

Steel Truss FWS+

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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 <u>www.frilo.com</u> in the Campus-download-section.

Further information and descriptions are available in the relevant documentations:

Wind and Snow Loads-PLUS

Separate description of the wind and snow loads dialog that is part of various applications.



Application options

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

- Parallel trusses
- Hip trusses
- Double-hip trusses
- Double-pitch roof trusses
- Single-pitch roof trusses
- Cross-sections and material can be defined differently for chords, posts or diagonals.
 This makes it possible to stagger the struts, for example, depending on the load.
- Continuous chords can be considered as flexurally rigid members.
- Member loads due to wind and snow are generated by the software.



Available standards

The FWS+ application performs structural safety analyses in accordance with EN 1993-1-1 and takes the corresponding National Annexes into account.

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

Snow and wind loads are based on the standards EN 1991-1-3 and EN 1991-1-4 and their National Annexes.

- DIN EN 1991-1-3:2019, DIN EN 1991-1-4:2010
- ÖNORM EN 1993-1-3:2018, ÖNORM EN 1993-1-4:2019
- BS EN 1991-1-3:2015, BS EN 1991-1-4:2011

Load transfer

You can transfer loads to the following software applications

- STS+ Steel Column
- H01+ Timber Column
- B5 Reinforced Concrete Column
- ST4 Steel Girder Support
- B9 Reinforced Concrete Corbel



Calculation / Verifications

The internal forces are determined with the help of the elastic frame method. The load combinations decisive for the design are calculated in a first-order analysis.

All necessary combinations of actions are automatically considered in accordance with the safety concept set forth in DIN EN 1990.

The verification of the cross-sectional resistance is based on the internal plastic limit forces. You can optionally select the theory of elasticity as verification method.

The component verifications (stability verifications) of the truss members are performed by the software. You can define lateral supports at the top and bottom chord perpendicular to the truss plane as well as at the vertical edge members, if any.

The software calculates the deformation of the structural system as well as the relative deformation of the individual components in the serviceability limit state in accordance with the selected design situation.

The support reactions are put out with the characteristic loads for each load case.

Load transfer

See Load transfer

Interface to BTII+ for advanced stability verifications

If you hold a licence for BTII+ (Lateral Torsional Buckling Analysis), you can <u>transfer</u> the top chord, the bottom chord and the vertical edge members, if any, to BTII+. This software application provides for the calculation of more complex systems.



Basic parameters

Standard and safety concept

Select the desired standard. Available standards - see <u>Application options</u>.

Snow as accidental loads:

Check this option if the snow loads shall be included automatically not only in the typical design situations but also as an accidental action. You can either specify a load factor for the accidental snow loads or have it determined automatically by the software (select the corresponding checkbox).

<u>ψ2 = 0.5:</u>

Check this option to increase the value of the combination coefficient $\psi 2$ to 0.5 for snow action in the seismic design situation.

(See introductory decree of the federal states, e.g. Baden-Württemberg)

Wind zone 3 or 4:

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 with wind being the leading action.

Equal yG for permanent loads:

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

Ultimate Limit State

Cross-section design	optional selection whether the elastic model as per equation 6.1 or on the plastic model as per equation 6.2. should be used.
Equivalent member verification	in accordance with 6.3.3 (annex A or B) or with 6.3.4.
Serviceability	
Design situation	select the design situation the verifications in the serviceability limit state should be based on (characteristic, frequent and quasi-permanent).
Verification absolute deformation	select this option to perform the serviceability verification with consideration of the deformation difference in relation to the undeformed system.
Absolute limit deformation	defines the permitted maximum absolute deformation of the structural system.
Verification relative deformation	select this option to perform the serviceability verification based on the effective lengths, which are determined by the turning points (moment passage) of the bending line.
Relative limit deformation	defines the permitted maximum relative deformation of the structural system.

Properties	д
Basic Parameters	0 @
⊕. System	~ 6
Load	
• Dimensioning	
Output	
	~

Design Standards and Safety	Concept	0
Design Standard	EN 1993:2015	•
Snow as accidental loads		
$\psi 2 = 0.5 \text{ for snow (AE)}$		
Location in windzone 3 or 4		
Equal yG for all permanent loads		\checkmark
Ultimate Limit State		0
Cross-section design	plastic	+
Equiv. beam detection acc.to	6.3.3 - annex B	-
Serviceability		0
Design situation	characteristic	-
Absolute deformation check		
Absolute ultimate deformation	[cm]	5.0
Relative deformation check		\checkmark
Relative ultimate deformation	[leff/]	300



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Structural system

Steel material

Selection of the steel type and steel grade.

System

Type of truss (Truss system)

Click on the button is to select the truss shape and type.

See also: graphical representation of the types of trusses in the chapter <u>Application options</u>.

Depending on the selected type of truss, the associated system dimensions are displayed for selection (number of spans, height, length etc.) - additional information is available via the respective tooltips.

Division of spans

The span lengths can be of equal length (constant), symmetrical or individually defined.

Flexurally rigid ridge point

Check this option to define a ridge point that is resistant to deflection.

Bottom chord free from hinges

Specifies whether the hinge definitions also apply to the bottom chord.

Properties		ą
Basic Parameters System Cross-sections a Bearings Coad Dimensioning Output	ind Materials	90
Steel		0
Туре	Structural steel	-
Grade	S235	-
Characteristic values		1
Operating temperature	[°C]	20.00
System		0
Truss system	Hip	1
Length	[m]	20.00
Left height	[m]	2.00
Right height	[m]	4.50
Span		4
ivision of the spans	constant span length	
Girder spacing	[m]	5.00
Top chord without joint		\checkmark
Joint free bottom chord		\checkmark
Remarks		0

... about the system



Cross-sections

Cross-sections and material can be defined differently for chords, posts or diagonals.

Cross-sections can optionally be installed rotated by 90°.

You can obtain a clear overview using the tables in the "Bar lists" (tabs below the graphic).

Click on the *select* the cross-sections.



Properties		P
Basic Parameters		90
Ecross-sections and Bearings Load Dimensioning Output	Materials	
Top chord (default CS)		0
Cross-section	HEB 180	2
Cross-section rotated		
Material	S235 (Standard)	•
List of bars Top chord	to the table	1 2
Bottom chord (Standard	CS)	۵
Cross-section	HEA 180	2
Cross-section rotated		
Material	S235 (Standard)	
List of bars Bottom chord	to the table	1
Post (default CS)		0
Diagonal struts (default	(5)	(3)

Select the cross-section either from 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 <u>Selecting /Defining Cross-Sections-PLUS</u> documentation as well as the programm <u>Steel Cross-Sections General QS+</u>.



Supports

Supports out of plane

Specify the supporting conditions of the different components (top chord, bottom chord, left edge, right edge).

- Distancedistance to the left or to the bottom, related to
the projection planeSpring value cydiscrete supporting conditions for translation in
the y-direction (rigid, 0 = free, >0 = elastically
supported)Application point available options are 'top edge', 'bottom edge'
and 'component axis'
- Spring value $c \pmb{\varphi} x \;\; \text{discrete supporting conditions for rotation} \\ around the component x-axis$

Continuous support (Bedding) of the top chord

Translational foundation top edge

translational foundation at the top edge of the top chord in the y-direction

Torsional foundation

torsional foundation of the top chord about the x-axis

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Supports from the	e plane		0
Bearing	() 2/2 🔘 🛃 🗙	🛅 🍃
Member		Top chord	•
Distance		[m]	0.50
Spring value	Су		rigid 🔽
Point of attack	Су	Center line of member	•
Spring value	Сфх	[kNm/rad]	0.0
Bedding of the top	chord		0
Elastic restraint of top	p chord	[kN/m²]	0.00
Rotational bedding		[kNm/rad/m]	0.0



Loads

Building and load parameters

Click on the building and load parameters.

Height above ground level

Specify the height of the bottom chord (system axis) above the top edge of the ground to consider different wind pressure values at different height levels. The wind pressure is calculated for the specified height.

<u>Trusses</u>

Number of trusses in the building.

Truss spacing

Specify the spacing of the trusses being the width of the load area.

Length of the building

The building length calculated from the number of trusses and their spacing is indicated.

Gable truss

This option allows you to define a gable truss. If you leave the option unchecked (default), the truss is treated as an inner truss. The option influences the selection of the wind area.

Affected width factor

Factor for the load application area on the truss. Width of load area = factor \cdot truss spacing.

Area with increased wind load

The load application area of the truss is exposed to increased wind load at the gable.

Wind and snow

Click on the *is* button to display the dialog of the border conditions for the calculation of the wind and snow loads. This dialog is described in the documentation <u>Wind and Snow Loads-PLUS</u>.

The different tabs (municipality, wind, snow...) provide access the respective dialogs and data-entry fields.

Town	Wind	Snow	Geometry	Wind Jads	Snow Loads
Locat	ion			÷	0
Countr	у			Great Britain	
Altitud	e of terrai	in	hMSL	[m]	-1000

Properties	4
Basic Parameters	9.0
System	
- Loads	
. Design	
Output	

Boundary conditions			0
Building / load characteristics			3
Wind and Snow Load			2
Load Cases			0
Standard Load Cases	to the table	2	2
Additional LC	to the table	2	2
Self-weight			0
Consider automatically			V
Roof load			0
Roof load	[kN/m²]	0.90	¥
Roof load based on	[Dfl] Roof area	а	•
Settings of load cases			0
Load case active			•
Settings of load cases	Notice		2
Remarks			0
Actions			7



Standard/additional load cases

The load case 'permanent', generated by the software, as well as the wind and snow load cases are standard load cases. The wind and snow load cases are generated automatically based on the truss dimensions, the position and installation height and the snow and wind zones.

You cannot edit them, and they are newly generated each time you modify the structural system. You can disable these load cases (by clearing the checkbox).

 1 Roof load 2 Wind from left case 1 3 Wind load from left side case 4 Wind load from left side withow 5 Wind load from left side withow 6 Wind load from left side withow 7 Wind load from left side withow 8 Wind load from left side withow 9 Wind load from left side withow 	Roof load	Permanent loads					100
2 Wind from left case 1 Wind loads ✓ 111 ✓ Details (6) 3 Wind load from left side case Wind loads ✓ 111 ✓ Details (6) 4 Wind load from left side withou Wind loads ✓ 111 ✓ Details (4)		a serie is sug	1	0		Details (1)	L\$
3 Wind load from left side case Wind loads ✓ 111 ☑ Details (6) 4 Wind load from left side withou Wind loads ✓ 111 ☑ Details (4)	Wind from left case 1	Wind loads	*	111	V	Details (6)	日間
4 Wind load from left side withou Wind loads - 111 📝 Details (4)	Wind load from left side case	Wind loads	-	111		Details (6)	
	Wind load from left side without	Wind loads	*	111	V	Details (4)	
5		Wind from left case 1 Wind load from left side case Wind load from left side withou Wind from right case 1	Wind from left case 1 Wind loads Wind load from left side case Wind loads Wind load from left side withor Wind loads Wind from right case 1 Wind loads	Wind from left case 1 Wind loads • Wind load from left side case Wind loads • Wind load from left side withor Wind loads • Wind from right case 1 Wind loads •	Wind from left case 1 Wind loads • 111 Wind load from left side case Wind loads • 111 Wind load from left side withor Wind loads • 111 Wind from right case 1 Wind loads • 111	Wind from left case 1 Wind loads 111 Wind load from left side case Wind loads 111 Wind load from left side withor Wind loads 111 Wind from right case 1 Wind loads 111	Wind from left case 1 Wind loads 111 Image: Control of the state case 1 Wind loads 111 Image: Control of the state case 1 Wind loads 111 Image: Control of the state case 1 Details (6) Wind load from left side withor Wind loads 111 Image: Control of the state case 1 Image: Contro of the state case 1 Image:

Additional load cases

To edit standard load cases, copy them in the table 'Additional load cases' and edit them as required ('Copy loads from load case' column).

If you need additional load cases, you can define them in this table.

Standard	Load Cases	Additional LC					
	Description	Action	Alt	Active	Copy loads from load case	Loads	2
a 1	Add. load case	Wind loads -	0	V		Edit (0)	
					Roof load Wind from left case 1 Wind load from left side case 3		



click on this button to add a new additional load case (a new table row).

Self-weight

Check this option to include the self-weight automatically as a permanent load in the calculation.



Roof load

Enter the permanent load of the roof superstructure.

Roof load from load value summary:

By clicking on the arrow icon vou can access a load value summary - see the description of the <u>LOAD+</u> application.

Select subsequently whether the roof load should be referenced to the roof area or the base area.

Load case control

You and enable and disable load cases in this section. Please read the tooltip below the information button.

Settings of load cases	0				
Load case active					
Settings of load cases	Switch off all Standard I C				
Remarks	Switch off all Standard LC Switch off all Wind LC All wind load cases on Switch off all LC Snow All snow load cases on Switch off all LC Wind left All load case wind from left on Switch off all LC Wind left All load cases wind from right All additional load cases off All additional load cases on				
Actions					



Design

Calculate

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

Load transfer

You can transfer the characteristic support reactions to the applications:

- Steel Column
- H01+ Timber Column
- B5+ Reinforced Concrete Column

In a intermediate dialog, parameters such as column height, height of the load application point and eccentricity can be specified.

- ST4 Steel Girder Support
- <u>B9+</u> Reinforced Concrete Corbel

The desired combination can be selected (marked) in a dialog.

Enhanced stability verifications BTII+

If you hold a licence for <u>BTII+</u> (Lateral Torsional Buckling Analysis), you can transfer the top chord, the bottom chord and the vertical edge members, if any, to BTII+. This software application provides for the calculation of more complex systems.

Connected programs

Here you can transfer the system to other FRILO programs such as \underline{RSX} or $\underline{FWH_{+}}$.



Properties	д	
Basic Parameters System Load Joinensioning Joinensioning Load transfer Extended stability check Output	۹.۵	
Left support		0
Steel column	STS+	1
Timber column	H01+	1
RC column	B5+	1
Girder support	ST4	1
Reinforced concrete corbel	B9+	
Rights support		0
Steel column	STS+	1
Timber column	HO1+	1
RC column	B5+	1
Girder support	ST4	1
Reinforced concrete corbel	B9+	





Results and output

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



Scope of the output and options

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

Properties	4
Basic Parameters	9.0
🛓 System	
Loads	
Design	
Output	

General	۵
Brief output	V
Notes	
System	0
System graphics 2D	V
System graphics 3D	
Force the scale	
Loads	0
Actions	V
Load Case Graphics	Details (7)
Results	0
Support reaction- characteristic per load case	V
Result Graphics	Details (6)
Resulting intern forces in table	Details (6)



Output as a PDF file

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

See also the document Output and printing.





Reference literature

/1/

- /2/ DIN 1052, 1996, Part 1 A1, Timber structures, Design and construction, Modifications
- /3/ DIN 1055: 1978, Part 1 to 5, Design loads for buildings
- /4/ DIN 1052:2004-08, Part 1, Draft, Design of timber structures General rules and rules for buildings
- /5/ DIN 1055:2001-03, Part 100, Actions on structures
- /6/ DIN 1055:2005-03, Part 4, Wind loads
- /7/ DIN 1055:2006-03, Part 4 Amendment 1, Wind loads, Amendments to DIN 1055-4:2005-03
- /8/ DIN 1055:2005-07, Part 5, Snow and ice loads
- /9/ DIN 18800: 1990, Part 1, Structural steelwork; design and construction
- /10/ DIN 18800: 1990, Part 2, Steel structures; Stability Buckling of bars and skeletal structures
- /11/ Krüger Ulrich, Stahlbau Teil 1+ 2, Ernst & Sohn Verlag 1998
- /12/ DIN EN 1993-1-1:2010, 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 on Structures:
- /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