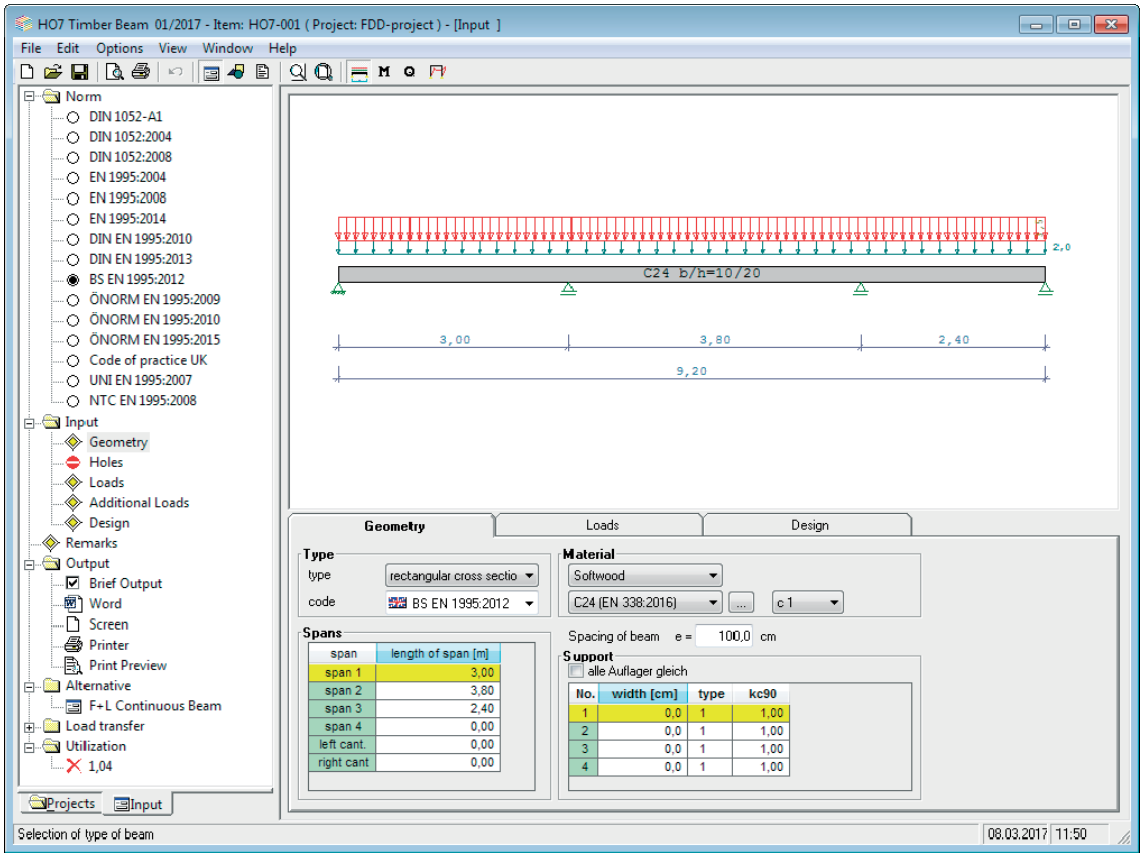
Timber Beam - HO7

FRILO Software GmbH
www.frilo.com
info@frilo.eu
As of 08/03/2017



Timber Beam - HO7

Note: *This document describes the **Eurocode-specific application**. Documents containing old standards are available in our documentation archive at www.frilo.de >> Dokumentation >>Manuals>Archive.*

Contents

Further information and descriptions are available in the relevant documentations:

FDC – Basic Operating Instructions	General instructions for the manipulation of the user interface
FDC – Menu items	General description of the typical menu items of Frilo software applications
FDC – Output and printing	Output and printing
FDC - Import and export	Interfaces to other applications (ASCII, RTF, DXF …)
FCC	Frilo.Control.Center - the easy-to-use administration module for projects and items
FDD	Frilo.Document.Designer - document management based on PDF
Frilo.System.Next	Installation, configuration, network, database

Application options

The HO7 application allows you to calculate continuous beams with up to 12 spans under uniform linear loads, concentrated loads and trapezoidal loads and design them as rectangular beams with a continuous cross section over the entire length.

In addition to rectangular cross sections, also web beams make STEICO can be calculated in accordance with European approval ETA-06/2038 and the load assumptions can optionally be based on the Code of Practice of the British Engineered Wood Product Committee.

You can define holes on STEICO beams.

Multipart cross sections can be defined as well.

Available standards

- EN 1995-1:2004/2008/2014
- DIN EN 1995:2010/2013
- BS EN 1995:2012
- ÖNORM EN 1995:2009/2010/2015
- UNI EN 1995-1-1 / NTC:2008
- Code of practice UK
- WPC Code of Practice:2006 (only for STEICO)
- DIN 1052:2004/2008 (description of the bases of calculation in accordance with DIN available in our manual archive at www.frilo.eu ▸ Service ▸ Documentation ▸ Manuals)

Multiplying factors are assigned to the loads. In addition, you can link each load component to the load influence width of a joist ceiling.

You can take biaxial loading into account.

The inclusion of creep deformation in the cross breaking strength verification is possible. It is calculated by multiplying the elastic deflections with a factor that is determined by the relations of the loads per span.

In the verifications, the equilibrium moisture is taken into account via the usage class, which has an influence on the resisting forces via the modification factor k_{mod}. The serviceability is automatically verified in the infrequent and the quasi-permanent situation. The stress verifications are based on the formulas specified by the standard. You may increase the permissible shear stress, if the distance to the beam end is more than 1.50 m (due to the reduced cracking risk).

The creep behaviour of the timber is taken into account in the calculation of the deflections via the deformation coefficient k_{def}.

You can optionally verify the vibration resistance as per EN 1995-1-1 7.3.

STEICO

STEICOjoist beams are timber web beams with a high load bearing-capacity and a low self-weight.

The flanges are made of mechanically dried and sorted finger-jointed timber.

The webs are made of hardboards that are joined with v-joints and bonded.

STEICOjoist beams are designed in accordance with the ETA-06/2038 approval. The load assumptions are based on the Code of Practice, the load combinatorics on DIN 1055-100, because no NAs to EN 1990 are available yet.

In the verifications in accordance with ETA-06/2038, the equilibrium moisture content is taken into account via the usage class, which has an influence on the resisting forces via the modification factor k_{mod}. As the flanges and webs are made of different materials, different k_{mod} values must be taken into account in the various verifications.

The bearing strength verifications are performed for those situations that may be produced by the involved load cases. The serviceability verifications are based on WEPC CoP:2006.

The creep behaviour of the timber is taken into account in the calculation of the deflections via the deformation coefficient k_{def}.

For STEICO beams, the existing design values of the internal forces and the supporting forces are compared to the permissible values specified by ETA-06/2038.

You can define holes on STEICO beams.

Basis of calculation

The calculation of the internal forces is based on the displacement method.

The software calculates automatically the maximum beam loading with the most unfavourable load combination and with permanent and live loads per span.

EN 1995-1-1

The verifications in the ultimate and serviceability limit states are based on EN 1995-1-1.

Deformation by creep is considered via the deformation coefficient k_{def}.

The available materials are coniferous, deciduous or laminated timber. The resisting forces are set in accordance with EN 338 or EN 1194.

Moisture action is considered via the usage class. The usage period determines the modification factor k_{mod} as per EN 1995-1-1, 2.3.1.3.

Usage class 1	closed and heated buildings, humidity < 65 %, equilibrium moisture content < 12 %
Usage class 2	open building with roofing, humidity < 85 %, equilibrium moisture content < 20%
Usage class 3	building exposed to weathering, humidity > 65 %, equilibrium moisture content > 20%

The bearing strength is verified in the permanent and transient situation as a standard. The accidental and earthquake situations are optionally selectable.

In load case combinations with actions of different action periods (table 3 and 4) the action with the shortest action period is decisive.

The combination rules specified by EN 1990:2002.

The serviceability verifications are performed for the corresponding situations, the combination rules of EN 1990:2202 are applied.

The support reactions are put out with their maximum and minimum values and their characteristic values referenced to the actions.

ÖNORM EN 1995

The particularities of the National Annex ÖNORM EN 1995-1-1 can be taken into account in all verifications.

The verifications in the ultimate and serviceability limit states are based on ÖNORM EN 1995-1-1.

In the shear resistance verification, the following coefficients k_{cr} are included in the calculation:

k_{cr} = 0.67 for solid timber

k_{cr} = 0.83 for laminated timber

k_{cr} = 1.0 for all other timber-based products as per EN 13986 and EN 14374

The value k_{cr} specified for laminated timber applies to all laminated timber classes under the condition that the characteristic shear strength is $f_{v,k}$ = 3.0 N/mm^2.

The verifications in the ultimate and serviceability limit states are based on ÖNORM EN 1995-1-1.

The following recommendations apply to the limit values in accordance with table 3:

	Span	Cantilever
$w_{Q,inst}$	L/300	L/150
$w_{fin} - w_{G,inst}$	L/200	L/100
$w_{fin} - w_{G,inst}$	L/250	L/125

The bearing strength is verified in the permanent and transient situations as a standard. The accidental and earthquake situations are optionally selectable.

The combination rules specified by ÖNORM EN 1990:2002 are used.

The serviceability verifications are performed for the corresponding situations, the combination rules of ÖNORM EN 1995-1-1, 5.7 are applied.

$$E_{d,rare} = E\left\{\sum_{j\geq 1} G_{k,j} \oplus Q_{k,1} \oplus \sum_{i>1} \psi_{0,i} \cdot Q_{k,i}\right\}$$

$$E_{d,perm} = E\left\{\sum_{j\geq 1} G_{k,j} \oplus \sum_{i\geq 1} \psi_{2,i} \cdot Q_{k,i}\right\}$$

The support reactions are put out with their maximum and minimum values and their characteristic values referenced to the actions.

STEICOjoist as per ETA-06/2038

The verifications in the ultimate and serviceability limit states are based on ETA-06/2038

(ETA = *European Technical Approval)*.

In the verifications, the internal design forces are compared to the permissible design values specified by the approval .

The calculation of the design values is based on the combination rules specified by DIN 1055-100.

Bending

$$\frac{\text{exist. } M_d}{\text{perm. } M_d} \leq 1 \qquad \text{with:}$$

$$\text{perm. } M_d = \frac{M_{k(ETA)} \cdot k_{mod(ETA)}}{\gamma_M}$$

$M_{k\,(ETA)}$	characteristic moment resistance (as per ETA-06/2038)
exist. M_d	design moment from the superposition
perm. $M_{d\,(ETA)}$	design value of the moment resistance
$k_{mod\,(ETA)}$	modification coefficient (as per ETA-06/2038)
γ_M	material safety factor

Shear force

$$\frac{\text{exist. } V_d}{\text{perm. } V_d} \leq 1 \qquad \text{with:}$$

$$\text{perm. } V_d = \frac{V_{k(ETA)} \cdot k_{mod(ETA)}}{\gamma_M}$$

$V_{k\,(ETA)}$	characteristic shear force resistance (as per ETA-06/2038)
exist. V_d	design shear force from the superposition
perm. $M_{d\,(ETA)}$	design value of the moment resistance
$k_{mod\,(ETA)}$	modification coefficient (as per ETA-06/2038)
γ_M	material safety factor

Supports

$$\frac{\text{exist. } A_d}{\text{perm. } A_d} \leq 1$$

$$\text{perm. } A_d = \frac{A_{k(ETA)} \cdot k_{mod(ETA)}}{\gamma_M}$$

$V_{k\,(ETA)}$	characteristic shear force resistance (as per ETA-06/2038)
exist. A_d	support reaction, based on partial safety concept
perm. $A_{d\,(ETA)}$	design value of the support reaction
$k_{mod\,(ETA)}$	modification coefficient (as per ETA-06/2038)
γ_M	material safety factor

Holes

All holes must be in the centre of gravity of the web. Holes with a diameter of up to 20 mm can be located anywhere on the beam. A clearance of 40 mm must be observed. The number of holes with a diameter of up to 20 mm in the same row is limited to three.

$$V_{hole,k} = V_k \cdot k_{hole}$$

$$k_{hole} = \frac{H - h_f - 0{,}9 \cdot D}{H - h_f}$$

$$D \le H - 2{,}2 \cdot h_f \le 200\text{mm}$$

V_k	characteristic shear force resistance
$V_{k,hole}$	characteristic shear force resistance of joist beams with round holes
k_{hole}	shear resistance coefficient for joist beams with round holes
h	height of the joist beam
h_f	height of the flange
D	hole diameter

The verifications in the ultimate and serviceability limit states are based on the EWPC Code of Practice:2006.

Initial deflection with shear deflection

Requirement:	from	$w_{inst} < l/300$
	to	$w_{inst} < l/500$
Requirement:		$w_{inst} \le 12.0$ mm

$$w_{G,inst} = \sum_{i \ge 1} G_{k,i}$$

$$w_{Q,inst} = \sum_{i \ge 1} Q_{k,i}$$

Final deflection with shear deflection

Requirement:	from	$w_{inst} < l/200$
	to	$w_{inst} < l/350$

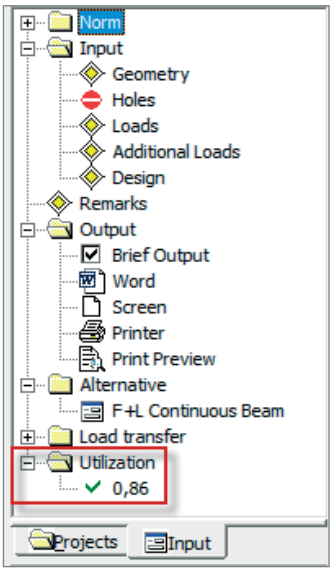
$$w_{G,fin} = \sum_{j \ge 1} G_{k,i} \cdot \left[1 + k_{def}\right]$$

$$w_{Q,fin} = \sum_{j \ge 1} Q_{k,i} \cdot \left[1 + \psi_2 \cdot k_{def}\right]$$

Abbreviations used in the output:

inst	initial deformation
fin	final deformation
gB	deformation by permanent loads due to bending
gS	deformation by permanent loads due to shear
qB	deformation by variable loads due to bending
qS	deformation by variable loads due to shear

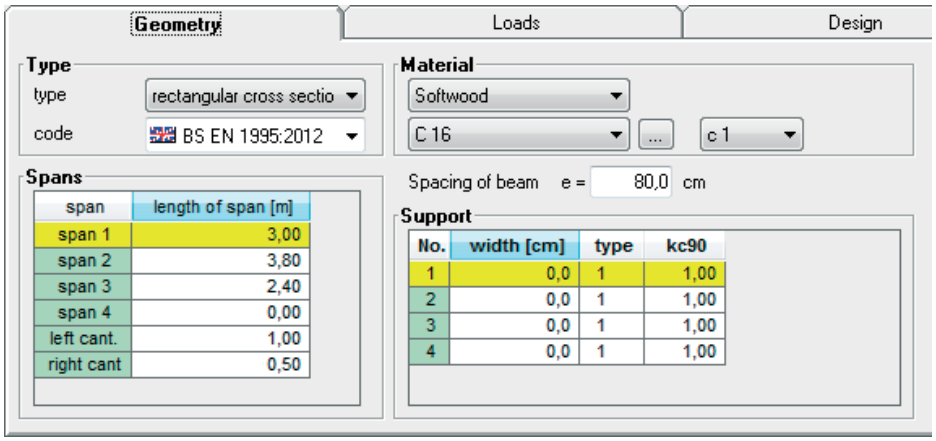
Definition of the structural system



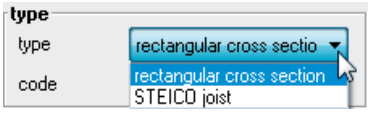
Notes concerning utilization

The maximum utilization can be checked at any time via the main menu. Clicking on the indicated value displays a list of all partial utilizations.

Geometry



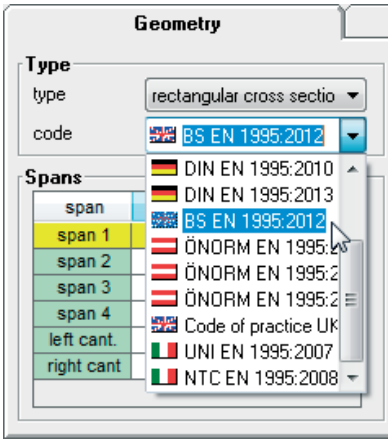
Selection of the beam type



The following types are optionally selectable:

- Rectangular cross sections
- STEICOjoist web beam

Standard selection



Select the desired standard;

see the chapter Application options.

The available standards depend on the selected beam type.

For STEICOjoist beams, only DIN 1052:2004/2008 and EWPC Code of Practice:2006 are available in the current software version.

Material selection

Select the timber species for rectangular cross sections

- softwood
- hardwood
- glulam

and the appropriate sorting and usage classes.

*Note: Softwood and hardwood according to EN 338: 2016 implemented. Laminated wood according to EN 14080:2013 for Germany/Italy. The "old" laminated wood is marked with a * (e.g., GL24c *).*

Clicking on the ... button displays an input window for the material coefficients (depending on the selected standard: specific weight Gamma ...).

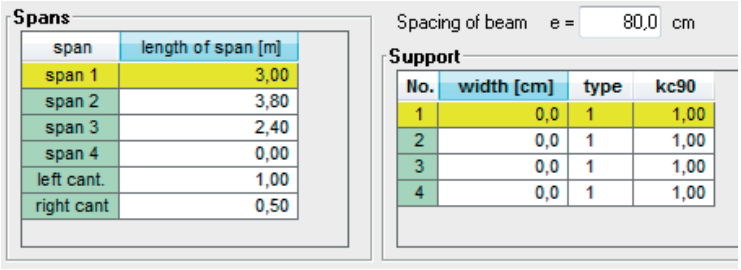
Spans

You can enter the span lengths of 12 spans maximum.

Definition of cantilevers:

Cant. left = cantilever on the left

Cant. right = cantilever on the right



Supports

No. consecutive number of the support

Width supporting width [cm] in the longitudinal direction of the beam

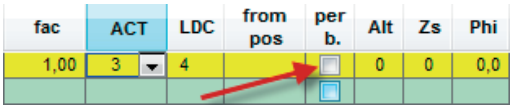
Type type of support: 1 = knife-edge support, 2 = direct, 4 = indirect

kc90 transversal pressure coefficient for the verification of the bearing stress resistance.

Reninf. for STEICOjoist beams, reinforcement is optionally selectable.

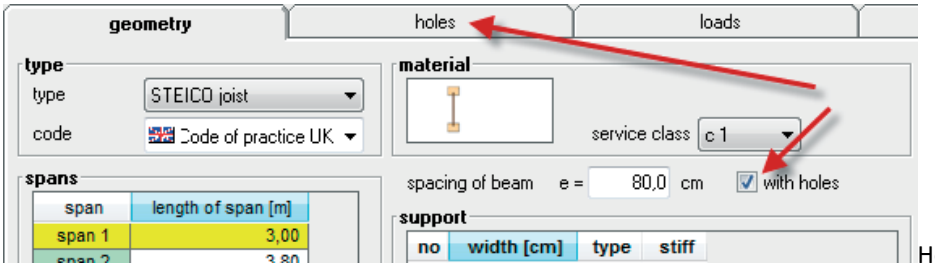
Beam spacing - load influence width e

When **calculating with beam spacing** the load ordinates are automatically adjusted to the defined spacing. The load values are calculated with a load influence width, if no checkmark was set in the column "per beam".
See also the chapter Additional loads.



Holes (STEICO only)

In combination with STEICO beams, you can display an additional tab for the definition of holes by checking the option "With holes".



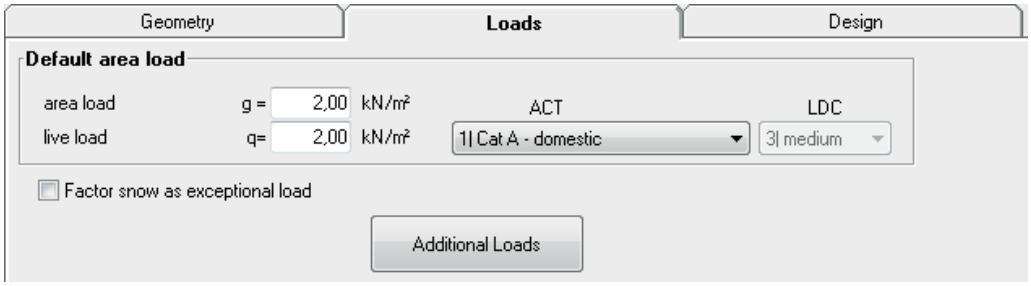
Holes are defined by specifying: the span number, the distance of (the axis or the edge of) the hole to the front end of the span and the diameter.

Loads

The standard loads (g, q) apply over the total length of the beam.

AG action group - assigned to the q load.

LAP the load action period is determined by the selected action and displayed for information only.



Factor for accidental snow load

If you check this option, the snow load is multiplied by the factor C_{esl} for the accidental design situation.

Auxiliary dialog for live and imposed loads

Depending on the selected standard, an auxiliary dialog for the live and imposed loads is displayed when you press the **F5** key in the entryfields g/q.

Activating the ... button accesses a selection table of live loads with default values and an exemplary description.

Additional loads

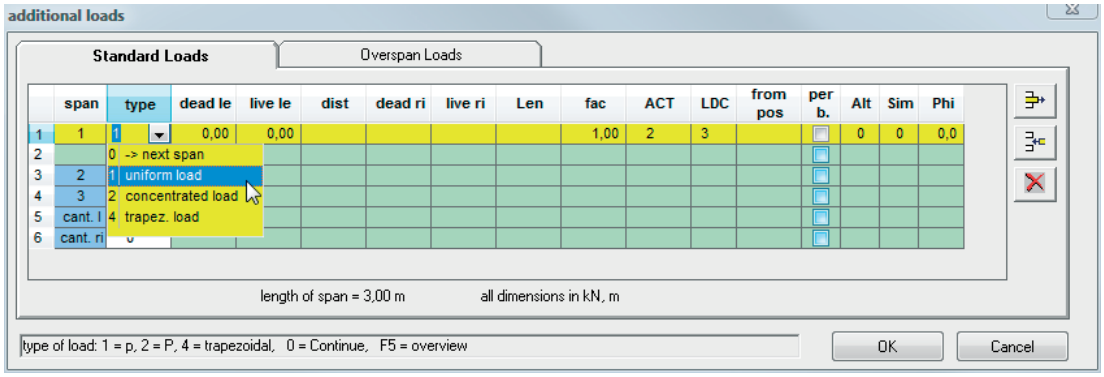
Loads can be entered separately for each span or for the entire beam.

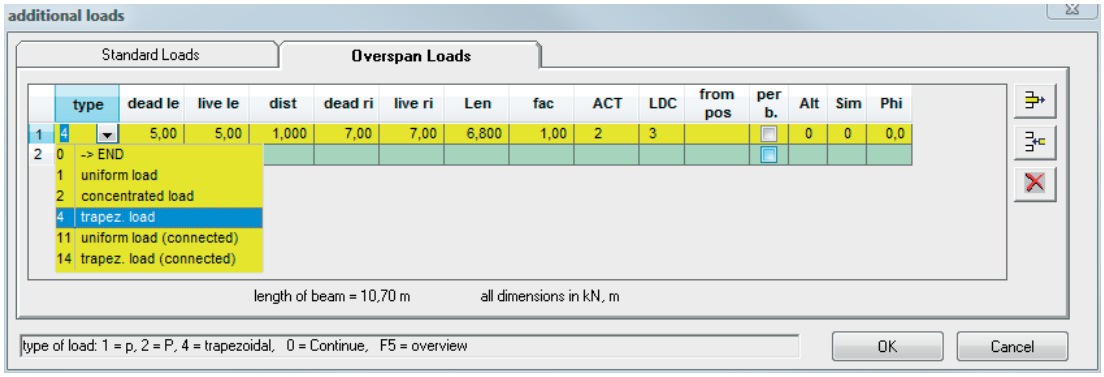
Span loads

The loads are defined for the spans and the cantilevers. They are separated into G and P loads.

Multi-span loads

The loads are defined for the entire beam and a distance to the left end of the beam is specified. They are separated into G and P loads. The P-portions of loads that apply over several spans are not separated according to spans.





Note: Positive loads always act from the top to the bottom.

Span for span loads: number of the span or the cantilever

Type load type: 1 = P = uniformly distributed load over a span

2 = P = concentrated load in a span

4 = P = trapezoidal load in a span

11= uniformly distributed load over several adjacent spans

14= trapezoidal load over several adjacent spans

Gle, Ple vertical load ordinates as main loads; G refers to the permanent loads, P to the variable live loads that apply only over a limited time.
Creep coefficients are calculated from the load relation G/(G+P). You should note that if you define only permanent loading, deflection will be twice as high as elastic deflection!

Dimension of a line load: [kN/m] · factor

Dimension of a concentrated load: [kN/m] · factor

Load transfer (F5 key)

Pressing the F5 key accesses the load transfer dialog, which allows you to take over support reactions from other items of the same project as numerical values (no automatic adjustment after changes!).

Dist distance [m] of a concentrated load or a trapezoidal load to the left member end.

Gri, Pri right load ordinates for G and P of trapezoidal loads

Length load length of a trapezoidal load.

Fact factor by which the specified load values are multiplied in the calculation.

AG action group.
Pressing the **F6** key displays a window with all action groups in the project and the associated combination coefficients and partial safety factors.

EN 1990

As per table A1.1 of EN 1990:2002.

Action group as per EN 1990 for the verification in accordance with EN 1995-1.

EWPC CoP:2006

AS per table A2 of DIN 1055-100, because no NAs are available yet.

Action group as per DIN 1055-100 for the verification in accordance with ETA-06/0238.

LAP displays the load action period.

From item indicates the source of the loading (after the import/load transfer).

Per beam if you check this option the loads are referenced directly to the beam.
See also Beam spacing - load influence width e.

Alt.Grp optional definition of an alternative group.
Different loads can be assigned to an alternative group by allocating a number (≥ 0) to them.
All loads with the same alternative number (unequal to "0") exclude each other.

Con.Grp optional definition of a concurrent group.
All loads of the same concurrent group always apply simultaneously. When using alternative and concurrent groups, please note that you can exclude some combinations completely under particular circumstances.

Phi inclination of the load, e.g. for biaxial loading. 0° = z-direction (vertical)

Design settings

Consider cantilevers with deflections

This problem is not handled in the standard. This option was implemented in order to avoid uneconomic cross sections produced by negative deformation

Creep

In the deformation resistance verifications, creep is automatically considered via the deformation coefficient k_{def}.

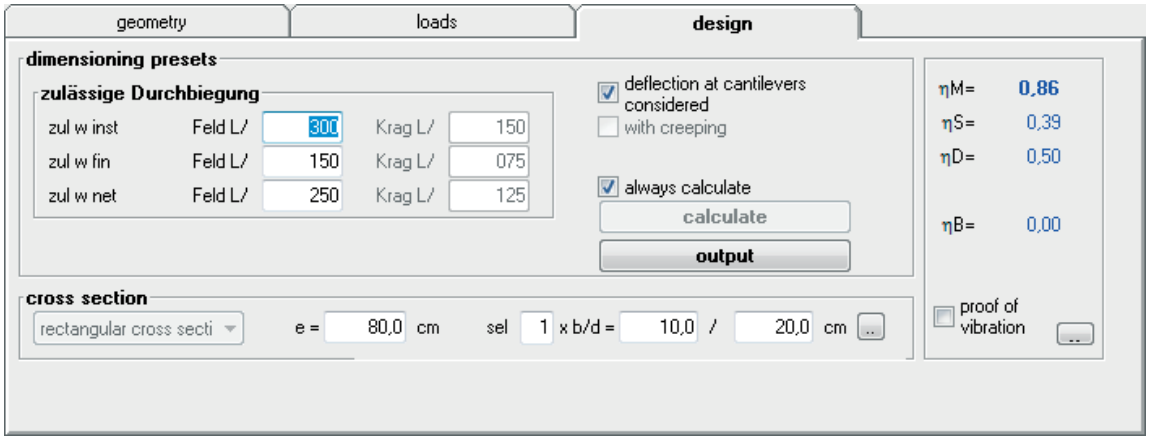
When including creep, always base the calculation on DIN 1052.

Always recalculate

When you check this option, a recalculation is done after each change.

Calculate

This button allows you to launch the calculation manually when the option "Always recalculate" has not been checked.



Limit state of serviceability

The following limits should be specified for the verification of the serviceability:

EN 1995 / DIN EN 1995

Perm. w_{inst}: L / 300 (cantilevers: L / 150)

Perm. w_{fin}: L / 150 (cantilevers: L / 75)

Perm. w_{net}: L / 250 (cantilevers: L / 125)

ÖNORM EN 1995

For the infrequent design situation

Perm. $w_{Q,inst}$: L / 300 (cantilevers: L / 150)

Perm. w_{fin}: L / 200 (cantilevers: L / 100)

For the quasi-permanent design situation

Perm. w_{net}: L / 250 (cantilevers: L / 125)

EWPC Code of Practice:2006

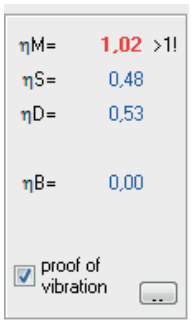
Perm. w_{inst}: L / 333 (cantilevers: L / 167)

Perm. w_{fin}: L / 250 (cantilevers: L / 125)

Perm. w_{inst} 12 mm as an absolute value.

For older standards, → see www.frilo.eu ▸ Service ▸ Documentation ▸ Manuals (DIN descriptions)

Cross section



e	beam spacing / load influence width
sel	Number of selected cross sections - see "multi-part cross sections" below.
b	width of a rectangular timber cross section
d	height of a rectangular timber cross section
ηB	value of maximum utilization for bending stress
ηQ	value of maximum utilization for shear stress
ηf	value of maximum utilization for deformations
ηdy	value of maximum utilization for vibrations
ηA	value of maximum utilization for bearing stress
...	this button allows you to access the cross section optimization dialog.

Multi-part cross sections

In the "gew" field, you can specify the number of profile sections next to each other. You can adjust this value with the help of the ↑↓ keys.

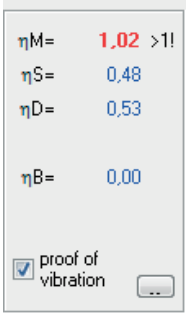
Two sections next to each other are treated in principle as if two members would lie next to each other and bear half of the load each.

STEICO joist

For STEICOjoist (www.steico.com) web beams, the cross section is either defined via a selection list or by clicking on the ... button to display the dialog "STEICO cross section selection". When accessing the dialog you can optionally select whether all cross sections should be calculated (Yes/No).

The permissible beams are marked **green**, the non permissible ones **red**. In the last column, the maximum utilization ratio of the corresponding profile is indicated.

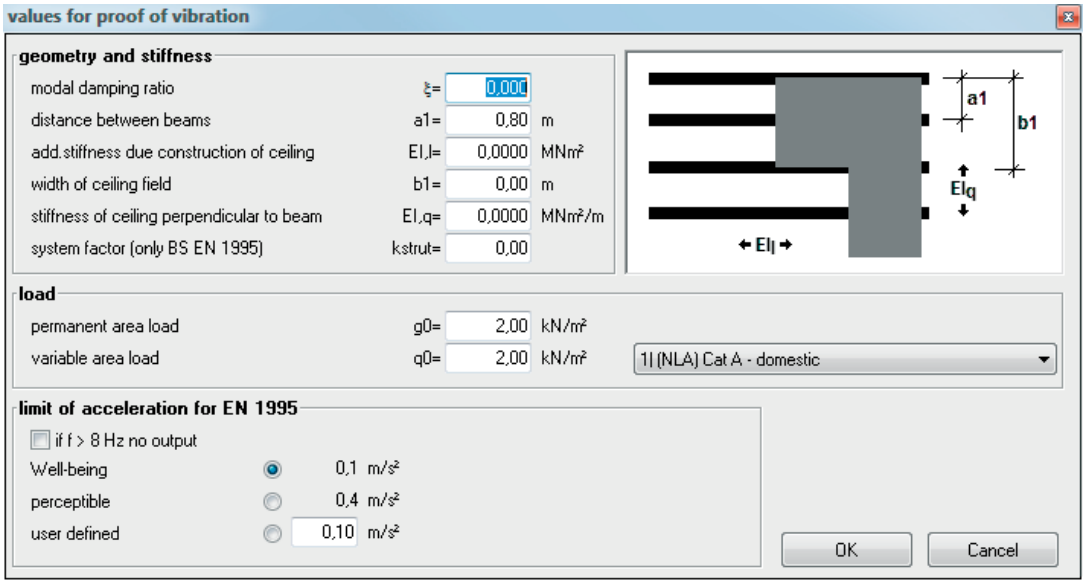
Vibration resistance verification



You can select the vibration resistance verification on the "Design" tab.

☑ activation/deactivation of the vibration resistance verification.

... this button allows you to access the vibration resistance verification dialog.



Geometry and stiffness

ξ	Modal damping ratio
a1	beam spacing
EI,l	additional stiffness due to the ceiling structure
b1	width of the ceiling span
EI,q	ceiling stiffness perpendicular to the beam
kstrut	system factor

Loading

g0	permanent area load
q0	variable area load

You can select an action group in the selection list on the right.

Limitation of acceleration for EN 1995

f resonance frequency

f > 8 Hz: In this case, the following requirements should be complied with for residential ceilings.

- Limitation of the deflection $\frac{w}{F} \leq a$ mm/KN
- Limitation of the vibrating velocity v caused by the unit pulse $v \leq \beta^{(f1 \cdot \zeta - 1)}$ m/(Ns²)

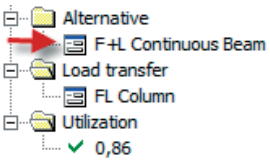
f ≤ 8 Hz: In this case, a separate examination should be carried out for residential ceilings. In this connection, two additional verifications are performed that correspond to the approach described in reference /1/.

/1/ Blaß, H. J. Erläuterungen zu DIN 1052-2004-08 , Bruderverlag March 2005

- Limitation of the vibrating velocity v caused by footfall $v \leq 6 \cdot \beta^{(f1 \cdot \zeta - 1)}$ m/(Ns²)
- Limitation of the acceleration $a_{vert} \leq 0{,}1 \text{ m/s}^2 - 0{,}4 \text{ m/s}^2$

You can optionally disable these additional verifications for structural systems with f > 8 Hz.
See also definition example Vibration as per DIN EN 1995 at www.frilo.eu
▸ Service ▸ Documentation ▸ Reference examples.

Alternative calculation with the DLT application



If you have installed the application DLT Continuous Beam in addition, you can launch this software by double-clicking on the corresponding menu item (Main menu ▸ Alternative) and calculate the current HO7 item in DLT. You can also launch the software via the **Edit** menu item.

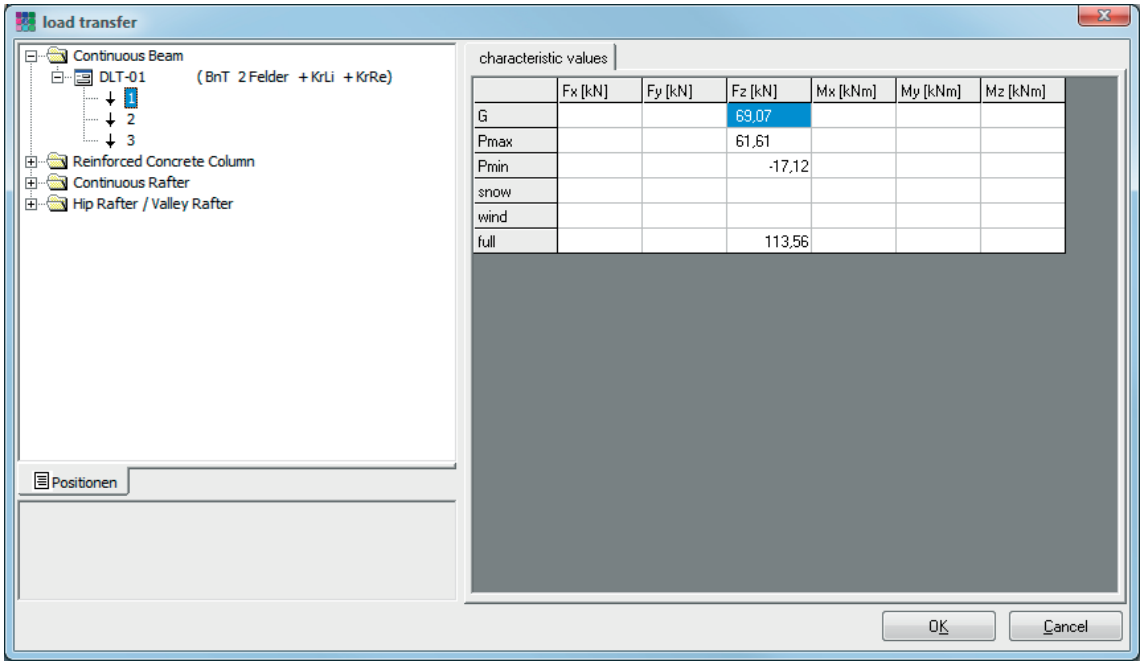
Important note!

STEICO beams cannot be handled in the current version of DLT!

Load transfer

Import of load values

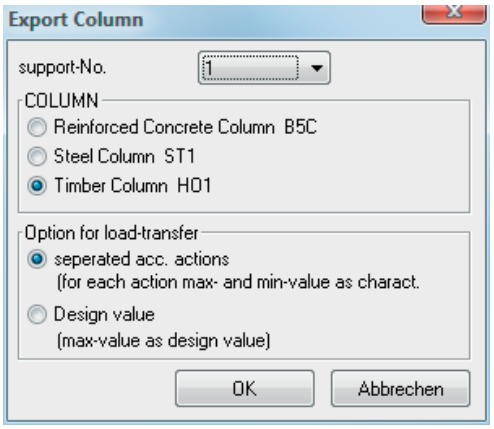
Pressing the F5 key when the cursor is in one of the fields Gli, Pli, Gre or Pre of the Load definition displays the load transfer dialog. Support reactions of other items of the same project can be taken over as numerical values (no automatic adjustment after changes). Select in the left window section the software application, the item and the desired support. Subsequently, click on the desired value in the right window section and confirm your selection by clicking OK.



Export of load values

Via the F+L Column item, you can access the dialog for the load transfer to the software applications B5 Reinforced Concrete Column, ST1 Steel Column and HO1 Timber Column.

Select the software, the support number and other associated options and confirm your settings with OK. The selected software is launched and the values are registered in the load table.



Output

The user can launch the output of system data, results and graphical representations on the screen or the printer via the Output menu item → See also the document Output and Printing - FDC and output in the Frilo.Document.Designer

Word	If installed on your computer, the text editor MS Word is launched and the output data are transferred. You can edit the data in Word as required.
Screen	displays the values in a text window on the screen
Printer	starts the output on the printer
Page view	(file menu) displays a Print preview.