

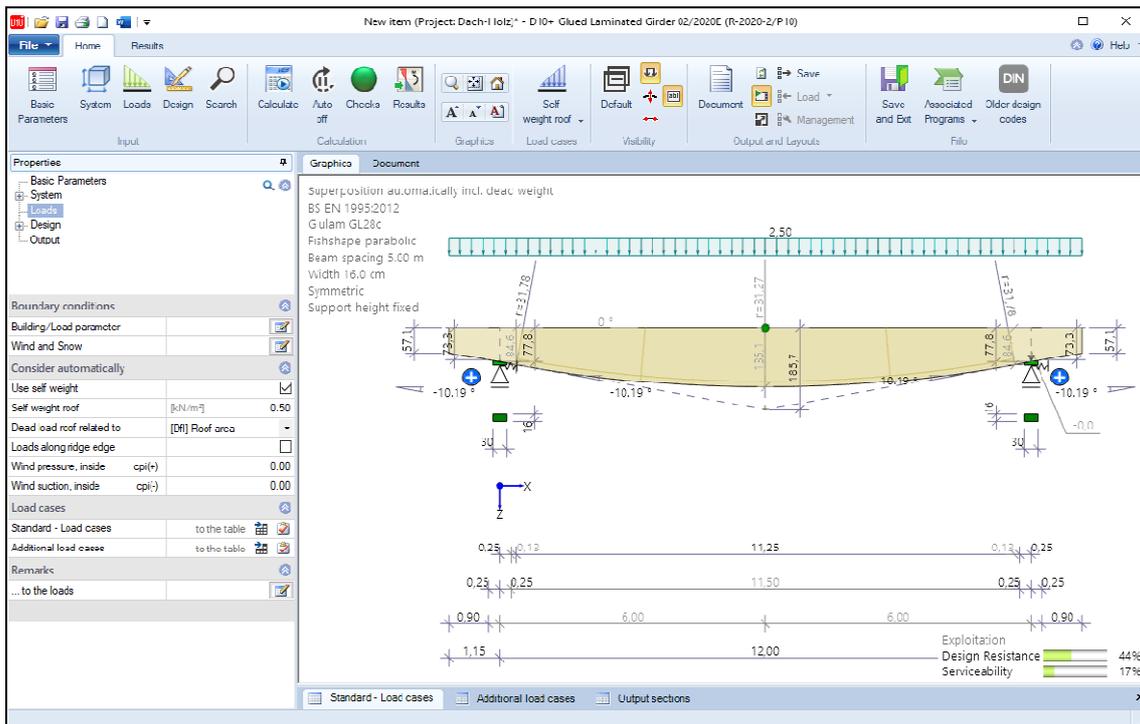
D10+ Glued Laminated Girder

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D10+ Glued Laminated Girder

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Basic Documentation - Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage www.frilo.com ▶ Support ▶ Articles/Information ▶ Basic operating instructions.

Application options

The D10+ program is suitable for the design and optimization of the following girder types:

- Parallel chord straight/curved
- Single-pitch roof
- Saddle roof UK straight/round
- Fishbelly circular/parabolic
- Ridge options
 - without saddle
 - sway saddle with raised dry joint
 - fixed saddle

The plies can optionally run in parallel to the girder top edge if the geometry allow this.

The structural systems that can be calculated in this program comprise single-span girders with one or two cantilevers.

Available standards

- DIN EN 1995
- ÖNORM EN 1995
- BS EN 1995
- NTC EN 1995
- EN 1995

Loads

The loading of the girder is realized by automatically generated "standard load cases" (wind/snow) and/or by freely definable "additional load cases".

Verifications - Calculation

Verifications are carried out for cut grains and shear stresses, the increased longitudinal edge stresses, transverse tension and the interaction between transverse tension and shear at ridge points as well as normal force.

In addition, the stability against tilting and the resistance to bearing stress and deformation are verified. A camber can be specified separately for the span and the cantilever to verify the serviceability.

The lateral girder load is determined and the rise of the initial imperfection can be specified.

Calculation options

- Depending on the relevant NA, options are offered for reducing the design shear force, such as the reduction of concentrated loads close to the supports.
- Optionally, torsion in the area of the supports due to pre-deformation can be taken into account in the shear resistance analysis including the calculation of the fork support moments.
- Transverse tensile reinforcements: automatic laying of transverse tensile reinforcements with glued-in threaded rods and fully threaded screws including dimensioning of the holes to be produced along the edges of the girder.
- By specifying a distance to the lower girder edge, the user can control the spacing in the transverse tension zones and how the spacing dimensions are rounded. The weakening of the cross section is taken into consideration in the other verifications.
- Fire protection: Verification of the fire resistance period.

Output

The scope of the output can be reasonably limited by options.

You can optionally include e. g. a parts list of the transverse reinforcements in the output.

Graphical display of results

The following graphics can be displayed for combinations and load cases

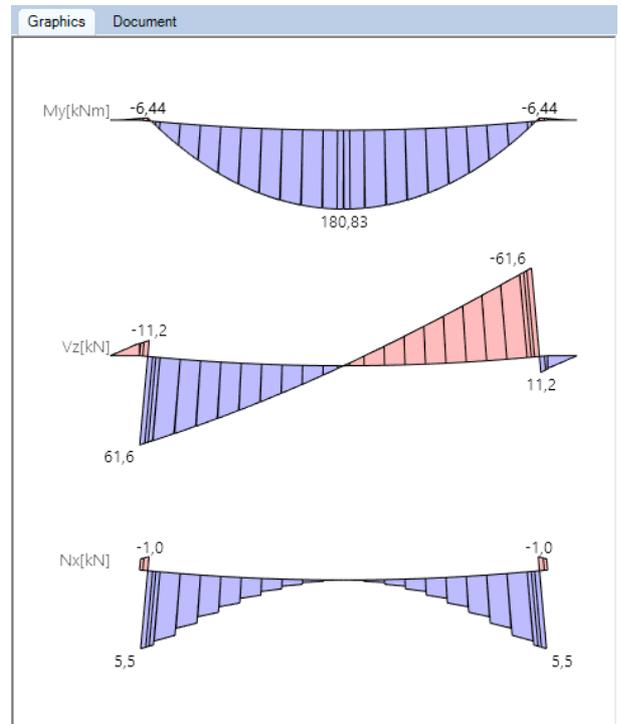
- Internal forces M, V
- Support reactions Az
- Deflection wz
- Maximum utilizations

Construction

- Timber volume and surface area to be coated

Load transfer

The bearing loads can be transferred to the program Timber Column HO1+ and the Toolbox module TB-HHP Timber Pressure.



Basis of calculation

All internal forces, superpositions and verifications are calculated with consideration to the special requirements of the selected design standard and its National Annexes.

The verifications of the bending load resistance with consideration of cut grains, the shear load resistance, the stability (against tilting, with different effective lengths for the cold and hot design, if applicable) and the serviceability (deflection) are performed.

In the area of the ridge and/or the curvatures, additional verifications to check increased strain on the longitudinal edge, transverse tension and the interaction of transverse tension and shear force can be performed.

Normal forces are taken into account in the verifications.

The design of transverse tensile reinforcements follows the rules of the selected standard. If it does not specify any rules for transverse tensile reinforcements, the calculation is based on the National Annex for Germany, which is considered as a generally acknowledged rule of engineering in this case.

With curved plies, the ratio of radius to ply thickness (R/t) is checked and, in case of an excessive curvature, a warning message is displayed!

The verifications in the area of the cantilevers are limited to bending stress and shear stress analyses. We like to point out, however, that due to the complex geometry in the area of the supports, stress states similar to those in the ridge area might occur under particular conditions. The required verifications cannot be performed in this program.

The girder is divided into subsections according to the changes in its geometry. Internal forces and deformations are determined in a strut-and-tie calculation.

Restrictions:

According to Eurocode, there are no restrictions regarding geometry and cut grains. Reference is made to the limitation of the cross grain cutting angle to 24° in the NAD.

D10+ allows the calculation of any defined geometry, in order to provide designers with a tool for the evaluation of their construction even in exotic cases. However, further verifications may be required.

Notches and cross-sectional jumps in the area of the support or the cantilever are not verified.

A verification of the stability against displacement is not performed.

Data entry

General notes concerning the data-entry fields

This program allows the calculation in accordance with various standards and National Annexes. Some of these standards differ considerably in regard to the load application, the combination rules, the determination of the decisive internal forces and the verification process.

Therefore, the data-entry fields and options can differ from those described below depending on the selected standard.

Basic parameters

Selection of the standards and the materials. Moreover, you can define the strength class and the service class as well as the specific weight in this section.

Strength class:

You can adjust the strengths and stiffnesses. To do this, click in the data-entry field and press the F5 key. In the pop-up menu "User-defined material" you can enter/edit/save/load new materials.

Combinatorial analysis

The available selection options and data-entry fields depend on the selected standard

- kmod** check this option to use the modification coefficient 'kmod' under wind action as an average value for the load duration classes 'short' and 'very short'.
- ψ_2** check this option to increase the value of the combination coefficient ψ_2 to 0.5 for snow action in the seismic design situation (AE). (See introductory decrees of the German federal states, e. g. Baden-Württemberg).

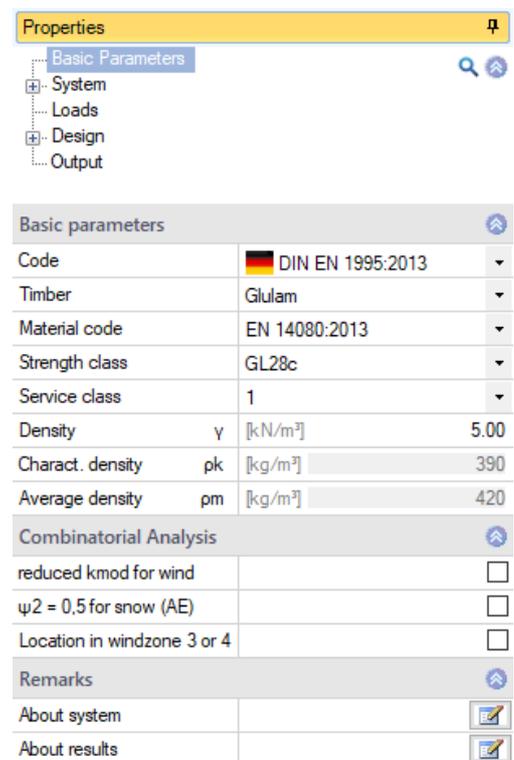
Wind zone check this option if the building is situated in wind zone 3 or 4. In this case, you need not consider snow as an accompanying action to wind, which is the leading action.

Consequence class select the consequence class to determine the partial safety factors.

Combination equation select the equation from EN 1990 that should be used for the load combination in the permanent/transient design situation (6.10 and 6.10 a/b).

Comments

You can enter texts about the system and the results, which optionally appear in the output.



The screenshot shows the 'Properties' window in the software. The 'Basic Parameters' section includes the following fields:

Code		DIN EN 1995:2013	
Timber		Glulam	
Material code		EN 14080:2013	
Strength class		GL28c	
Service class		1	
Density	γ	[kN/m ³]	5.00
Charact. density	ρ_k	[kg/m ³]	390
Average density	ρ_m	[kg/m ³]	420

The 'Combinatorial Analysis' section includes the following options:

reduced kmod for wind	<input type="checkbox"/>
$\psi_2 = 0,5$ for snow (AE)	<input type="checkbox"/>
Location in windzone 3 or 4	<input type="checkbox"/>

The 'Remarks' section includes the following options:

About system	
About results	

Structural system

Recommendation: Enter the structural system and the girder shape directly via the [context-sensitive menu](#) on the graphic screen!

Selection of the girder type.

Straight TC/BC	parallel chord girder or single-pitch roof girder
Gable roof	double-pitch roof girder with straight bottom edge
General	girder with curved bottom edge, with or without fixed saddle and arch beam

- Parallel chord straight/curved
- Single-pitch roof
- Saddle roof bottom edge straight/round
- Fishbelly circular/parabolic

To simplify the input, the option "Symmetrical" can be clicked.

Roof pitch roof pitch on the upper chord left and right.

Girder spacing the girder spacing is assumed to be the load influence width when generating standard load cases.

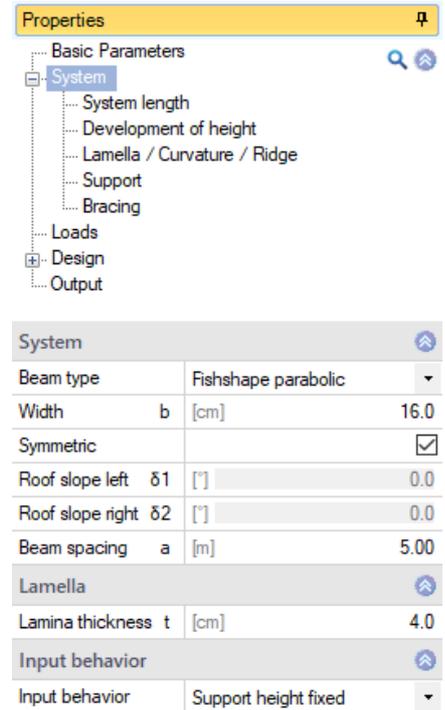
Input behaviour

Note: You can toggle during editing without changing the structural system!

Fixed RP and ridge the roof pitch and the position of the ridge in the span are retained when entering data. The bottom edge and the elevation of the supports are adjusted.

Fixed support elevations the elevation of the supports is retained when entering data. Top edge, ridge point and roof pitch are adjusted if necessary. If a roof pitch is changed, the ridge is shifted, the elevation of the ridge and the construction height remain the same.
[Construction height \$H_m\$](#) : Distance of the intersection of the upper edges to the line connecting the ends of the support areas a_1/a_2 on the span sides.

*Note: Both modes develop their individual strengths in **asymmetrical** systems.*



System	
Beam type	Fishshape parabolic
Width	b [cm] 16.0
Symmetric	<input checked="" type="checkbox"/>
Roof slope left	δ1 [°] 0.0
Roof slope right	δ2 [°] 0.0
Beam spacing	a [m] 5.00
Lamella	
Lamina thickness	t [cm] 4.0
Input behavior	
Input behavior	Support height fixed

System lengths

In this section, you can enter the horizontal dimensions of the girder. The system lengths L1 and L2 refer to the ridge point.

Cantilever notch the bottom edge of the cantilever can be above or below the bearing surface, unlike in the previous version of D10. This allows the realization of constructive roof overhangs with a smaller cross-section or birdsmouth joints.

Elevation development

Enter the vertical cross-section heights and the pitches of the bottom edges in this section.

Construction height Hm: Distance of the intersection of the upper edges to the line connecting the ends of the support areas a1/a2 on the span sides.

Right z-coordinate of support: relative elevation of the support on the right, in relation to the support on the left.

Properties  

- ... Basic Parameters
- [-] System
 - System length
 - Development of height
 - Lamella / Curvature / Ridge
 - Support
 - Bracing
- ... Loads
- [+] Design
- ... Output

System length 			
Field length	L	[m]	12.00
Field length left	L1	[m]	6.00
Field length right	L2	[m]	6.00
Length cantilever left	Lk1	[m]	1.15
Length cantilever right	Lk2	[m]	1.15
Cantilever left notch	Lk1	[m]	0.90
Cantilever right notch	Lk2	[m]	0.90
Support width 			
Cantilever left	ak1	[m]	0.25
Field left	a1	[m]	0.25
Inclined left			<input checked="" type="checkbox"/>
Field right	a2	[m]	0.25
Cantilever right	ak2	[m]	0.25
Right inclined			<input checked="" type="checkbox"/>

Properties  

- ... Basic Parameters
- [-] System
 - System length
 - Development of height
 - Lamella / Curvature / Ridge
 - Support
 - Bracing
- ... Loads
- [+] Design
- ... Output

Beam height 			
Support left	H1	[cm]	77.8
Support right	H2	[cm]	77.8
Cantilever left	Hk1	[cm]	73.3
Cantilever right	Hk2	[cm]	73.3
Cantilever left notch	Hk1u	[cm]	0.0
Cantilever right notch	Hk2u	[cm]	0.0
Cantilever end left	HEk1	[cm]	57.1
Cantilever end right	HEk2	[cm]	57.1
Inclination lower edge 			
Inclination field left bottom	$\delta 1$	[°]	-10.2
Inclination field right bottom	$\delta 2$	[°]	-10.2
Inclination cantilever btm	$\delta k 1$	[°]	-10.2
Inclination cantilever ri. btm	$\delta k 2$	[°]	-10.2
Other values 			
Support Z-coordinate right	ΔZ	[cm]	0.0
Construction height	Hm	[cm]	185.7

Plies / Curvature / Ridge

Note: The menu is adjusted according to the selected girder type.

In this section, you can define the length of the curvature, the radius of curvature, the thickness of the plies as well as the orientation of the plies.

The informative field 'R/t' indicates the ratio of the radius to the ply thickness. A value of 300 or more is considered a good value for production.

Type of saddle: in connection with the options 'without saddle' or 'with sliding saddle' you can specify the height 'hm' in the ridge or the position of the dry joint.

Properties

- Basic Parameters
- System
 - System length
 - Development of height
 - Lamella / Curvature / Ridge
 - Support
 - Bracing
- Loads
- Design
- Output

Curvature			
Length of curvature	Lc	[m]	11.25
Arc Radius	R	[m]	31.78
Ration	R/t		794

Ridge			
Ridge			No ridge
Height of beam (ridge)	hm	[cm]	185.8
Lamina thickness	t	[cm]	4.0
Lamellas direction			Parallel lower edge

Supports

In this section, you can enter the lengths of the support areas and the dimensions of the supports.

The dimensions of the supports are limited by the length of the support areas ak1,a1, a2, ak2 and the girder width.

Properties

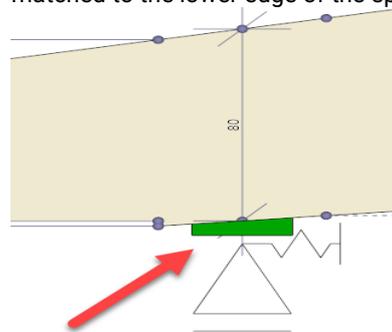
- Basic Parameters
- System
 - System length
 - Development of height
 - Lamella / Curvature / Ridge
 - Support
 - Bracing
- Loads
- Design
- Output

Support area

ak1/ak2 the dimension from the support axis to the end of the support area on the cantilever.

a1/a2 the dimension from the support axis to the end of the support area in the span.

Left/Right inclined each support area can be inclined - the inclination is matched to the lower edge of the span.



D10SystemSupports

LenA1SigmaReduceEff		<input type="checkbox"/>
LenA2SigmaReduceEff		<input type="checkbox"/>

Support area left			
Cantilever	ak1	[m]	0.25
Field	a1	[m]	0.25
Inclination			<input checked="" type="checkbox"/>
Längsspannungen reduzieren			<input type="checkbox"/>

Support area rights			
Field	a2	[m]	0.25
Cantilever	ak2	[m]	0.25
Inclination			<input checked="" type="checkbox"/>
Längsspannungen reduzieren			<input type="checkbox"/>

Support left			
Length	Lx	[cm]	30.0
Width	By	[cm]	16.0
Transverse pressure factor	kc,90		1.75

Support right			
Length	Lx	[cm]	30.0
Width	By	[cm]	16.0
Transverse pressure factor	kc,90		1.75

Bearing conditions			
Bearing X-direction			Both with low

Lx length of the support area in girder direction. It is at most as large as the support area.

By width of the support area across the girder.

kc,90 transversal pressure coefficient for the bearing pressure analysis.

In the section 'Bearing conditions', you can define whether the support is fixed:

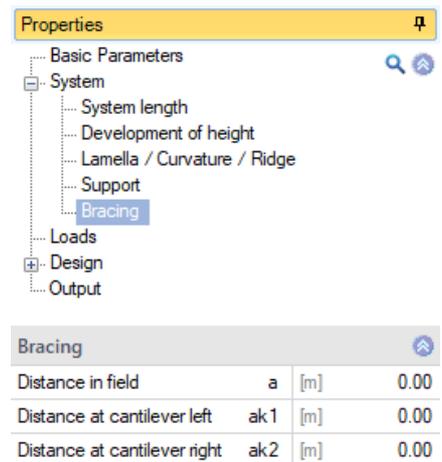
Support x-direction fixed/soft for left and right

Alternatively, the simulation of two very soft supports (spring approx. 1 kN/m) is available to simulate a girder on two cantilever columns for instance.

Bracing

a distance of the lateral restraints in the span, 0 = continuous

ak1/ak2 distance of the lateral restraints on the cantilever arm, 0 = continuous



The screenshot shows a 'Properties' window with a tree view on the left and a table on the right. The tree view includes 'Basic Parameters', 'System', 'System length', 'Development of height', 'Lamella / Curvature / Ridge', 'Support', 'Bracing', 'Loads', 'Design', and 'Output'. The 'Bracing' section is expanded, showing a table with the following data:

Bracing			
Distance in field	a	[m]	0.00
Distance at cantilever left	ak1	[m]	0.00
Distance at cantilever right	ak2	[m]	0.00

Loads

Border conditions

Building/Load Parameters

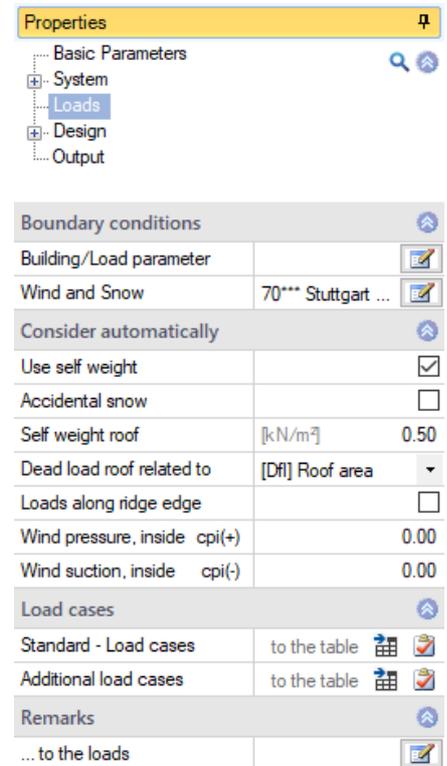
A dialog for entering the values for the building geometry and the position of the girder in the building is displayed:

- Elevation of the left support above the ground
- Number of girders including gable walls/gable girders
- Distance between girders, corresponds to the load influence width
- Length of the building
- Continuity factor: the load influence width (girder spacing) is multiplied by this factor
- Area with increased wind suction: the girder is exposed to increased wind suction in the edge/corner area at the gable

Wind and snow

A dialog for entering the values to determine the snow and wind loads is displayed:

- Selection of a municipality/altitude above sea level.
- Selection of wind and snow zones.
- View of building with snow and wind loads



Boundary conditions		
Building/Load parameter		
Wind and Snow	70*** Stuttgart ...	
Consider automatically		
Use self weight		<input checked="" type="checkbox"/>
Accidental snow		<input type="checkbox"/>
Self weight roof	[kN/m ²]	0.50
Dead load roof related to	[Dfl] Roof area	
Loads along ridge edge		<input type="checkbox"/>
Wind pressure, inside cpi(+)		0.00
Wind suction, inside cpi(-)		0.00
Load cases		
Standard - Load cases	to the table	
Additional load cases	to the table	
Remarks		
... to the loads		

Consider automatically

Self-weight	the self-weight of the girder and its distribution over the girder length is automatically included. The type of saddle is taken into account. You can optionally switch off the automatic consideration.
Accidental snow	you can apply snow as an accidental load, e. g. for the Northern Lowlands of Germany.
Factor for acc. snow	factor for the accidental snow load, typically 2.3 in the Northern Lowlands of Germany
Dead load roof	permanent loads of the roof construction consisting of purlins, bracings, roof covering etc.
Dead load roof related to	the dead load can be related either to the roof area or the floor area.
Wind pressure/suction inside cpi	coefficients for wind pressure/suction inside the building. They depend on openings in the outer skin and open sides of the building. Suction = positive value; pressure = negative value. Internal suction and internal pressure are added to the respective load cases of imposed roof loads acting in the same direction. This means either suction on the roof and internal pressure or pressure on the roof and internal suction.

Load cases

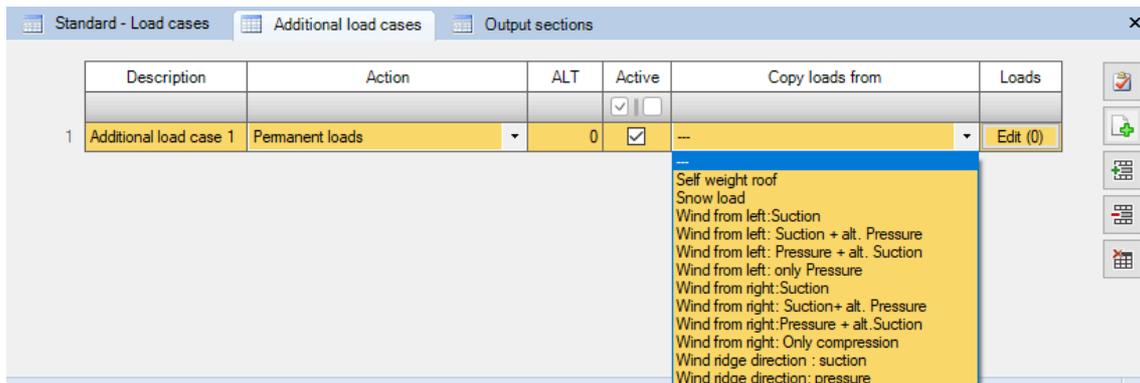
Via the icon "to table" or via the tabs below the graphic screen, you can access the input tables for the standard load cases and the additional load cases.

Standard load cases

Wind and snow loads are automatically generated as "standard load cases" according to the relevant standards. These load cases can be switched on and off individually or as a whole in the "Active" column but cannot be edited. Internal pressure or suction can be enabled via the fields cpi(+) and cpi(-). "Standard load cases" can be copied to "Additional load cases" and edited there (column: "Copy loads from"). In addition, [accidental snow load](#), e. g. in the North German lowlands, can be taken into account with a freely selectable factor.

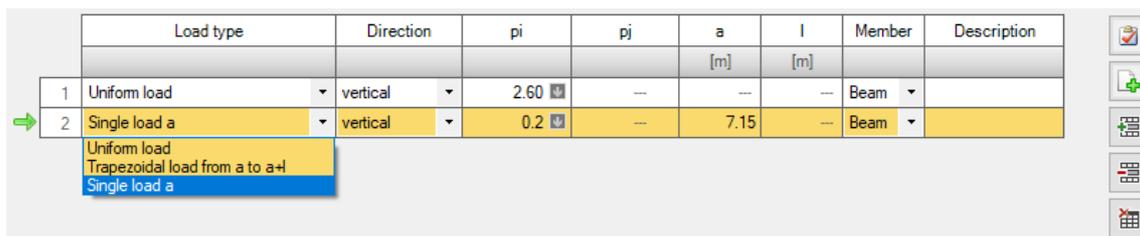
Additional load cases

In this section, you can define your own load cases or copy "standard load cases" to supplement or modify them.



Alt load cases of the same alternative group (> 0) do not apply simultaneously

For each load case, you can enter loads via the "Edit" button.



Note: To add a new table row, click on the "+" icon on the right.

- Load type uniform linear load, trapezoidal load and concentrated load.
- Direction transverse, vertical, v. projection
- pi, pj load value at the beginning or end of the line load
Via the arrow icon , a load value compilation can be called up - see description in the LAST+ program.
- a specifies the distance of the load to the front end of the component.
- l specifies the length of the line load.

During the calculation, all load cases (standard and additional load cases) that are set to active are automatically superimposed in accordance with the valid combination rules and with consideration of alternative groups.

Design

Shear design

Reduction of line loads

The share of distributed loads in the design shear force is determined at a distance $a = 1 * h$.

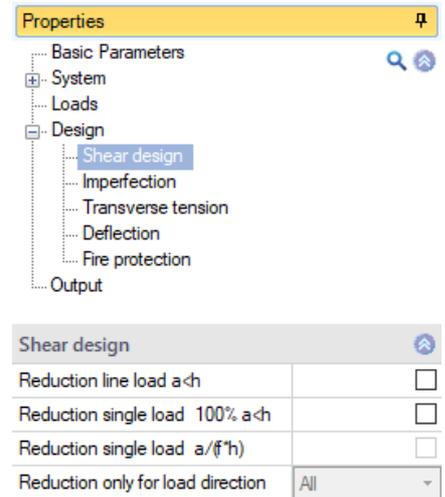
This option may be used for girders under bending stress with supports at the lower girder edge and load application at the upper girder edge. Accordingly, the essential loads should act opposite the support and press into the support.

Reduction of concentrated loads

The share of concentrated loads in the design shear force is not considered if the concentrated load applies at a distance of maximally $a = 1 * h$ from the edge of the support.

This option may be used for girders under bending stress with supports at the lower girder edge and load application at the upper girder edge. Accordingly, the essential loads should act opposite the support and press into the support.

Optionally, you can reduce all loads or only loads acting in a particular direction.



Imperfection

Optional application of the German rule for torsion by horizontal deformation:
"Md/80 rule"

Imperfection horizontal	horizontal imperfection in middle of the span related to the span length. L/400 pre-deformation L/500 deformation of the bond L/222 = total = entered value Exact values of a deformation calculation of the bond may also be used.
Elevation of bond	distance of the bond from the girder axis in relation to the cross-section height. Upper edge = 0.5; lower edge = -0.5. This takes the backing effect of the bond into account.
Parabolic shape	the parabolic shape corresponds to the derivation with the result: $MT = Md / 83.33$
Always for...	Optionally, the torsional moment is always applied for the cross-section design in front of the support. The rule $\lambda_{ef} < 225$ to dispense with the torsional moment is disregarded.

Transverse tension

You can select how the minimum force for transverse tensile reinforcements should be determined:

According to standard the reinforcement is designed in accordance with the standard.

Constructive constructive reinforcement for transverse tension caused by climate conditions.

Full reinforcement the reinforcement is designed for the full transverse tensile force.

As a connection device type you can select:

- glued-in threaded rods
- fully threaded screws
- other means of connection

Deflection

Perm. w_{NetFin} permissible total deflection $w_{NetFin}(\text{standard}) = L/150$

Cambers

Span camber upwards is positive

Cantilever camber left upwards is positive

Cantilever camber right upwards is positive

Deflection analyses

Here you can enable/disable the deflection analyses for spans and cantilevers.

Fire protection

If the option "Fire exposure" is checked you can specify the required fire resistance period (t_F) in minutes and select the exposed sides of the girder.

Based on these specifications, the program selects the charring rates, which depend on the material and the selected standard.

Always perform shear analysis

The shear analysis under fire exposure is not required by all standards. There is no verification defined in EN 1995, for instance. If laminated girders are used, which often have the smallest cross sections in the areas with the highest shear loading, the analysis should always be performed.

The option "Always perform shear analysis" ensures the required verifications also in combination with standards and NAs that do not explicitly require this analysis. Old German verifications are used, which have been converted into the modern form of verification (DIN 4102-4:1994 and DIN 4102-22:2004, cf. Holz-Brandschutz-Handbuch, Verlag Ernst & Sohn). According to these standards, the shear utilization under fire exposure is derived from the shear utilization at normal temperatures. It results from the formula:

$$\eta_{fi} = 0,5 \cdot \frac{\eta_{NT} \cdot b_{NT} \cdot h_{NT} \cdot k_{mod,NT}}{b_{fi} \cdot h_{fi} \cdot k_{fi}}$$

Always simplified

Most standards allow principally a more accurate and a simplified method. For some verifications, a particular method is stipulated.

Therefore, the application switches automatically to the suitable method in accordance with the selected standard, NA and the loading. The additional charring rates associated to each verification are automatically taken into account.

The "Always simplified" option makes sure that the simplified method is used in all verifications, even if it is not allowed by the selected standard. In most cases, the simplified method is on the safe side.

The applied method and the residual cross sections are indicated in the output.

Lateral restraints under fire

Check this option to enter other distances in the event of a fire, e. g. due to the failure of the bond or the roof panel. Bracing components (such as the roof bond, panel, ...) may have a lower fire resistance period than the girder.

See also → [Fire protection verification of timber components.pdf](#)

Output

Before starting the output, click on the calculation icon if the option "automatic calculation after each input" is switched off ("Auto off" icon).

After the calculation, the utilization is displayed in the lower right section of the graphics window and provides a good overview of the efficiency of the structural system entered.

Output scope

By checking the desired options, you can determine the scope of data to be put out. You can also define output sections and/or have them put out by the "Verifications at significant sections" program.

Properties	
Basic Parameters	<input type="checkbox"/>
System	<input type="checkbox"/>
Loads	<input type="checkbox"/>
Design	<input type="checkbox"/>
Output	<input checked="" type="checkbox"/>
Comment to system	<input checked="" type="checkbox"/>
Volume, surface, transport height	<input type="checkbox"/>
Cross-section values I, A, W	<input type="checkbox"/>
Remarks to the loads	<input checked="" type="checkbox"/>
Load case graphics	<input type="checkbox"/>
Support reactions load cases	<input type="checkbox"/>
Combination factors	<input type="checkbox"/>
Combination schedule (decisive)	<input type="checkbox"/>
Support reactions combinations	<input type="checkbox"/>
Graphics inner forces decisive combination	<input checked="" type="checkbox"/>
Grafik maßgebende Ausnutzungen	<input type="checkbox"/>
Design results	Decisi
Checks at significant points	None
Output sectio	0/0
Field	L
X	X [m]
Summary beam results	None
Bearing stress	<input checked="" type="checkbox"/>
Side load qs load cases	<input type="checkbox"/>
Schedule of connection means	<input checked="" type="checkbox"/>
Deflection design	<input checked="" type="checkbox"/>
Deformation support	<input type="checkbox"/>
Remarks to the result	<input checked="" type="checkbox"/>

Result options

File Home Results

Combinations

System

Lc 1: STR(*) : 1.35xLC1 + 1.35xLC2 + 1.50xLC3 + 1.35xLC14 (

System Internal forces

Internal forces Support forces Deflection w_z Maximum utilization Utilization

Via the "Results" tab, you can display the different result graphs.

Output as a PDF document

Via the Document tab, you can displays the document in PDF and print it.

See also [Output and printing.pdf](#)