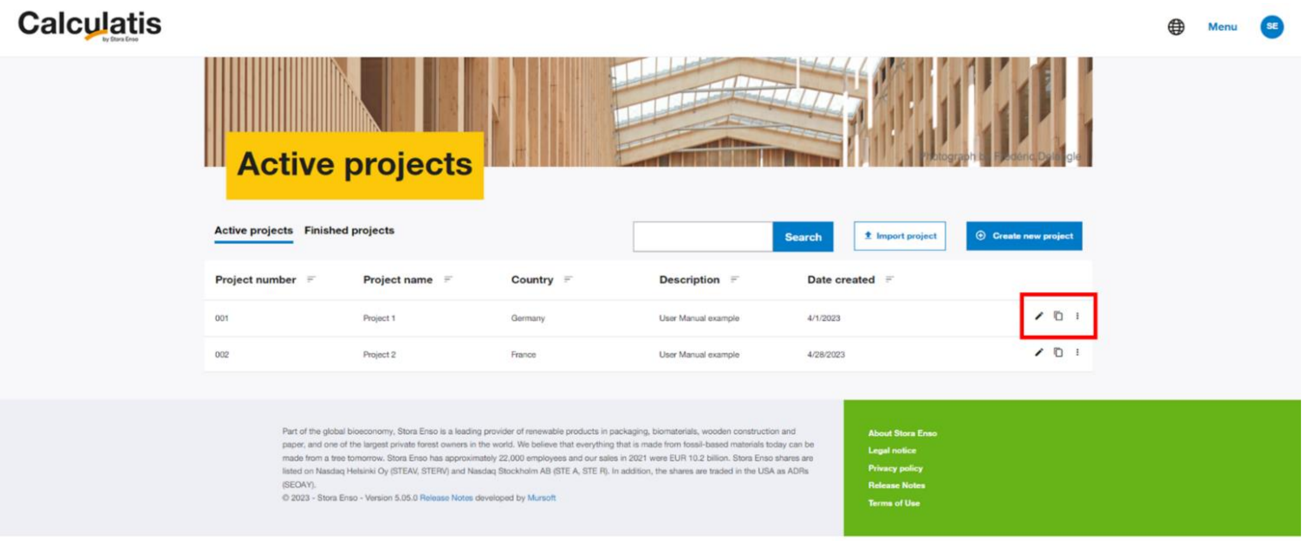


In the pulldown menu for country, you have to pick a country for your project. This setting will apply to your entire project.

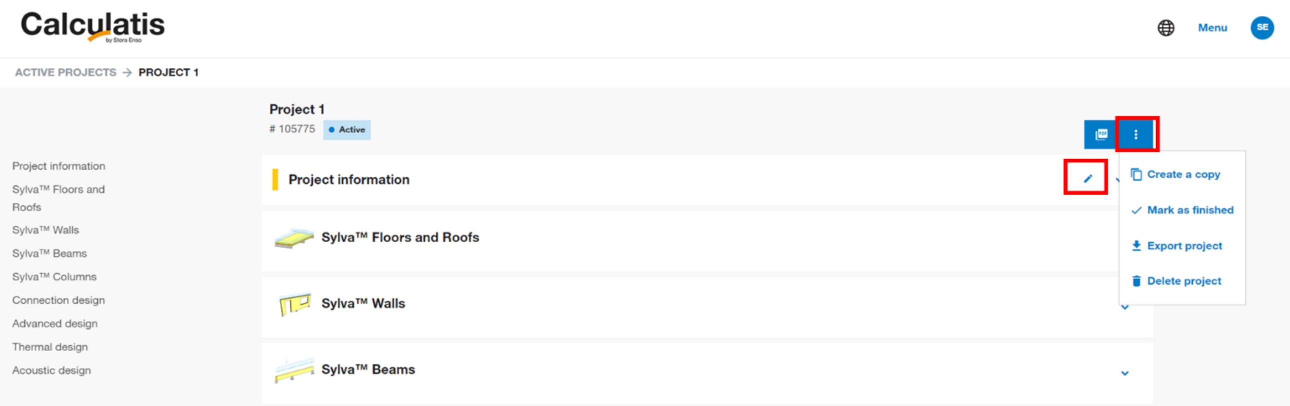
IMPORTANT: The country selected for your project will define the applicable national regulations applied to your design (national annexes of the Eurocode standards). **You cannot change the country after starting an analysis.**

The list of design relevant documents will be listed in the output of the software.

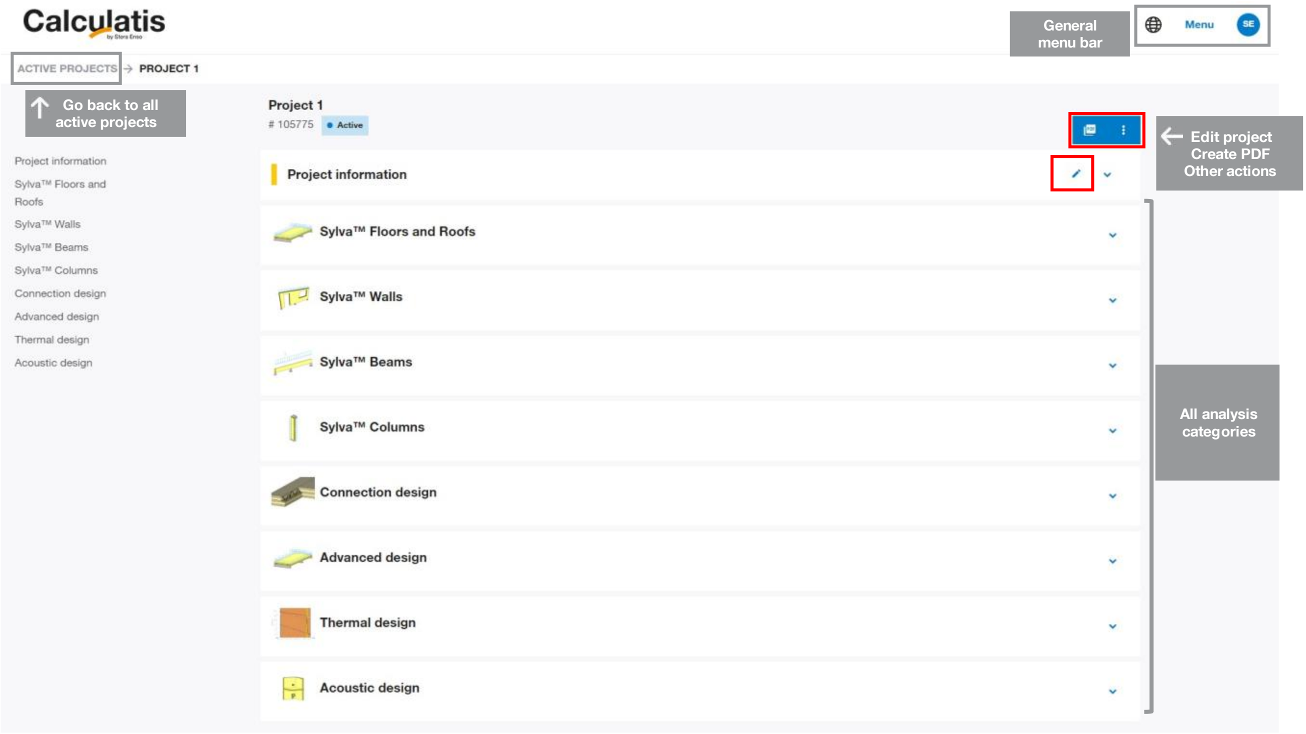
You can change other project information**, copy, mark as finished, export or delete the project anytime** in the main screen or after opening a project:



Change info, or other actions when you opened your project:



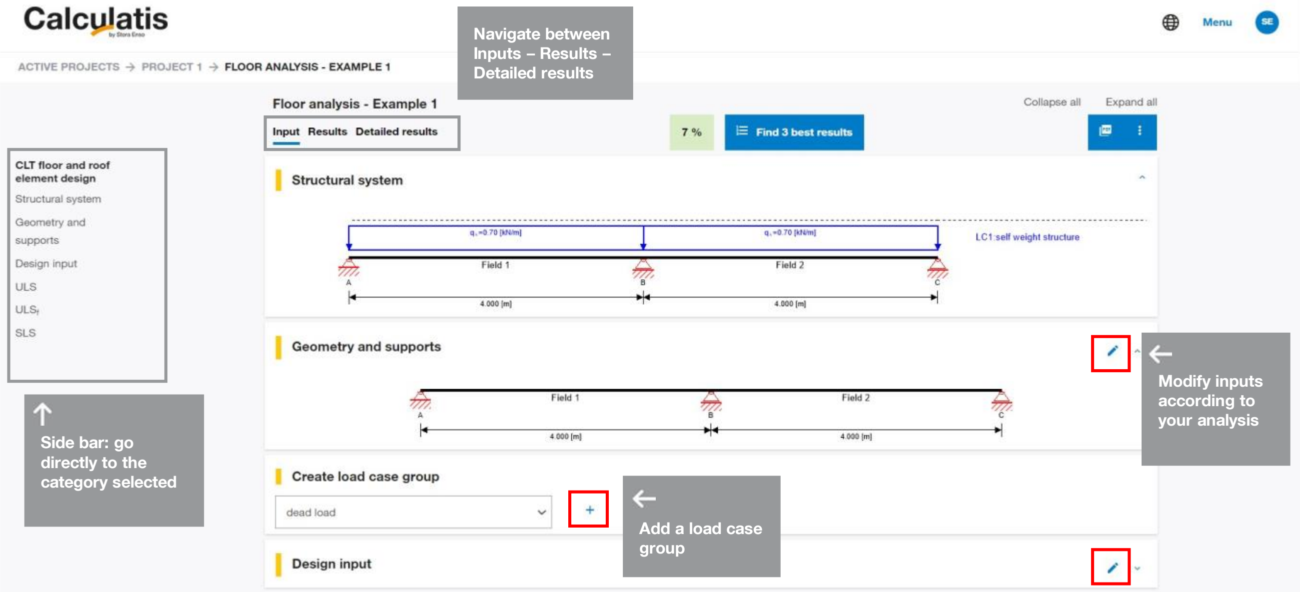
A typical project screen will look as shown in the figure below:



1.3. Analysis modules overview

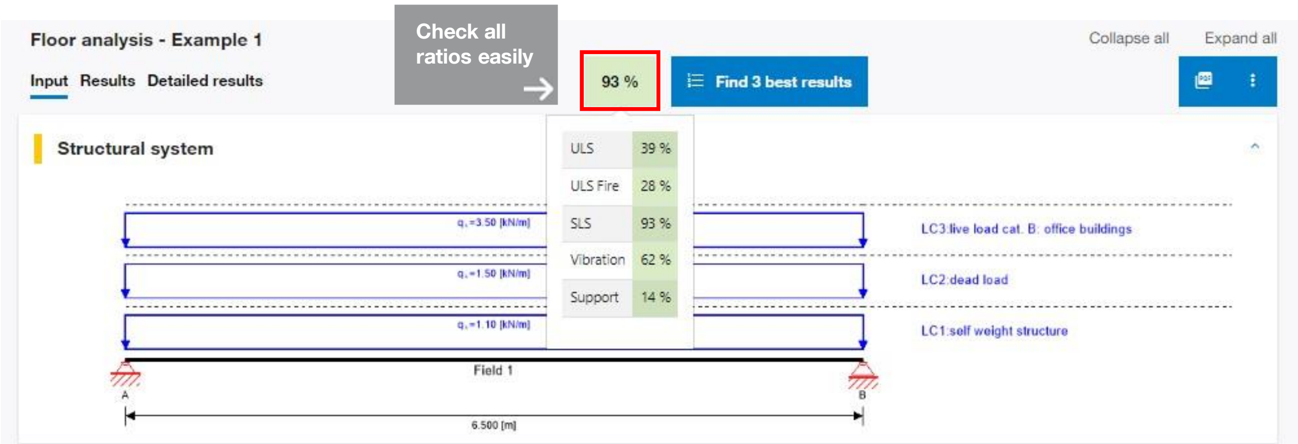
1.3.1. Inputs

When clicking **new calculation**, a new analysis page will open, showing a default beam:



Modify the geometry and supports according to your project, add load cases and loads, and modify design inputs.

Check for the utilization ratios directly from the Inputs, at any time during your design process:



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1.3.2. Results and Detailed results

You can now go to the **Results** or **Detailed results** to check all calculations parameters, results, and ratios.
Find a summary of all utilization ratios in the Results or Detailed results:

Utilization ratios

Global utilization ratio	ULS	ULS Fire	SLS	Vibration	Support
93 %	39 %	28 %	93 %	62 %	14 %

At any given time in the analysis progress, you will find the total design ratio for the given system. If the ratio is below 100%, the system is not overloaded – beyond 100% some adjustments need to be done, to design a system that suits the applicable loading and geometry.

1.3.3. Reference documents

At the end of each design result a list shows all reference documents that the given analysis is based on.

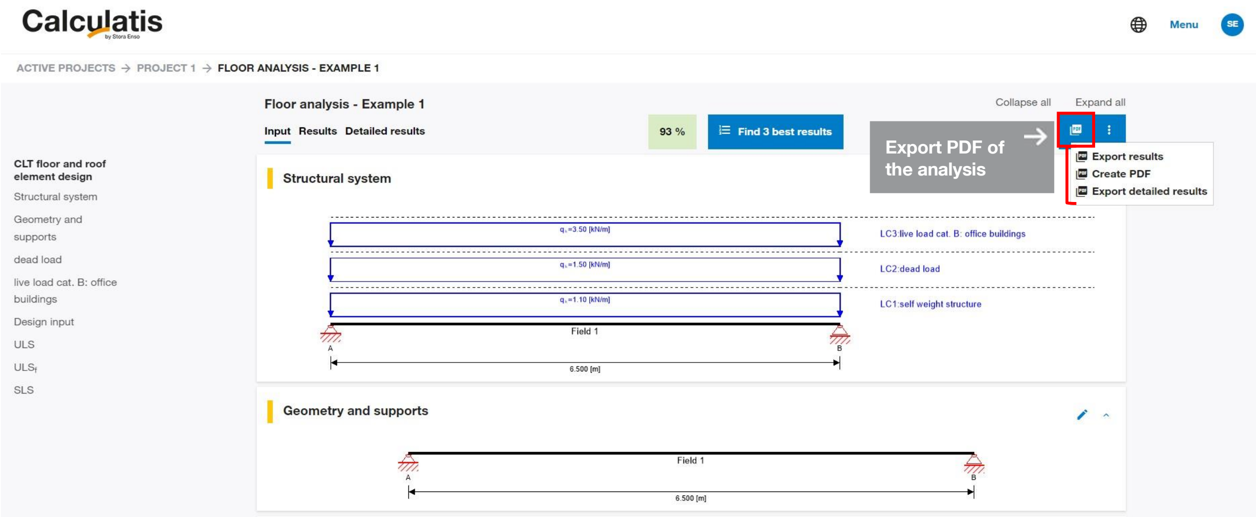
Reference documents for this analysis

Valid for Germany

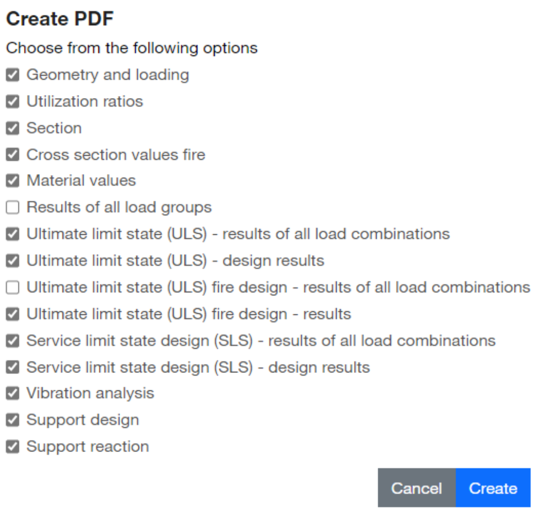
English title	Description
EN 338	EN 338 - Structural timber ? Strength classes
ETA-14/0349	European Technical Assessment ETA-14/0349 of 02.10.2014
Expertise Rolling shear - no edge gluing, H.J. Blass	Expertise on Rolling shear for CLT
EN 1995-1-2	EN 1995-1-2 - Eurocode 5 — Design of timber structures — Part 1-2: General — Structural fire design
EN 14080	EN 14080 - Timber Structures - Glued laminated timber and glued solid timber - Requirements
DIN EN 1995-1-1	EN 1995-1-1 - Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
DIN EN 1995-1-1 NA	EN 1995-1-1 - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General ? Common rules and rules for buildings
Technical expertise 122/2011/02: analysis of load bearing capacity and separation performance of CLT elements	Verification of the load bearing capacity and the insulation criterion of CLT structures with Stora Enso CLT
Technical expertise 2434/2012 - BB: failure time tf of gypsum fire boards (GKF) according to ON B 3410	Expertise on failure time tf of gypsum wall fire boards according to ON B3410 and gypsum wall boards type DF according to EN 520
EN 1990	EN 1990 - Eurocode ? Basis of structural design
Fire safety in timber buildings - technical guildeline for Europe	Fire safety in timber buildings - technical guideline for Europe; publishes by SP Technical Research Institute of Sweden
National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12	ÖNORM EN 1995-1-2 - National specifications concerning ÖNORM EN 1995-1-2, national comments and national supplements, chapter 12
DIN EN 1995-1-2_NA	DIN EN 1995-1-2 - Germany - National Annex - Eurocode 5: Design of timber structures ? Part 1-2: General ? Structural fire design ? National specifications concerning DIN EN 1995-1-2, national comments and national supplements
Expertise Rolling shear, H.J. Blass	Expertise on rolling shear strength and rolling shear modulus of CLT panels
ÖNORM EN 1995-1-1_NA, chapter 7.3	ÖNORM EN 1995-1-1 - Austria - National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General- Common rules and rules for buildings; chapter 7.3

1.3.4. PDF creation

You can also **create a pdf** of your analysis:



Export results: Short summary of relevant results (approx. one page)
Export detailed results: all results and parameters are displayed
Create PDF: Create a personalized PDF page, chose the categories you want to print



2. Basis of design and fundamentals

2.1. Calculations according to Eurocodes

The structural performance of the elements in Calculatis is verified in accordance with **the limit state design principles and rules specified in the Eurocodes**. In general, the calculation method regarding the ultimate limit state (ULS) and the serviceability limit state (SLS) is used according to EN 1995-1-1 and EN 1995-1-2.

According to EN 1990, the following equation for the property under consideration shall be fulfilled:

$$E_d \leq R_d$$

Where E_d is the design value of the effect of actions

R_d is the design value of the corresponding resistance

The **design values** are calculated as:

$$X_d = k_{mod} \cdot \frac{X_k}{\gamma_M}$$

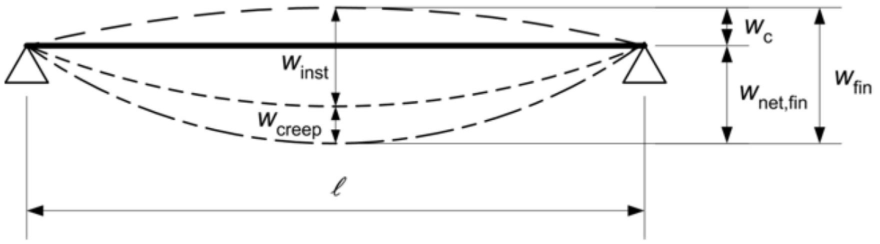
With:

X_d design strength
X_k characteristic strength
k_{mod} modification factor
γ_M partial safety factor

Actions to be used in the design may be obtained from the relevant parts of EN 1991. Combinations of actions shall be considered acc. to EN 1990. Assignments to a load-duration class shall be made according to EN 1995-1-1, section 2.3.1.2.

2.2. SLS design – Deformations

Depending on the national annex of Eurocode 5, different design verifications might be required. Usually the **instantaneous deflection, the net final deflection and the final deflection** need to be checked.



Components of deflection, Figure 7.1 of EN1995-1-1

SLS design and the national specifications

	SLS – deformation – deflection of beams	Note
Austria	$w_{inst} = \underbrace{\sum_{j\geq1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	
	$w_{fin} = \underbrace{\sum_{j\geq1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq1} w_{inst,G,j} + \sum_{i\geq1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination}$	
	$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber}$ $= \left[\sum_{j\geq1} w_{inst,G,j} + \sum_{i\geq1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot (1 + k_{def}) - w_c$	
Finland	$w_{inst} = \underbrace{\sum_{j\geq1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	
	$w_{fin} = \underbrace{\sum_{j\geq1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq1} w_{inst,G,j} + \sum_{i\geq1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination}$	
	$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber}$ $= \left[\sum_{j\geq1} w_{inst,G,j} + \sum_{i\geq1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot (1 + k_{def}) - w_c$	
France	$w_{inst\ (Q)} = \underbrace{w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	

	$w_2 = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination} - \underbrace{w_{G1,inst}}_{loads\ before\ finishings}$	2
	$w_{net,fin} = w_{inst} + w_{creep} - \underbrace{w_c}_{camber}$ $= (1 + k_{def}) \cdot \sum_{j\geq 1} w_{inst,G,j} + (1 + \psi_2 \cdot k_{def}) \cdot w_{inst,Q1}$ $+ \sum_{i\geq 1} (\psi_{0,i} + \psi_{2,i} \cdot k_{def}) \cdot w_{inst,Q,i} - w_c$	
Germany	$w_{inst} = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	
	$w_{fin} = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination}$	
	$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber}$ $= \left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot (1 + k_{def}) - w_c$	

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	SLS – deformation – deflection of beams	Note
Italy	$w_{inst} = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	
	$w_{fin} = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination}$	
	$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber} = \left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot (1 + k_{def}) - w_c$	
Spain	$w_{inst(Q)} = \underbrace{w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	
	$w_{act} = \underbrace{w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination}$	1
	$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber} = \left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot (1 + k_{def}) - w_c$	
United Kingdom	$w_{inst} = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{characteristic\ load\ combination}$	
	$w_{fin} = \underbrace{\sum_{j\geq 1} w_{inst,G,j} + w_{inst,Q1} + \sum_{i>1} \psi_{0,i} \cdot w_{inst,Q,i}}_{w_{inst}\ characteristic\ load\ combination} + \underbrace{\left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot k_{def}}_{w_{creep}\ quasi\ permanent\ load\ combination}$	
	$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber} = \left[\sum_{j\geq 1} w_{inst,G,j} + \sum_{i\geq 1} \psi_{2,i} \cdot w_{inst,Q,i}\right] \cdot (1 + k_{def}) - w_c$	

<table>
<tr><th></th><th>SLS – deformation – deflection of beams</th><th></th><th>Note</th></tr>
<tr><td rowspan="3">Australia</td><td>$w_{inst} = \underbrace{w_{inst}}_{characteristic\ load\ combination}$</td><td rowspan="3">Char. Load combination
$\sum G + \sum W$
$\sum G + \psi_2 \cdot \sum Q$
$\sum G + \psi_1 \cdot \sum Q + \sum W$
$\sum G + \psi_1 \cdot \sum Q + \sum E$
$\sum G + \psi_1 \cdot \sum Q + \sum S$
Quasi permanent load combination
$\sum G + \psi_1 \cdot \sum Q$
$\sum G + \psi_1 \cdot \sum Q + \sum S$</td><td></td></tr>
<tr><td>$w_{fin} = \underbrace{w_{inst}}_{characteristic\ load\ combination} + \underbrace{w_{creep}}_{quasi\ permanent\ load\ combination}$</td><td></td></tr>
<tr><td>$w_{net,fin} = \underbrace{w_{inst,2} + w_{creep}}_{quasi\ permanent\ load\ combination} - \underbrace{w_c}_{camber}$</td><td></td></tr>
</table>

Notes:

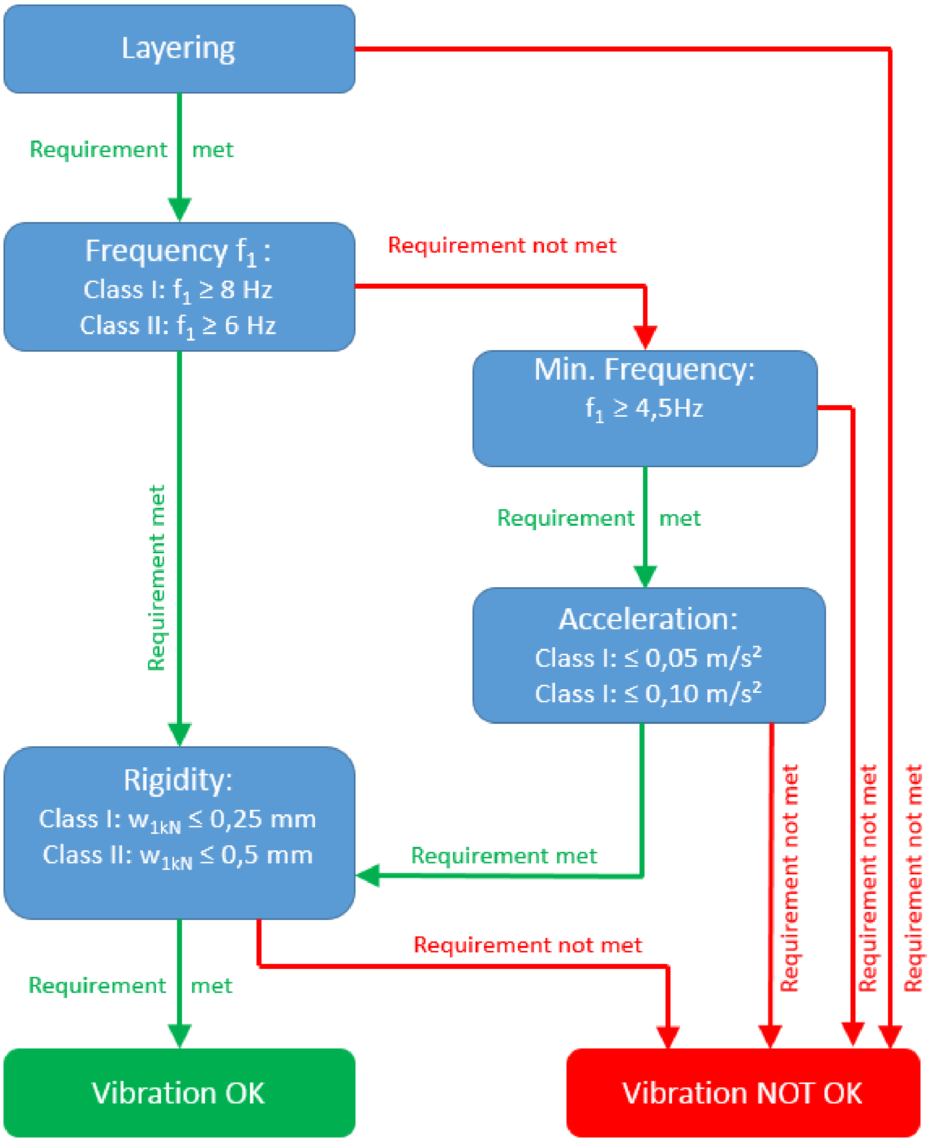
1. w_{act} in UNE EN 1995-1-1 NA
2. w_2 is used in some local French regulations and is mentioned in NF EN 1995-1-1 NA as well

Fragile finishing loads must be added as dead load g2k in Calculatis for the correct calculation of w2

2.3. SLS design – Vibrations

The vibration control is made by setting limits to the natural frequency and on the stiffness. In the calculation the average values are used.
The vibration analysis shall be executed according to EN1995-1-1 and the applicable national annex.
In case an applicable national annex to a Eurocode standard is deviating from given recommendations in this document, automatically the national annex is governing.
In the basic edition of EN 1995-1-1, the vibration design is very poorly regulated. Currently the **Austrian national annex** of EN1995-1-1 contains the most extensive vibration design guide lines, which are closely related to the research findings by Patricia Richter and Antje Hamm. Their research is among timber construction experts considered state of the art.

The vibration design shall be summarized in the following flow chart:



2.4. CLT analysis methods

CLT is created by laminating timber lamination battens crosswise (orthogonal) in layers. Therefore, a panel has longitudinal layers and cross layers. If a panel is subject to loading out of plane, the crosswise layering will influence the distribution of internal forces and the mechanical properties of a CLT section.
The fact that the cross layers are quite weak in comparison to the longitudinal layers, one cannot ignore these weak layers. Their effect needs to be included in the structural analysis. There are many analysis methods that are applicable to CLT design, such as the Modified Gamma Theory, the Shear Analogy, Timoshenko Theory and Finite Element Analysis.

Calculatis analysis are based on the Timoshenko Theory, unless specified otherwise.

For the Service Limit State (SLS) design, deformations originating from flexural moments and from shear need to be considered. The Timoshenko Theory is for CLT panels a solid and good analysis method, which provides reasonable design results, compared to all other methods, within the range of practical construction.

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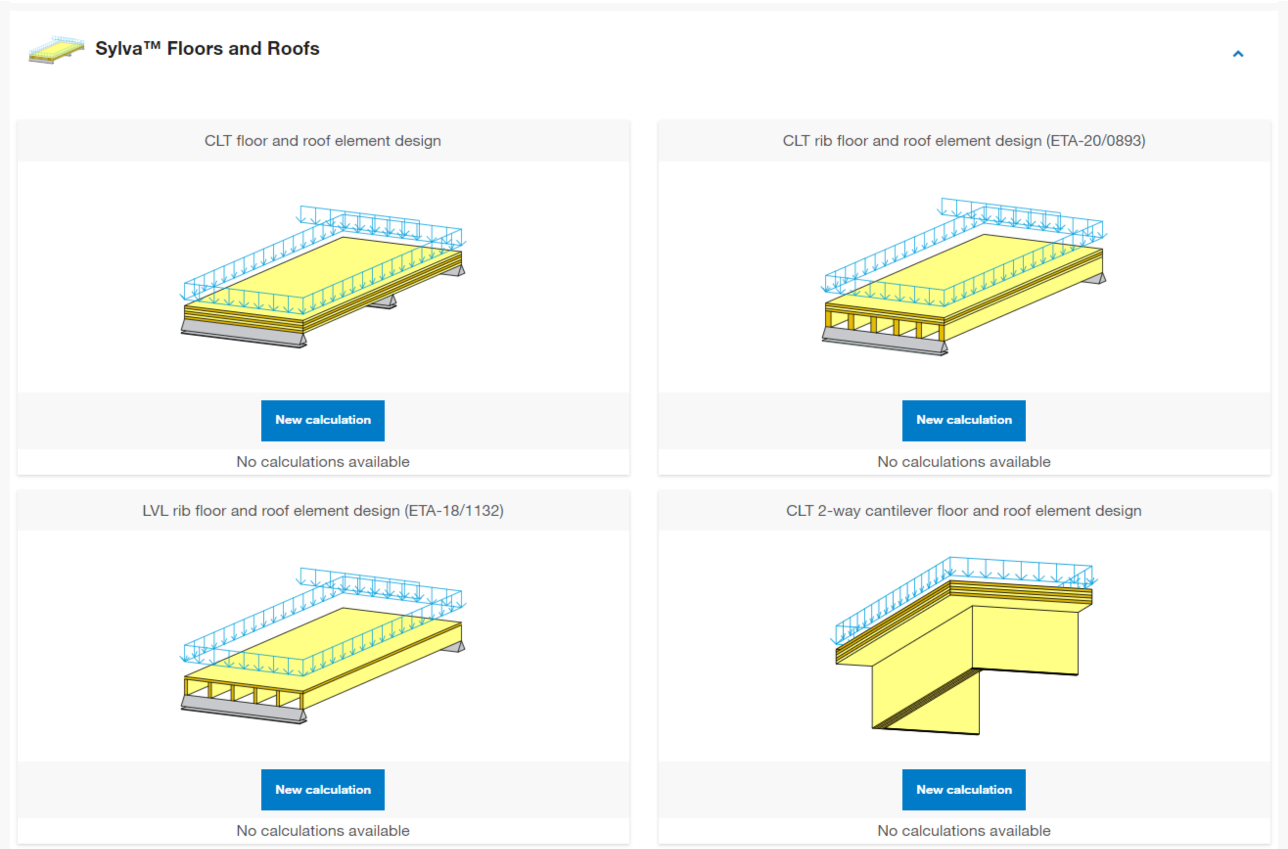
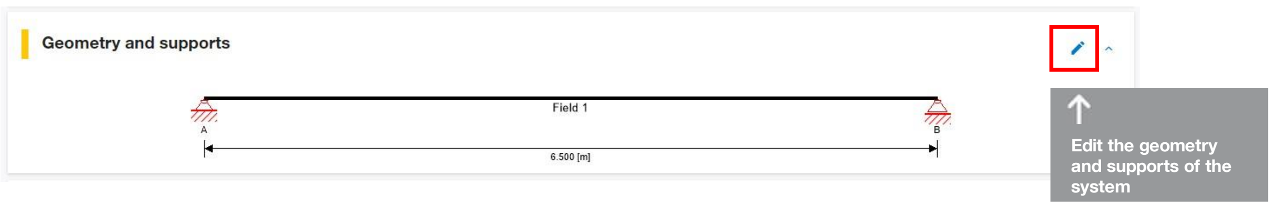
3. Sylva™ Floors and roofs



3.1. Common features

This section shows the common inputs needed for analysis and the type of results related.

3.1.1. Geometry and supports



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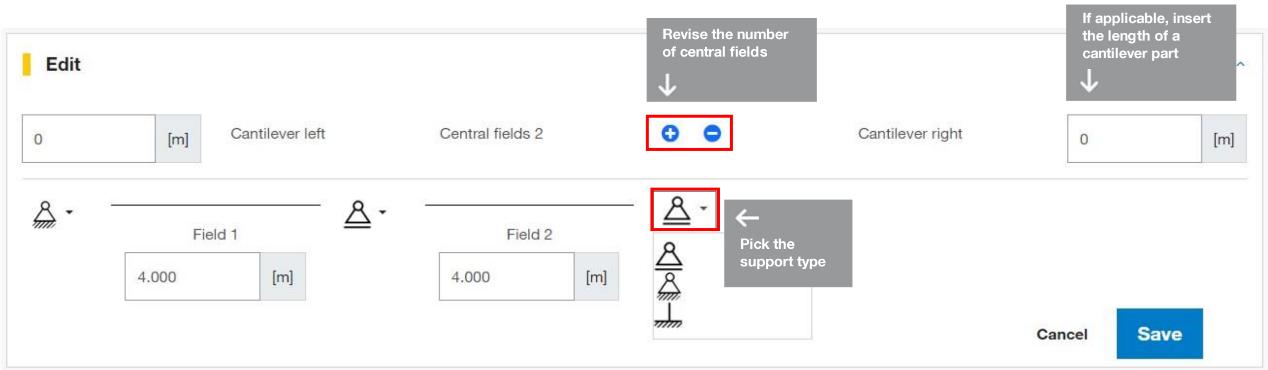
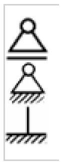


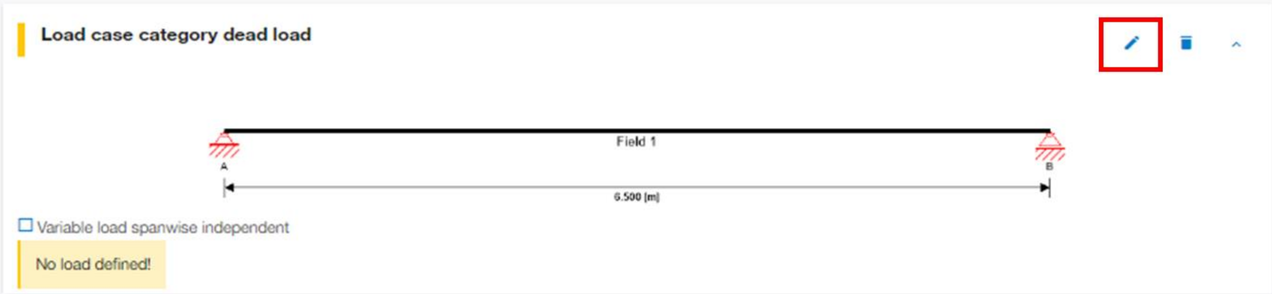


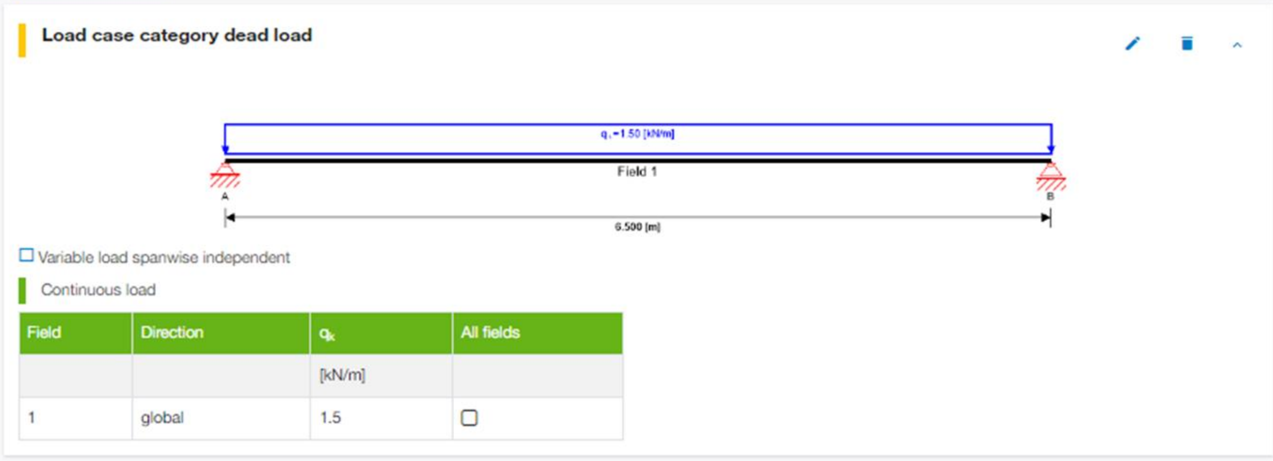
Pinned support, fixed in horizontal direction

Pinned support, free in horizontal direction

Fixed support (no translatory/rotatory movement possible)

3.1.2. Loading





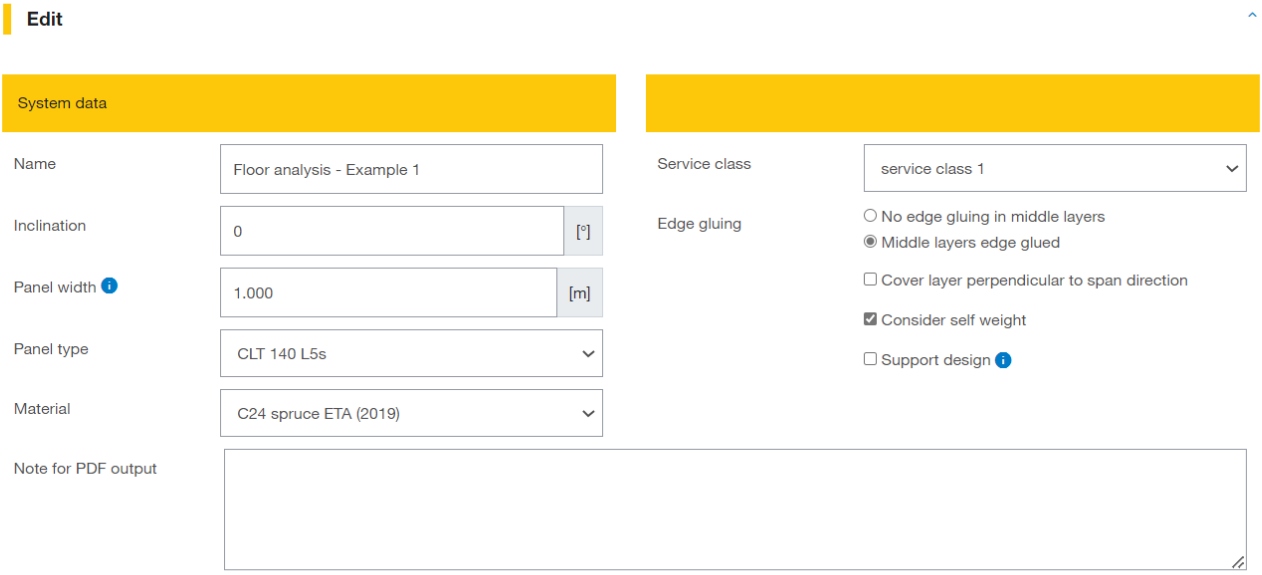
If you would like to add a load to a load case group, select for each span the load type that shall be applied (**continuous, point load or trapezoidal load**), and edit the value and the geometric parameters.

Clicking the check box **apply to all fields** can be activated if a load shall be applied in the given magnitude to all fields. This makes the input procedure more efficient.

Clicking the field **variable load spanwise independent** is usually applied with variable loads. Variable loads on a continuous beam can or may not be present along the entire system. They might occur only in one span and not in the others. If this effect shall be reflected in the analysis and if the software shall do all possible load combinations, put a check mark in the box and the software will include all the required possible combinations automatically.

3.1.3. System data

Here you can input the name of the analysis, geometrical parameters and the product's specifications.



Inclination: for a floor the inclination will be typically 0°. For roofs give the inclination, measured between the CLT plane and the horizontal plane.

Panel width: Usually this will be 1,00 m (by default). If you analyze a panel that is only 0,80 m wide, edit the value accordingly. All loading that will be applied to the system will be entered in **kN per linear meter**.

Material: pick from the pulldown menu the material of the product

Service class: pick the service class (1 or 2 – class 3 for CLT by Stora Enso is not permitted).

Edge gluing: All layers of CLT by Stora Enso are usually edge glued. This setting effects the rolling shear strength.

Consider self weight: The self weight of the product is considered by default (visible in the system sketch on top of the page).

Support design: choose if the support pressure in at the supports shall be verified or not.

3.1.4. Fire design

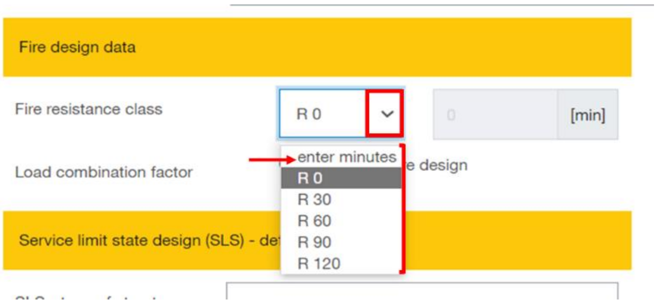
It is assumed that only the bottom of the floor is exposed to fire.

The fire design is being executed according to EN1995-1-2 and its national annexes.
As an alternative, the user can choose to do the fire design (determination of the residual timber section) according to the guideline Fire Safety in Timber Buildings if a fire protection system is applied on the ceiling.

Edit the fire design data:

Fire resistance class: If R0 is chosen, no fire design will be executed.

The user can also choose a personalized resistance time in minutes.



Load combination factor: Generally Eurocode 5 leaves it up to the engineer, if the load combination for fire design is applying a load combination factor of $\psi 2$ or $\psi 1$. The user can choose this here in the input for fire design.

Fire protection system: If a fire protective cladding is attached to the ceiling, this shall be selected in the pull down menu.

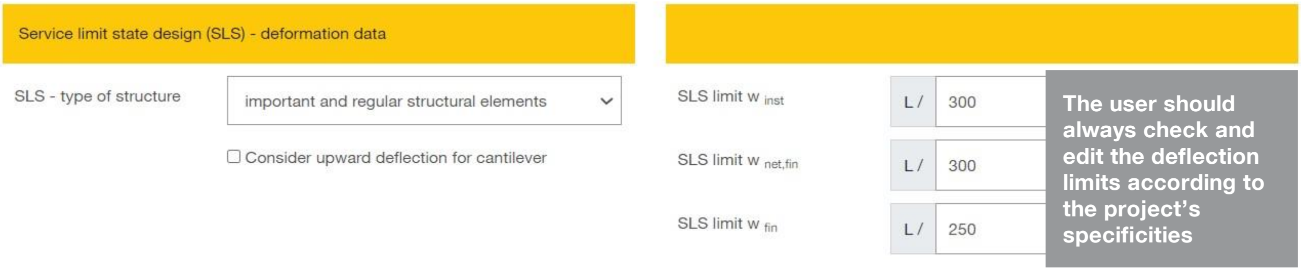
This results in a variation of the following parameters:

- Single or double ply
- Attached directly to the CLT or with an insulated plumbing cavity in between
- Design according to EN1995-1-2 and ON B 1995-1-2 or design according to Fire Safety In Timber Buildings

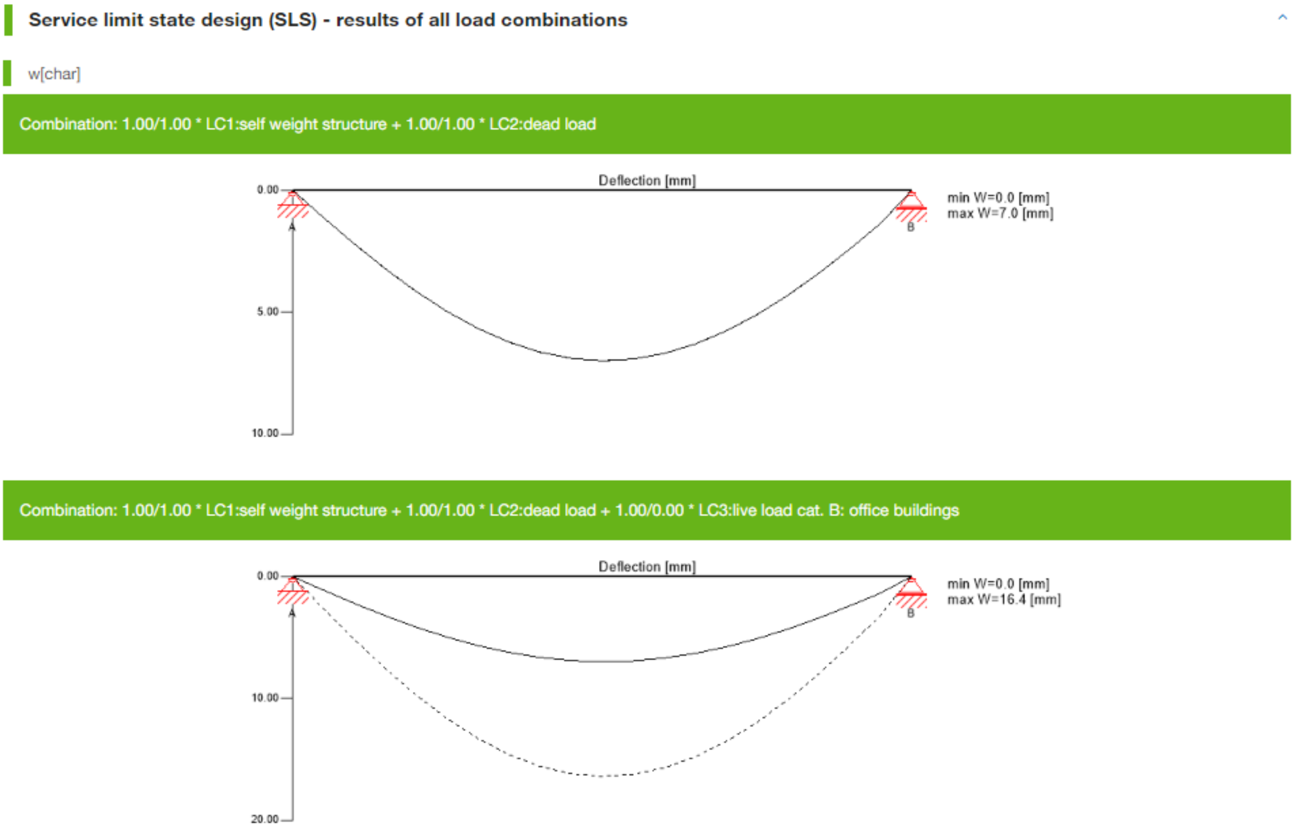
Except for the analysis according to Fire Safety in Timber Buildings, the Austrian national annex is always included in the fire design, because it is currently more detailed than the national annex of other countries.

3.1.5. SLS design – Deformations

Set the system type that suits your project assumptions or requirements. Suggested deflection limits for the SLS design are automatically added. **However, the user should always check and edit these limits according to the project's requirements.**



All deflection curves for the different load combinations are being displayed in the detailed results:



Maximum and minimum values are given next to the curve. Intermediate values are displayed in a table, when clicking on the curve.

The design results of the Service Limit State (SLS) design are displayed in a table:

Service limit state design (SLS) - design results (93 %)

w_{inst} = w[char]

Field	K_{def}	L_{ref}	Limit	$w_{calc.}$	Utilization
		[m]	[mm]	[mm]	
1	0.8	6.5	L/300 = 21.7	16.4	76 %

w_{fin} = w[char] + w[q.p.]*kdef

Field	K_{def}	L_{ref}	Limit	$w_{calc.}$	Utilization
		[m]	[mm]	[mm]	
1	0.8	6.5	L/250 = 26.0	24.3	93 %

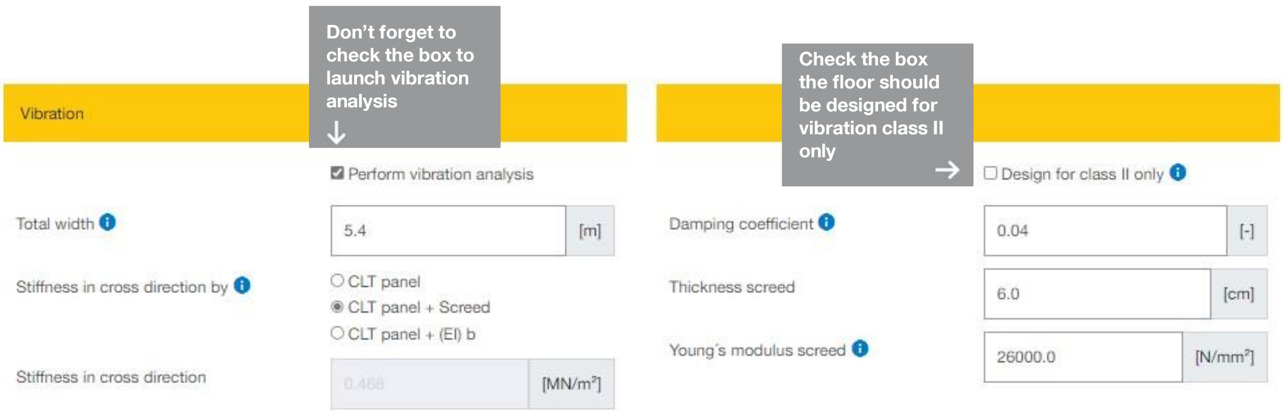
$w_{net,fin}$ = w[q.p.] + w[q.p.]*kdef

Field	K_{def}	L_{ref}	Limit	$w_{calc.}$	Utilization
		[m]	[mm]	[mm]	
1	0.8	6.5	L/300 = 21.7	17.7	82 %

For each span a reference length is given. This length is the base for the deflection limits (e.g.: L/150). In a deflection limit L/150, the reference length Lref is being divided by 150. In all applied design standards, the deflection limits of cantilevers are double of those for spans, with supports on both ends. Therefore the reference length of cantilevers is the double of the system length of the respective cantilever.

Please go to chapter *2.2 SLS design – Deformations* for more information about deformation verifications and national specifics.

3.1.6. SLS design – Vibrations



If a vibration analysis is required, set the check mark accordingly (perform vibration analysis).
This is usually not required for roofs.

Total width: This is the total width of the floor system. It's usually equal to the width of the room that is hosting the floor. This width is only being used for the vibration analysis and can be different from the system width, entered in "system data" above.

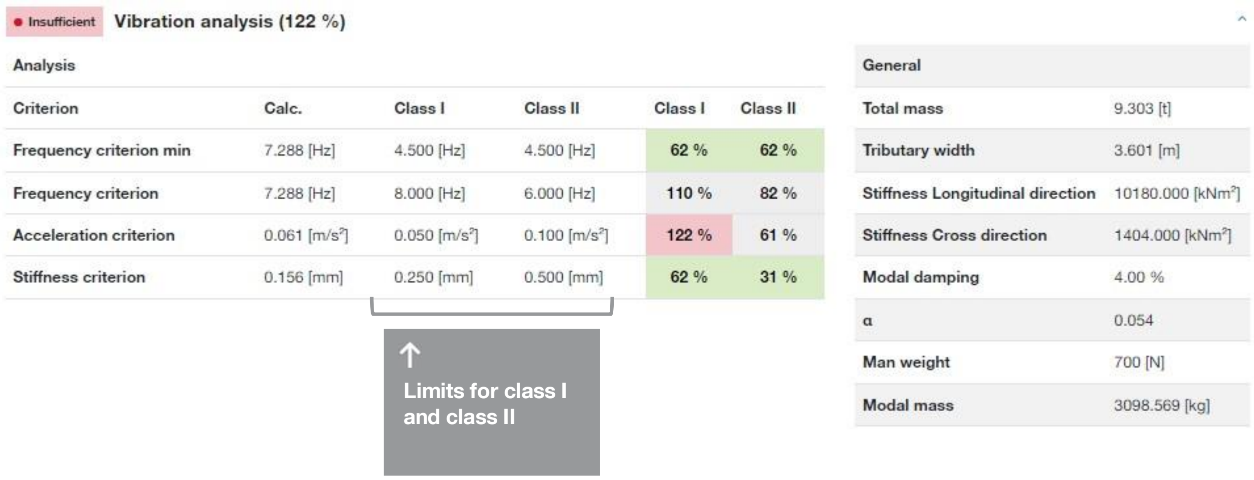
Stiffness in cross direction: pick if the stiffness in cross direction (perpendicular to principal direction) is being contributed by:

— **CLT panel**: only by the CLT panel´s cross layers

- **CLT panel + screed**: by the CLT panel´s cross layers and additionally by the screed on top of the panel
  For that you need to insert the **Young´s modulus for the screed** and the **thickness** of the screed.
- **CLT panel + (EI)b**: Here the user can define an **arbitrary value** for the additional stiffness in cross direction. Additional stiffness means the stiffness that is provided by any other element (layer) on top of the CLT or below the CLT.

The stiffness of the CLT is considered in all cases.

Damping coefficient: This value is usually in a range between 1% (0,01) and 5% (0,05). For a CLT floor with a wet screed on top (separated by an insulation layer), 4% (0,04) will usually be the applicable damping coefficient.



Insufficient Vibration analysis (122 %)

Analysis					
Criterion	Calc.	Class I	Class II	Class I	Class II
Frequency criterion min	7.288 [Hz]	4.500 [Hz]	4.500 [Hz]	62 %	62 %
Frequency criterion	7.288 [Hz]	8.000 [Hz]	6.000 [Hz]	110 %	82 %
Acceleration criterion	0.061 [m/s²]	0.050 [m/s²]	0.100 [m/s²]	122 %	61 %
Stiffness criterion	0.156 [mm]	0.250 [mm]	0.500 [mm]	62 %	31 %

General	
Total mass	9.303 [t]
Tributary width	3.601 [m]
Stiffness Longitudinal direction	10180.000 [kNm²]
Stiffness Cross direction	1404.000 [kNm²]
Modal damping	4.00 %
α	0.054
Man weight	700 [N]
Modal mass	3098.569 [kg]

The vibration analysis results are given in a table as shown in the figure above.

This software was created for many countries and their applicable standards. Unfortunately the vibration design is still very poorly described in Eurocode 5 (EN 1995-1-1). The Austrian national annex includes at this point the most extensive rules related to the vibration analysis.

Except if the local national annex provides a different requirement explicitly, the design method and limits of the Austrian national annex are applied to all countries.

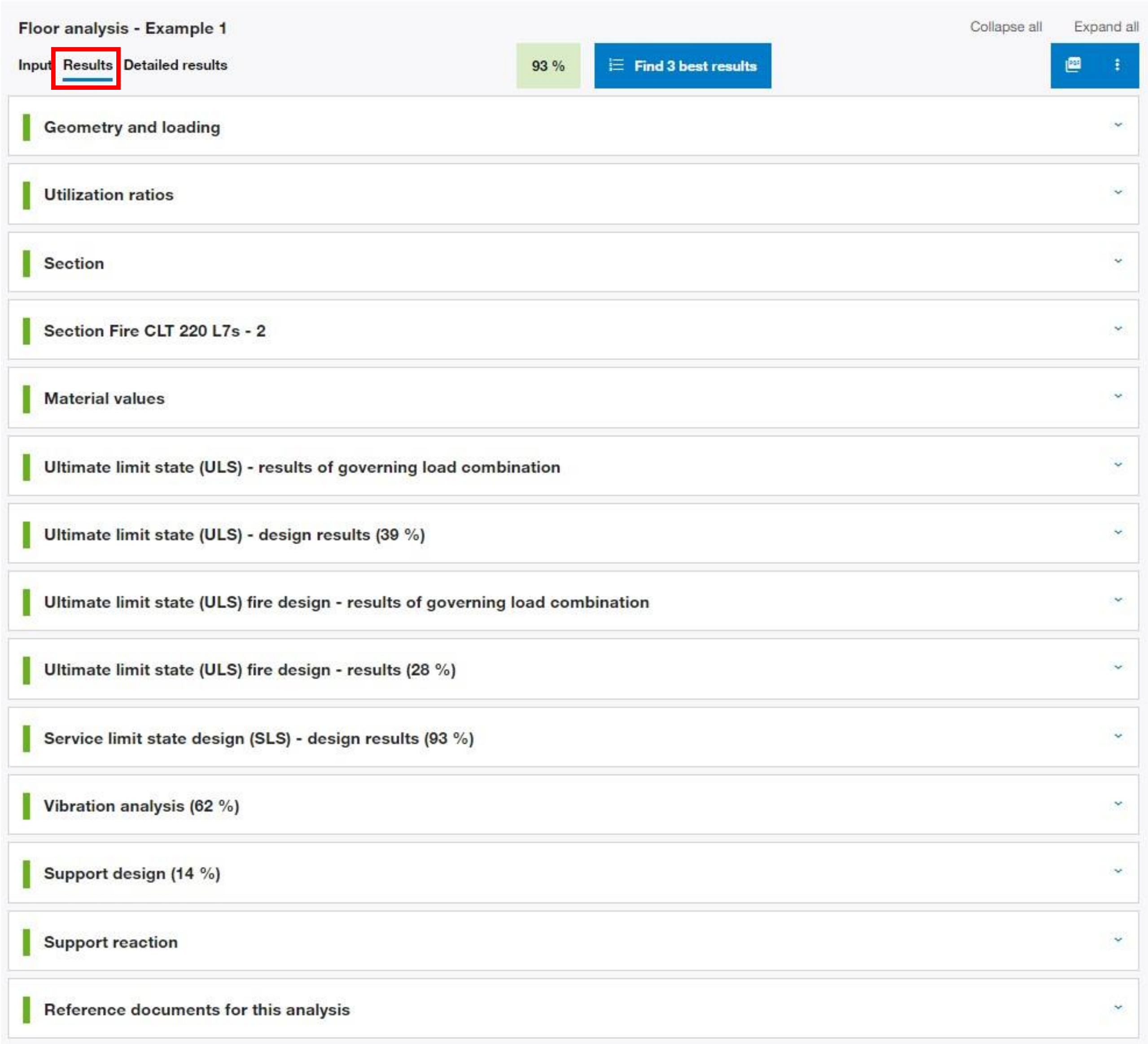
In the Austrian national annex, 2 vibration classes are being introduced: class I and class II. This is a similar approach as by Hamm & Richter. In that document Hamm & Richter refer to floors that extend across more than just one unit (room) or floors that only serve one unit (room). Obviously for floors that serve more units at the time, stricter requirements apply. The same idea was adopted in the national annex of Eurocode 5. Here Eurocode 5 refers to a class I (more strict requirements) and class II.

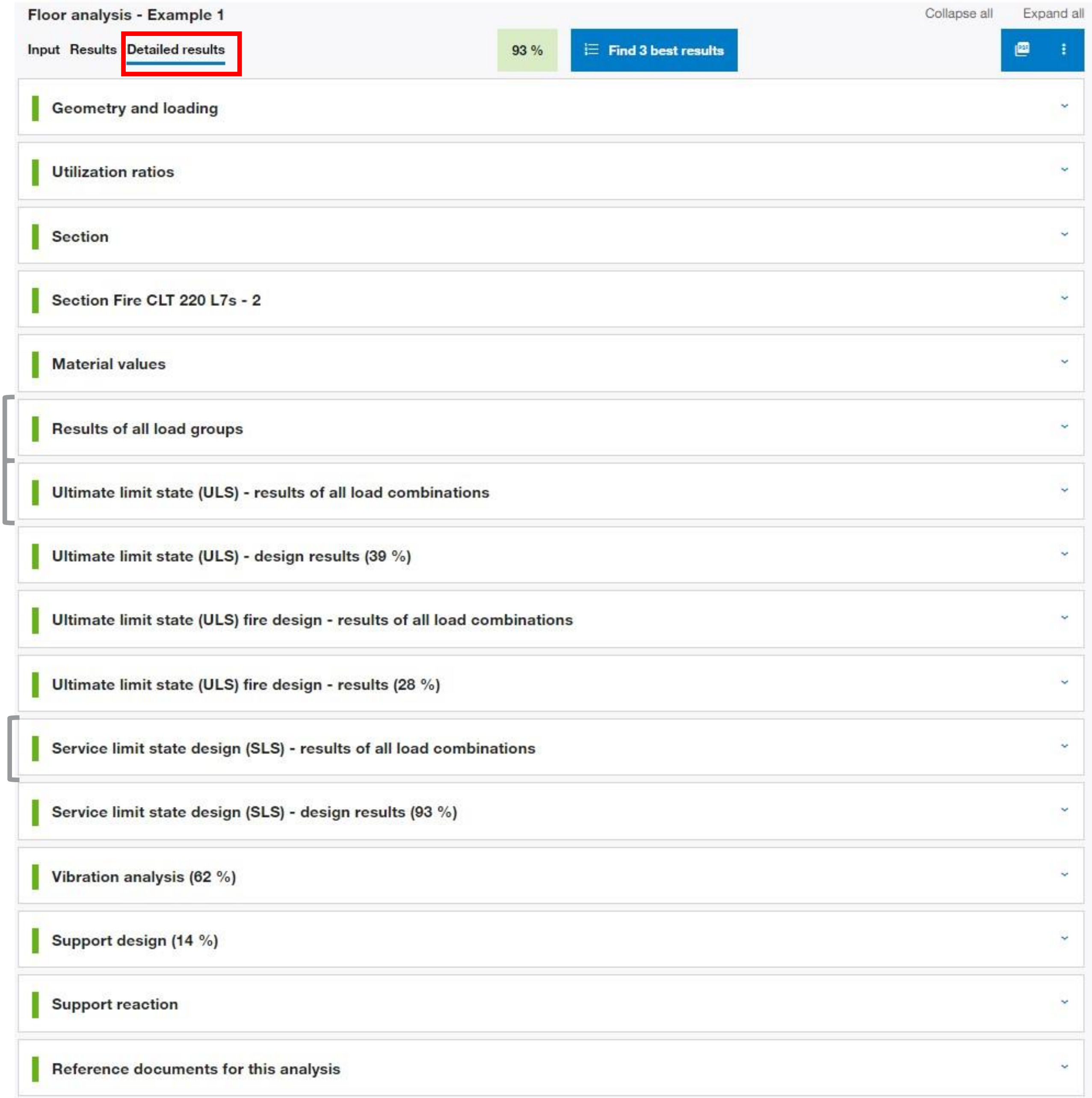
The equation NA.7.5-E1 is not considered for the calculation of the frequency in Calculatis.

It is finally up to the user to decide which class is the most relevant for their design.

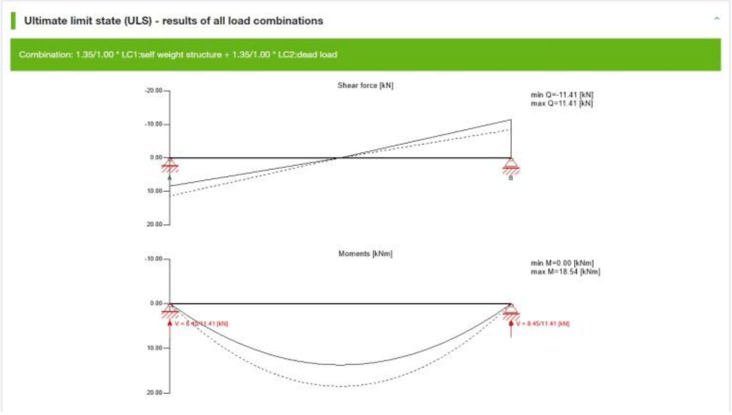
3.1.7. All results

The user has the choice to either see only the design relevant results by clicking **Results** or the entire list of results can be displayed by clicking **Detailed results**.




Floor analysis - Example 1
Collapse all
Expand all
Input
Results
Detailed results
93 %
Find 3 best results
Geometry and loading
Utilization ratios
Section
Section Fire CLT 220 L7s - 2
Material values
Results of all load groups
Ultimate limit state (ULS) - results of all load combinations
Ultimate limit state (ULS) - design results (39 %)
Ultimate limit state (ULS) fire design - results of all load combinations
Ultimate limit state (ULS) fire design - results (28 %)
Service limit state design (SLS) - results of all load combinations
Service limit state design (SLS) - design results (93 %)
Vibration analysis (62 %)
Support design (14 %)
Support reaction
Reference documents for this analysis

Diagrams of all load groups and all load combinations for the respective design (ULS, SLS, fire) being displayed.
The maximum and minimum values are given in the diagrams. Other values from intermediate points along the beam can be retrieved in a table by clicking the respective curve or diagram:



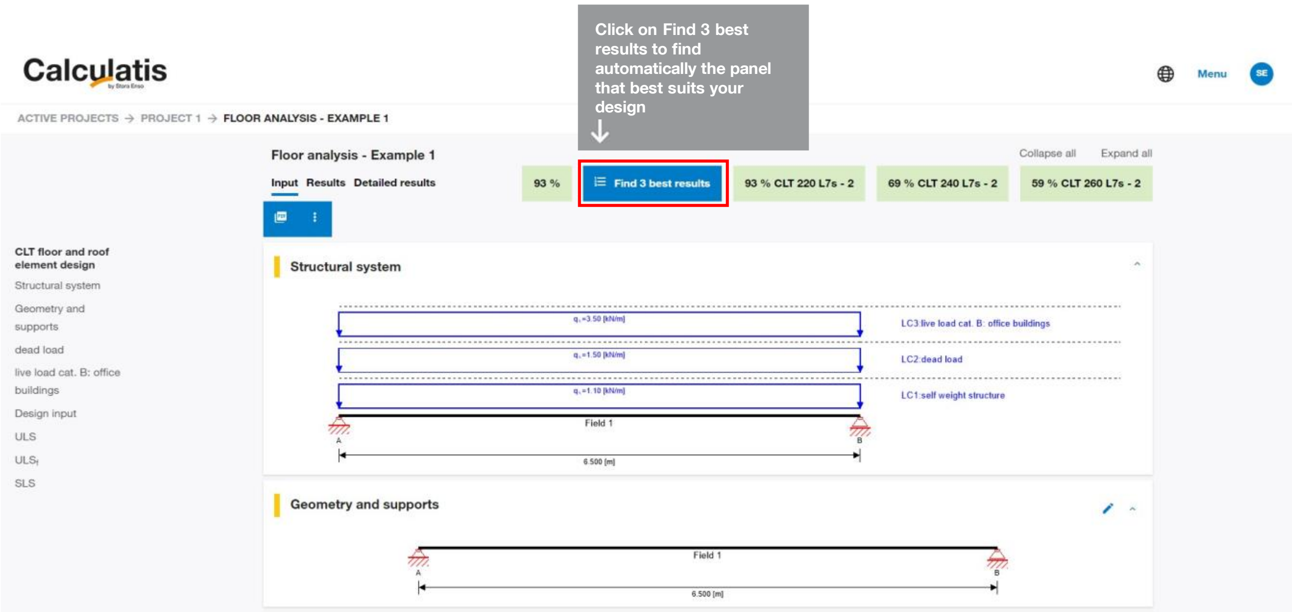
All values are displayed by clicking on the curve →

× Value for 1.35/1.00 * LC1:self weight structure + 1.35/1.00 * LC2:dead load

Distanz	min W	max W	min ϕ	max ϕ	min Qz	max Qz	min My	max My
0.0	0.0	0.0	-0.004135	-0.003063	8.450	11.408	0.000	0.000
0.325	0.001125	0.001519	-0.004076	-0.003019	7.605	10.267	2.609	3.522
0.65	0.00221	0.002983	-0.003904	-0.002892	6.760	9.126	4.943	6.673
0.975	0.003228	0.004358	-0.003633	-0.002691	5.915	7.985	7.003	9.454
1.3	0.004157	0.005613	-0.003275	-0.002426	5.070	6.845	8.788	11.864
1.625	0.004979	0.006721	-0.002843	-0.002106	4.225	5.704	10.298	13.903
1.95	0.005675	0.007661	-0.002349	-0.00174	3.380	4.563	11.534	15.571
2.275	0.006234	0.008415	-0.001805	-0.001337	2.535	3.422	12.495	16.869
2.6	0.006644	0.008969	-0.001224	-0.000907	1.690	2.282	13.182	17.796
2.925	0.006898	0.009312	-0.000618	-0.000458	0.845	1.141	13.594	18.352
3.25	0.006991	0.009438	0.0	0.0	0.000	0.000	13.731	18.537
3.575	0.006923	0.009346	0.000458	0.000618	-1.141	-0.845	13.594	18.352
3.9	0.006694	0.009037	0.000907	0.001224	-2.281	-1.690	13.182	17.796
4.225	0.006309	0.008518	0.001337	0.001805	-3.422	-2.535	12.495	16.869
4.55	0.005776	0.007798	0.00174	0.002349	-4.563	-3.380	11.534	15.571
4.875	0.005105	0.006891	0.002106	0.002843	-5.704	-4.225	10.298	13.903
5.2	0.004309	0.005817	0.002426	0.003275	-6.844	-5.070	8.788	11.864
5.525	0.003405	0.004596	0.002691	0.003633	-7.985	-5.915	7.003	9.454
5.85	0.002412	0.003256	0.002892	0.003904	-9.126	-6.760	4.943	6.673
6.175	0.001352	0.001826	0.003019	0.004076	-10.267	-7.605	2.609	3.522
6.5	0.0	0.0	0.003063	0.004135	-11.408	-8.450	0.000	0.000

3.2. CLT floor and roof

Use the button **Find 3 best results** to find automatically and easily the most suitable panel for your design.



3.3. CLT Rib floor and roof (ETA-20/0893)

The structural performance of CLT Rib floor and roof elements is verified according to the Eurocodes, ETA-20/0893 and the Structural Design Manual for CLT Rib Panels by Stora Enso.

CLT Rib Panel by Stora Enso is covered by the **ETA-20/0893**. CLT Rib Panels by Stora Enso are composite slab elements consisting of Stora Enso Cross Laminated Timber (CLT) according to ETA-14/0349 as panel stiffened out of plane by Glued Laminated Timber (GLT) ribs according to EN 14080 in the direction of the span. **These two components are assembled by structural gluing**. The cover layers of the CLT shall have same grain orientation as the glulam rib. CLT Rib Panels by Stora Enso contain screws to create gluing pressure or to fix secondary construction elements, but they do not have an influence on the composite effect.

3.4. LVL rib floor and roof (ETA-18/1132)

The structural performance of LVL Rib floor and roof elements is verified according to the Eurocodes, ETA-18/1132 and the Structural Design Manual for LVL Rib Panels by Stora Enso.

LVL Rib Panel by Stora Enso is covered by the **ETA-18/1132**. LVL Rib Panels by Stora Enso are **composite slab elements made of X- and S types structural LVL** (Laminated Veneer Lumber). The adhesive is of type EN 15425 polyurethane (PUR) adhesive. LVL Rib Panels by Stora Enso may contain screws and nails, but they do not have an influence on the composite effect but they are only used to fix secondary construction elements.

3.5. CLT 2-way cantilever floor and roof

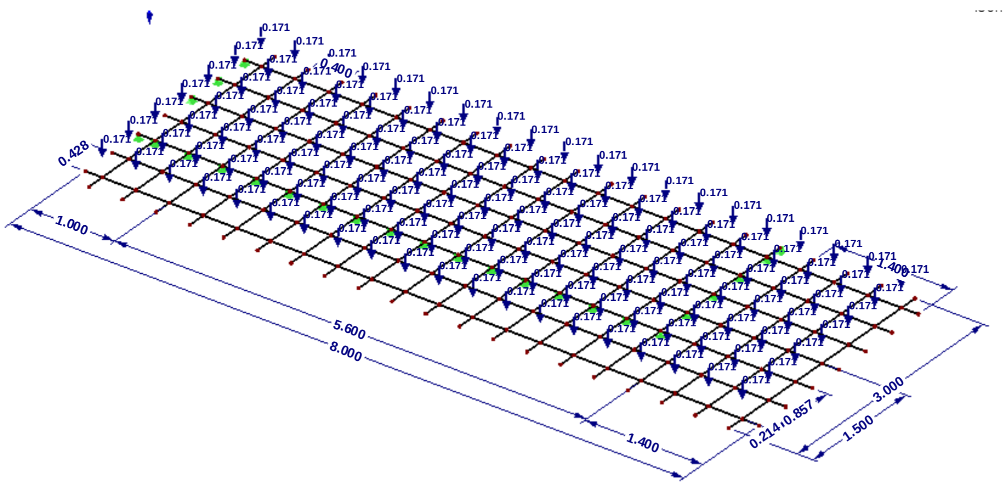
3.5.1. Analysis method

This module will design a CLT panel that is located at the corner of a building and is cantilevering out in 2 directions (in principal direction and in cross direction). In design practice, engineers used so far good judgement and some simplified engineering approaches, by trying to interpret a beam with a cantilever into the system. Probably the best approach to such a problem would be a FE analysis. This module shall help the user to save time and help these, who don´t have access to FE software. The here presented method is an engineering approach as well, but a closer approach to the real solution than to interpret a beam (spanning in one direction only) with a cantilever into the system.

Since this is only a solid engineering method, the results of this module **deviate from a FE model**, but the deviations are on the **conservative side**.

The design approach at this module is, to describe the CLT panel as a **beam grid model**. There are beams that run in principal direction of the panels and beams that run in cross direction. The beams in principal direction have the rigidity and moment of inertia of the CLT panel in principal direction and the beams in cross direction have the properties of the CLT in cross direction.

In this design module, the CLT panel is being modeled by **a beam grid with a square mesh width of about 40 cm**. The exact width will be a multiple of the panel dimension. All loading is being applied as point load in the intersecting nodes of the beam grid model.

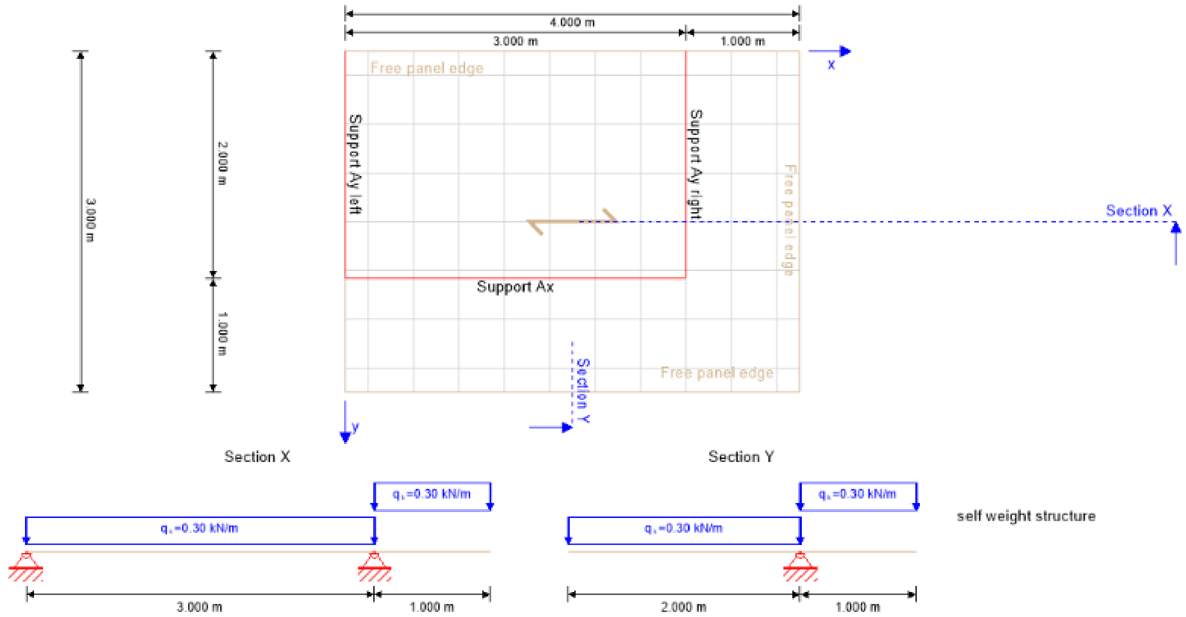


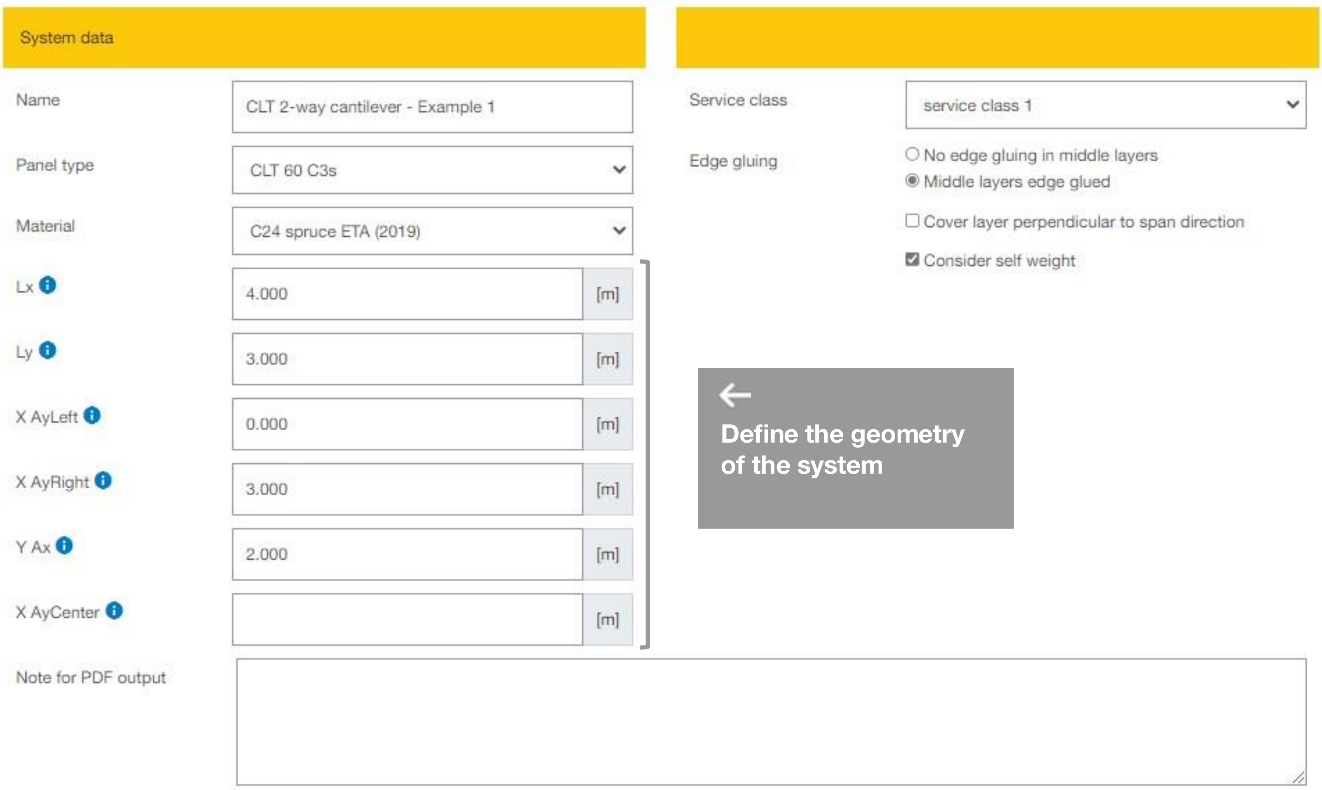
The deformation of the system is being analyzed according to the Timoshenko beam theory, taking all deformation due to flexural moments and shear into account.

$$w_{total} = w_M + w_V = \frac{1}{E \cdot I_{eff}} \cdot \int (M \cdot \bar{M})\, dx + \frac{1}{G \cdot A_{eff,G}} \cdot \int (V \cdot \bar{V})\, dx$$

3.5.2. System data and geometry

Panel in plan view

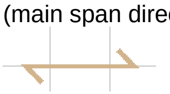




System data			
Name	CLT 2-way cantilever - Example 1	Service class	service class 1
Panel type	CLT 60 C3s	Edge gluing	○ No edge gluing in middle layers ◉ Middle layers edge glued
Material	C24 spruce ETA (2019)		☐ Cover layer perpendicular to span direction ☑ Consider self weight
Lx	4.000 [m]		
Ly	3.000 [m]		
X AyLeft	0.000 [m]		
X AyRight	3.000 [m]		
Y Ax	2.000 [m]		
X AyCenter	[m]		
Note for PDF output			

← **Define the geometry of the system**

Lx is the total length in X direction and **Ly** is the total length on Y direction. When starting the design and the input at this module, there is already some existing data and a corresponding system sketch above. Comparing the values in the list with those in the sketch might help to understand the logic of the input.
X AyLeft is the X coordinate of the left support line (red line) in Y direction.
X AyRight is the X coordinate of the right support line (red line) in Y direction.
X AyCenter is the X coordinate of the central support line (red line) in Y direction. If there is no support line in the middle, then leave this box blank.
Y Ax is the Y coordinate of the support line in x direction.
The principal direction of the CLT is indicated in the system sketch and is usually oriented in X direction (main span direction).



Check the box “**Cover layer perpendicular to span direction**”, If the principal direction shall be in Y direction.
The system sketch includes a section in X and in Y direction for a better understanding of the system.

3.5.3. Loading

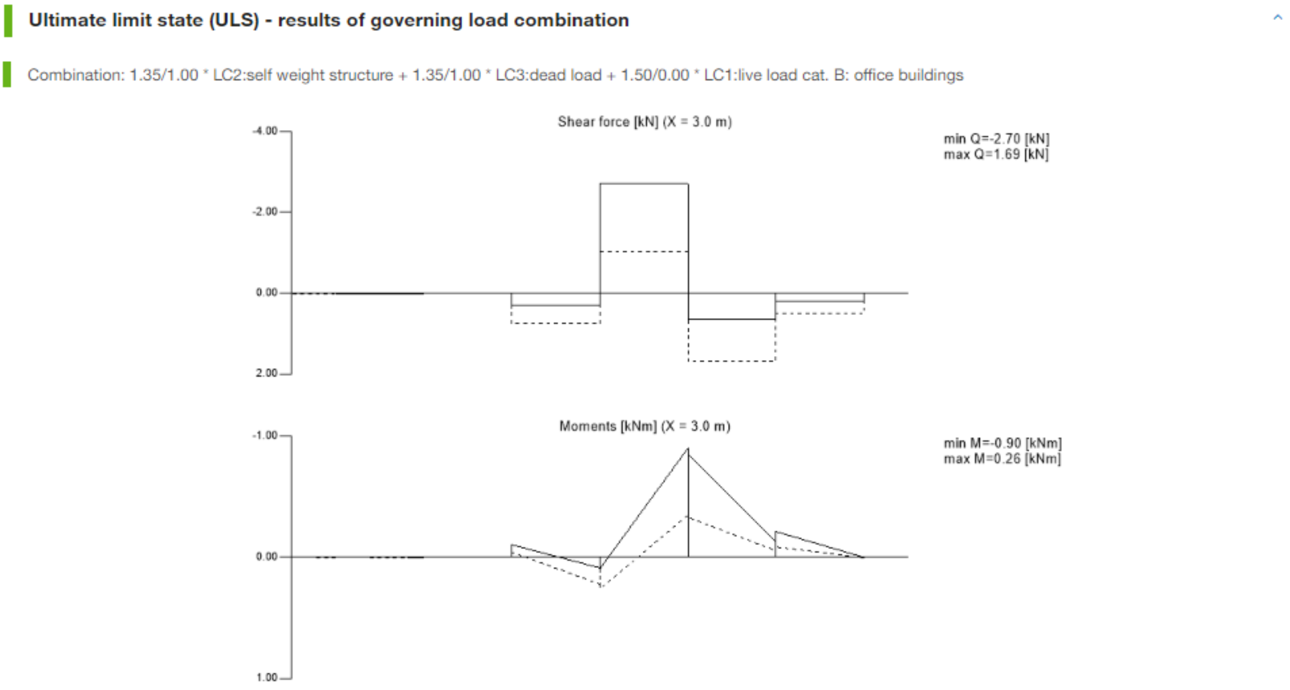
This module allows the user to add:

- **Surface loads on the interior** part of the panel (area that is enclosed by the supports)
- **Surface loads on the exterior** part of the panel (area that is on the other side of the supports)
- **Line load in X direction** puts a line load along the panel edge in the cantilever portion on the edge that is oriented in X direction
- **Line load in Y** direction puts a line load along the panel edge in the cantilever portion on the edge that is oriented in Y direction

Line loads could be for example a dead load of a parapet wall around the edge of a roof.

3.5.4. Results and Detailed results

ULS design



The design governing shear force and moments are displayed in the diagrams. All internal forces are being calculated at the intersection points of the beam grid model. That is the reason, why the curves are not smooth, but polygonal.

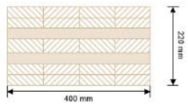
As in other modules, only the extreme values are indicated. All intermediate values can be viewed by a click on the respective diagram and will be displayed in a table.

The values are given for a beam grid element with a given width (= mesh width of the beam grid model). The exact width of the beam elements is given in the section properties, in the result page:

Exact grid spacing in both directions →

Section

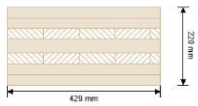
Section Y



Layer	Thickness	Type	Material
1	30.0 mm	L	C24 spruce ETA (2019)
2	30.0 mm	L	C24 spruce ETA (2019)
3	30.0 mm	C	C24 spruce ETA (2019)
4	40.0 mm	L	C24 spruce ETA (2019)
5	30.0 mm	C	C24 spruce ETA (2019)
6	30.0 mm	L	C24 spruce ETA (2019)
7	30.0 mm	L	C24 spruce ETA (2019)

Area	Width	Iy,netto	Wy,netto
[mm²]		[mm⁴]	[mm³]
64,000	0.4	323,733,300	2,943,030

Section X



Layer	Thickness	Type	Material
1	30.0 mm	L	C24 spruce ETA (2019)
2	30.0 mm	L	C24 spruce ETA (2019)
3	30.0 mm	C	C24 spruce ETA (2019)
4	40.0 mm	L	C24 spruce ETA (2019)
5	30.0 mm	C	C24 spruce ETA (2019)
6	30.0 mm	L	C24 spruce ETA (2019)
7	30.0 mm	L	C24 spruce ETA (2019)

Area	Width	Ix,netto	Wx,netto
[mm²]		[mm⁴]	[mm³]
25,714	0.4285714	33,428,570	668,572

The results for the SLS design are being displayed in plan view, with deflection values for each intersecting node. Each load combination is being displayed in a separate figure.

The blue curves to the outside of the panel are the deformation curves of the panel edges.

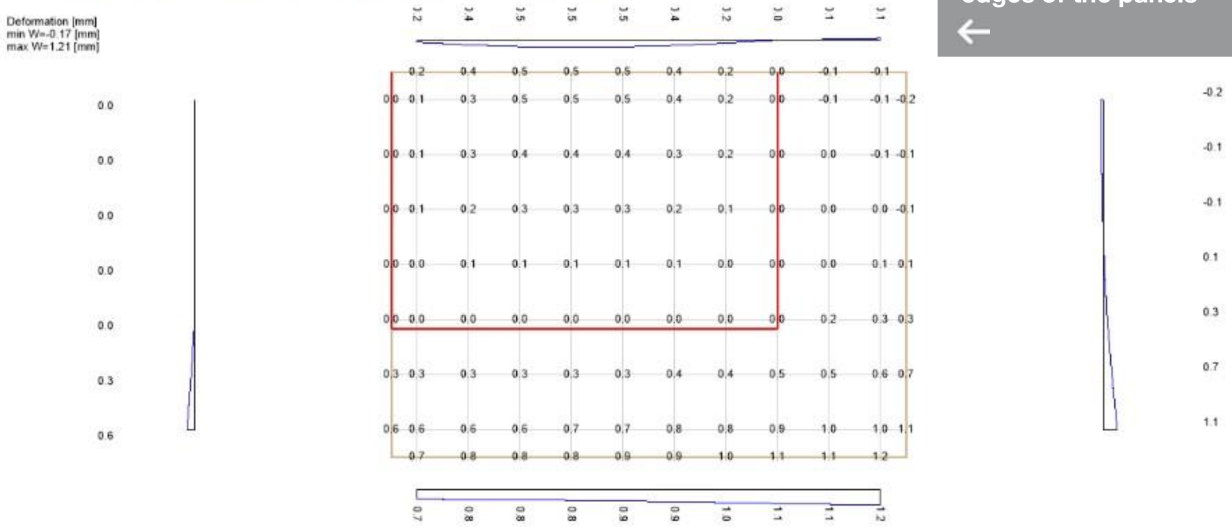
Calculatis by Stora Enso

Service limit state design (SLS) - results of all load combinations

w[char}

Combination: 1.00/1.00 * LC1:self weight structure + 1.00/1.00 * LC2:dead load

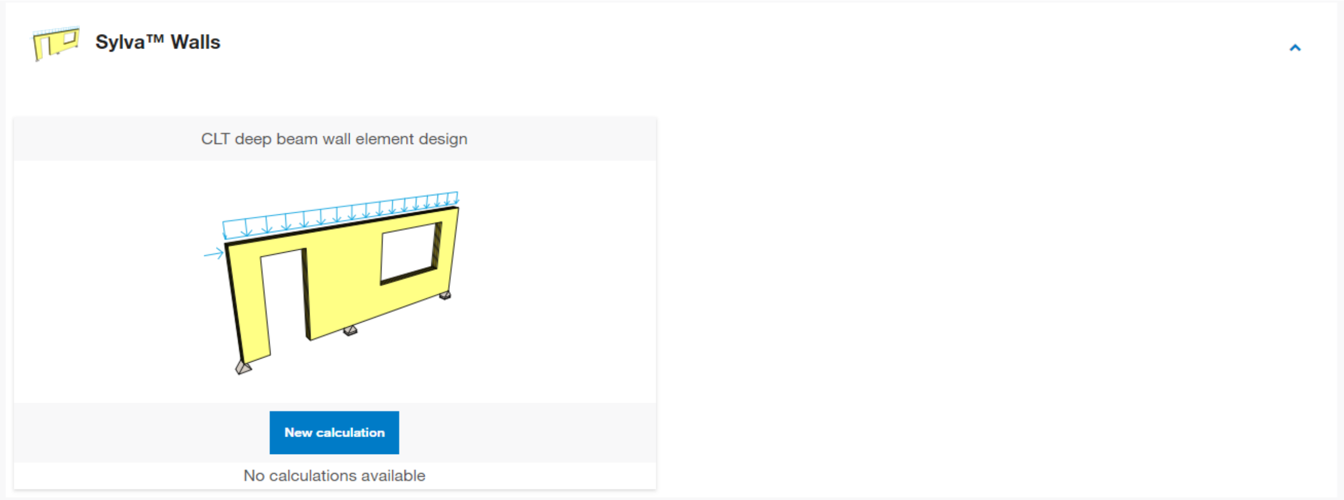
Deformation of the edges of the panels ←



The design governing point in the panel is being displayed with its X and Y coordinate, to clearly indicate the spot, where the given deformation occurs.

Calculatis by Stora Enso

4. Sylva™ Walls

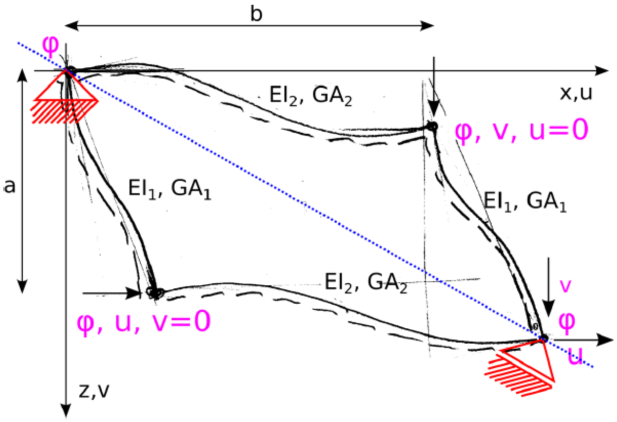


The module CLT wall / CLT deep beam is made for CLT panels with loading in the plane of the CLT (wall, CLT beam, deep CLT beam, etc.) and out of plane of the CLT.
The CLT element can include voids for door and window openings as well.

4.1. Analysis method

This would be normally a case for a finite elements analysis. The goal was to create a design module that can handle an analysis under the given boundary conditions as mentioned above, but with a simplified engineering approach. The solution to this approach was the creation of a grid model, similar to the module for the 2-way cantilever CLT panel. With the help and expertise of Holzbau Forschungs GmbH (TU-Graz), an analysis model could be elaborated, that can describe the rigidity of a CLT wall (for all standard CLT sections of Stora Enso). Details about that model are described in the report "Berechnung von BSP-Wandscheiben mit Gitterrostmodellen" (Engl.: Analysis of CLT shear walls with beam grid models).

Beam grid model:
The figure below describes the boundary conditions for the beam grid model.



The beam grid model was based on the Bernoulli beam theory with a certain correction coefficient.
The global equation matrix for the beam grid model is as follows:

$$\begin{bmatrix} \frac{24\cdot EI_1}{a^3} & 0 & -\frac{24\cdot EI_1}{a^2} & a \\ 0 & \frac{24\cdot EI_2}{b^3} & \frac{24\cdot EI_2}{b^2} & -b \\ -\frac{24\cdot EI_1}{a^2} & \frac{24\cdot EI_2}{b^2} & \frac{24\cdot EI_1}{a}+\frac{24\cdot EI_2}{b} & 0 \\ a & -b & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ \varphi \\ Z \end{bmatrix} = \begin{bmatrix} 2\cdot t\cdot a \\ 2\cdot t\cdot b \\ 0 \\ 0 \end{bmatrix}$$

Boundary condition for the equation above:

u * a = v * b → u * a – v * b = 0

Solving the equation leads to the following result:

$$\begin{bmatrix} u \\ v \\ \varphi \end{bmatrix} = \begin{bmatrix} \frac{\left(a^2\cdot b^4\cdot EI_1 + a^3\cdot b^3\cdot EI_2\right)\cdot t}{12\cdot\left(a^2+b^2\right)\cdot EI_1\cdot EI_2} \\ \frac{\left(a^3\cdot b^3\cdot EI_1 + a^4\cdot b^2\cdot EI_2\right)\cdot t}{12\cdot\left(a^2+b^2\right)\cdot EI_1\cdot EI_2} \\ \frac{a\cdot b\cdot\left(EI_1\cdot b^3 - EI_2\cdot a^3\right)\cdot t}{12\cdot\left(a^2+b^2\right)\cdot EI_1\cdot EI_2} \end{bmatrix}$$

The restraint force Z is in that case 0.
Both flexural rigidities EI_1 and EI_2 shall be adjusted with a calibration factor f, so the shear strain in a shell element is equal to the shear strain in the beam grid element.
Shear strain in a shell element:

$$\gamma_{Scheibe} = \frac{t}{c_{xy}}$$

Shear strain in the beam grid model:

$$\gamma_{Gitterstab} = \frac{u(t)}{a} + \frac{v(t)}{b} = \frac{\left(a^2\cdot b^4\cdot f\cdot EI_1 + a^3\cdot b^3\cdot f\cdot EI_2\right)}{12\cdot\left(a^2+b^2\right)\cdot f^2\cdot EI_1\cdot EI_2}\cdot\frac{t}{a} + \frac{\left(a^3\cdot b^3\cdot f\cdot EI_1 + a^4\cdot b^2\cdot f\cdot EI_2\right)\cdot t}{12\cdot\left(a^2+b^2\right)\cdot f^2\cdot EI_1\cdot EI_2}\cdot\frac{t}{b}$$

Equating these two shear strains leads to the calibration factor f:

$$f = \frac{a\cdot b\cdot c_{xy}\cdot\left(EI_1\cdot b + EI_2\cdot a\right)}{12\cdot EI_1\cdot EI_2}$$

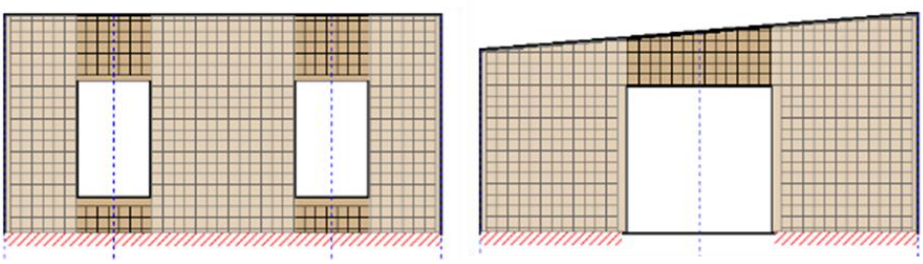
In a comparative study of several different shear walls, the deviation to a FE solution has been analyzed. Generally, the results of the derived beam grid model were deviating from the FE solution to a maximum extent of about 15%. In all these cases the results of the beam grid model were on the conservative side. In comparisons that include a sloped top edge, the deviations approached the 30%. This was caused by the cut beam grid elements at the top that were cantilevering and were not supported in horizontal direction. This aspect relativizes the high deviation. Given the fact that a practical engineering method had to be found in order to substitute a FE solution, the resulting method with deviations of about 15% on the conservative side are satisfactory.

More details about the analysis method can be found in the report “Berechnung von BSP-Wandscheiben mit Gitterrostmodellen”.

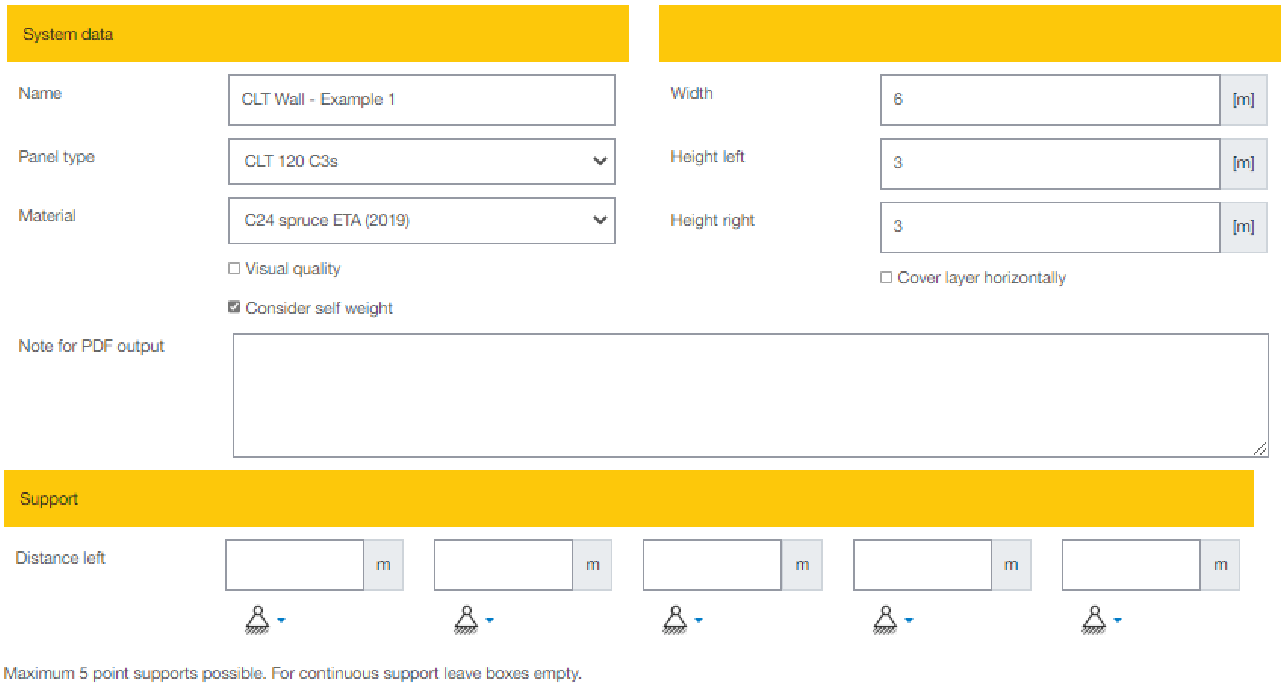
Additionally to the analysis of internal forces and rigidity analysis in the plane of CLT, according to “Berechnung von BSP-Wandscheiben mit Gitterrostmodellen”, the stability of the panel is being analyzed according to EN 1995-1-1, chapter 6.3.

Generally, for the stability analysis (buckling) it was assumed, that the effective length (buckling length) is equal to the wall height in that part of the wall, where the stability analysis is being conducted. This is a conservative approach.

For the buckling design, only parts of a wall with no openings are being analyzed. These parts are being shaded in the system sketch in a lighter color (beige). Areas above window openings that are not included in the buckling design are shaded a bit darker. All loading out of plane will therefore be redistributed to areas that are being analyzed for buckling. The symmetry axis for this load distribution is indicated at the center of openings (blue dashed line). All loading until the blue dashed line shall be part of the tributary area for loading, for the stability analysis.



4.2. System data and supports



Width: insert the width of the entire wall/beam (> 1,00 m)
Height left/right: insert the height at the left end and the right end (> 1,00 m). If the top edge is sloped, these values are different (e.g. wall underneath a roof).
Cover layer horizontally: by default the cover layer is assumed to be vertically (ideal for walls with a continuous support at the bottom). If that shall not be the case, check the box "cover layer horizontally" (ideal for deep beams)
Visual quality needs to be checked, if the panels are visual grade.

The lamination width of visual grade is 100 mm and the lamination width of non-visual grade is 150 mm. This is determining the mesh width of the grid model

If no data is being entered in the support boxes, then the CLT element will be supported on the entire length of the bottom edge (typical for walls. The linear support in that case is a pin support out of plane (M=0). The support will take tension and compression. A non-linear support condition (e.g.: taking compression only, but not tension) is currently not possible in this design tool (possible future development).
Entering data in the boxes for point supports will place supports at the entered distance from the **point of origin**, which is the **bottom left corner of the panel**. The supports can be chosen either **fixed or pinned**.

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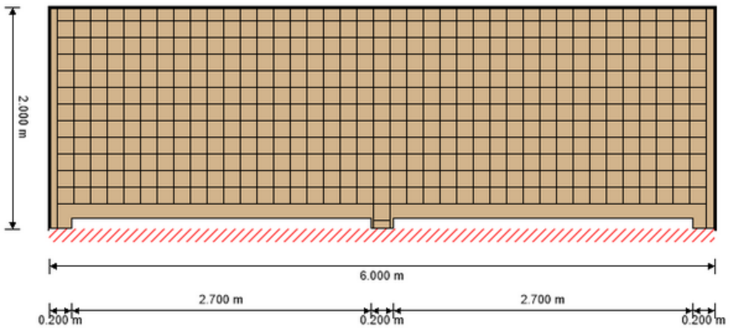
In case you want to study the high force concentration at point supports, the following design can be done. Make the model 10 cm taller and place at the bottom edge voids with a height of 10cm in the length of the clear span of the (deep) beam. This will create a beam with linear supports. For a 6 m long beam with 3 supports (each 20 cm long), the solution could look like that:



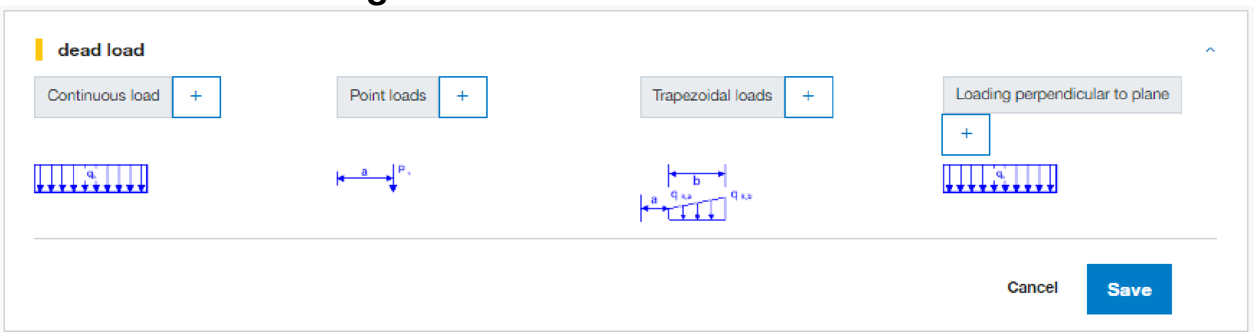
4.3. Voids

Voids

Voids			
Distance from left	Distance from bottom	Width	Height
[m]	[m]	[m]	[m]
1.000	0.500	1.000	1.600
4.000	0.500	1.000	1.600

The **reference point** for each void is the bottom left corner of the void. Only rectangular voids are possible.
Distance from left: is the horizontal distance from the point of origin (left bottom corner of the CLT panel) to the reference point of the void (bottom left corner of the void).
Distance from bottom: is the vertical distance from the point of origin (left bottom corner of the CLT panel) to the reference point of the void (bottom left corner of the void).
Width: width of the void
Height: height of the void

4.4. Loading



Continuous load: Add a continuous load at the top edge of the panel. The load can be either vertical or horizontal with reference to the global coordinate system, local coordinate system or as projected load.
Point load: Add a point load at the top edge of the panel, in a horizontal distance a from the left edge of the panel. The load can be either vertical or horizontal with reference to the global coordinate system, local coordinate system or as projected load.
Trapezoidal load: Add a trapezoidal load at the top edge of the CLT panel in distance a from the left vertical panel edge. The length of the trapezoidal load is the variable b and shall be entered by the user. The load can be either vertical or horizontal with reference to the global coordinate system, local coordinate system or as projected load.
Loading perpendicular to plane: Add a constant surface load to the CLT. This could be for example a wind load.

By checking the box "**load covers openings**" the user can choose, to apply the load also over wall openings (e.g.: wind load would usually be applied over openings too, if they are glazed).

4.5. Fire design

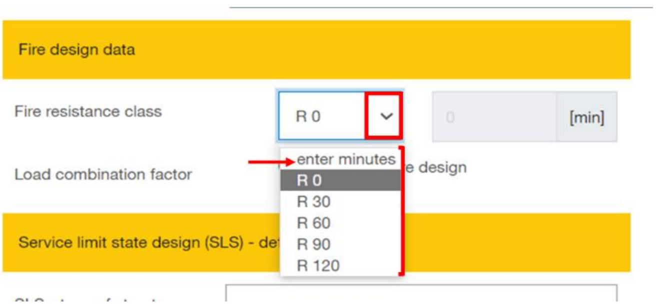
The fire design is being executed according to EN1995-1-2 and its national annexes.

As an alternative, the user can choose to do the fire design (determination of the residual timber section) according to the guideline Fire Safety in Timber Buildings if a fire protection system is applied on the wall.

Edit the fire design data:

It's possible to consider that **both faces of the wall are exposed to fire** in case of an interior wall for example

The user can also choose a personalized resistance time in minutes.



Load combination factor: Generally Eurocode 5 leaves it up to the engineer, if the load combination for fire design is applying a load combination factor of $\psi2$ or $\psi1$. The user can choose this here in the input for fire design.

Fire protection system: If a fire protective cladding is attached to the ceiling, this shall be selected in the pull down menu.

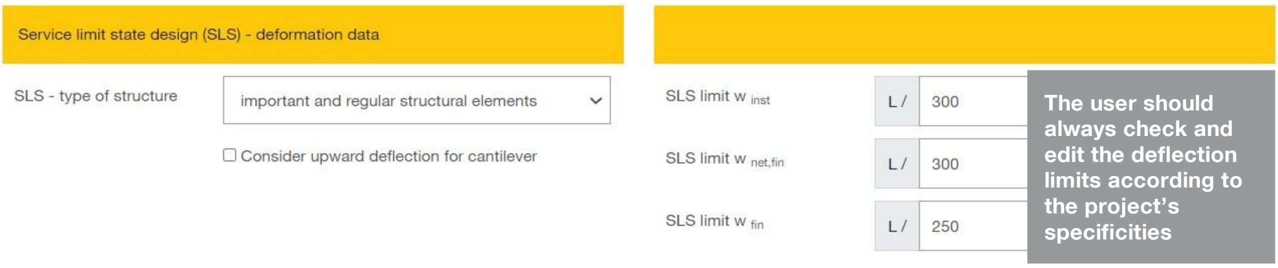
This results in a variation of the following parameters:

- Single or double ply
- Attached directly to the CLT or with an insulated plumbing cavity in between
- Design according to EN1995-1-2 and ON B 1995-1-2 or design according to Fire Safety In Timber Buildings

Except for the analysis according to Fire Safety in Timber Buildings, the Austrian national annex is always included in the fire design, because it is currently more detailed than the national annex of other countries.

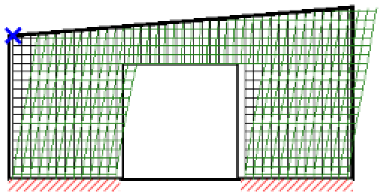
4.6. SLS design – Deformations

Set the system type that suits your project assumptions or requirements. Suggested deflection limits for the SLS design are automatically added. **However, the user should always check and edit these limits according to the project's requirements.**



The results of the analysis are shown graphically.

Horizontal deformation (25 %)



1.00/0.00 * :wind load

Node with maximum utilization (blue mark)

Id	X	Z	w_{limit}	Limit	$v_{h,max}$	Ratio
[-]	[m]	[m]	[mm]	[mm]	[mm]	[%]
579	0.075	2.50625	8.4	L/300 = 8.4	2.0814	24.9 %

Click a node in the graphic

The image for horizontal deformation shows actually the graphic of the design governing deformation of the entire panel. The point of the maximum utilization regarding a horizontal deformation is indicated with the blue cross mark.

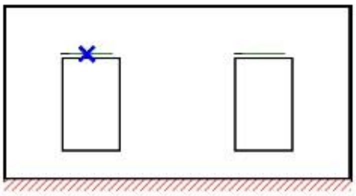
Note: the maximum utilization at **the horizontal deformation does not necessarily mean the absolute maximum deformation**. The utilization rate of the horizontal deformation is derived from the ratio of deformation to a deformation limit (H/300) – see ÖNORM B 1990-1:2003, item 8.3. This limit for horizontal deformation in plane was applied to all other country settings as well. Therefore the maximum utilization is dependent on the height of the element at a given point. If the display of the deformation at any other point is desired, just click that point in the graphic and the values will be displayed.

The following other deformation results are being displayed for vertical deformations in voids:

- Initial deflection
- Final deflection
- Net final deflection

These deflections are being compared to the applicable limits in the respective national annex of EN 1995-1-1.

w_{inst} = w[char] (2 %)



1.00/1.00 * LC2:self weight structure + 1.00/1.00 * LC3:dead load + 1.00/0.00 * :live load cat. A: domestic, residential areas

Node with maximum utilization (blue mark)

Id	X	Z	K_{def}	L_{ref}	Limit	w_{limit}	$w_{calc.}$	Ratio
[-]	[m]	[m]		[m]	[-]	[mm]	[mm]	
610	1.425	2.175	0.8	1.0	1/300	3.3	0.1	2 %

Selected node

Id	X	Z	K_{def}	L_{ref}	Limit	w_{limit}	$w_{calc.}$	Ratio
[-]	[m]	[m]		[m]	[-]	[mm]	[mm]	
612	1.725	2.175	0.8	1.0	1/300	3.3	0.0	1 %

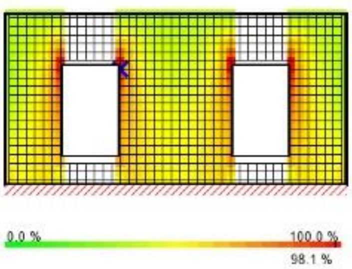
Click on a node to display the detailed results

4.7. Results

The results of the analysis are shown graphically. It was chosen to show for different internal forces the utilization rate and the design results of the maximum utilized spot. This spot is being indicated with a blue cross mark.

If any other design values shall be displayed, just **a simple click in the graphic at the point of interest** is required, to display the result in this very node. That way, the design result of any of the nodes can be displayed. This applies to all graphics within this module.

Fire Utilization rate for buckling (98 %)



1.00/1.00 * LC1:self weight structure + 1.00/1.00 * LC2:dead load + 1.00/0.00 * 0.30 * LC3:live load cat. A: domestic, residential areas

Node with maximum utilization (blue mark)

Id	X	Z	l_k	λ_y	β_c	$k_{c,y}$	$f_{c,0,d}$	$\sigma_{c,0,d}$	$\sigma_{m,y,d}$	Ratio
[-]	[m]	[m]	[m]	[-]	[-]	[-]	[N/mm²]	[N/mm²]	[N/mm²]	[%]
574	2.025	2.025	3.0	260	0.2	0.053	24.15	-1.27	0.00	98 %

Selected node

Id	X	Z	l_k	λ_y	β_c	$k_{c,y}$	$f_{c,0,d}$	$\sigma_{c,0,d}$	$\sigma_{m,y,d}$	Ratio
[-]	[m]	[m]	[m]	[-]	[-]	[-]	[N/mm²]	[N/mm²]	[N/mm²]	[%]
420	2.925	1.425	3.0	260	0.2	0.053	24.15	-0.60	0.00	47 %

Click on a node to display the detailed results

The following internal forces are being displayed:

- Shear in plane on the gross section of CLT
- Shear in plane on the net section of CLT (shear perpendicular to the grain)
- Torsional shear in the face glued surfaces at the lamination intersections
- Axial stress in horizontal lamination
- Axial stress in vertical lamination
- Stability analysis of panel portions with no voids (loading from portions with voids are being transferred to adjacent portions without voids, where the stability analysis is being executed).

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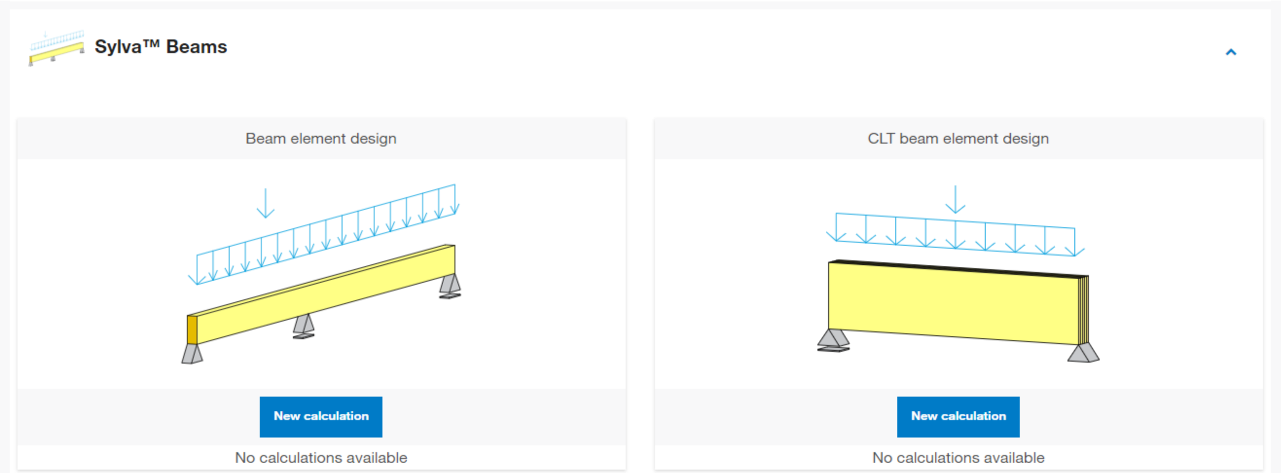
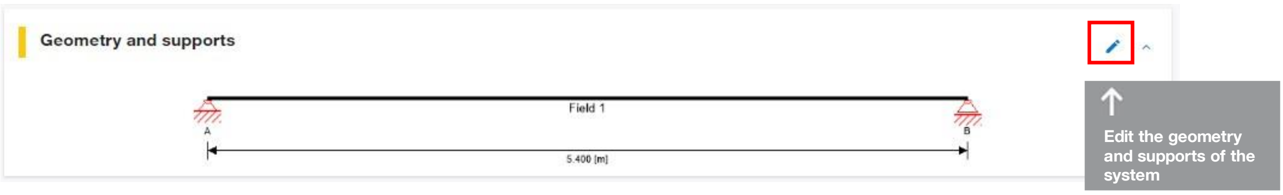
5. Sylva™ Beams

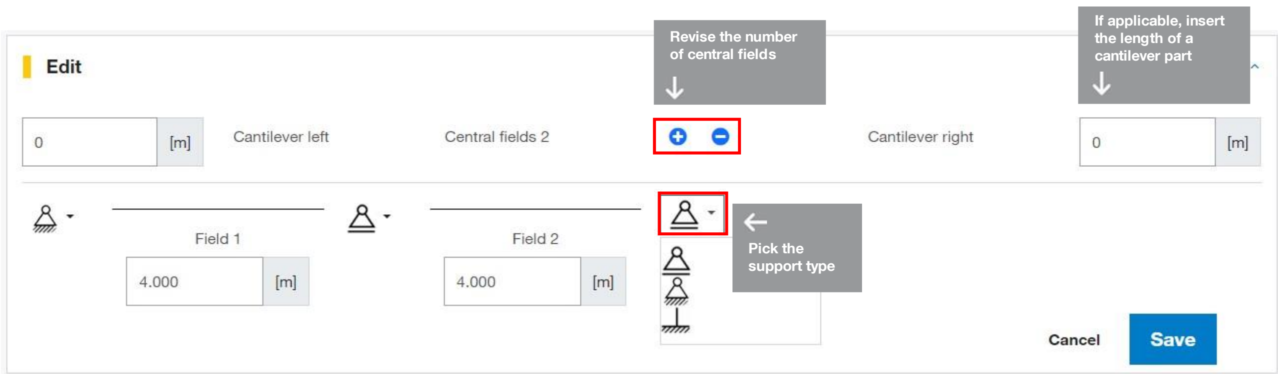


5.1. Common features

Beam modules will design beams with a **rectangular section** in solid timber, glued-laminated timber (GLT), LVL or CLT.

5.1.1. Geometry and supports





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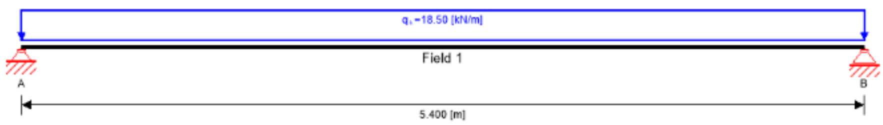
Pinned support, fixed in horizontal direction

Pinned support, free in horizontal direction

Fixed support (no translatory/rotatory movement possible)

5.1.2. Loading

Load case category dead load



☐ Variable load spanwise independent

Continuous load

Field	Direction	q_k	All fields
		[kN/m]	
1	global	18.5	☐

If you would like to add a load to a load case group, select for each span the load type that shall be applied (**continuous, point load or trapezoidal load**), and edit the value and the geometric parameters.

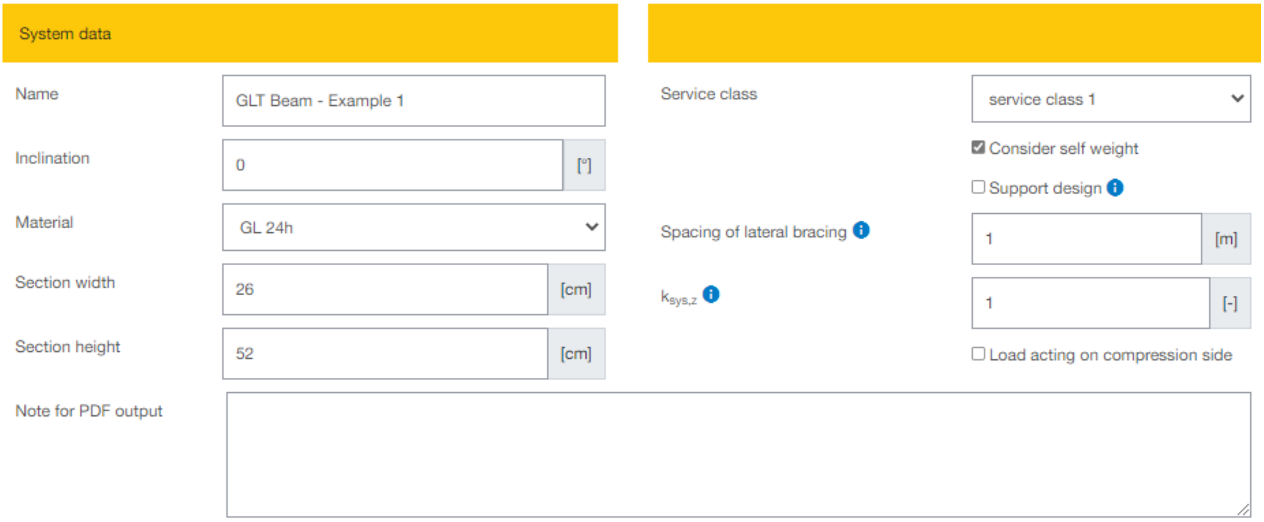
Clicking the check box **apply to all fields** can be activated if a load shall be applied in the given magnitude to all fields. This makes the input procedure more efficient.

Clicking the field **variable load spanwise independent** is usually applied with variable loads. Variable loads on a continuous beam can or may not be present along the entire system. They might occur only in one span and not in the others. If this effect shall be reflected in the analysis and if the software shall do all possible load combinations, put a check mark in the box and the software will include all the required possible combinations automatically.

Use the direction of the load as local or projective if the beam is inclined.

5.1.3. System data

Here you can input the name of the analysis, geometrical parameters and the product's specifications.



Inclination: for a floor the inclination will be typically 0°. For roofs give the inclination, measured between the beam axis and the horizontal plane.

Consider self weight: The self weight of the product is considered by default (visible in the system sketch on top of the page).

Support design: choose if the support pressure in at the supports shall be verified or not.

Spacing of lateral bracing: Insert the spacing at which the beam is held in lateral direction. This value is entering the lateral torsional buckling design. The spacing could be for example the spacing of purlins or rafters that are supported by the beam. If a panel or sheathing is fastened at the top flange of the beam, then put 0 as spacing, meaning the beam is continuously held.

$k_{sys,z}$: It's the **system factor** for the given beam section in z-direction (see EN1995-1-1_6.6). Assuming a glulam designed, then the lamination is usually layered in vertical direction. Therefore no system factor can be applied for bending around the Y-axis. For bending about the Z-axis, the tension face of the beam (lateral surface) is divided in all the lamination layers and therefore a system factor can be applied in this direction.

The feature **Load acting on the compression side** relates to the effective length of the beam for the lateral torsional buckling analysis, according to EN1995-1-1_6.3.3(3).

5.1.4. Fire design

Choose which faces of the beam are exposed to fire at the "charring" selection, by adding check marks next to the relevant face.

Fire resistance class: If R0 is chosen, no fire design will be executed.

The user can also choose a personalized resistance time in minutes.

Load combination factor: Generally Eurocode 5 leaves it up to the engineer, if the load combination for fire design is applying a load combination factor of $\psi2$ or $\psi1$. The user can choose this here in the input for fire design.

Fire protection system: If a fire protective cladding protects the beam, this shall be selected in the pull down menu.

This results in a variation of the following parameters:

- Single or double ply
- Attached directly to the CLT or with an insulated plumbing cavity in between
- Design according to EN1995-1-2 and ON B 1995-1-2 or design according to Fire Safety In Timber Buildings

Except for the analysis according to Fire Safety in Timber Buildings, the Austrian national annex is always included in the fire design, because it is currently more detailed than the national annex of other countries.

5.1.5. SLS design - deformation

Set the system type that suits your project assumptions or requirements. Suggested deflection limits for the SLS design are automatically added. **However, the user should always check and edit these limits according to the project's requirements.**

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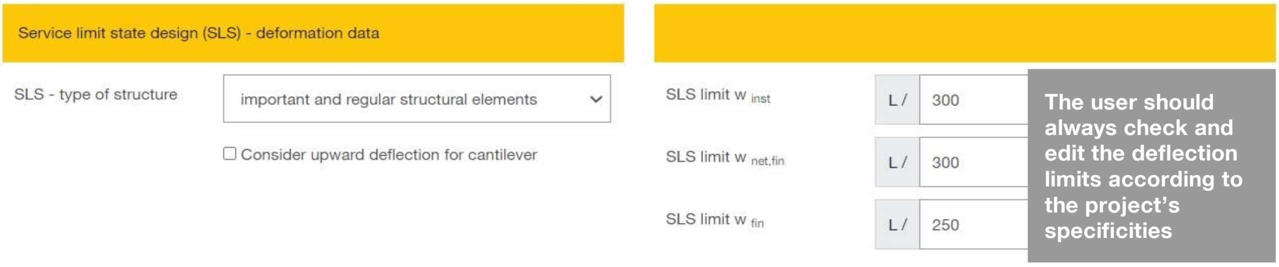
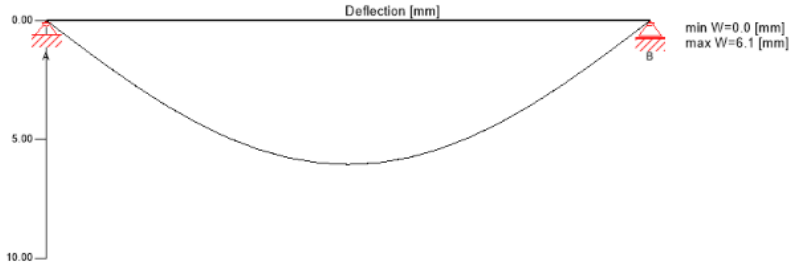


All deflection curves for the different load combinations are being displayed in the detailed results:

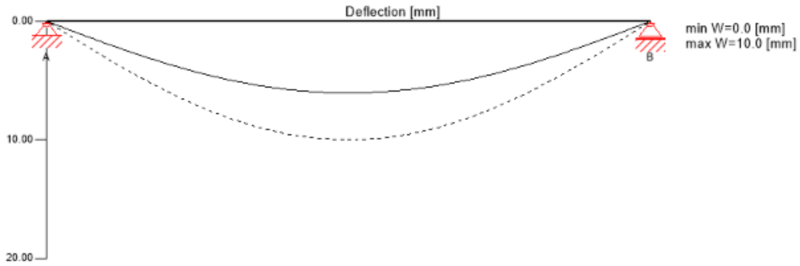
Service limit state design (SLS) - results of all load combinations

w[char]

Combination: 1.00/1.00 * LC2:dead load + 1.00/1.00 * LC1:self weight structure



Combination: 1.00/1.00 * LC2:dead load + 1.00/1.00 * LC1:self weight structure + 1.00/0.00 * LC3:live load cat. B: office buildings



Maximum and minimum values are given next to the curve. Intermediate values are displayed in a table, when clicking on the curve.

The design results of the Service Limit State (SLS) design are displayed in a table:

Service limit state design (SLS) - design results (66 %)

w_{inst} = w[char]

Field	K_{def}	L_{ref}	Limit	$w_{calc.}$	Utilization
		[m]	[mm]	[mm]	
1	0.6	5.4	L/300 = 18.0	10.0	56 %

w_{fin} = w[char] + w[q.p.]*kdef

Field	K_{def}	L_{ref}	Limit	$w_{calc.}$	Utilization
		[m]	[mm]	[mm]	
1	0.6	5.4	L/250 = 21.6	14.4	66 %

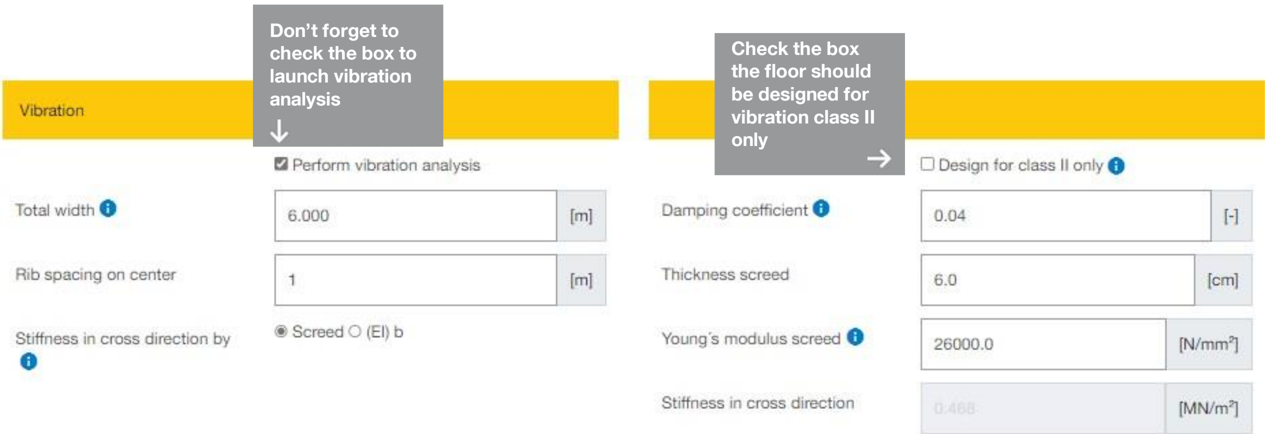
$w_{net,fin}$ = w[q.p.] + w[q.p.]*kdef

Field	K_{def}	L_{ref}	Limit	$w_{calc.}$	Utilization
		[m]	[mm]	[mm]	
1	0.6	5.4	L/300 = 18.0	11.6	64 %

For each span a reference length is given. This length is the base for the deflection limits (e.g.: L/150). In a deflection limit L/150, the reference length Lref is being divided by 150. In all applied design standards, the deflection limits of cantilevers are double of those for spans, with supports on both ends. Therefore the reference length of cantilevers is the double of the system length of the respective cantilever.

Please go to chapter *2.2 SLS design – Deformations* for more information about deformation verifications and national specifics.

5.1.6. SLS design – Vibrations



If a vibration analysis is required, set the check mark accordingly (perform vibration analysis). This is usually not required for roofs.

Total width: This is the total width of the floor system. It's **usually equal to the width of the room** that is hosting the floor. This width is only being used for the vibration analysis and can be different from the system width, entered in "system data" above.

Stiffness in cross direction: pick if the stiffness in cross direction (perpendicular to principal direction) is being contributed by:

- **Screed**: by the screed on top of the floor system

For that you need to insert the **Young´s modulus for the screed** and the **thickness** of the screed.

- **(EI)b**: Here the user can define an **arbitrary value** for the additional stiffness in cross direction. Additional stiffness means the stiffness that is provided by any other element (layer) to the beam.

Damping coefficient: This value is usually in a range between 1% (0,01) and 5% (0,05). For a CLT floor with a wet screed on top (separated by an insulation layer), 4% (0,04) will usually be the applicable damping coefficient.For a floor with joists and a wet screed on top of a sheathing (separated by an insulation layer), 3% (0,03) will be an appropriate damping coefficient. For lighter versions, the damping will be less (about 2%).

Vibration analysis (62 %)

Analysis

Criterion	Calc.	Class I	Class II	Class I	Class II
Frequency criterion min	7.262 [Hz]	4.500 [Hz]	4.500 [Hz]	62 %	62 %
Frequency criterion	7.262 [Hz]	8.000 [Hz]	6.000 [Hz]	110 %	83 %
Acceleration criterion	0.022 [m/s²]	0.050 [m/s²]	0.100 [m/s²]	44 %	22 %
Stiffness criterion	0.056 [mm]	0.250 [mm]	0.500 [mm]	22 %	11 %

Limits for class I and class II

General	
Total mass	63.334 [t]
Tributary width	1.663 [m]
Stiffness Longitudinal direction	35502.820 [kNm²]
Stiffness Cross direction	468.000 [kNm²]
Modal damping	4.00 %
α	0.055
Man weight	700 [N]
Modal mass	8769.959 [kg]

The vibration analysis results are given in a table as shown in the figure above.

This software was created for many countries and their applicable standards. Unfortunately, the vibration design is still very poorly described in Eurocode 5 (EN 1995-1-1). The Austrian national annex includes at this point the most extensive rules related to the vibration analysis.

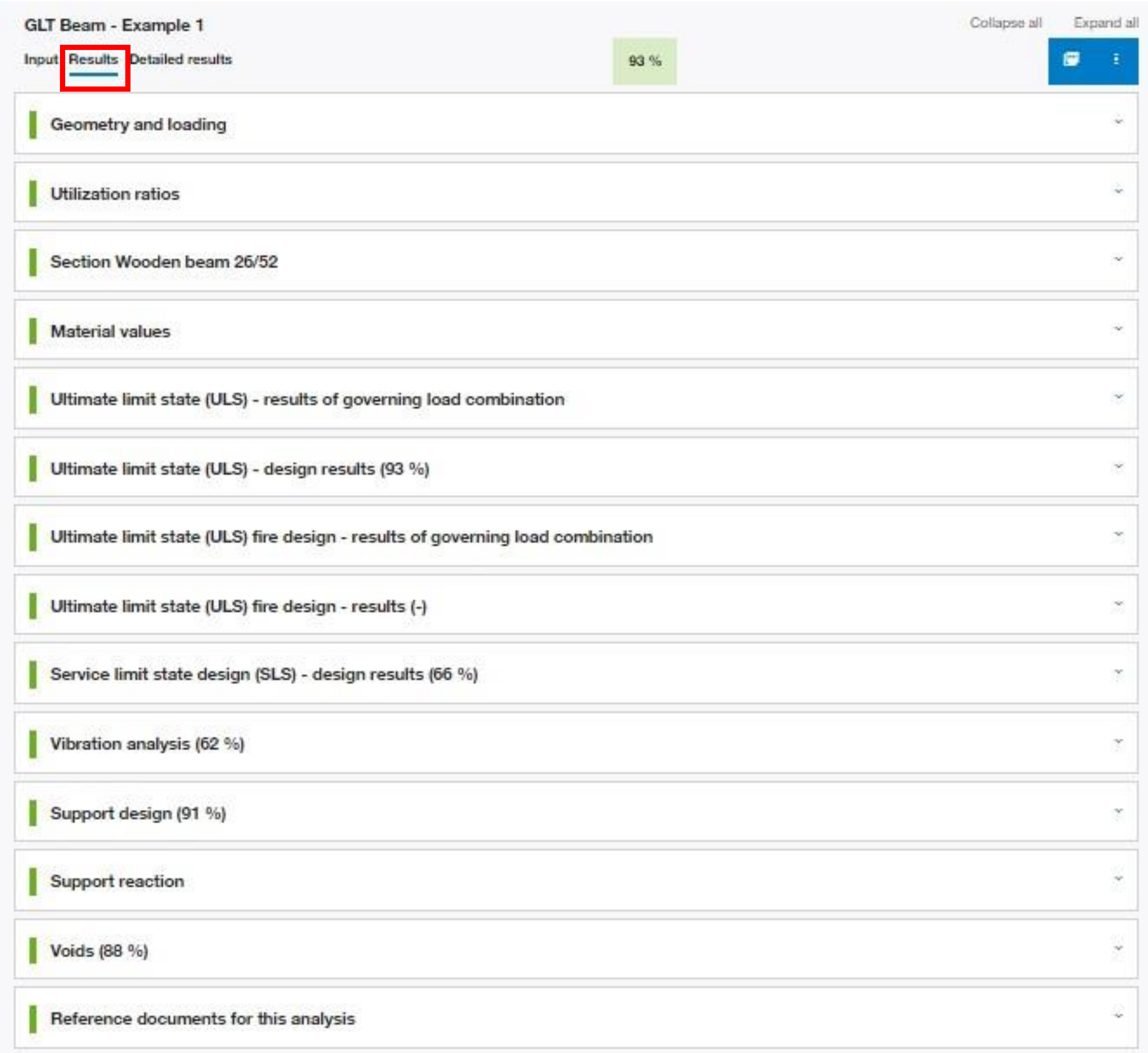
Except if the local national annex provides a different requirement explicitly, the design method and limits of the Austrian national annex are applied to all countries.

In the Austrian national annex, 2 vibration classes are being introduced: class I and class II. This is a similar approach as by Hamm & Richter. In that document Hamm & Richter refer to floors that extend across more than just one unit (room) or floors that only serve one unit (room). Obviously for floors that serve more units at the time, stricter requirements apply. The same idea was adopted in the national annex of Eurocode 5. Here Eurocode 5 refers to a class I (more strict requirements) and class II.

It is finally up to the user to decide which class is the most relevant for their design.

5.1.7. All results

The user has the choice to either see only the design relevant results by clicking **Results** or the entire list of results can be displayed by clicking **Detailed results**.



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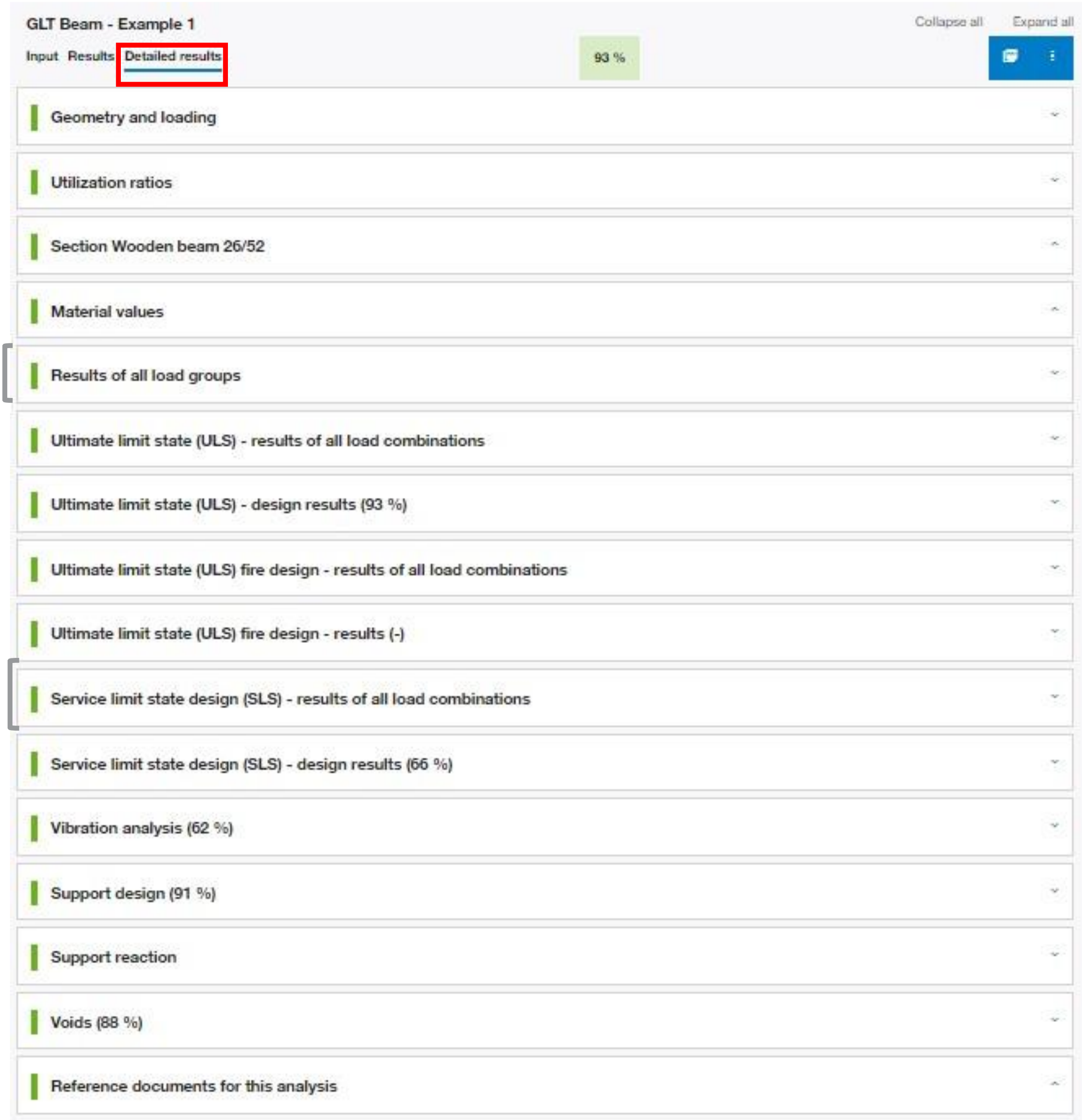


Calculatis by Stora Enso

5.2. Beam element

5.2.1. Voids

It's possible to design voids in the beam if no fire resistance is required:

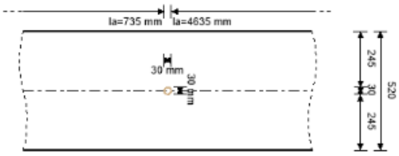
Voids

Voids Rectangular

Voids Circular

Field	Distance from left	ex.	Diameter
	[m]	[m]	[mm]
1	0.750	0.000	30

Voids (88 %)



Void

Field	Distance from left	ex.	Diameter
	[m]	[m]	[mm]
1	0.750	0.000	30

k_{cr}	b_{ef}	$l_{t,90}$	$k_{t,90}$	h_{cr}	h_r	$h_{r,o}$	$h_{r,u}$
[-]	[mm]	[mm]	[-]	[m]	[mm]	[mm]	[mm]
0.71	186	270.50	0.93	0.25	249.50	245.00	245.00

Distance(s)

Analysis	Existing	Limit	Unit	Utilization
la >= 0.5 h	0.735	0.26	m	35 %
lv >= h	0.735	0.52	m	71 %
a <= 2.5 hd	0.03	0.075	m	40 %
h_{ro} >= 0.35 h	0.245	0.182	m	74 %
h_{ru} >= 0.35 h	0.245	0.182	m	74 %

Design Tension perpendicular to grain

V_d	M_d	$F_{t,V,d}$	$F_{t,M,d}$	$f_{t,90,d}$	$\sigma_{t,90,d}$	Ratio
[kN]	[kNm]	[N]	[N]	[N/mm²]	[N/mm²]	
84.37	82.98	3646	2661	0.31	0.27	88 %

Design Shear stress

k_τ	V_d	$f_{v,d}$	τ_d	Ratio
[-]	[kN]	[N/mm²]	[N/mm²]	
1.11	96.42	2.15	1.76	82 %

Design Moment

$W_{n,top}$	$W_{n,bot}$	V_d	M_d	$f_{m,d}$	$\sigma_{m,d}$	Ratio
[mm³]	[mm³]	[kN]	[kNm]	[N/mm²]	[N/mm²]	
11715080	11715080	84.37	82.98	14.77	7.08	48 %

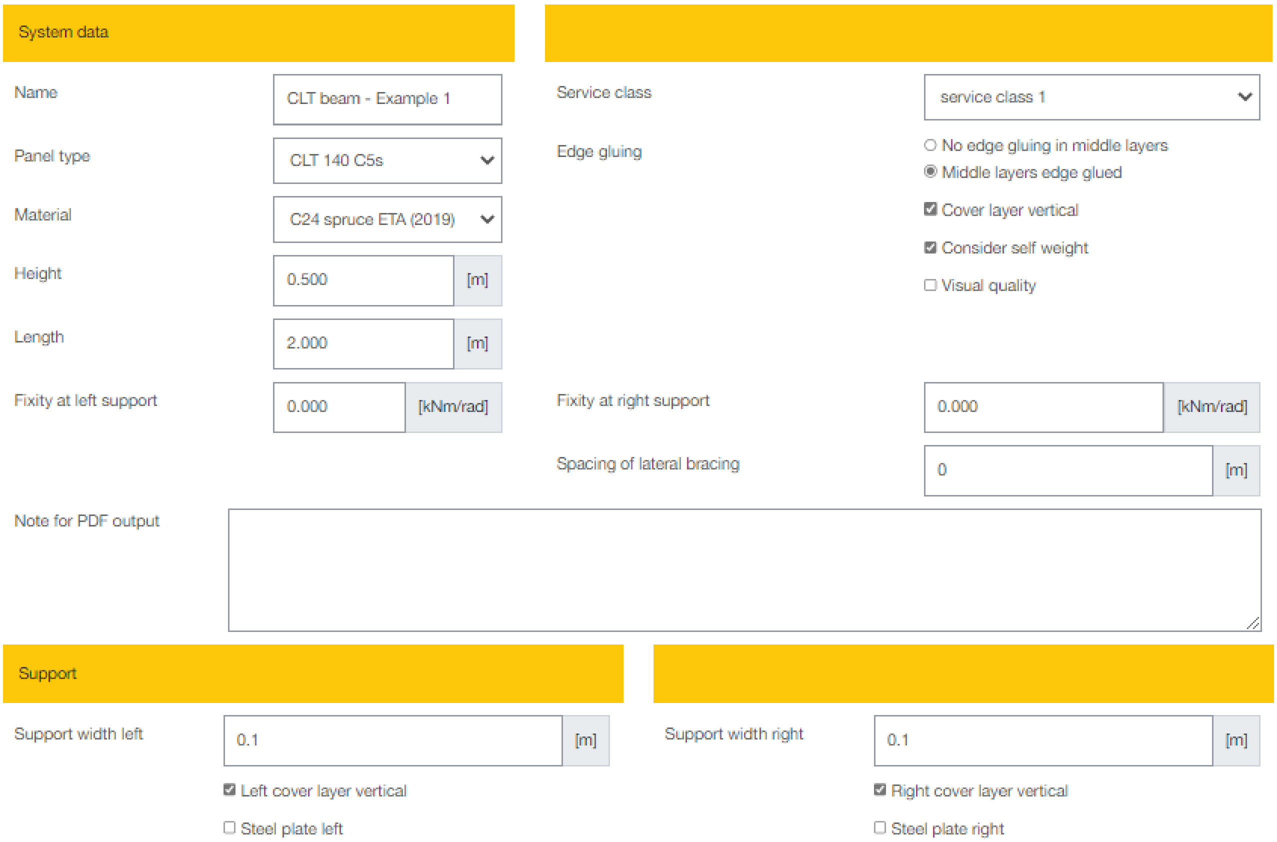
5.3. CLT beam element

The module CLT beam is made for CLT with loading, in the plane of the CLT (e.g.: window or door header, etc.).
The module is limiting the CLT beam design to **single span** beams. This will cover the need of engineers in most cases of a daily work routine. In case a CLT beam with loading in plane needs to be analyzed that has more than 1 span and might even cantilever, or have voids too, we suggest to use the module CLT wall and deep beam element design – see chapter *4 SylvaTM Walls*

To describe the flexural analysis of a CLT beam with loading in plane in a very simple way, one could say, that the section is being analyzed as homogeneous, rectangular section, just taking the lamination in principal direction into account, disregarding the cross layers (vertical layers).

The shear analysis is being done according to the technical expertise by Prof Blass on shear in the plane of CLT.

5.3.1. Geometry and supports



Height and **length** are determining the geometry of the header.
Fixity at left (or right) support: In case the header is fixed at the end and not supported by a pin support, a degree of fixity can be defined [kNm/rad].

By default the cover layer of the CLT panel in this module is assumed to be horizontal. Is this not the case, the box "**cover layer vertical**" needs to be checked.

5.3.2. ULS design

Shear design – gross section

Shear design in plane of CLT - gross section

Dist.	$f_{v,IP,Gross,k}$	γ_m	k_{mod}	$f_{v,IP,Gross,d}$	V_d	$\tau_{IP,Gross,d}$	Utilization
[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kNm]	[N/mm²]	
0.0	3.50	1.30	0.80	2.15	37.64	0.81	37 %

↑ Shear resistance for the gross section

↑ Maximum shear force

For this shear failure mode it is assumed that the **shear can be transferred between adjacent lamination plates** within a CLT layer, due to **edge gluing**. In that case the effective section for the shear design is the **gross section**.

For homogenous wood beams (glulam, solid timber, LVL, etc.), the shear design does not have to be done at the point of the absolute maximum shear (at the support), but can be done in a distance of h (height of the section) from the support – see Austrian National annex to Eurocode 5, part 1, chapter 6.1.7.

This shear reduction is not applicable for CLT beams with loading in the plane of CLT.

Shear design – net section

Shear design in plane of CLT - net section

Dist.	$f_{v,IP,Net,k}$	γ_m	k_{mod}	$f_{v,IP,Net,d}$	$V_{Net,d}$	$\tau_{v,IP,Net,d}$	Utilization
[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kNm]	[N/mm²]	
0.0	3.90	1.30	0.80	2.40	37.64	1.13	47 %

↑ Shear resistance for the net section

This shear force occurs equally in total in the longitudinal layers and in the cross layers. Design governing will be the effective **net width of the CLT section with the minimum thickness**.

Shear design – torsional shear in face glued intersecting surfaces

Torsional shear design in plane of CLT - in face glued surfaces

$f_{v,T,Node,k}$	γ_m	k_{mod}	$f_{v,T,Node,d}$	$V_{\delta,d}$	I_p	$\tau_{T,Node,d}$	Utilization
[N/mm²]	[-]	[-]	[N/mm²]	[kNm]	[mm⁴]	[N/mm²]	
2.50	1.30	0.80	1.54	37.64	84375010.00	0.42	27 %

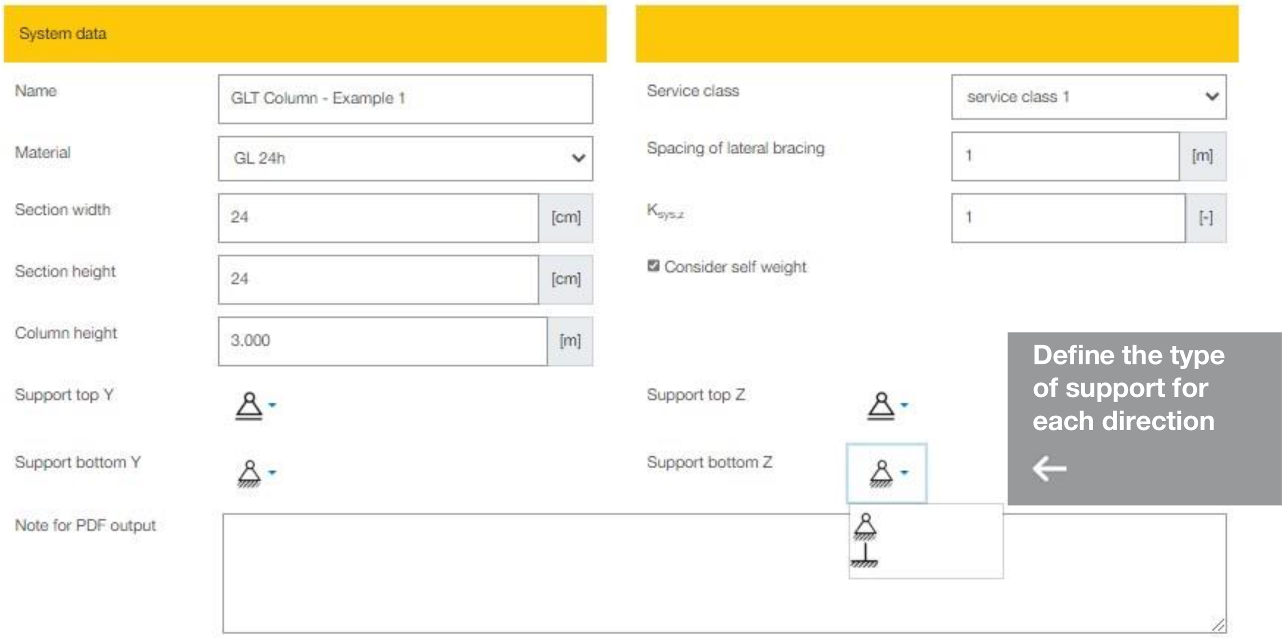
↑ Torsional shear resistance

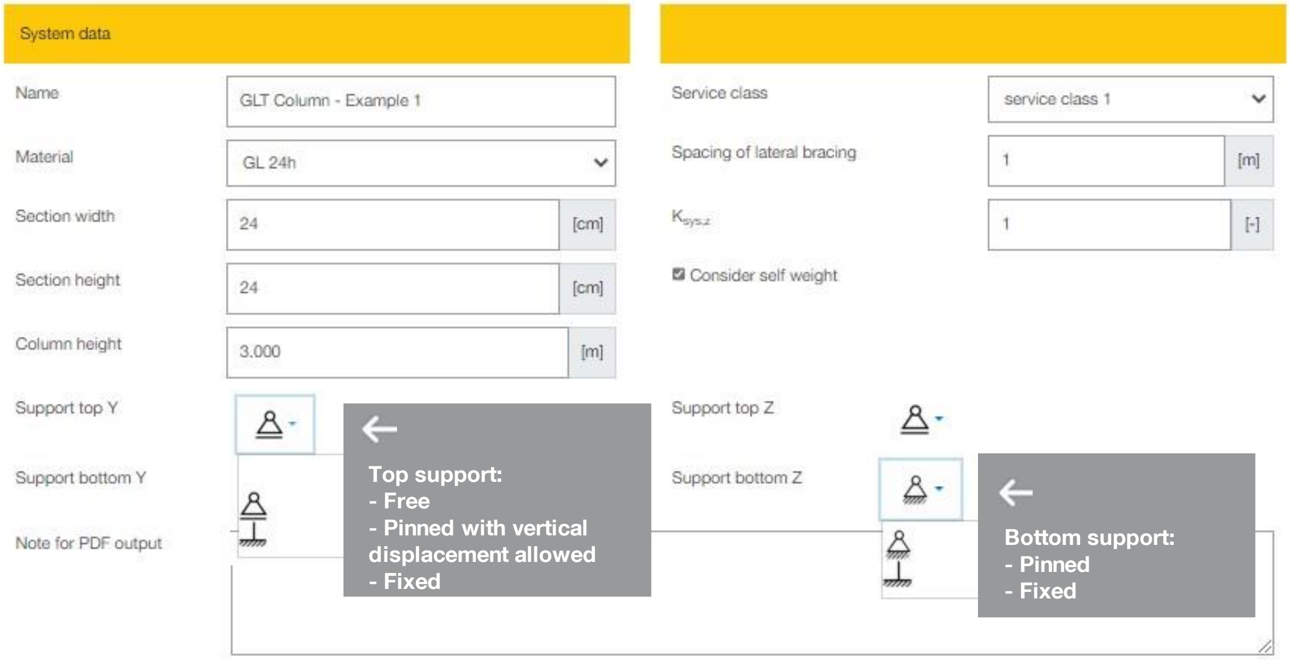
For this failure mode it is assumed that adjacent lamination plates do not have edge gluing, or the edge gluing opened up and is not effective. Therefore all the shear transfer between lamination layers happens through **torsional shear in the face glued intersecting surfaces of CLT**.

6. Sylva™ Columns

6.1. Common features

6.1.1. System data



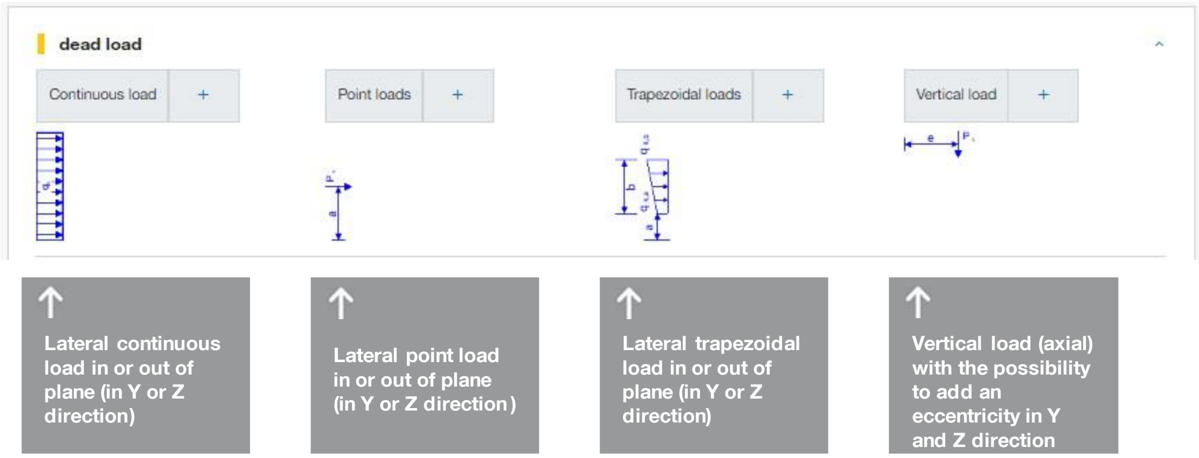


Column width and **column height** define the geometry of the column.
The **boundary conditions** of the supports need to be selected in the pull-down menu.

Note: free is displayed as white box on white background (not visible). For free, click above the pin icon.

6.1.2. Loading

Create a load case and define the loads:



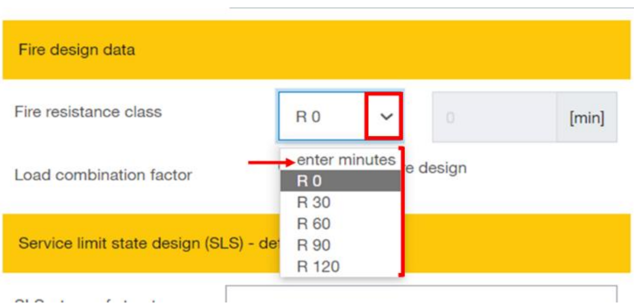
It's possible to add an **eccentricity** in both directions for the vertical load

6.1.3. Fire design

Choose which faces of the beam are exposed to fire at the "charring" selection, by adding check marks next to the relevant face.

Fire resistance class: If R0 is chosen, no fire design will be executed.

The user can also choose a personalized resistance time in minutes.



Load combination factor: Generally Eurocode 5 leaves it up to the engineer, if the load combination for fire design is applying a load combination factor of $\psi 2$ or $\psi 1$. The user can choose this here in the input for fire design.

Fire protection system: If a fire protective cladding protects the beam, this shall be selected in the pull down menu.

This results in a variation of the following parameters:

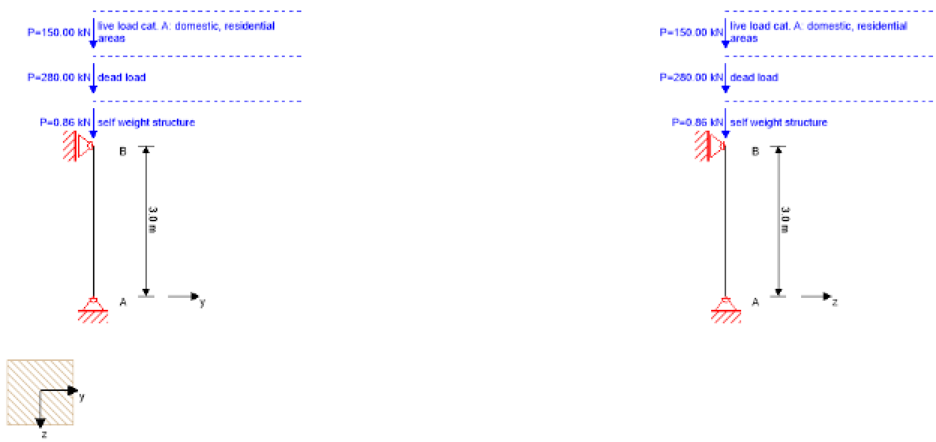
- Single or double ply
- Attached directly to the CLT or with an insulated plumbing cavity in between
- Design according to EN1995-1-2 and ON B 1995-1-2 or design according to Fire Safety In Timber Buildings.

Except for the analysis according to Fire Safety in Timber Buildings, the Austrian national annex is always included in the fire design, because it is currently more detailed than the national annex of other countries.

Calculatis by Stora Enso

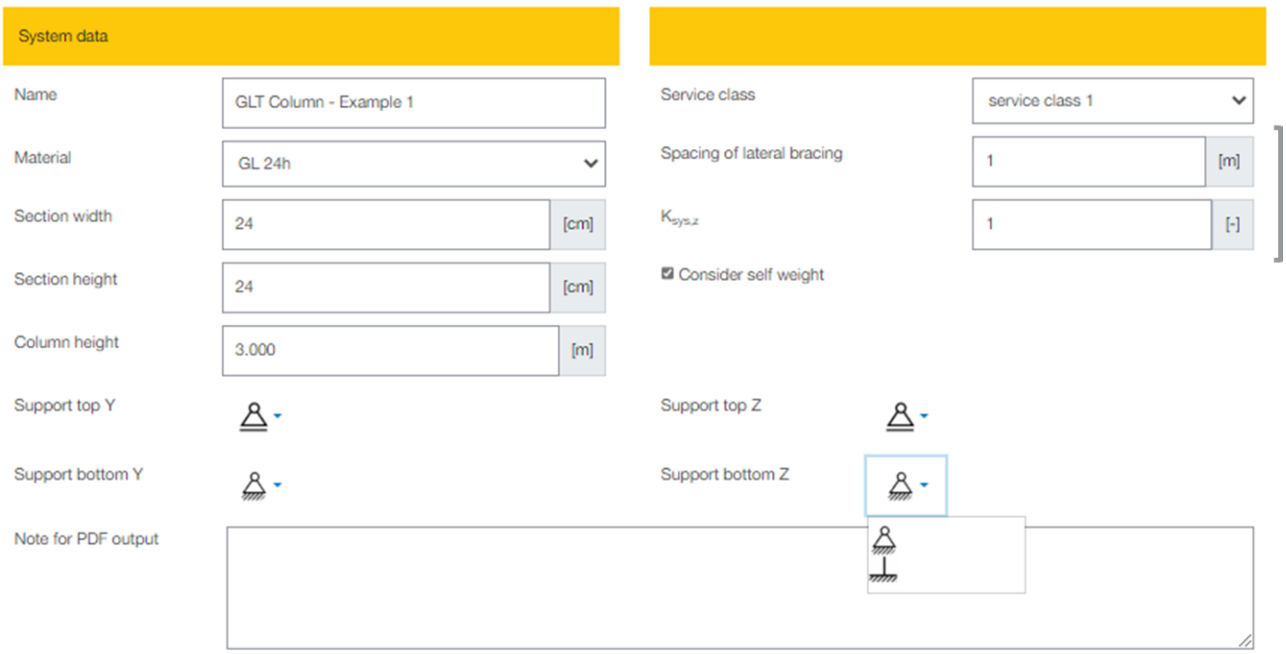
6.2. Column element

Structural system



The module is made for the structural analysis of columns made from rectangular sections of either GLT (glue laminated timber), solid timber or LVL. Loading can be in plane and/or out of plane.

6.2.1. System data



Spacing of lateral bracing: insert the spacing at which the beam is held in lateral direction. This value is entering the lateral torsional buckling design. The spacing could be for example the spacing of purlins or rafters that are supported by the beam. If a panels or sheathing is being fastened at the top flange of the beam, then put 0 as spacing, meaning the beam is continuously held.

$k_{sys,z}$: is the system factor for the given beam section in z-direction (see EN1995-1-1_6.6). Assuming a glulam beam is being picked, then the lamination is usually layered in vertical direction. Therefore no system factor can apply for bending about the Y-axis. For bending about the Z-axis, the tension face of the beam (lateral surface) is divided in all the lamination layers and therefore a system factor can be applied for bending about the Z-axis.

6.2.2. ULS design

The **flexural design** includes the analysis according to EN1995-1-1, chapters 6.1.2, 6.1.4, 6.1.6 and 6.2

Shear stress for loading in 2 different directions is being combined and verified according to the Austrian national annex of EN 1995-1-1, equation NA.6.15-E1. This combination is applied to all countries.

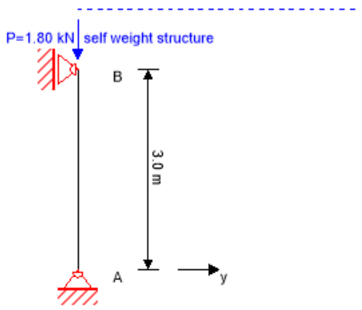
$$\left(\frac{\tau_{y,d}}{f_{v,d}}\right)^2 + \left(\frac{\tau_{z,d}}{f_{v,d}}\right)^2 \leq 1$$

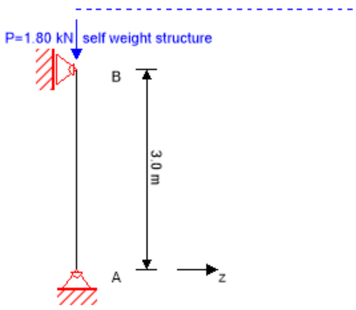
This design module performs the **stability analysis** according to EN 1995-1-1, chapter 6.3.

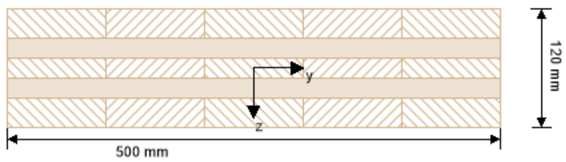
Calculatis by Stora Enso

6.3. CLT column element

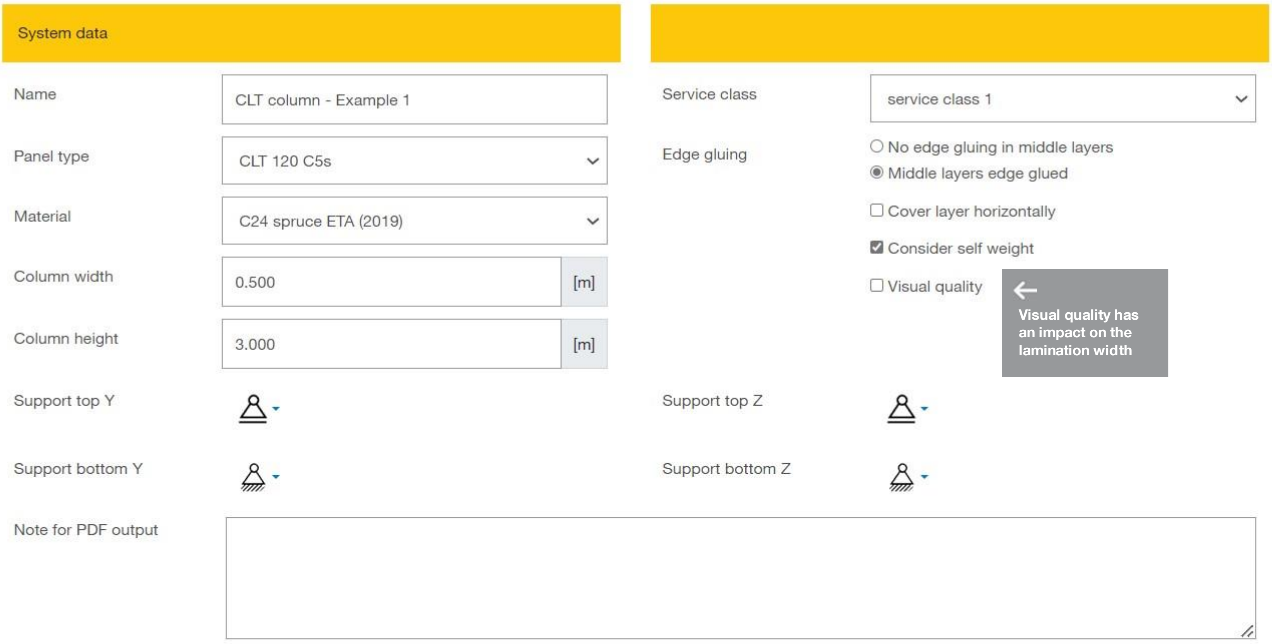
This design module performs the stability analysis according to EN 1995-1-1, chapter 6.3. The analysis of internal forces is done, using the net section of the CLT.







6.3.1. System data



Visual quality shall be checked, if the CLT shall be from visual grade. This is influencing the maximum lamination width and this parameter will enter the design for loading in the plane of CLT.

The selection “**cover layer horizontally**” shall be selected, if the cover layer shall be oriented horizontally. Choosing a “C” or a “L” panel when selecting the CLT section does not influence the orientation of the cover layer. The cover layer is in this module by default oriented vertically.

6.3.2. ULS design

Flexural design

Dist.	$f_{m,k}$	$f_{c,0,k}$	$f_{t,0,k}$	γ_m	k_{mod}	$k_{sys,y}$	$k_{h,m,y}$	$k_{h,m,z}$	k_l	$f_{m,y,d}$	$f_{m,z,d}$	$f_{c,0,d}$	$f_{t,0,d}$
[m]	[N/mm²]	[N/mm²]	[N/mm²]	[-]	[-]	[-]	[-]	[-]	[-]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]
0.0	24.00	21.00	14.00	1.30	0.80	1.10	1.00	1.00	1.00	16.25	14.77	12.92	8.62

Dist.	$M_{y,d}$	$M_{z,d}$	$N_{c,d}$	$N_{t,d}$	$\sigma_{m,y,d}$	$\sigma_{m,z,d}$	$\sigma_{c,d}$	$\sigma_{t,d}$	Utilization
[m]	[kNm]	[kNm]	[kN]	[kN]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	
0.0	0.00	0.00	-242.43	0.00	0.00	0.00	6.06	0.00	47 %

Flexural design includes the analysis according to EN1995-1-1, chapters 6.1.2, 6.1.4, 6.1.6 and 6.2

Shear analysis

Dist.	$f_{v,k}$	γ_m	k_{mod}	$k_{h,v}$	$f_{v,d}$	V_d	$\tau_{v,d}$	Utilization
[m]	[N/mm²]	[-]	[-]	[-]	[N/mm²]	[kN]	[N/mm²]	
3.0	4.00	1.30	0.90	1.00	2.77	0.00	0.00	0 %

Rolling shear

Dist.	$f_{r,k}$	γ_m	k_{mod}	$f_{r,d}$	V_d	$\tau_{r,d}$	Utilization
[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kN]	[N/mm²]	
3.0	1.25	1.30	0.90	0.87	0.00	0.00	0 %

Shear and rolling shear analysis for shear load perpendicular to the plane of CLT

Shear design in plane of CLT - gross section

Dist.	$f_{v,IP,Gross,k}$	γ_m	k_{mod}	$f_{v,IP,Gross,d}$	V_d	$\tau_{IP,Gross,d}$	Utilization
[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kNm]	[N/mm²]	
0.0	3.50	1.30	0.90	2.42	15.75	0.39	16 %

Shear design in plane of CLT - net section

Dist.	$f_{v,IP,Net,k}$	γ_m	k_{mod}	$f_{v,IP,Net,d}$	$V_{Net,d}$	$\tau_{v,IP,Net,d}$	Utilization
[m]	[N/mm²]	[-]	[-]	[N/mm²]	[kNm]	[N/mm²]	
0.0	3.90	1.30	0.90	2.70	15.75	0.59	22 %

Shear design in plane of CLT - gross section Combined

Dist.	γ_m	k_{mod}	$f_{v,d}$	$f_{v,IP,Gross,d}$	V_d	$\tau_{v,d}$	$V_{Gross,d}$	$\tau_{IP,Gross,d}$	Ratio
[m]	[-]	[-]	[N/mm²]	[N/mm²]	[kN]	[N/mm²]	[kNm]	[N/mm²]	
0.0	1.30	0.90	2.77	2.42	0.00	0.00	15.75	0.39	3 %

Shear design in plane of CLT - net section Combined

Dist.	γ_m	k_{mod}	$f_{v,d}$	$f_{v,IP,Net,d}$	V_d	$\tau_{v,d}$	$V_{Net,d}$	$\tau_{IP,Net,d}$	Ratio
[m]	[-]	[-]	[N/mm²]	[N/mm²]	[kN]	[N/mm²]	[kNm]	[N/mm²]	
0.0	1.30	0.90	2.77	2.70	0.00	0.00	15.75	0.59	5 %

Shear analysis for shear load in the plane of CLT for the net and gross section

Torsional shear design in plane of CLT - in face glued surfaces

$f_{v,T,Node,k}$	γ_m	k_{mod}	$f_{v,T,Node,d}$	$V_{\delta,d}$	I_p	$\tau_{T,Node,d}$	Utilization
[N/mm²]	[-]	[-]	[N/mm²]	[kNm]	[mm⁴]	[N/mm²]	
2.50	1.30	0.90	1.73	15.75	84375010.00	0.18	10 %

Torsional shear that occurs in each face glued surface

The **shear design** follows the Expertise by Prof Blass on shear in the plane of CLT.

Shear stress for loading in 2 different directions is combined and verified according to the Austrian national annex of EN 1995-1-1, equation NA.6.15-E1. This combination is applied for all countries.

EN 1995-1-1, equation NA.6.15-E1

$$\left(\frac{\tau_{y,d}}{f_{v,d}}\right)^2 + \left(\frac{\tau_{z,d}}{f_{v,d}}\right)^2 \leq 1$$

— **Shear combination for shear on gross section**

Adapted to shear in and out of plane, this means:

$$\underbrace{\left(\frac{\tau_{v,d}}{f_{v,d}}\right)^2}_{perpendicular\ to\ plane} + \underbrace{\left(\frac{\tau_{v,Gross,d}}{f_{IP,Gross,d}}\right)^2}_{in\ plane} \leq 1$$

— **Shear combination for shear on net section**

Adapted to shear in and out of plane, this means:

$$\underbrace{\left(\frac{\tau_{v,d}}{f_{v,d}}\right)^2}_{perpendicular\ to\ plane} + \underbrace{\left(\frac{\tau_{v,Net,d}}{f_{IP,Net,d}}\right)^2}_{in\ plane} \leq 1$$

— **Torsional shear in each face glued surfaces**

For this, the lamination plate width needs to be known.

For CLT by Stora Enso it is assumed, that the lamination width is as follows:

- Non-visual grade CLT (NVI): lamination plate width a_{lam} = 15 cm
- Visual grade CLT (VI & IVI): lamination plate width a_{lam} = 10 cm

$$\tau_{t,d} = \frac{M_{T,i,d}}{I_{p,i}} + \frac{a_{lam}}{2}$$

$M_{T,I,d}$ = design torsional moment per glued surface, derived from the design moment
$I_{p,i}$ = polar moment of inertia for the intersecting surface = a_{Lam}^4 / 6

Buckling design

Dist.	$f_{m,k}$	$f_{c,0,k}$	γ_m	k_{mod}	$k_{sys,y}$	$k_{sys,z}$	$l_{k,y}$	$l_{k,z}$	λ_y	λ_z	$\lambda_{rel,y}$	$\lambda_{rel,z}$	β_c	$k_{h,m,y}$	k_l
[m]	[N/mm²]	[N/mm²]	[-]	[-]	[-]	[-]	[m]	[m]	[-]	[-]	[-]	[-]	[-]	[-]	[-]
1.5	24.00	21.00	1.30	0.90	1.10	1.00	3.000	3.000	75	21	1.23	0.34	0.2	1.00	1.00

Dist.	k_y	k_z	$k_{c,y}$	$k_{c,z}$	$f_{m,y,d}$	$f_{m,z,d}$	$f_{c,0,d}$	$M_{y,d}$	$M_{z,d}$	$N_{c,d}$	$\sigma_{c,d}$	$\sigma_{m,y,d}$	$\sigma_{m,z,d}$	Utilization
[m]	[-]	[-]	[-]	[-]	[N/mm²]	[N/mm²]	[N/mm²]	[kNm]	[kNm]	[kN]	[N/mm²]	[N/mm²]	[N/mm²]	
1.5	1.34	0.56	0.53	0.99	18.28	16.62	14.54	0.00	7.09	-242.43	6.06	0.00	2.13	92 %

Lateral torsional buckling design

Dist.	$f_{m,k}$	$f_{c,0,k}$	γ_m	k_{mod}	$k_{sys,y}$	l_{ef}	l_k	λ_y	$\lambda_{rel,y}$	$\lambda_{rel,m}$	β_c	k_y	$k_{c,y}$	$k_{h,m,y}$	$k_{h,m,z}$	k_l
[m]	[N/mm²]	[N/mm²]	[-]	[-]	[-]	[m]	[m]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]	[-]
1.5	24.00	21.00	1.30	0.90	1.10	3.000	3.000	75	1.23	0.57	0.2	1.34	0.53	1.00	1.00	1.00

$\sigma_{m,crit,y}$	$\sigma_{m,crit,z}$	k_{crit}	$f_{m,y,d}$	$f_{m,z,d}$	$f_{c,0,d}$	$M_{y,d}$	$M_{z,d}$	$N_{c,d}$	$\sigma_{c,d}$	$\sigma_{m,y,d}$	$\sigma_{m,z,d}$	Utilization
[N/mm²]	[N/mm²]	[-]	[N/mm²]	[N/mm²]	[N/mm²]	[kNm]	[kNm]	[kN]	[N/mm²]	[N/mm²]	[N/mm²]	
861.14	75.18	1.00	18.28	16.62	14.54	0.00	7.09	-242.43	6.06	0.00	2.13	81 %

Buckling and lateral torsional buckling analysis follow EN 1995-1-1, chapter 6.3

7. Connection design

The design of connections is done according to the respective manufacturer's technical guidance and EN 1995-1-1.
Please refer to their documentation for more information about the design.

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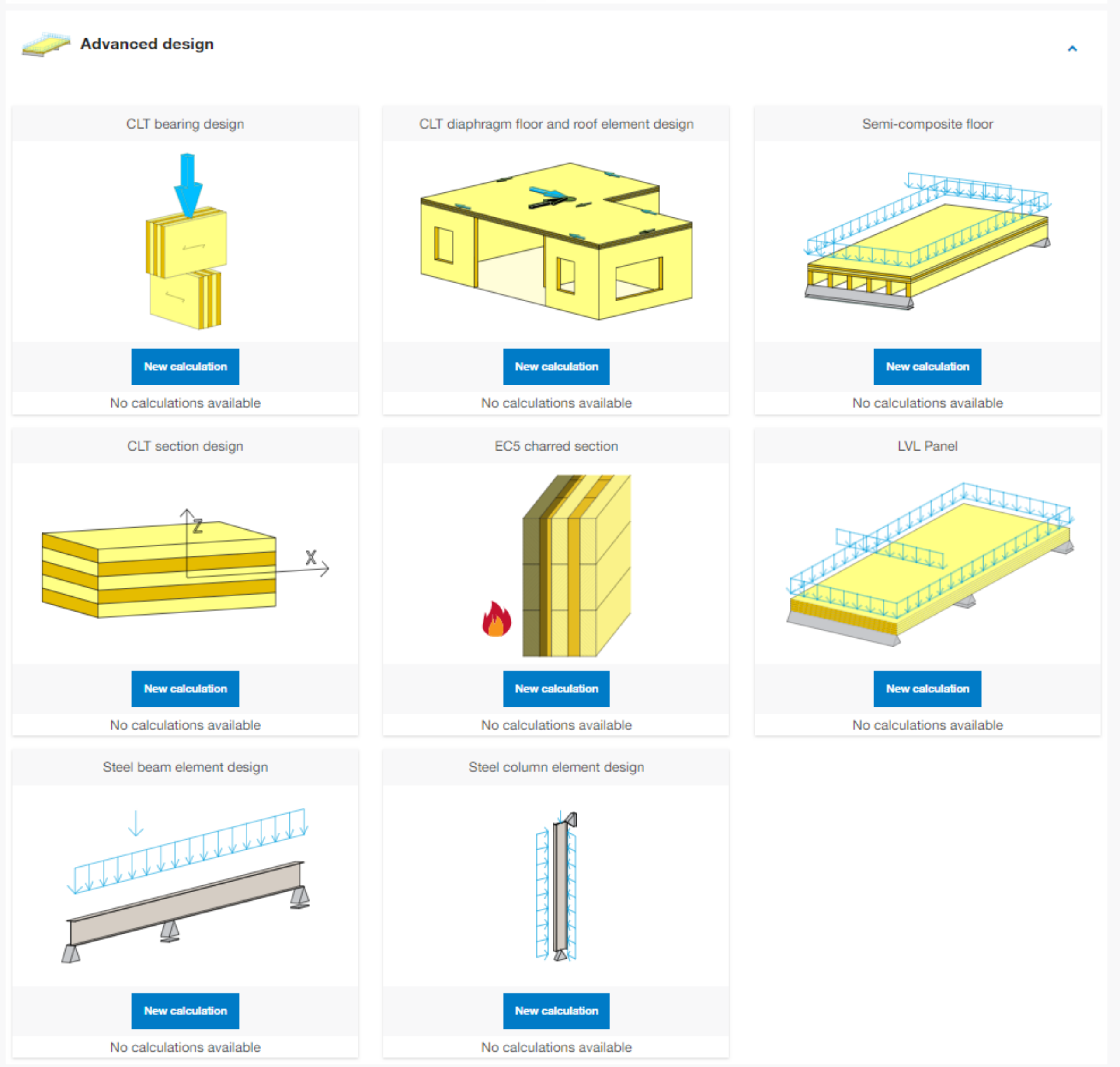
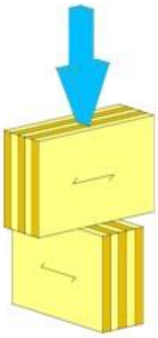
8. Advanced design



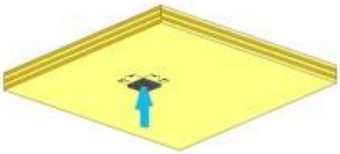
8.1. CLT bearing design

The design module is divided in 3 categories:

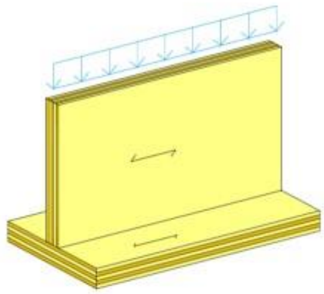
- Point supports of linear elements (wall elements and/or beam elements – in line or crossed)
- Point supports of CLT panels, out of plane
- Linear support of CLT panels



Point supports of linear elements



Point supports of CLT panels, out of plane



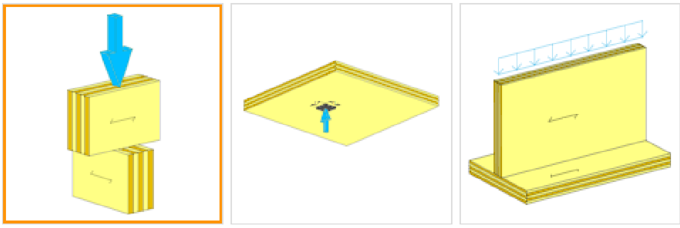
Linear supports of CLT panels

All design modules are performing a bearing pressure analysis. Either bearing pressure acting parallel to the grain, or perpendicular to the grain.

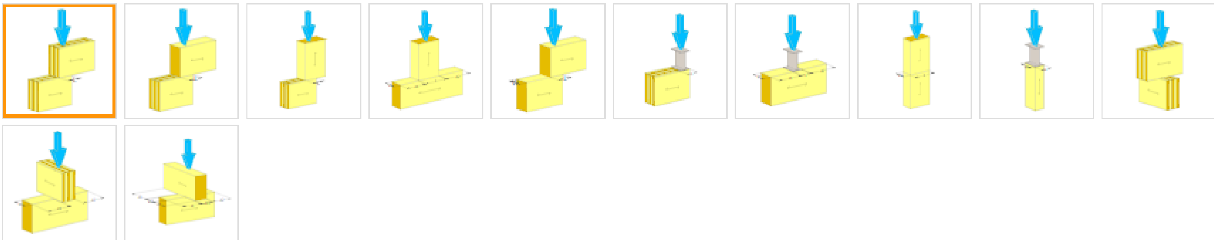
In case of CLT it is not always clear, if the bearing pressure, acting on a net section with strength parallel to the grain would be able to resist a higher load than the entire gross section with strength perpendicular to the grain. Calculatis analyzes both cases and will pick the design governing condition.

The user has to select first the support category that shall be analyzed, by clicking the respective icon and then select the support type:

Support Group

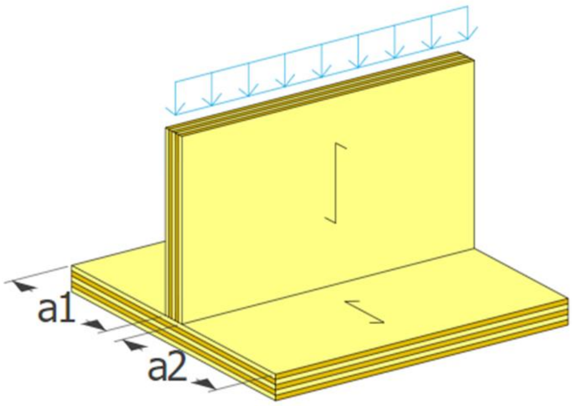


Support



8.1.1. Linear panel support

System data



Name	CLT linear support - Example 1
Support reaction	40 [kN/m]
Support reaction fire design	30 [kN/m]
K_{mod}	0.8 [-]
Material upper element	C24 spruce ETA (2019)
Material lower element	C24 spruce ETA (2019)
Upper CLT panel	CLT 120 C3s
Lower CLT panel	CLT 160 L5s - 2
a1	2 [m]
a2	2 [m]

Note for PDF output

Support reaction is the design value of the support reaction, that a given support needs to resist for an ULS design.
Support reaction fire design is the fire design value of the support reaction, that a given support needs to resist for the fire design.
k_{mod} is the applicable k_{mod} factor for ULS design.
Material upper/lower element: pick from the pulldown menu the material of the lamination of the CLT (typically C24 spruce).
Upper/Lower CLT panel: choose a CLT panel from the pull-down menu.
a1, a2: edge distances for the vertical (upper) CLT panel.

Results

Upper element

Name	Width	Length	Extension	Area	k_{mod}	γ_m	$k_{c,90}$	$f_{c,k}$	$f_{c,d}$	V_{max}	$\sigma_{c,90,d}$	Utilization
	[mm]	[mm]	[mm]	[cm²]	[-]	[-]	[-]	[N/mm²]	[N/mm²]	[kN]	[N/mm²]	
CLT 120 C3s	80	1000	0	800.00	0.80	1.30	1.00	21.00	12.92	80.00	1.00	8 %

Lower element

Name	Width	Length	Extension	Area	k_{mod}	γ_m	$k_{c,90}$	$f_{c,k}$	$f_{c,d}$	V_{max}	$\sigma_{c,90,d}$	Utilization
	[mm]	[mm]	[mm]	[cm²]	[-]	[-]	[-]	[N/mm²]	[N/mm²]	[kN]	[N/mm²]	
CLT 160 L5s - 2	120	1000	60	1800.00	0.80	1.30	1.80	2.50	2.77	80.00	0.44	16 %

If the effective support surface can be extended, according to EN 1995-1-1, item 6.1.5, the respective value (either 30 mm, or 60 mm) will be listed in the column “extension” among the results

8.1.2. Point supported CLT panels

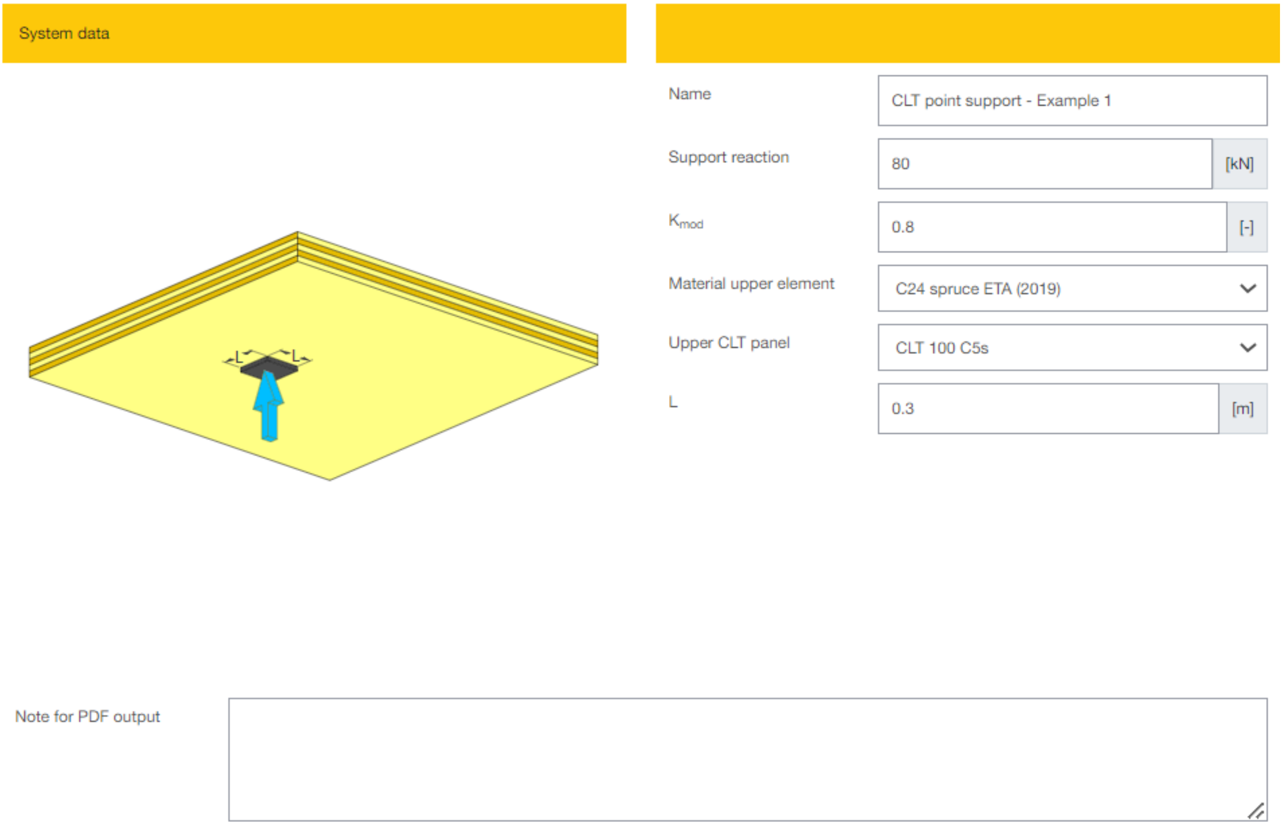
The design module for point supports is not only analyzing the bearing pressure (pressure perpendicular to the grain of the CLT), but also the shear transfer (rolling shear) from the bearing plate to the CLT panel. This shear analysis is based on the doctoral thesis of Peter Mestek. The research of these thesis was conducted under some restrictive boundary conditions as follows:

- Bearing plate is square (side length of the bearing plate = L)
- CLT has a minimum of 5 layers
- Thickness of CLT lamination in X-direction = thickness of CLT lamination in Y-direction
  → all lamellas have the same thickness

Stora Enso is offering among the standard panels only 2 panels that match the criterions above: CLT 100 L5s and CLT 200 L5s.

This module is dealing with the very specific analysis procedure for point supports (bearing pressure and shear analysis). This module will not do the flexural stress analysis. Flexural stress, deformation, etc. widely depends on the geometry, loading and boundary conditions of a CLT panel.

This analysis has to be done by some simplified approach, applying simple beam theory and using the help of other modules of Calculatis. If a FE analysis is used to determine the internal forces in the CLT panel, the support analysis can be done with the help of this module. If the FE software is not capable of designing CLT, the section calculator of Calculatis will do the CLT design part and will do the remaining flexural stress analysis.



Once a system is selected (3 different point support types are possible: central support, edge support and corner support), design relevant data can be entered.

Support reaction is the design value of the support reaction, that a given support needs to resist for an ULS design.
k_{mod} is the applicable k_{mod} factor for ULS design.
Material upper element: pick from the pulldown menu the material of the lamination of the CLT (typically C24 spruce).
Upper CLT panel: choose a CLT panel from the pull-down menu.
L: side length of the bearing plate.

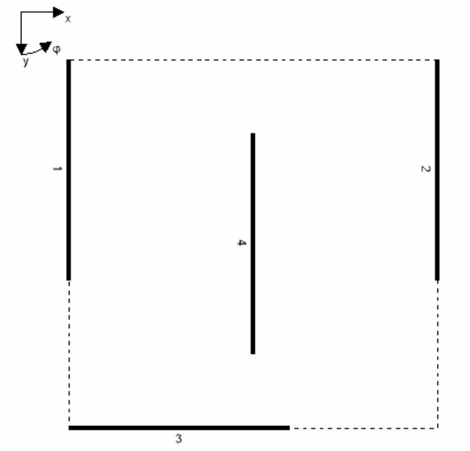
8.2. CLT diaphragm floor and roof

The module CLT diaphragm floor and roof shall help the engineer to distribute a resulting horizontal load that applies to a story in a building, to all the shear walls. Such a horizontal load is usually an earthquake load or a wind load. Earthquake and wind loads usually act on the center of mass of the floor above the analyzed story. Generally such a rigid diaphragm analysis (RDA) is performed on the shear walls of a story and the floor that is sitting on top of these shear walls.

Forces that act on the floor in horizontal direction (in plane of the floor) are being spread out through the rigid diaphragm. Such a spread of forces is only possible, if the diaphragm is rigid. For CLT floor, this can usually be assumed. Light framed timber floors (joists and sheathing on top) would be normally classified as flexible diaphragm. In a flexible diaphragm, tributary loads to walls can be distributed by simple geometric breakdown in tributary areas of the floor.

Is the diaphragm rigid, the force in the diaphragm (total force) is being distributed to the shear walls, dependent on their rigidity (openings in shear walls, panel type, wood grade, geometry of the wall, etc.), relative location to the center of mass or center of gravity and their orientation (angle between the direction of force and the direction of the wall).

8.2.1. System data



System data			
Name	CLT diaphragm - Example 1	F_x	80 [kN]
Accidental eccentricity ? e	5 [%]	F_y	80 [kN]
		☐ Combine Fx and Fy	
Note for PDF output			

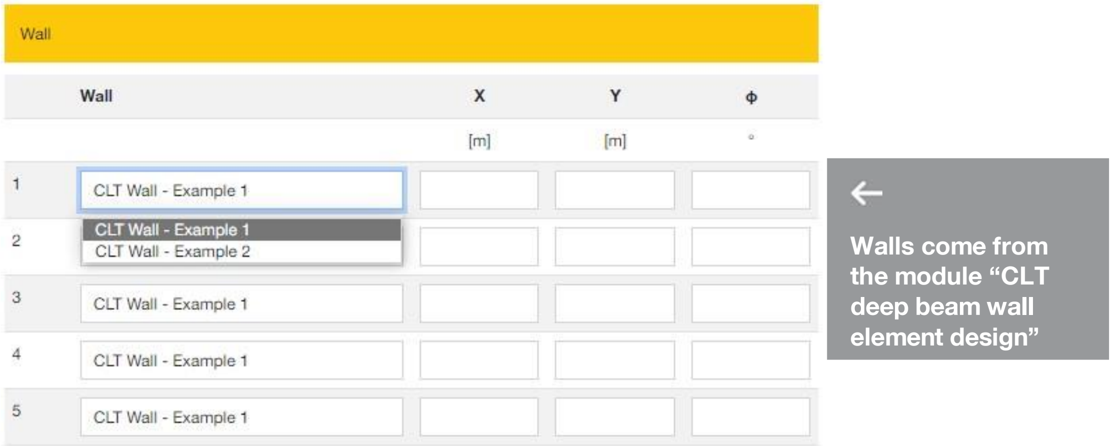
Δ_e is the accidental eccentricity in the diaphragm. This is usually a percentage of the overall length and overall width of the building in plan view. For seismic loading, this is usually 5% - see EN 1998-1, item 4.3.2. For wind loading this can be different and is not regulated in all countries. Therefore this value is to be entered by the user.

F_x is the horizontal force in X direction.

F_y is the horizontal force in Y direction. (usually equal to the force F_x)

Combine F_x and F_y needs to be checked, it the force in X and the force in Y direction are acting simultaneously.

8.2.2. Wall details



For each wall that shall be placed in the building plan, a wall type shall be selected in the pull-down menu.

The **walls listed in this menu are all walls that are entered in the module CLT deep beam wall element design**.

If a wall is not entered in the module CLT wall, it will not be available in this RDA module. The reason for the need to enter walls in the CLT wall module is the analysis of the rigidity of the respective wall panel, including all voids and support boundary conditions. It is possible to select one wall type from the CLT wall module more than once for the RDA. A wall that appears several times in the plan with the same dimensions therefore only needs to be entered once in the CLT wall module (as far as it concerns the RDA).

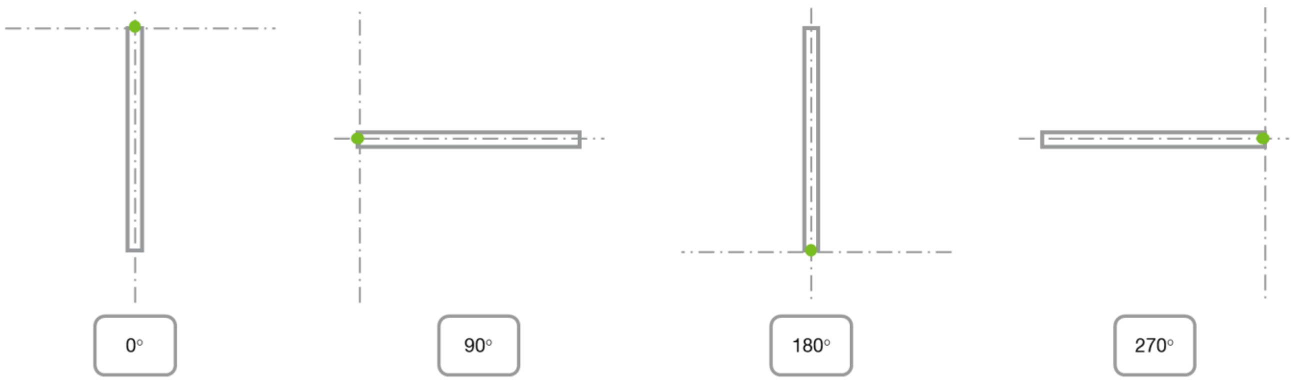
All walls entered in the module CLT wall have their reference point at the bottom left corner.

This is the point that the RDA module refers to, when entering the coordinates X and Y in the RDA module.

X is the X coordinate of the reference point of the respective wall.

Y is the Y coordinate of the reference point of the respective wall.

Direction gives the orientation of the wall in degree:



8.2.3. Floor perimeter

The perimeter of the floor needs to be defined with the coordinates of the floor polygon.

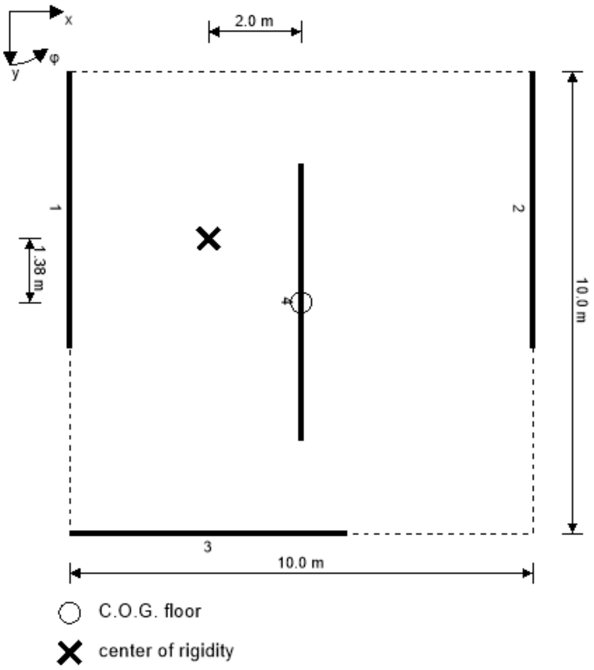
Note: the coordinates need to be entered, **following strictly the polygon** – either clockwise or counterclockwise. The last point of the polygon will be automatically connected to the first point entered. No need to enter one point twice.

Floor polygon

X	Y
[m]	[m]
0	0
10	0
10	10
0	10

8.2.4. Results

The results include a system sketch, lining out the plan of the building at the respective level with the floor above (dashed line).



The general results of the RDA module give values of the maximum dimensions, coordinates for C.O.G and center of rigidity, accidental eccentricity, total eccentricity, and the stiffness:

	X	Y	
Maximum floor dimension	10.000	10.000	[m]
C.O.G. floor	5.000	5.000	[m]
Center of rigidity	5.000	10.000	[m]
e_{net}	0.000	5.000	[m]
?e	0.500	0.500	[m]
$e = e_{net}$ + ?e	0.500	5.500	[m]
Center of rigidity $_{gross}$	5.000	10.500	[m]
Σ Stiffness	50610.710	151832.100	[kN/m]
Σ Stiffness * d^2	12652.680	2530535.000	[kNm]
T	440.000	40.000	[kNm]

F_x

Pos	Name	Width	$Center_x$	$Center_y$	R	R_x	R_y	d_x	d_y	$F_{x,i}$	$F_{y,i}$	F_i	f_i
		[m]	[m]	[m]	[kN/m]	[kN/m]	[kN/m]	[m]	[m]	[kN]	[kN]	[kN]	[kN/m]
1	CLT Wall - Example 1	6	0.000	3.000	50610.710	0.000	50610.710	5.000	7.500	0.000	44.000	44.000	7.333
2	CLT Wall - Example 1	6	10.000	3.000	50610.710	0.000	50610.710	5.000	7.500	0.000	44.000	44.000	7.333
3	CLT Wall - Example 1	6	3.000	10.000	50610.710	50610.710	0.002	2.000	0.500	960.000	0.000	960.000	160.000
4	CLT Wall - Example 1	6	5.000	5.000	50610.710	0.000	50610.710	0.000	5.500	0.000	0.000	0.000	0.000

F_y

Pos	Name	Width	$Center_x$	$Center_y$	R	R_x	R_y	d_x	d_y	$F_{x,i}$	$F_{y,i}$	F_i	f_i
		[m]	[m]	[m]	[kN/m]	[kN/m]	[kN/m]	[m]	[m]	[kN]	[kN]	[kN]	[kN/m]
1	CLT Wall - Example 1	6	0.000	3.000	50610.710	0.000	50610.710	5.000	7.500	0.000	30.667	30.667	5.111
2	CLT Wall - Example 1	6	10.000	3.000	50610.710	0.000	50610.710	5.000	7.500	0.000	30.667	30.667	5.111
3	CLT Wall - Example 1	6	3.000	10.000	50610.710	50610.710	0.002	2.000	0.500	80.000	0.000	80.000	13.333
4	CLT Wall - Example 1	6	5.000	5.000	50610.710	0.000	50610.710	0.000	5.500	0.000	26.667	26.667	4.444

The results are split for force in x and in y direction, if these forces do not act simultaneously. If they do act at same time, the result includes only 1 table.

Center x and y give the coordinates of the center of rigidity of the respective wall.
R is the rigidity of the respective wall.
Rx and **Ry** are the x and y components of the rigidity of the respective wall.
dx and **dy** are relative distances from the wall´s center of rigidity to the total center of rigidity
$F_{x,i}$ and **$F_{y,i}$** are the resulting force components in x and in y direction that the wall is receiving.
F_i is the resulting force that the wall is receiving in direction of the wall.
f_i is the force **F_i** expressed in kN per linear meter of the wall.

8.3. Semi-composite floor

The semi-composite floor module is for rib decks with the following layout:
- CLT deck on top of ribs (glulam, solid timber or LVL)
- ribs (glulam, solid timber or LVL) on top of a CLT deck
- ribs (glulam, solid timber or LVL) with a CLT deck above and below (box girder)

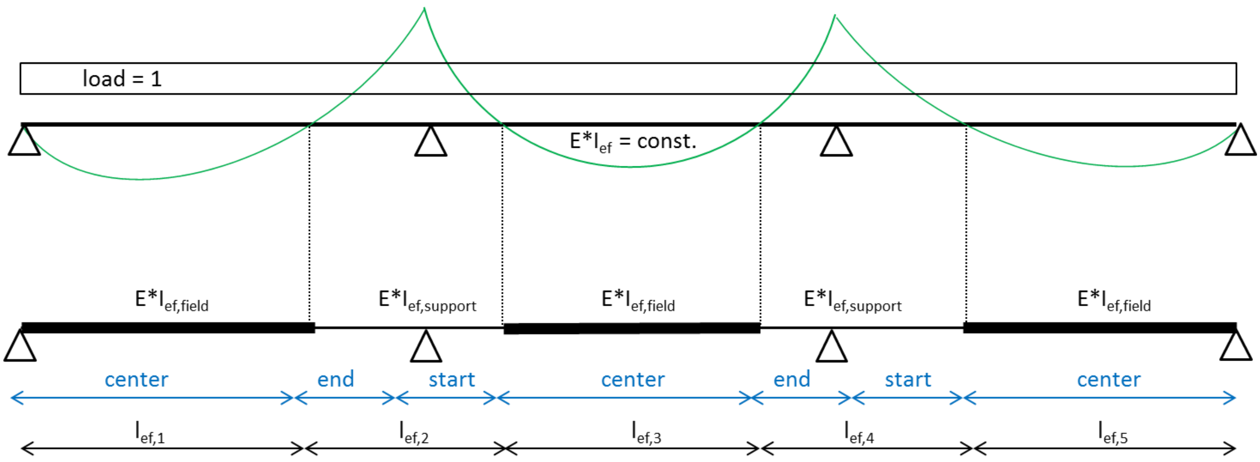
The CLT can be attached to the ribs in **a rigid way (glued) or flexible (mechanical connectors)**.

The rib deck can be a simply supported beam with one span, a continuous beam with several spans with or without cantilevers at either end.

8.3.1. Design basics

For the analysis of semi-composite elements, it was chosen to apply the **gamma method.** The reason for that was, that an analysis with the Timoshenko theory would not be able to analyze the flexural stress in a rib deck section, with a flexible joint and reflect the influence of this flexibility in the joint between rib and deck. The shear analogy method reaches its limits, due to the large asymmetry in the section and the Steiner components in the moment of inertia (CLT section with rather small spacing between the lamination in principal direction and then the large distance to the C.O.G. of the rib). This lead to the decision, to use the gamma method.

The **effective length** of a beam portion is being determined by the location of zero points in a moment curve for a continuous constant load (load = 1) over the entire beam (incl. cantilevers). For a single span beam, the moment curve has its zero points exactly in the support points. Therefore the effective length is equal to the span. In case of a continuous beam, the beam is being divided in 3 zones: start, center and end. For these 3 zones the respective effective length will be taken into account, when calculating the γ-values.



Since the Rigidity (red) is part of the γ-equation

$$\gamma_i = \frac{1}{\left(1 + \frac{\pi^2 \cdot E_i \cdot A_i}{{l_{ref}}^2} \cdot \frac{d_{ij}}{b_{ij} \cdot G_{R,ij}}\right)} = \frac{1}{\left(1 + \frac{\pi^2 \cdot E_i \cdot A_i}{{l_{ref}}^2} \cdot \frac{s_i}{K_i}\right)}$$

the γ-values will be different, in ULS and SLS design, because in SLS design K_{ser} is being used and in ULS design K_u.

This module does the structural analysis for a rib deck in the span direction. The analysis of the deck itself, spanning between the ribs, perpendicular to the span direction, is not included in the design. This design can be easily done, using the CLT floor and roof element module.

8.3.2. System data

For the selection of the CLT panel type it shall be mentioned that it does not make any difference, whether the user specifies a C or a L panel. In this module the principal direction of the CLT deck is always oriented in span direction. Therefore **the grain in the cover layers of the CLT will always be parallel to the grain of the rib**.

For the support design: it is assumed that **the rib deck is only being supported off the ribs**. This is a conservative approach.

Rib width and **height** are the dimensions of the rib.
Rib spacing is the spacing, measured from center line of a rib to the center line of the adjacent rib (not the clear spacing).
$\mathbf{W_{eff}}$ is the effective width of inside the CLT deck that is contributing to the load bearing action of the composite section (rib + CLT). It is recommended to leave this input box empty. In that case the software will determine the effective width itself. This analysis is based on the report "Darstellung und praxistaugliche Aufbereitung für die Ermittlung mitwirkender Plattenbreiten von BSP-Elementen".

By choosing the **position of the CLT deck**, it can be chosen, whether the deck is located above, below or above and below the ribs.

In case the CLT deck is located below the ribs, lateral torsional buckling of the ribs is not considered, because it is assumed that the compression side of the ribs is always braced laterally by either sheathing of a support.

The selection of the connectors is only determining the rigidity k_{ser} . The design of the connector that analyzes the load bearing capacity and any clearance and spacing is not part of this module. The verification should be done separately.

$\mathbf{l_{ef}}$ is the effective length of the screw. This dimension is important for fully threaded screws. Ideally the embedment length in both (CLT and the rib) are equal, however the chosen screw length and CLT thickness will determine the effective embedment length. This effective length needs to be entered by the user.

Based on diameter and effective length a $\mathbf{k_{ser}}$ [N/mm] will be calculated of **one** connector. The additional input of the spacing and rows of connectors lead to a final rigidity of the CLT-rib joint.

If the desired connector cannot be found in the pull-down menu, the user can define an **arbitrary** $\mathbf{k_{ser}}$ by entering (overwriting) a value in the box. This gives the user a good amount of flexibility in the design.

s is the connector spacing in span direction from C.O.G. of a connection (e.g. crossed screws) or a connector (one screw or nail) to the C.O.G. of the next connection/connector.

The number or **rows** is counting the rows of connectors/connections perpendicular to the span (principal) direction.

8.3.3. Fire design

For semi-composite elements it is assumed that fire acts from the bottom. It is assumed that the fire protection cladding is attached directly to the bottom of the element and runs straight from rib to rib, creating a non-insulated cavity between the ribs. The fire protection is calculated as if the CLT was attached directly to the CLT and ribs. This is a conservative approach. In this module the feature of insulated cavities is not available. Only analysis according to EN1995-1-2, incl. Önorm B 1995-1-2 is possible.

8.3.4. SLS design

For rib decks a common k_{def} is being applied. Since most of the flexural rigidity originates from the ribs, the k_{def} value is the one applicable for the rib, in the given country and utilization class. However, if a user would like to apply a different value, a user defined k_{def} can be entered in the input field for the SLS data.

8.3.5. Loading

For the input of a load in the plane of the rib deck, the direction needs to be set to a **local** coordinate system and the inclination of the load needs to be set to **horizontal**.
Attention needs to be paid to the orientation of a load in the plane of a rib deck. The arrows in the load diagram indicate the direction of a positive load. If the load needs to be applied in the opposite direction, the value needs to be entered negative.

In the field “**ex.**”, an **eccentricity** can be applied to the loading in plane (horizontal inclination). The eccentricity is being measured from the center of gravity of the entire rib deck section.

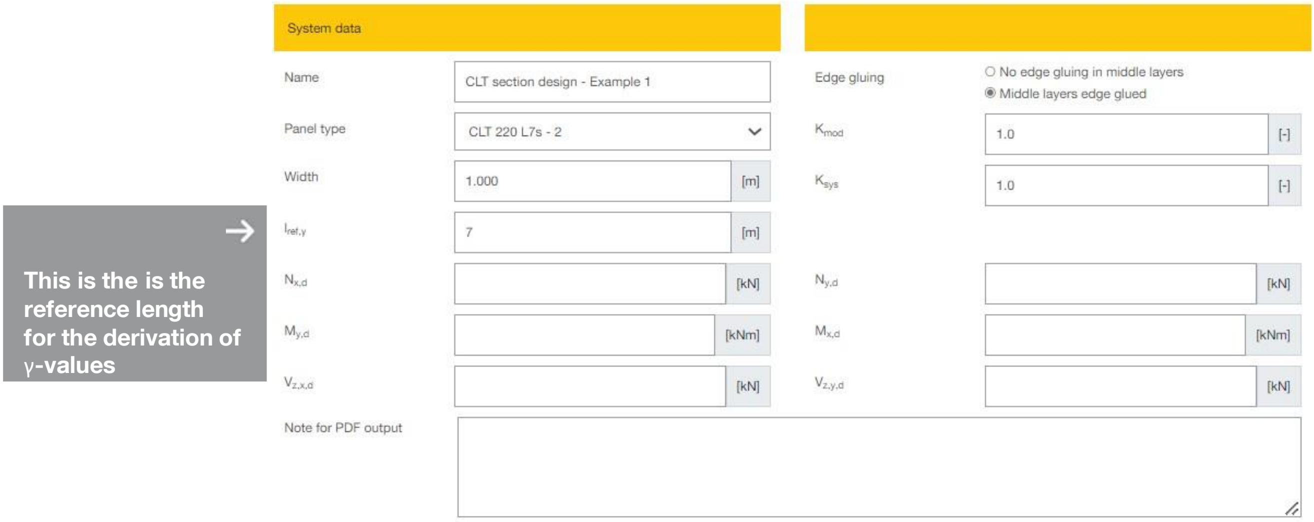
If loads in the plane of the rib deck element are defined, buckling design will be conducted as well.

8.4. CLT section design

The section calculator shall give information about the most important section properties of a CLT panel, before and after fire. These section properties are moment of inertia, section modulus, etc. Additionally the module can calculate an utilization rate, at given internal forces.

This module can also be used to compare the Timoshenko beam theory and the Gamma method.

8.4.1. System data



Width: enter the section width (recommended: 1,00 m)
$l_{ref,\gamma}$ is the reference length for the derivation of γ-values.
$N_{x,d}$ is the design axial force in X direction.
$N_{y,d}$ is the design axial force in Y direction.
$M_{x,d}$ is the design moment about X axis.
$M_{y,d}$ is the design moment about Y axis.
$V_{x,d}$ is the design shear force in X direction.
$V_{y,d}$ is the design shear force in Y direction.
k_{sys} is the system factor.
k_{mod} is the applicable k_{mod} for the given design internal forces.

In this module, the wood grade of each lamination layer can be edited separately.

8.4.2. Results

The section properties are given separately for X and for Y direction and for the case before and after fire.

The values in **analysis using net section** are the section properties, as they would be used for a CLT design, using the Timoshenko beam theory.
The values in **results according to Gamma method** are the section properties according to gamma method, along with the gamma values.

If internal forces are entered at the input page, the section will be designed for the given forces (flexural stress and shear stress). This function is only applicable for loading out of plane and axial forces in plane (no shear in plane). Serviceability and stability are not covered in that module.

Calculatis by Stora Enso

8.5. EC5 charred section

This module determines the load bearing capacity (R) and analyses the integrity (E) and insulation (I) of CLT elements, according to EN1995-1-2, the ETA-14/0349 and expert statement or other local regulations.

During exposure to fire and to the resulting effect of temperature on the CLT cross-section, the use of polyurethane adhesives between individual layers can lead to softening. A possible consequence of this may be that small sections of the heat-insulating char layer fall off, and the protective function of this layer may be lost at certain points.

Therefore, in the case of ceiling elements and other horizontal components, possible delaminations must be taken into account, and, for the subsequent fire-exposed layers, it is necessary to mathematically estimate an increased charring rate until the formation of a new 25 mm-thick char layer.

The design value of charring rates for unprotected horizontal CLT elements are defined as:

- β_0: if only one layer is affected by exposure to fire
- $\beta_{0,a}$: for any additional layers affected by exposure to fire until charring or the formation of a 25 mm-thick char layer. Thereafter, a charring rate β_0 can be applied up to the next bonded joint.

For unprotected vertical CLT elements, the charring rates are defined as:

- β_0: if only one layer is affected by exposure to fire
- $\beta_{0,a}$: for each additional layer affected by exposure to fire

In the case of initially protected members, the time of start of charring behind the protective layer or cladding t_{ch} and the failure time of the protective cladding t_f is essential.

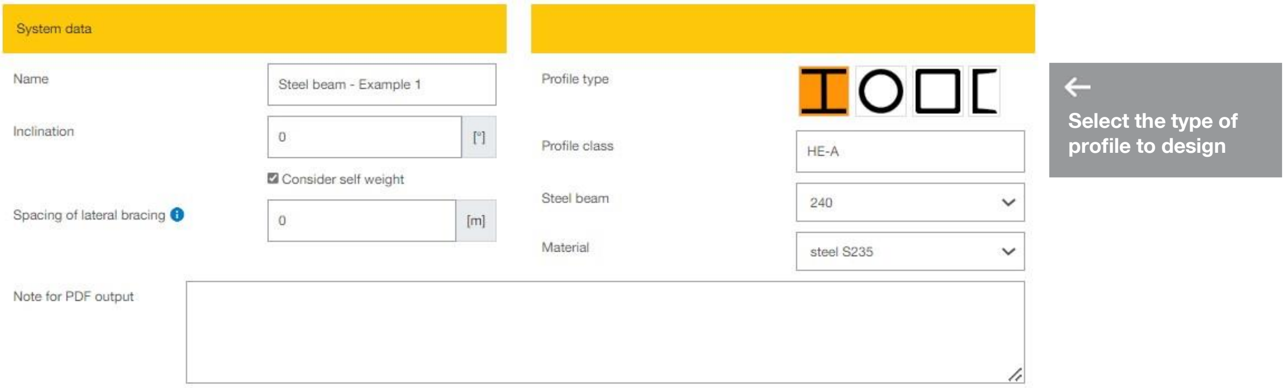
To determine the load bearing capacity (R) of CLT elements, Calculatis uses the **reduced cross-section method** according to 1995-1-2..For verification in the fire situation, this method uses a reduced cross-section or residual cross-section, calculated on the basis of increased charring (roundings or corner charring), and an additional area affected by temperature (reduction of mechanical properties due to the effect of temperature.

To analyze the integrity (E) and insulation (I) of CLT elements, Calculatis uses the extended method for determining the integrity (EI) of wall and ceiling structures in accordance with ÖNORM B 1995-1-2:2011 or the European guideline “Fire safety in timber buildings”.

8.6. Steel beam element design

This module will design a steel beam with a typical rolled or welded steel section. The module is set-up in a similar way as the timber beam element module – see *5. SylvaTM* Beams

The analysis in this design module is based on Eurocode 3 and its national annexes.



Pick a profile by clicking the profile type icon and then choose in the pull-down menu below the section class, the beam size and finally the material.

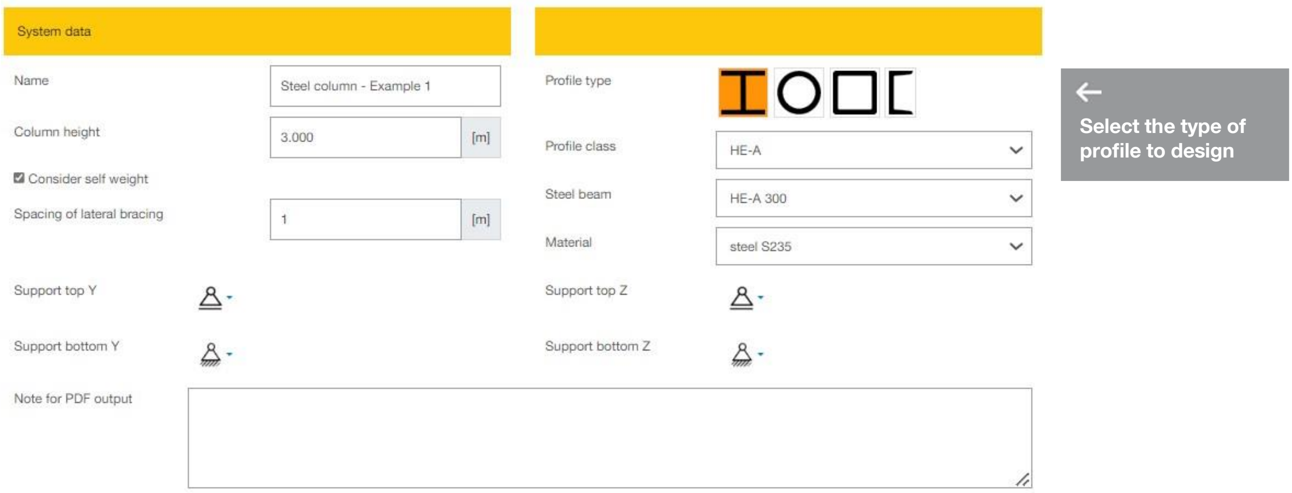
Utilization rates, material parameters and results of the different load case categories and combinations are shown in a similar way as for the modules, described in the previous sections.

This module comprises the flexural design, shear analysis, combined flexion and shear analysis, buckling and SLS-deformations. This does not include fire design or vibration analysis.

8.7. Steel column element design

The module steel columns is used for the structural analysis of columns made from steel sections (wide flange or tubes).
The input is mostly analogous to the module of timber columns – see *606.SylvaTM* Columns

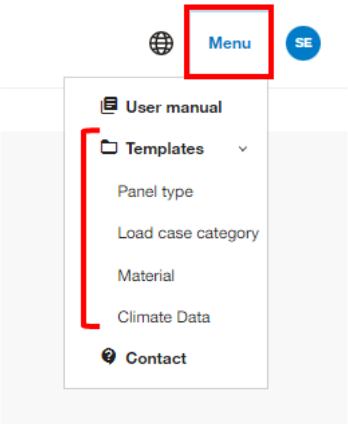
This design module performs the stability analysis according to EN 1993-1-1.



Spacing of lateral bracing: insert the spacing at which the beam is held in lateral direction (weak axis). This value is entering the lateral torsional buckling design. The spacing could be for example the spacing of purlins or rafters that are supported by the beam. If a panels or sheathing is being fastened at the top flange of the beam, then put 0 as spacing, meaning the beam is continuously held.
Profile type selection gives the possibility to select between wide flange, circular tube, rectangular tube and channel profiles.
Depending on the selected **profile type**, a profile class (e.g.: HE-A, IPB, HE-M, etc.) can be chosen.
In the selection **steel beam** the final profile will be selected (size).
In the pull-down menu “**material**”, the steel grade can be chosen.

9. Templates

The following templates shall help the user, to pick among common panel layups, load case categories and materials, that are specific for a given country. By default, some basic data is already included in the templates.



Only items (load case categories, materials, panel layups) that are not used in any saved project can be deleted. This means that the user first needs to delete the analysis or project that includes the item. Then the item itself can be deleted.

Although all values in the templates have been entered with the uttermost attention and the consideration of all relevant design codes for the related country, errors can still occur. All software users need to check the input values, no matter if they originate from a template, or if they are entered directly by the user within the design session. We kindly ask all users to report any errors in the templates and in the software in general, using the contact function in the software.

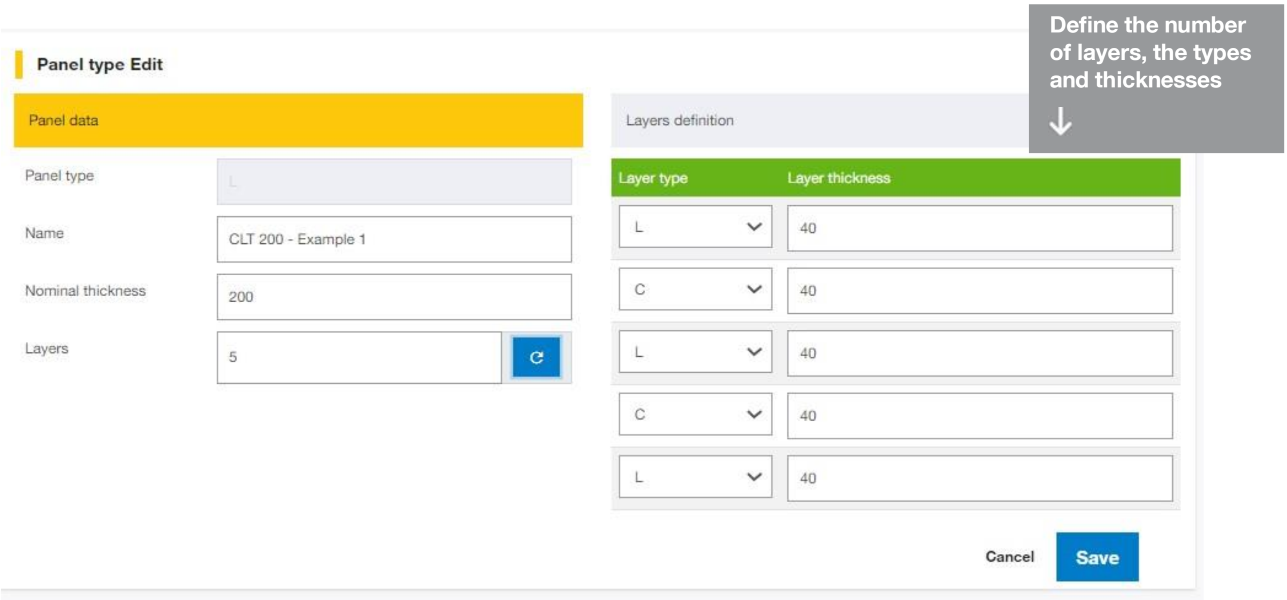
Calculatis by Stora Enso

9.1. Panel type

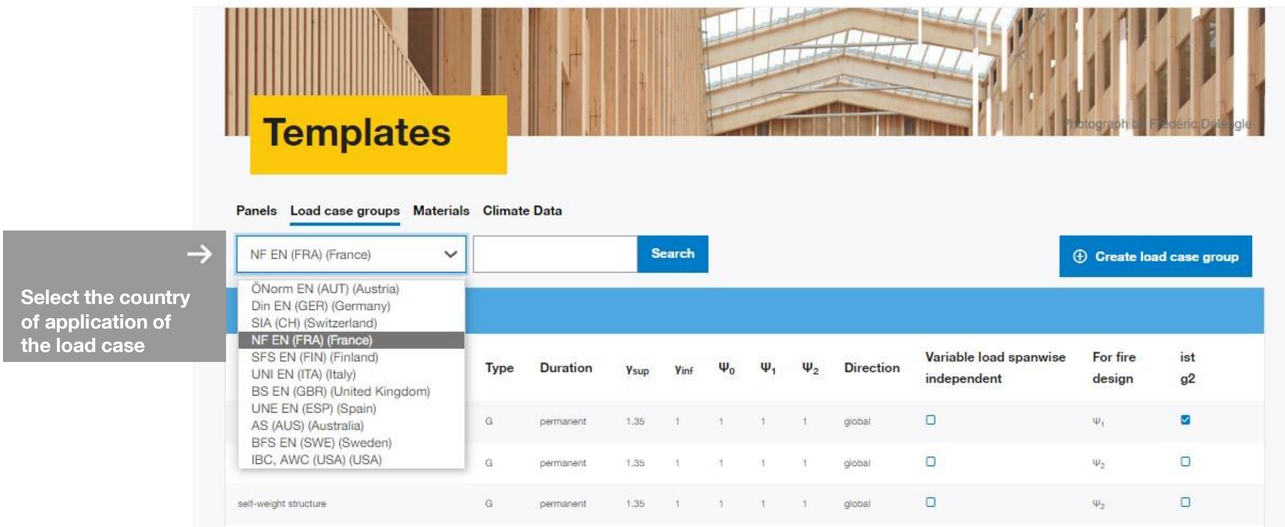
The user can create **CLT panels type C or L, and LVL-G panels**.

L panels: Cover layers are orientated in the main direction
C panels: Cover layers are orientated in the cross direction

To create LVL-G panels, all layers must be defined as “G” layers

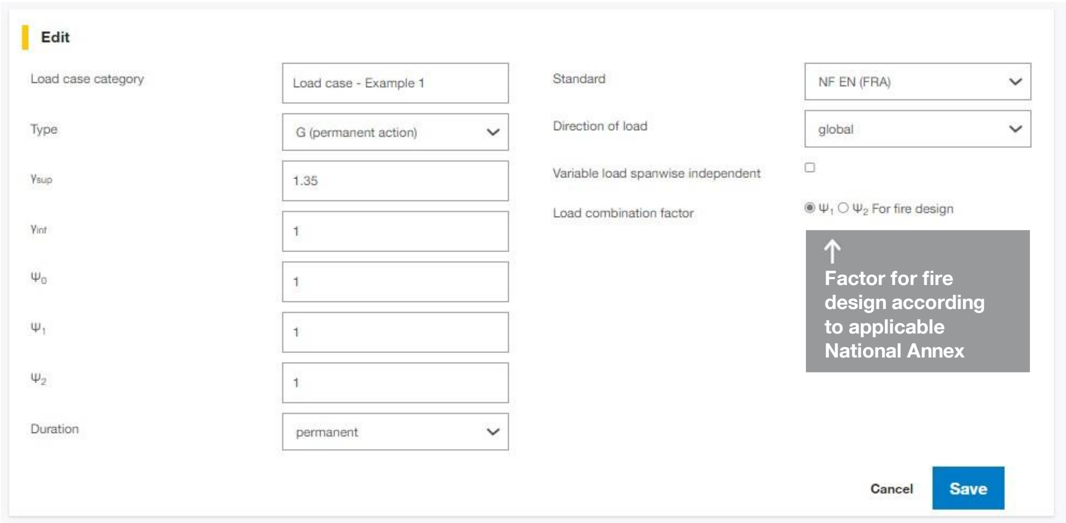


9.2. Load case category



Calculatis by Stora Enso

Coefficients for combinations of actions according to EN 1990



9.3. Material

This template library contains all design materials.

All material templates are categorized, according to the following table. Some material categories and sub categories have structural design values, some have building physics design values and some have both.

Category	Sub category	Material, such as:	structural	building physics
wood and wood based materials	wood and wood based materials	MDF, OSB, etc.		■
	wood	Hardwood panel		■
	CLT material	C24 spruce	■	■
	solid timber & glulam	C16, GL 24h, etc.	■	
concrete, screed and concrete blocks	concrete, screed and concrete blocks	Light weight concrete, reinforced concrete		■
	concrete	C25/30, etc.	■	
brick and blocks	bricks	Masonry bricks etc.		■
	blocks	Masonry blocks, etc.		■
insulation	insulation			■
	mineralwool			■
	wood fibre			■
	EPS			■
	fire protection cladding			■
waterproofing and vapor barrier	waterproofing			■
	vapor barrier			■
granular fill	granular fill			■
wall and ceiling cladding, plaster, stucco	wall and ceiling cladding, plaster, stucco			■
roofing	roofing			■
flooring	flooring	tiles		■
miscelaneous	miscelaneous			■