# Module "Compression perpendicular to grain"

|  | CLTdesigner - Compression perpendicular to  | grain              |
|--|---|--------------------|
| File Edit Window Help  |   |                    |
|  |   | EDM                |
| CLT <sup>designer</sup>  |   | 8: 9 🖬 💻 🧱 🖬 🖬 🚍 🚞 |
|  |   |                    |
| Cross section  | Dimensions and type of load introduction  |                    |
| User-defined © CLT-products with technical aggressits     O RFC CLT cross sections      Number of Laper     Number of Laper     Thickness     Orientation     Ca2er     Ca2er     Ca2er     S     do mm     S     Ca2er     Ca2er     S     do mm     S     Ca2er     Ca2er      Thickness     O mm     S     Ca2er      Thickness     O | Files         1.000           Length         N.000           Widzh         1.000           Image: Second |                    |
|  | Cantinuous Continuous   | 2%mn               |
|  | e lecal e local   |                    |
| Options<br>Load distribution angle no 4510 *   | 1 200 mm 1 200 mm   |                    |
| $a_{\mu\mu} = \frac{1}{35m}  ,$ Height factor for one-sided load introduction $b_{\rm fs} = \frac{1}{100}$   | N1         2001         erm         V2         2001         erm           N1         5001         erm         012         5001         erm           R11         5001         erm         012         5001         erm           R13         5001         erm         012         5001         erm           R13         5001         erm         012         5001         erm  |                    |
|  |   | • (J00'mm          |
| Winimum load introduction area   |   |                    |
| A <sub>camin</sub> 40,000 mm <sup>1</sup>  |   |                    |
| Autonas 52,892 mm²<br>Uni 222 mm<br>Mari 257 mm  |   |                    |
| z 80 mm  |   |                    |
| A <sub>4,90</sub> 1.5  |   |                    |
| Acto "Acesia 59,880 mm"  |   |                    |
| Udituation nation<br>Compression perpendicular to grain n <sub>clife</sub> 77.3.9  |   |                    |
|  | 0   |                    |
|  |   | System hosted at   |

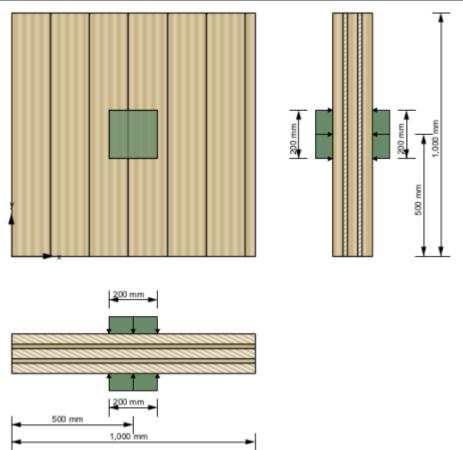
# Input data

The input is divided into:

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

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

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## **Cross-section**

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

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

|                | O My CLT cro       | ss sections |            |
|----------------|--------------------|-------------|------------|
| lumber of laye | ers 5 💌            |             |            |
| Layer          | Thickness          | Orientation | Material   |
| 1              | 40 mm              | 0           | GL24h*     |
| 2              | 20 mm              | 90          | GL24h*     |
| 3              | 40 mm              | 0           | GL24h*     |
| 4              | 20 mm              | 90          | GL24h*     |
| 5              | 40 mm              | 0           | GL24h*     |
|                | ickness / width t/ |             | 160 🗧 mm 🔻 |
| acto bourd chi | citicos , matrici, |             |            |

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

The ratio of board thickness to board width can also be changed here. The default setting is 1:4.

#### My CLT cross sections

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

The library can be displayed with the button .

| Saved cross sections |                     |           |             |          |
|----------------------|---------------------|-----------|-------------|----------|
| Test 1               | Project name Test 1 |           |             |          |
| Test 2               | Lawer               | Thickness | Orientation | Material |
| Test 3               | Layer               |           |             |          |
|                      | 1                   | 23 mm     | 0           | GL24h*   |
|                      | 2                   | 20 mm     | 90          | GL24h*   |
|                      | 3                   | 40 mm     | 0           | GL24h*   |
|                      | 4                   | 20 mm     | 90          | GL24h*   |
|                      | 5                   | 23 mm     | 0           | GL24h*   |
|                      |                     |           |             | - unit   |
|                      | -                   | 1,000 mm  |             | 256 mm   |

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

#### Syntax of the csv file



name;number of layers n;layer thickness in [m]  $t_1$  to  $t_n$ ;orientation of the layers  $o_1$  to  $o_n$  (0 or 90);name of material

Example: Test layup;5;0.03;0.02;0.02;0.02;0.03;90;0;90;0;90;GL24h\*

#### My materials

With the button is the material library can be displayed.

| • • •           |              | My materials                             |          |                   |    |
|-----------------|--------------|--|----------|-------------------|----|
| Saved materials |              |  |          |                   |    |
| Mat 1           | Project name | Mat 1                                    |          |                   |    |
|                 |              | bending strength                         | 24 +     | N/mm <sup>2</sup> | ŀ  |
|                 |              | tensile strength parallel                | 16.5     | N/mm²             |    |
|                 |              | tensile strength perpendicular           | 0.5      | N/mm²             | ŀ  |
|                 |              | compressive strength parallel            | 24 7     | N/mm <sup>2</sup> | ŀ  |
|                 |              | compressive strength perpendicular       | 2.7      | N/mm <sup>2</sup> | •  |
|                 |              | shear strength                           | 3 👘      | N/mm <sup>2</sup> | •  |
|                 |              | rolling shear strength                   | 1.25     | N/mm²             | •  |
|                 |              | Youngs modulus parallel                  | 11,600 - | N/mm²             |    |
|                 |              | 5%-quantile from Youngs modulus parallel | 9,667    | N/mm <sup>2</sup> | •  |
|                 |              | Youngs modulus perpendicular             | 0 7      | N/mm <sup>2</sup> | •  |
|                 |              | shear modulus                            | 720      | N/mm²             | •  |
|                 |              | rolling shear modulus                    | 72 7     | N/mm <sup>2</sup> | •  |
|                 |              | density                                  | 380 +    | kg/m³             | •  |
|                 |              | density mean value                       | 500 -    | kg/m³             | •  |
|                 |              | in plane shear strength                  | 5.5      | N/mm²             | ŀ  |
|                 |              | torsional strength                       | 2.5      | N/mm²             | •  |
|                 |              | bending strength in-plane                | 21       | N/mm <sup>2</sup> | ŀ  |
|                 |              |  |          |                   |    |
|                 |              |  |          |                   | ок |

- With where the edit mode can be entered.
- With 💷 the changes are saved.
- With 💷 the chosen material in the sidebar can be removed from the library.
- With materials from a csv file can be imported.
- With the materials from the library can be exported to a csv file.

#### Syntax of the csv file

- 1. row: description of the parameters
- 2. row: units of the parameters
- 3. row: value
- delimiter: ";"

Example:

Name;f\_m,k;f\_t,0,k;f\_t,90,k;f\_c,k;f\_c,90,k;f\_v,k;f\_r,k;E\_0;E\_0,05;E\_90;G;G\_r;rho\_k;rho\_mea n;f\_v,k,IP;f\_T,k;f\_m,k,IP ;N/mm2;N/ Last update: 2018/04/003 en:clt:hotspot:software:cltdesigner:manual:modul\_compression\_perpendicular\_to\_grain https://www.bspwiki.at/doku.php?id=en:clt:hotspot:software:cltdesigner:manual:modul\_compression\_perpendicular\_to\_grain&rev=1522768435 17:13

The user-defined materials are then displayed in the material selection list.

| Material                   |   |
|----------------------------|---|
| Mat 1 (User-defined)       | • |
| Spruce-Pine-Fir No.3 E90=0 |   |
| Northern No.1/No.2 E90=0   |   |
| Northern No.3 E90=0        |   |
| CL 24h                     |   |
| CL 28h                     |   |
| ON_B_1995_1_1_2015         |   |
| proHolz 2016               |   |
| Mat 1 (User-defined)       | • |

#### **Optimization of layup**

Use the button Beta! Optimise cross section... to display the window for layup optimization.

| onsider in the optimisatio                                       | n:  |  |   |  |
|--|---|--|---|--|
| Producer   |   | Number of laye   | ers   |  |
| best wood SCHNEIDER  | ✓ KLH   | 3 🖌 5  | 6 🖌 7 🗌 8 🛄 9   | 11   |
| Cross Timber Systems   | 🔲 Mayr-Melnhof Holz   | Plate thickness  | 5   |  |
| Derix  | Piveteaubois  | min 60 -   | mm max 320 ÷ mm   |  |
| Eugen Decker   | Stora Enso  | Saved cross se   | ctions  |  |
| Hasslacher   |   | My CLT cro   |   |  |
|  |   | Options  |   |  |
|  |   | Outer cross  | a layers  | Double layers  |
|  |   | Vibration v  | erification according to I  | EN   |
| Start Stop   |   |  |   |  |
| Producer   | Cross section   | Plate thickness  | Governing proof   | Utilisation ratio  |
|  |   | Plate thickness  | Governing proof<br>Vibration  | Utilisation ratio<br>99.2 %  |
| Producer   | Cross section   |  |   |  |
| Producer   | Cross section<br>180mm 5s DL  | 180 mm   | Vibration   | 99.2 %   |
| Producer<br>KLH<br>KLH   | Cross section<br>180mm 5s DL<br>190mm 5s DL   | 180 mm<br>190 mm   | Vibration<br>Vibration  | 99.2 %<br>95.4 %   |
| Producer<br>KLH<br>KLH<br>KLH                                    | Cross section<br>180mm Ss DL<br>190mm Ss DL<br>200mm Ss DL  | 180 mm<br>190 mm<br>200 mm   | Vibration<br>Vibration<br>Vibration   | 99.2 %<br>95.4 %<br>90.1 %   |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH                             | Cross section<br>180mm 5s DL<br>190mm 5s DL<br>200mm 5s DL<br>220mm 7s DL   | 180 mm<br>190 mm<br>200 mm<br>220 mm   | Vibration<br>Vibration<br>Vibration<br>Vibration  | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %   |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH                      | Cross section<br>180mm 5s DL<br>190mm 5s DL<br>200mm 5s DL<br>220mm 7s DL<br>240mm 7s DL  | 180 mm<br>190 mm<br>200 mm<br>220 mm<br>240 mm   | Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration   | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %<br>78.4 %   |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH | Cross section           180mm 5s DL           190mm 5s DL           200mm 5s DL           220mm 7s DL           240mm 7s DL           180mm 7ss DL           200mm 7ss DL           240mm 7ss DL           200mm 7ss DL           200mm 7ss DL  | 180 mm<br>190 mm<br>200 mm<br>220 mm<br>240 mm<br>180 mm   | Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration                           | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %<br>78.4 %<br>93.9 %<br>82.8 %<br>73.1 %                     |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH        | Cross section           180mm 5s DL           190mm 5s DL           200mm 7s DL           220mm 7s DL           240mm 7s DL           180mm 7ss DL           200mm 7ss DL   | 180 mm<br>190 mm<br>200 mm<br>220 mm<br>240 mm<br>180 mm<br>200 mm                               | Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration                           | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %<br>78.4 %<br>93.9 %<br>82.8 %<br>73.1 %<br>65.8 %           |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH | Cross section 180mm 5s DL 190mm 5s DL 200mm 5s DL 220mm 7s DL 240mm 7s DL 180mm 7ss DL 200mm 7ss DL 220mm 7ss DL 220mm 7ss DL 260mm 7ss DL 260mm 7ss DL   | 180 mm<br>190 mm<br>200 mm<br>220 mm<br>240 mm<br>180 mm<br>200 mm<br>220 mm                     | Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration                           | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %<br>78.4 %<br>93.9 %<br>82.8 %<br>73.1 %<br>65.8 %<br>61.6 % |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH | Cross section           180mm Ss DL           190mm Ss DL           200mm Ss DL           220mm 7s DL           240mm 7s DL           240mm 7ss DL           200mm 7ss DL | 180 mm<br>190 mm<br>200 mm<br>220 mm<br>240 mm<br>180 mm<br>200 mm<br>220 mm<br>220 mm           | Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration              | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %<br>78.4 %<br>93.9 %<br>82.8 %<br>73.1 %<br>65.8 %           |
| Producer<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH<br>KLH | Cross section 180mm 5s DL 190mm 5s DL 200mm 5s DL 220mm 7s DL 240mm 7s DL 180mm 7ss DL 200mm 7ss DL 220mm 7ss DL 220mm 7ss DL 260mm 7ss DL 260mm 7ss DL   | 180 mm<br>190 mm<br>200 mm<br>220 mm<br>240 mm<br>180 mm<br>200 mm<br>220 mm<br>240 mm<br>260 mm | Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration<br>Vibration | 99.2 %<br>95.4 %<br>90.1 %<br>85.3 %<br>78.4 %<br>93.9 %<br>82.8 %<br>73.1 %<br>65.8 %<br>61.6 % |

With the help of this tool, the possible layups can be determined for the given system and load situation. The optimization can be restricted with regard to producers, number of layers or by means of limits for the panel thickness. Furthermore, outer cross layers or double layers can be included or excluded. With the option "Vibration verification according to EN" the base document is included in the vibration check or not.

With the buttons "Start" and "Stop" the calculation is controlled. Please be patient, depending on the selected parameter the calculation may take a little longer.

The possible setups are then displayed in the table and the selected setup can be transferred to the main window by clicking the "Choose the selected cross section" button.

Cross section · 2017/11/14 17:11

### Plate dimensions and gap execution

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

| Plate  |  |
|--------|--|
| Length | 1,000 - mm                                   |
| Width  | 1,000 - mm                                   |
| not    | side bonded or cracks in top layers expected |
| Gap:   | s or cracks > 1 mm                           |

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

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

## Load data and design factors

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

| Loads to induce and design factors |             |  |  |  |
|------------------------------------|-------------|--|--|--|
| F <sub>c,90</sub>                  | 100,000 - N |  |  |  |
| k <sub>mod</sub>                   | 1           |  |  |  |
| YM                                 | 1.25        |  |  |  |

# Load configuration

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

If the load is applied locally, it needs to be defined by entering the dimensions of the load surface (length  $I_{1,2}$  in direction x and width  $w_{1,2}$  in direction y) and the position. The position is defined as the distance between the center of a load surface and the origin of the coordinate system (lower left

| Last                           |   |
|--------------------------------|---|
| update:<br>2018/04/03<br>17:13 | en:clt:hotspot:software:cltdesigner:manual:modul_compression_perpendicular_to_grain https://www.bspwiki.at/doku.php?id=en:clt:hotspot:software:cltdesigner:manual:modul_compression_perpendicular_to_grain&rev=1522768435 |

corner of the plate). Currently, centers of the top and the bottom load surface are coupled and cannot be moved relative to each other.

| Load introduction above             | Load introduction below        |  |  |
|-------------------------------------|--------------------------------|--|--|
| one                                 | one                            |  |  |
| Continuous                          | Continuous                     |  |  |
| Iocal                               | Iocal                          |  |  |
| I <sub>1</sub> 200 <sup>▲</sup> mm  | I <sub>2</sub> 200 <u>↑</u> mm |  |  |
| w <sub>1</sub> 200 $\frac{1}{2}$ mm | w <sub>2</sub> 200 – mm        |  |  |
| e <sub>l,1</sub> 500 - mm           | e <sub>l,2</sub> 500 ÷ mm      |  |  |
| e <sub>w,1</sub> 500 - mm           | e <sub>w,2</sub> 500 ÷ mm      |  |  |
|                                     |                                |  |  |

# **Calculation options**

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

| Options                                       |                 |        |
|---|-----------------|--------|
| Load distribution angle                       | α0              | 45 ÷ ° |
|   | α <sub>90</sub> | 15 * * |
| Height factor for one-sided load introduction | k <sub>ls</sub> | 0.4 🗧  |
|   |                 |        |

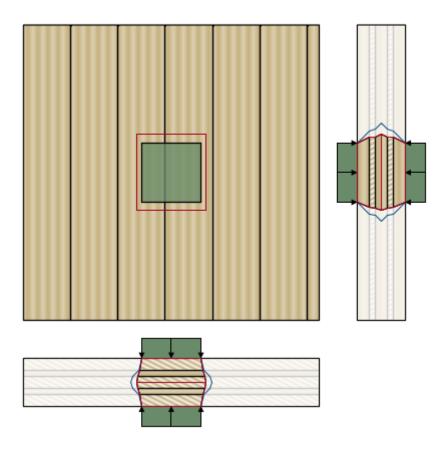
# **Results and Output**

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

The utilisation ratio for compression perpendicular to grain is indicated by  $\eta_{c,00}$  in [%].

|                                       | ad introduction ar<br>0,000 mm² | ea                      |        |
|---------------------------------------|---------------------------------|-------------------------|--------|
| A <sub>ef,max</sub>                   | 59,880 mm <sup>2</sup>          |                         |        |
| l <sub>ef</sub>                       | 233 mm                          |                         |        |
| w <sub>ef</sub>                       | 257 mm                          |                         |        |
| z                                     | 80 mm                           |                         |        |
| k <sub>c,90</sub>                     | 1.5                             |                         |        |
| k <sub>c,90</sub> *A <sub>c,min</sub> | 59,880 mm²                      |                         |        |
| Utilisation r<br>Compressio           | ratios<br>on perpendicular to   | grain η <sub>c,90</sub> | 77.3 % |

The following figure shows the distribution of the effective area  $A_{ef,max}$  over the cross section (red line) as well as the assumed load distribution (blue line).



# Implemented calculation methods

Compression perpendicular to grain - Verification

Model for the determination of the kc,90 factor

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