FWT – Trusses Timber/Steel

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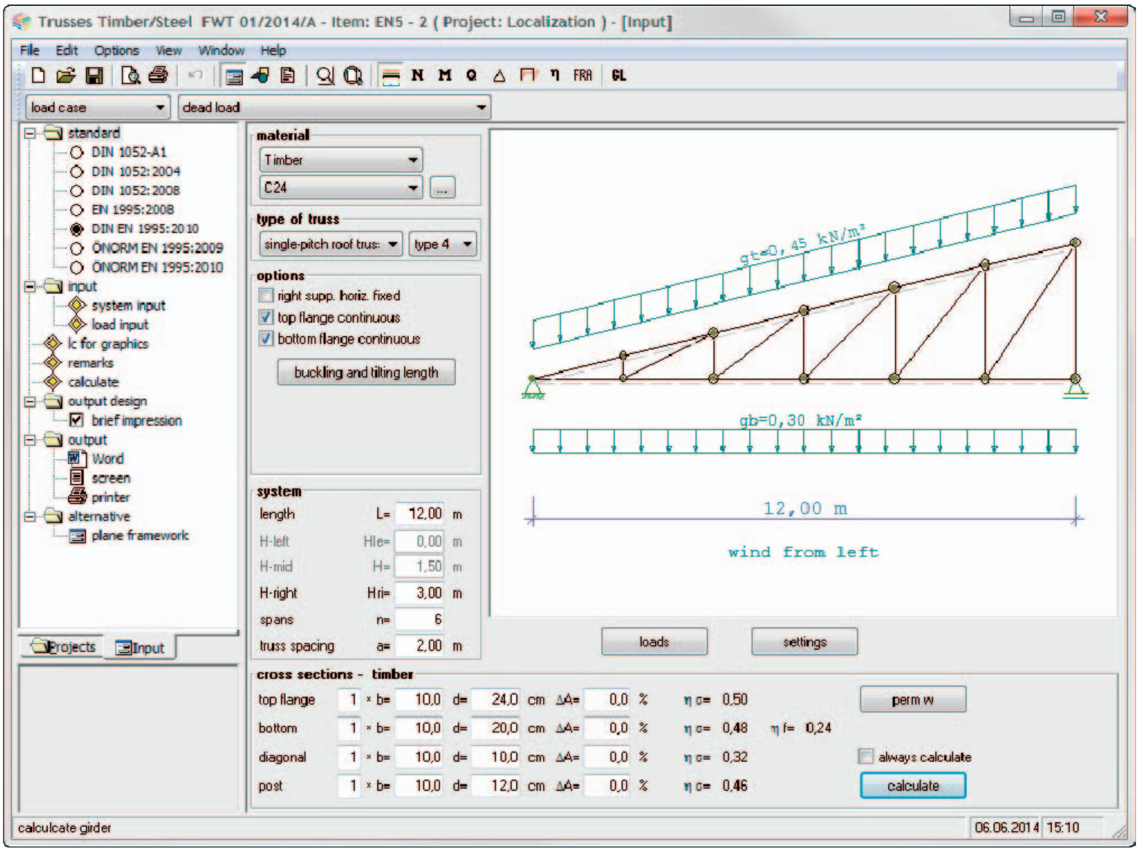


FWT – Trusses Timber/Steel

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

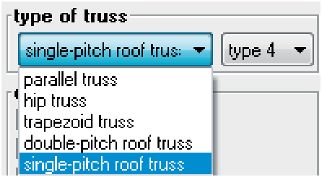
Further information and descriptions are available in the relevant documentations:

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 software is suitable for the structural calculation and design of trusses (timber/steel) typical in the construction of portal frames:

- Parallel truss
- Hip truss
- Trapezoidal truss
- Double-pitch roof truss
- Single-pitch roof truss



Continuous chords can be taken into account as rigid members.

Deflection is calculated in accordance with the first order theory.

Available standards

EN 1995

DIN EN 1995

ÖNORM EN 1995

EN 1991

DIN EN 1991

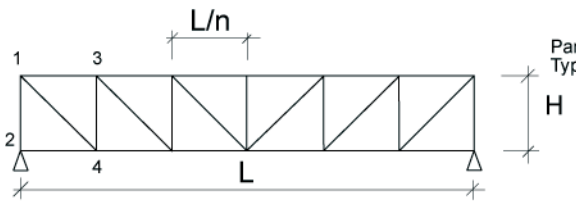
ÖNORM EN 1991

Obsolete standards still available:

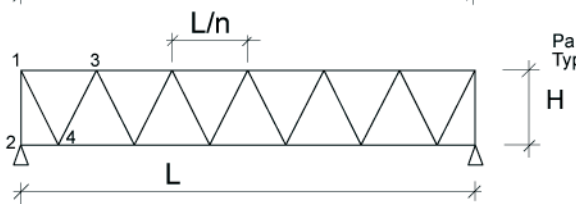
DIN 1052

DIN 1055

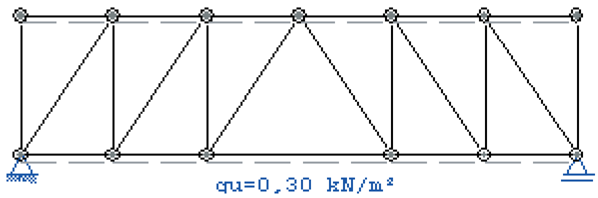
Graphical representation of lattice types



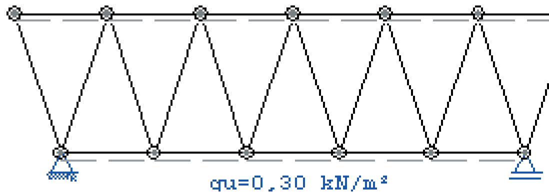
Parallel truss
Type 1



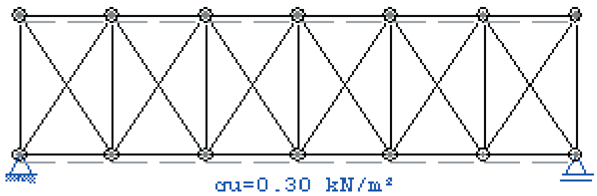
Parallel truss
Type 2



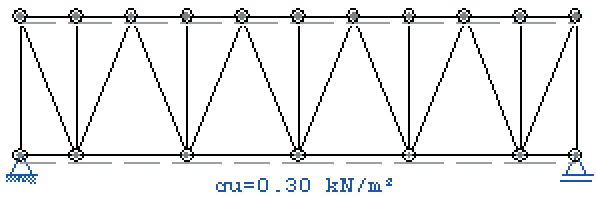
Type 5



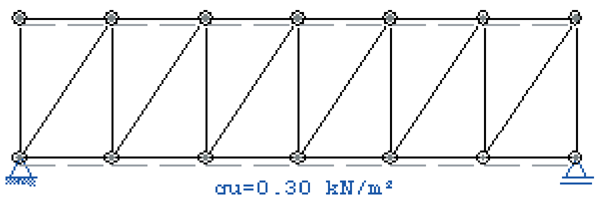
Type 6



Type 8



Type 12



Type 20

Basis of calculation

First, the individual load cases are determined in accordance with the selected truss system. The load case combinations are generated subsequently.

See the chapter → Generation of combinations for timber - DIN 1055 / EN 1990

See the chapter → Generation of combinations for steel - DIN 18800

The individual member forces for the different load cases are determined in accordance with the strut-and-tie theory.

The maximum internal forces are determined for the different member types:
- top chord
- bottom chord
- post member
- diagonal member

Depending on the selected material and cross section, stress resistance is verified for the existing internal forces and, for lattice girders of timber, also the stability verifications are performed.

The verifications of the stability of the lattice girder components against lateral buckling and lateral torsional buckling are not performed in this software. However, the buckling load factors for the global system and the individual members can be determined. The decisive internal forces of the different components can be directly transferred to other FL applications.

See the chapter → Verifications for timber – DIN 1052/EN 1995

See the chapter → Verifications for steel - DIN 18800

The support reactions are always determined for the simple loads. Optionally, you can put out the loads on the supports separately for the different action groups.

Generation of combinations for timber

The combination rules are based on the probabilistic partial safety concept (DIN 1055-100/EN 1990).

For the structural safety verifications, the combinations are generated for the permanent and transient situations. If an accidental action applies, the combinations for the accidental design situation are generated in addition.

For the serviceability verification, only the infrequent and quasi-permanent situations are relevant.

The software generates internally all combinations in accordance with the corresponding rules (DIN 1055, EN 1990) and performs all associated verifications. Only the combinations that are decisive in the individual verifications are printed/displayed, however.

The following load cases are examined by the software:

- Permanent loads, separately for the top and bottom chords
- Snow on one side either left or right
- Wind from the left, if a ridge was defined
- Wind from the right, if a ridge was defined.
  Wind from the right is considered as the alternative to wind from the left.
- Live loads on the top chord

Impounding wind pressure values

In order to take different impounding wind pressure values for different heights above ground level into account, you can specify the height of the bottom chord above the ground level. In this case, the software applies the different impounding wind pressure values to the different sections in accordance with the standard. Section-specific load cases are not generated, however.

Verifications for timber - DIN 1052:2008/EN 1995

Stress resistance/stability verifications

The stress resistance verifications are based on 10.2 (DIN) or 6.1 and 6.2 (EN).

For the shear stress resistance verification, the full shear force applying to the support is taken into account.

The stability verification is based on the equivalent member method described in 10.3 (DIN) or 6.3 (EN).

The user can optionally define the effective lengths.

Support reactions

The maximum support reactions in the vertical and horizontal directions are determined and put out separately for each load case and each action (as characteristic values) and as design values for the maximum combinations.

You can optionally put out the minimum support reactions. You are not allowed to use these support reactions for the uplift resistance verification, however!

Generation of combinations for steel

Combination rules as per DIN 18800 Part 1

G_i permanent action i

γ_{gi} partial safety factor for G_i, normally 1.35

Q_i variable action i

γ_{qi} partial safety factor for Q_i, normally 1.5

F_a accidental action

Fundamental combination 1

$$\sum_{i=1}^{n}\left(G_i \cdot \gamma_{gi}\right)+\sum_{i=1}^{m}\left(Q_i \cdot \gamma_{qi}\right)$$

with all unfavourable Q_i actions.

If all variable actions are taken into account in the structural calculation, the improbability of their simultaneous occurrence should be taken into account via a combination factor of 0.9.

Fundamental combination 2

$$\sum_{i=1}^{n}\left(G_i \cdot \gamma_{gi}\right)+Q_{max} \cdot \gamma_{qmax}$$

with Q_{max} as the most unfavourable action Q_i.

Instead of the load case H, the fundamental combination 2 is used, which includes the decisive variable load in addition to the permanent loads.

Accidental actions F_a are currently not taken into account by the software.

Generation of combinations in the FWT application

The following load cases are examined by the software in view of the fundamental combination 1:

- Permanent loads separately for the top and bottom chords
- Snow on one side either left or right
- Wind from the left; if a ridge was defined, the distinction between windward and leeward is made
- Wind from the right. If a ridge was defined, the distinction between windward and leeward is made. Wind from the right is considered as the alternative to wind from the left.
- Live loads on the top chord

In order to take different wind pressure values for different heights above ground level into account, you can specify the height of the bottom chord above the ground level. In this case, the software applies the different wind pressure values to the different sections in accordance with DIN 1055-4. Section-specific load cases are not generated, however.

For the generation of the fundamental combination, the user can optionally select whether the load cases snow + wind/2 and wind + snow/2 should be taken into account as a variable action each as required by DIN 18800, Part 1, Annex 5; → see Settings.

Note:

According to the Standards Work Committee (NABau) for Wind Loads, you can use wind suction/2 instead of leaving out the suction load generated by the roof with its favourable effect (see "Mitteilungen Institut für Bautechnik", ISSN 0172-3006 of 3 October 1988).

By default, the software examines whether the omission of the favourable suction load generated by roof produces a higher utilization rate (see also the description of the generation of combinations above).

A forced consideration of half of the suction load on the roof, which would produce more favourable design results, is currently not implemented.

In the current software version, the partial material safety coefficient γ_M is always considered on the load side. An optional selection by the user is not implemented yet.

Verifications for steel

Structural safety verifications

The software performs a simple first-order stress analysis based on the elastic-elastic method with consideration of the generated combinations.

The following stresses are determined and compared to the permissible stresses:

- maximum axial stress
- maximum shear stress
- maximum comparative stress

For each item, the stress is determined at the point in the profile section, where it reaches its maximum value.

The partial safety coefficient of the material is taken into account on the load side in the calculation of the internal forces. Hence, the calculated stresses are compared to the characteristic material parameters.

The verifications of the stability against lateral buckling and lateral torsional buckling are not performed by this software. The user must perform them separately. The software determines the buckling load factor η_{ki} for the global system instead, and derives from it the buckling load factors η_{ki} of the individual components. For buckling load factors < 10, the user must verify the stability against lateral buckling and lateral torsional buckling separately. FWT offers an interface to the Frilo-software BTII - Lateral Torsional Buckling. It allows you to launch BTII for the desired component and the decisive internal forces via the corresponding item in the FWT main menu.

In addition, you can access the Frilo-software ST7 via the main menu for the decisive internal forces of the stress resistance verification elastic-elastic. The ST7 software allows you to perform additional elastic-plastic verifications for the selected component.

Serviceability verification

The software calculates the deflection of the global load-bearing structure from the simple and gamma-fold actions.

The unfavourable values and the contributing variable effects are displayed in each case.

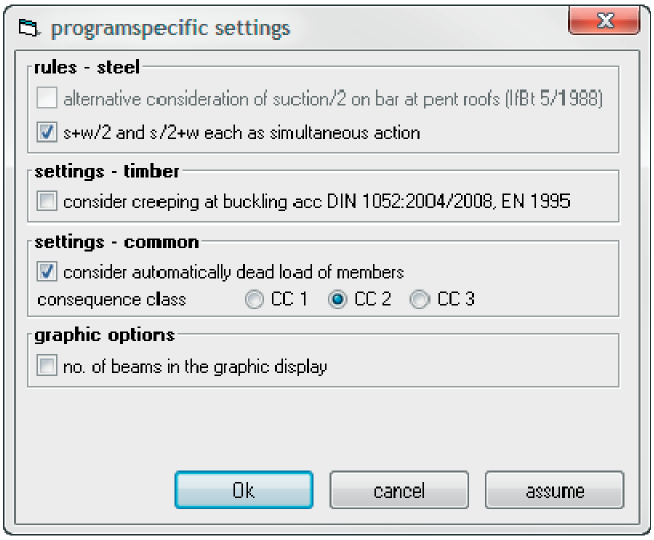
You can optionally specify a limit for the deformation. The software compares the calculated deflections to this value and puts out the utilization of the deflection.

Settings

Access either via ▸ the Settings button below the graphic window or
the menu item ▸ Options ▸ Settings FWT

Calculation rules for steel

For the generation of the fundamental combination, the user can optionally select whether the load cases snow + wind/2 and wind + snow/2 should be taken into account as a variable action each, as required by DIN 18800, Part 1, Annex 5; → see Generation of combinations for steel.



Calculation rules for timber

You can optionally take creep into account as per 8.3(3), when the design value of the permanent load portion exceeds 70 % of the design value of the total load.

General calculation rules

You can optionally take the self-weight of the truss components into account. The specific weight of timber components can be specified in the Material options section.

Consequence classes

CC1 to CC3 - see EN 1990, Annex B.

Graphic options

If you check this option, the member numbers are displayed in the graphical representation.

Definition of the structural system

Material

Select the desired material:

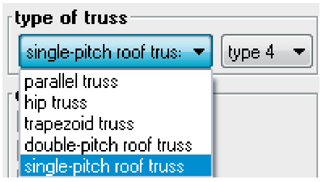
Timber: Softwood, Hardwood, Glulam

Selection of the sorting/usage classes

The button [...] allows you to access the definition dialog. If required, you can specify the specific weight in this section.
A moisture content of ≤ 18 % is assumed.

Steel: S235, S355, StE 460 StE 690

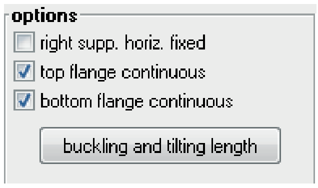
Truss type



First, select the types of truss and lattice.

See also: graphical representation of the lattice types in the chapter "Application options".

Options



Support on the right, horizontally rigid

When you check these options, both supports are assumed as horizontally rigid. You should not check this options if the support stiffness of the selected roof truss is uncertain.

Continuous top chord

If this option is checked, support moments are generated in the top chords above the struts.

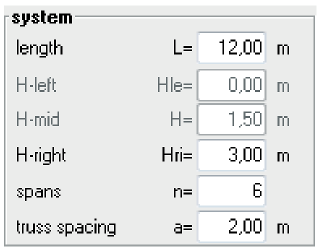
Continuous bottom chord

If this option is checked, support moments are generated in the bottom chords underneath the struts.

Effective lengths for buckling and lateral buckling (button).

A dialog is displayed that allows you to define optionally the effective lengths for buckling and lateral buckling.

Structural system



The displayed input fields vary in accordance with the selected lattice type.

L total girder length

Hle girder height at the left end

H girder height in the middle, ridge height of the pitch if a single-pitch roof truss was defined

Hri girder height at the right end

n number of spans.

a spacing of the girders

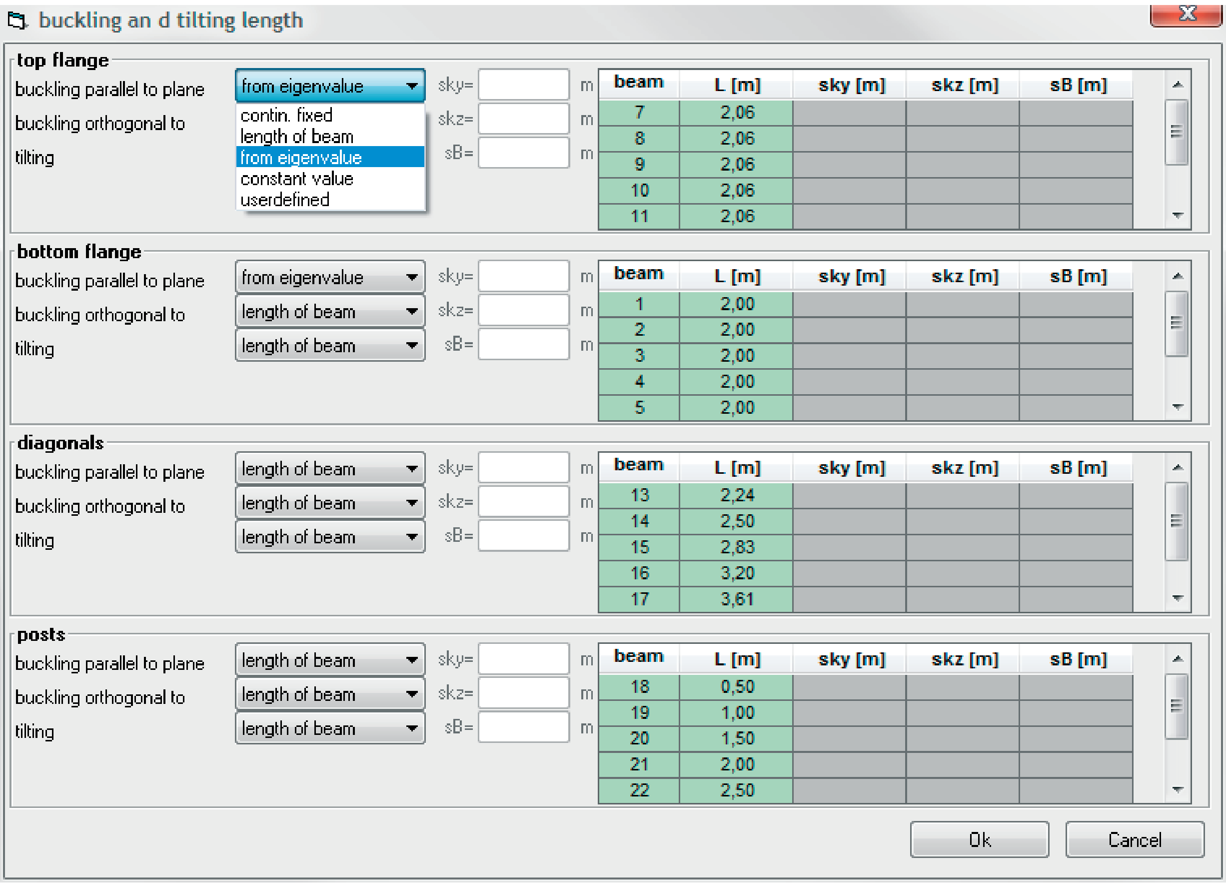
Effective length for buckling and lateral buckling

You can specify the corresponding lengths for each component separately. Depending on the component, separate settings for buckling in the lattice plane or out of the plane and for the lateral buckling lengths are available.

Select the corresponding options in the drop down list:

- from eigenvalue determination (only for buckling in the plane)
- continuously supported (effective length = 0)
- effective length = member length
- same value for all members of the component (corresponding input field is enabled)
- user-defined effective lengths for each member (in the associated table cells)

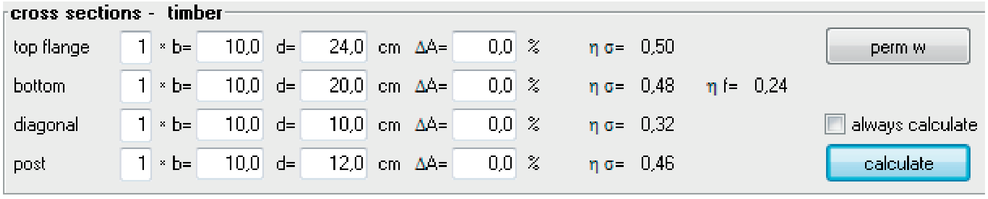
The selected settings are documented in the output.



Definition of the cross section

Timber

Specify the number, width, height/thickness and the reductions in the cross-sectional area (in %).

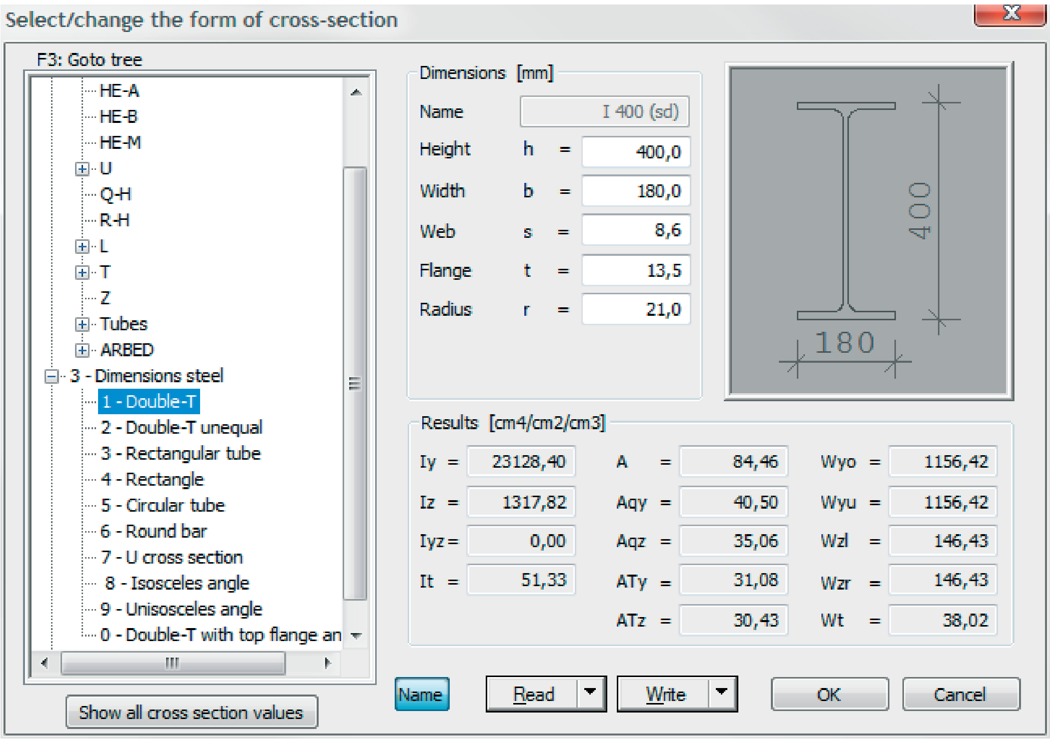


See also design and calculation.

Steel

The button >> allows you to access the dialog for the selection of the steel cross section.

You can either select it in the Frilo profile selection file or define it by specifying the dimensions. You can also edit defined cross sections in this dialog.



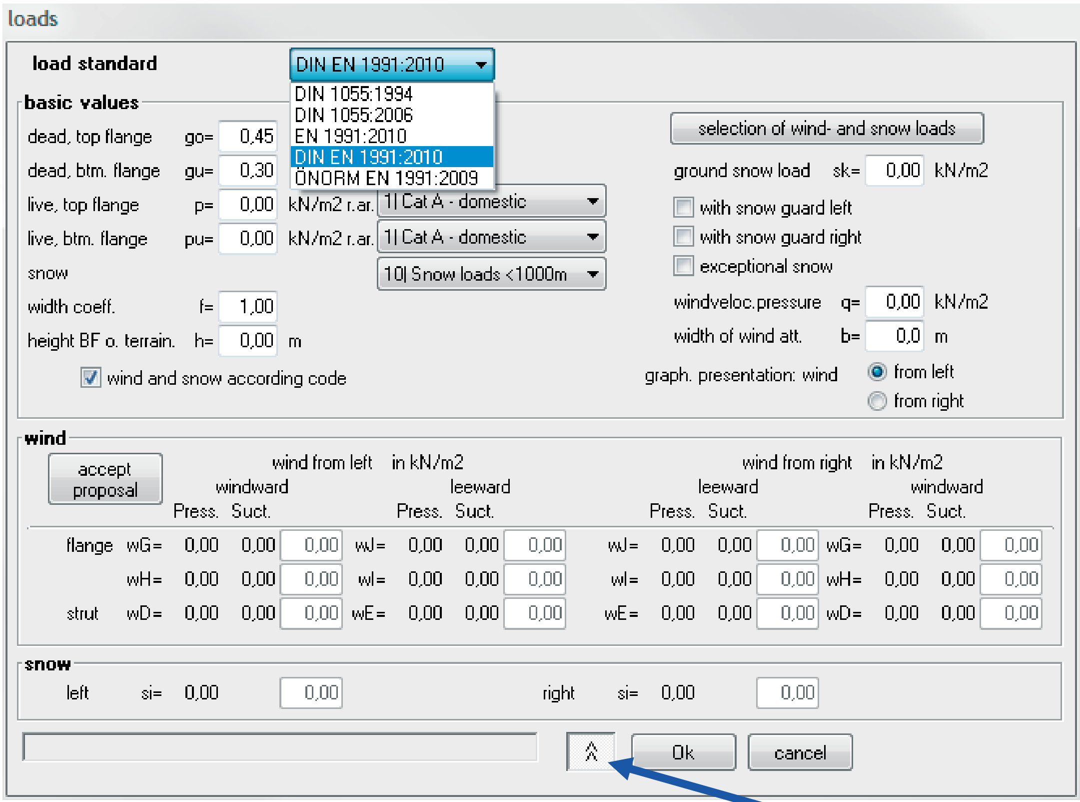
See also the document Select - edit cross section_eng

Definition of the loads

The button loads allows you to access the load definition dialog.

Select the desired load standard: The available input fields depend on the selected standard.

All loads apply to the top chord with the exception of the weight load g_u of the substructure.



The wind dialog section is not displayed by default. Click on the ≚ button to display the corresponding input fields, click on the ≙ button to hide them again.

width coeff.	factor for the affected width of all line loads (load distribution factor).
Height above ground	you can define the height of the bottom chord above the ground level in order to take impounding wind pressure into account at the different height levels. The reference for this specification is the system axis of the bottom chord.
Wind and snow according to..	the impounding wind pressure *q* and the ground snow load *sk* are set in accordance with the selected standard. To specify these values manually uncheck this option.
Graph. represent.	select the wind direction for the graphical representation.
Ground snow load sk	you can either specify the value manually or via the settings in the "Wind and snow loads" dialog → Access the dialog by clicking to the Wind and snow loads button.

Wind and snow loads

activating the "Wind and snow loads" button displays a dialog for the definition of the basic parameters for the wind and snow loads.

See the document "Wind and snow loads"

The leeward and windward loads (kN/m^2) are determined for different aerodynamic areas in accordance with the selected standard.

The load values can be edited and replaced manually in the wind section (button) for further calculations.

The snow loads are calculated in accordance with the selected standard. You can edit these values too (button).

Wind velocity pressure *q*

you can either specify the value for q manually or via the settings in the "Wind and snow loads" dialog
→ Access via the "Wind and snow loads" button.

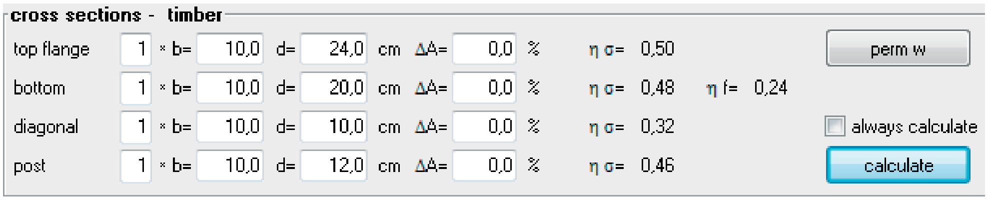
Wind action width *b*

the parameter wind action width *b* is required for the determination of the wind reference length *e* for the wind-affected areas.

Design and calculation

Calculate

Define the cross sections of the top chord, the bottom chord, the post member and the diagonal member. Click on the "Calculate" button. After completion of the calculation, the utilization ratios are displayed.



Perm. deflection

the "Perm. w" button accesses the definition dialog for the permissible deflection.

Always recalculate

check this option if recalculation should be done after every modification of the structural system. Otherwise, you must launch a recalculation manually by activating the "Calculate" button.

Output

The menu option Output ▸ Screen/Printer allows you to launch the output on a printer or the screen.

The following results are shown in the form of tables in addition to the system and load data:

- Maximum values of the vertical and horizontal support reactions and the associated load case combination.
- The maximum deflections of the load-bearing structure as well as the associated load case combination and the utilization ratio referenced to the specified maximum deflection, if applicable.
- The design of the individual components top chord, bottom chord, post members and diagonal members with the most important design values of the required verifications for the decisive load case combinations in each case.

Screen	displays the values in a text window on the screen
Printer	starts the output on a printer.
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.

Graphical representation

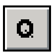
Load case selection

The drop-down list in the tool bar allows selecting the load case that should be displayed.

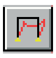
The buttons activate the following representations:

Axial force area (behaviour of tension and compression in the member axis)

Moment area (moment behaviour in the member)



Shear force area (shear force behaviour in the member)


Deformations

Stress utilization E-E

Show frame data for checking purposes

Access 3D representation

Interfaces to other FRILO applications

Verifications el-pl	interface to the ST7 application - Steel Section Design
Verifications Stx	interface to the STX application - Stability Verifications for Steel
Verifications BDK	interface to the BTII application - Lateral Torsional Buckling Analysis
Plane frame	interface to the ESK application - General Plane Frame  display frame data for checking
Export ESK-ASCII	alternative option for the transfer of data in ASCII files. Accessible via the Edit menu.

File ▸ Import

HO8 item	selection and import of an item from the HO8 application - Lattice Truss.

Application-specific menu items

General menu items are described in the document FDC Menu Items.

Application-specific menu items:

Open-GL	three-dimensional representation of the structural system.
LC select. for GUI	selection of the load case to be represented.

Reference literature

/1/ DIN 1052: 04.88, Teil 1, Holzbauwerke, Berechnung und Ausführung

/2/ DIN 1052, 10.96, Teil 1 A1, Holzbauwerke, Berechnung und Ausführung, Änderungen

/3/ DIN 1055: 1978, Teil 1-5, Lastannahmen für Bauten

/4/ DIN 1052:2004-08, Teil 1, Entwurf, Berechnung und Bemessung von Holzbauwerken, Allgemeine Bemessungsregeln und Bemessungsregeln für den Hochbau

/5/ DIN 1055:2001-03, Teil 100, Einwirkungen auf Tragwerke

/6/ DIN 1055:2005-03, Teil 4, Windlasten

/7/ DIN 1055:2006-03, Teil 4 Berichtigung 1, Windlasten, Berichtigungen zu DIN 1055-4:2005-03

/8/ DIN 1055:2005-07, Teil 5, Windlasten

/9/ DIN 18800: 1990, Teil 1, Stahlbauten, Bemessung und Konstruktion

/10/ DIN 18800: 1990, Teil 2, Stahlbauten, Stabilitätsfälle, Knicken von Stäben und Stabwerken

/11/ Krüger Ulrich, Stahlbau Teil 1+ 2, Ernst & Sohn Verlag 1998

/12/ EN 1995-1-1:2010, Design of timber structures – Part 1-1: General

/13/ EN 1990:2010, Basis of structural design

/14/ EN 1991-1-1:2010, Actions on structures - Part 1-1: General actions

/15/ EN 1991-1-3:2010, Actions on structures – Part 1-3: General actions - Snow loads

/16/ EN 1991-1-4:2010, Actions on structures – Part 1-4: General actions - Wind loads

/17/ EN 1991-1-7:2010, Actions on structures – Part 1-7: General actions - Accidental actions

/18/ DIN EN 1995-1-1/NA:2010, National Annex to EN 1995-1-1

/19/ DIN EN 1990/NA:2010, National Annex to EN 1990

/20/ DIN EN 1991-1-1/NA:2010, National Annex to EN 1991-1-1

/21/ DIN EN 1991-1-3/NA:2010, National Annex to EN 1991-1-3

/22/ DIN EN 1991-1-4/NA:2010, National Annex to EN 1991-1-4

/23/ DIN EN 1991-1-7/NA:2010, National Annex to EN 1991-1-7