Steel Bracing ST12+

Contents

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 in the Campus-download-section.

Tip: Go back - e.g. after a link to another chapter / document - in the PDF with the key combination "ALT" + "left arrow key".

Application options

The software is suitable for the structural calculation and design of bracing typical in the construction of portal frames:

- Diagonal tying with compression slack diagonal steel struts for buildings with trussed girders

Available standards

The internal forces are determined in a second-order analysis with consideration of the failure of the diagonal compression struts. The approach to imperfections is based on the following optional solution methods:

- DIN EN 1993:2010/2015
- ÖNORM EN 1993:2007/2017
- BS EN 1993:2008
- Petersen

For the diagonal tension struts a verification of the cross section is performed and for the compression posts in addition a stability analysis.

A verification of the chord for the additional axial chord force is not performed in this software.

Reference literature

/1/ DIN EN 1993-1-1

/2/ Petersen: Stahlbau (1990, 2nd improved edition, Braunschweig/ Wiesbaden, Publisher Vieweg & Sohn

/3/ DIN 4114: Steel construction; stability cases (buckling, tilting, bulging), design principles, guidelines, 1953

Basis of calculation

Loading

For the calculation of the internal forces of the braces the following loads and forces are to be considered:

- the wind load at the height of the bracing
- the compressive chord forces of all roof trusses

The axial chord forces are γ-fold results of a previous frame and girder calculation. The γ-fold equivalent load for the bracing system is calculated from the axial chord forces. The bracing system itself is designed for this equivalent load and the additional γ_w-fold wind load.
Additional loads in the bracing plane can considered in the software.

The user can specify the axial force in the compression chord or have it calculated from the internal forces by the software.

The calculation of the axial chord force for double-symmetrical I-shapes is based on /3/:

$$N_{Gurt} = \sigma_d \left(b_1 \cdot t_{f1} + \frac{1}{5} A_w \right) - \frac{N_{Ed}}{2}$$

Second-order influences must be considered in the design of the bracing system.

To do this, assumptions concerning the imperfections have to be made. Because the consideration of imperfections is not clearly defined, you can find different relations in literature.

Bracing in accordance with Petersen

Petersen replaces the laterally pre-deformed chords with a hinged bar chain. The deviation forces are applied to these hinges.

They are included as node loads acting on the truss. The internal forces are calculated in a second-order analysis with consideration of the failure of the compression members.

The approximation formulae by Petersen apply only to truss systems with a constant span length.

The calculation is based on the initial imperfection $e = \frac{L}{500}$.

Bracing as per DIN EN 1993-1-1

The stabilizing equivalent forces are calculated as constant UDL* as per DIN EN 1993-1-1, 5.3.3.

The internal forces are calculated in a second-order analysis with consideration of the failure of the compression member.

Verification of the diagonal tension struts and of the compression members

The verification of the cross-sectional resistance is based on the internal plastic limit forces. Optionally, a stress analysis based on the elastic model can be performed.

For the compression members, the stability verification is performed in accordance with DIN EN 1993-1-1, 6.3.1.

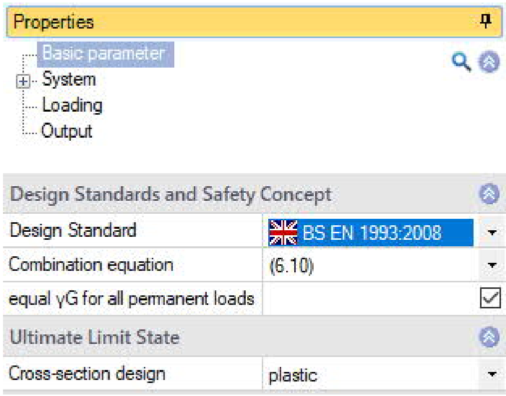
* uniformly distributed load

Basic parameters

Design Standards and Safety Concept

Selection of the standard:

- DIN EN 1993
- BS EN 1993
- ÖNORM EN 1993



Combination equation (BS EN 1993)

Specifies the combination rule to be used in the in the transient/permanent design situation.

Consequence class (ÖNORM EN 1993)

Specifies the reliability level (in terms of the respective consequence class) of the partial safety factors.

Equal γ_G for all permanent loads

Check this option if all permanent loads or load cases shall be included with the same partial safety factor ($\gamma_{G,sup}$ or $\gamma_{G,inf}$). Otherwise, all permanent loads or load cases are combined with each other with '$\gamma_{G,sup}$' and '$\gamma_{G,inf}$'.

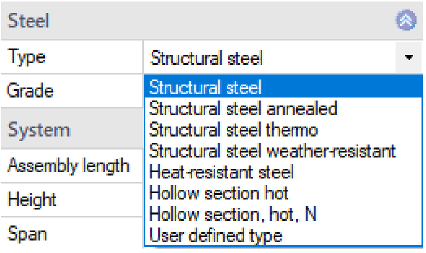
Ultimate Limit State

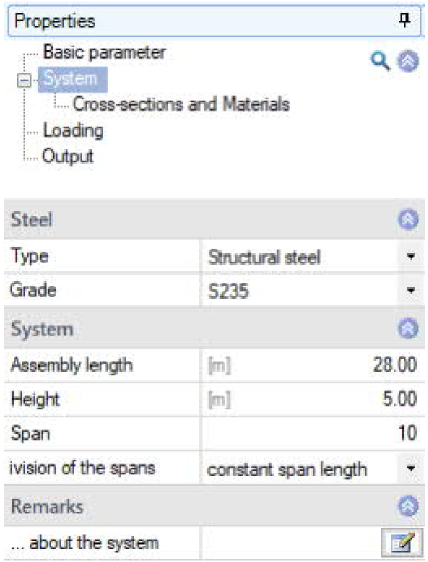
Cross-section design	optional selection whether the design of the cross section should be based on the elastic model as per equation 6.1 or on the plastic model as per equation 6.2.

System

Steel

Selection of the steel type and grade for the chords, posts and diagonals.





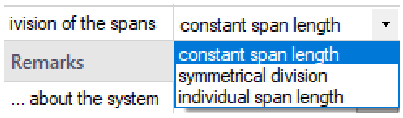
System

Assembly lenght — the total length of the bracing (span length of the system).

Height — the height of the bracing corresponds to the distance of the girders.

Spans — allows you to specify how many cross beams there are in total.

Division of the spans — equal span length is the default setting. In addition, different/individual span lengths can be selected and entered via a separate "Edit" dialog.
The calculation method described by Peters applies only to structural systems with equal span lengths!

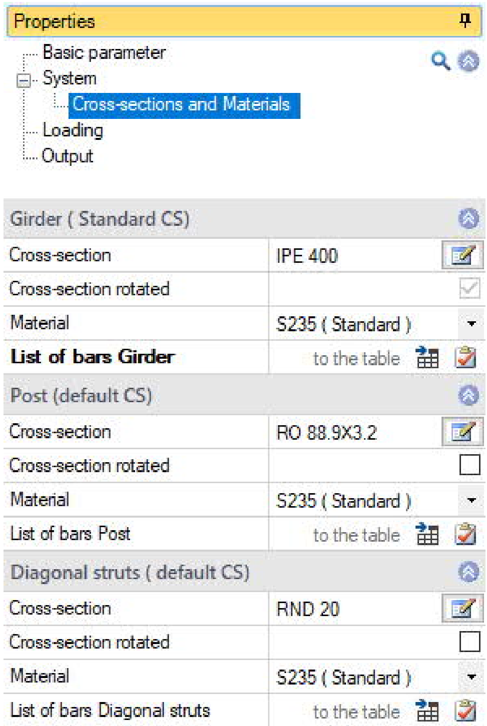


Cross sections

Different cross sections and materials can be defined for each component. Thus, the staggering of e.g. the posts and diagonals is possible depending on the stress.

The button allows you to access the dialog for the selection of the steel cross-section. You can select cross sections separately for the horizontal, vertical and diagonal members from the Frilo Profile Library
You can also define a cross-section by selecting ‘User-defined’.

See also the document ▸ Selecting/Defining Cross-Sections - PLUS



Girders — you can select among I-shapes and I-shapes with inclined flanges.

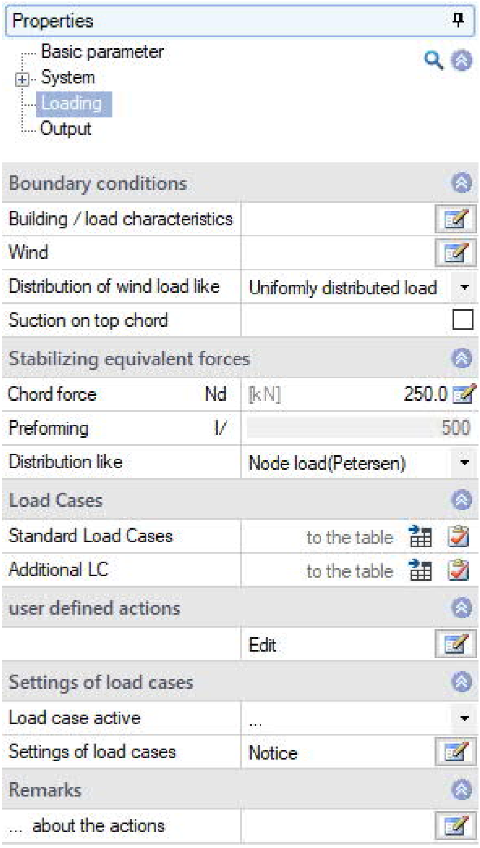
Posts — in addition to I-shapes and I-shapes with inclined flanges, rectangular and round hollow sections are available.

Diagonal struts — in addition to the shapes available for girders and posts, round steel, flat steel and thin-walled open profiles are available for selection. For open profiles, you need to define the dimensions

... rotated — Tick this option if the cross-section is installed rotated by 90°.

Loading

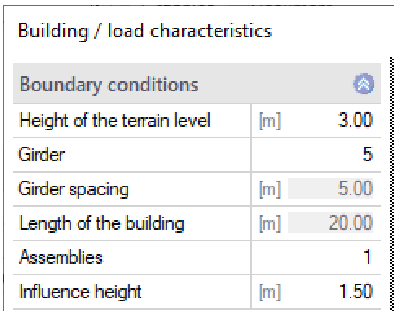
You can access the respective input dialogs via the button .



Boundary conditions

Building/Load characteristics

Height of the terrain level	the altitude of the bracing above the ground level; the wind pressure is calculated for this height level.
Girders	number of girders in the building.
Assemblies	number of braces acting together.
Influence height	the affected height relating to wind action on the bracing plane. The calculated wind pressure is multiplied with this value.

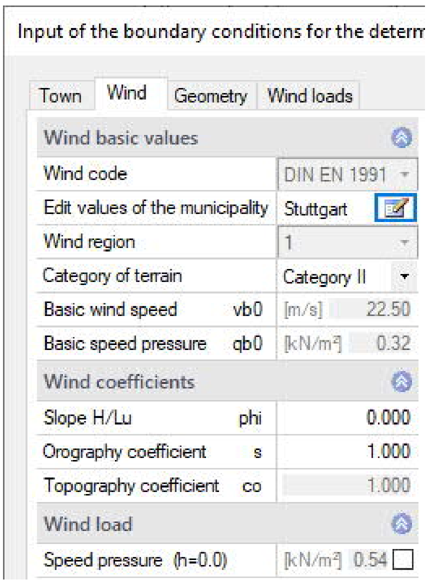


Wind

Select the federal state and the municipality from a list to determine the associated wind zone as well as the altitude above MSL.
You can uncheck the option “municipality selection”, however, to specify these values in the subsequent dialogs.

The corresponding dialogs are only enabled when you uncheck the municipality selection option.

Selection/Input of the wind zone, the terrain category, Basic wind speed - the display value qb0 results from the basic wind speed.



Slope H/Lu

Value ‘H/Lu’ in flow direction with ‘H’ for the height of the slope and ‘Lu’ for the length of the slope, see also EN 1991-1-4, A.3 (1).
On isolated mountains, mountain chains or rocks, different wind speeds result from the slope of the ground surface.

Orography coefficient

Factor as per EN 1991-1-4, figure A.2 for cliffs or offsets in the ground surface or A.3 for hilltops and hill crests, related to the effective length ‘Le’ of the windward gradient.

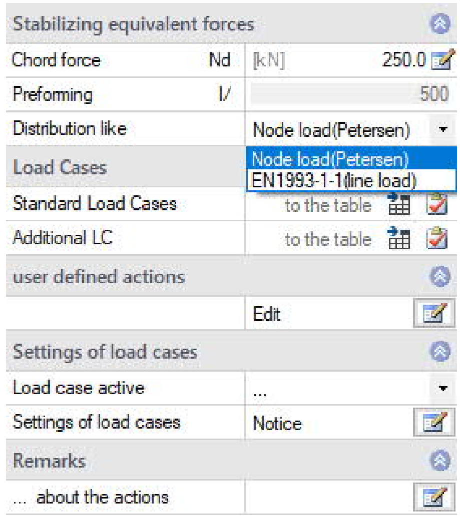
Topography coefficient

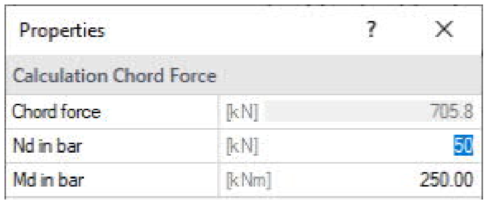
Indication of the coefficient as per EN 1991-1-4, 4.3.3. At places where the topography (e. G. mountains, cliffs etc.) increases wind speed by more than five percent, the speed increase is to be considered via the topography factor ‘*co*’.

Speed pressure (h=0)

The dynamic wind pressure at the altitude of 0.0 m can be modified for further calculations.

Stabilizing equivalent forces





Chord force – bracing loads are calculated from '*Nd*'using the method described by [Petersen] or as per DIN EN 1993-1-1, 5.3.3. You can either enter the axial force in the chord directly or have it calculated by the software. The calculation is based on '*Nd*' and '*Md*' which you can specify for the upright member by clicking on the editing button.

'*Nd*' is the existing axial force in the girder (axis).
'*Md*' is the existing moment in the girder, used to calculate the chord force.

Initial imperfection l/500 – indication of the imperfections of the supported girders.

Distribution like – the wind load can either be applied as a uniform load [EN 1993-1-1] or nodal loads [Petersen].
By default, wind pressure and wind suction are applied to the upper chord.

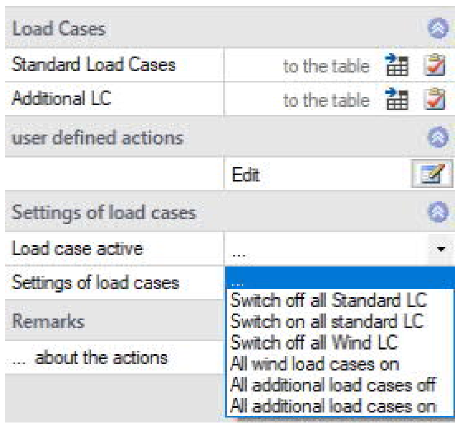
User defined actions

User-defined actions can be created in a separate dialog.

Load cases

Standard load cases

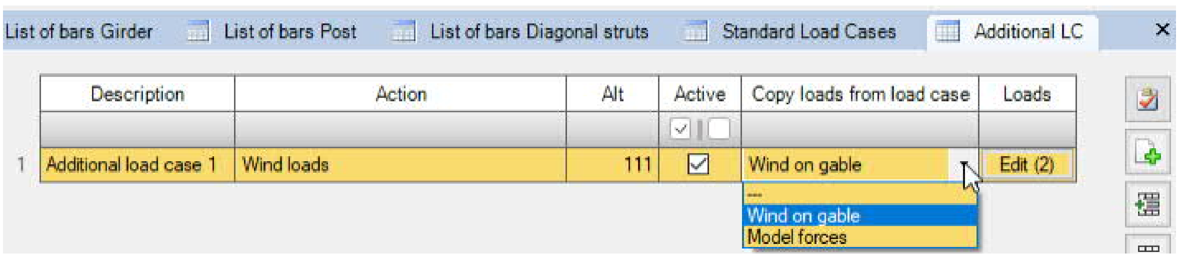
The default load cases are 'wind on gable' and 'equivalent forces'. They are generated automatically from the defined system data, the border conditions and the axial chord force. They cannot be edited but you can disable them via the 'Load case active' option.



Additional load cases

Additional load cases are registered in the table. Loads can be entered in a table or in the graphic and be edited there.

Use the "+" button to create a new table row. Load cases can be copied as a template and changed using the "Edit" button.

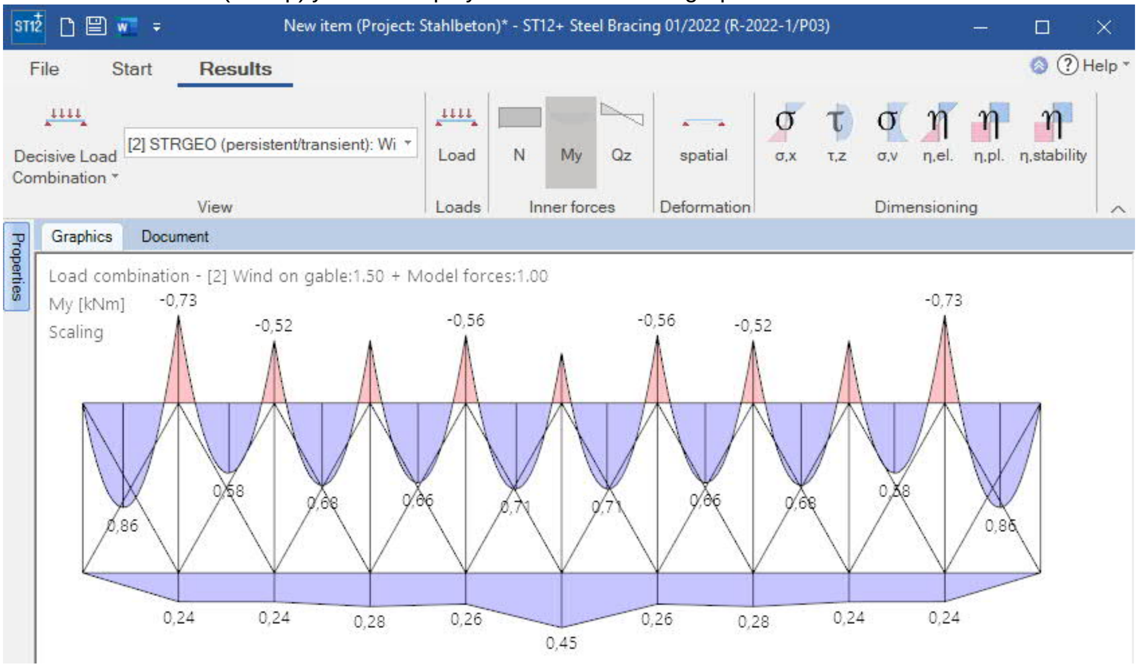


Design

Click on the "Calculate" button. After completion of the calculation, the utilizations are displayed.

Output

Via the ‘Results’ tab (on top) you can display the different result graphs.



The ‘Output’ menu item allows you to define the desired scope of data to be put out by checking the corresponding options.

The output document can be accessed by clicking on the ‘Document’ tab (above the graphic screen).

See Output and printing.