

Butt Plate Joint SPS+

Contents

Application options	2
Data entry	3
Basic parameters	4
Structural system	6
Material	7
Bolts	7
Loading	8
Output	9

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.friilo.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 SPS+ program is suitable for the design of end plate joints in steel construction.

In an end plate joint, two beams are connected with a welded-on end plate either flush to the surface or projecting. Two or four vertical bolt rows are used to create a moment-resistant connection. The permissible profile types are I-shaped steel profiles.

Standards

- DIN EN 1993
- ÖNORM EN 1993

Calculation bases

The calculation of the connections is based on the methods described in DIN EN 1993-1-8.

In the verification of end plate joints with four vertical bolt rows, the model described in the following publications is used:

- Research Report 3/2009: Entwicklung eines Bemessungsmodells für geschraubte momententragfähige Kopfplattenverbindungen mit 4 Schrauben in einer Schraubenreihe auf der Grundlage der prEN 1993-1-1:2003; Deutscher Ausschuss für Stahlbau DASt, Düsseldorf.
- WAGENKNECHT: Stahlbau-Praxis nach Eurocode 3, Band 3 Komponentenmethode, 2nd edition; Beuth Verlag GmbH, Berlin, Wien, Zürich 2017.

Data entry

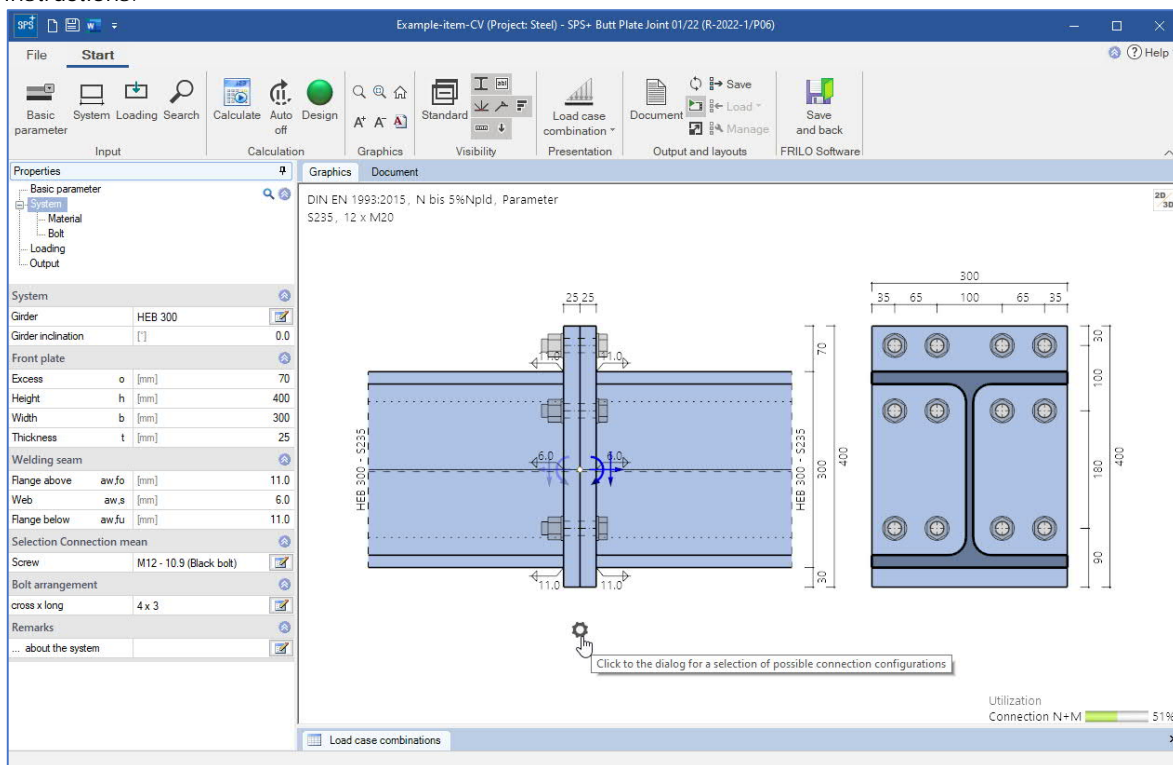
Assistant

After starting the program, the [assistant](#) is displayed first. You can define the most important and required parameters to have a first calculable basic system at hand that you can further customise subsequently.

Interactive graphical user interface (GUI)


You can enter data in the left menu or directly in the GUI (click on objects or use the right mouse button).

For more information, read the chapter "[Interactive Graphical User Interface](#)" in the Basic Operating Instructions.



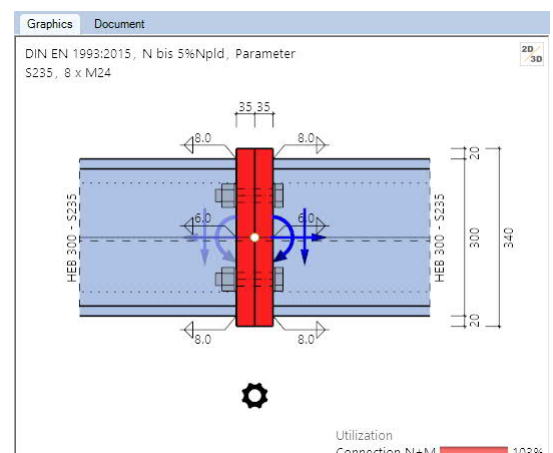
- Click on the individual components (beam, butt plate, screw, load arrows) to display the appropriate parameter dialog.
- You can make changes to the dimensions directly in the dimension chains.
- The text links (top left) are also interactive.

Suggestion function for suitable typical designs of the butt plate

Click on the gear symbol  to display the suggestion dialog. You can then choose from a list of typical designs of the butt plate.

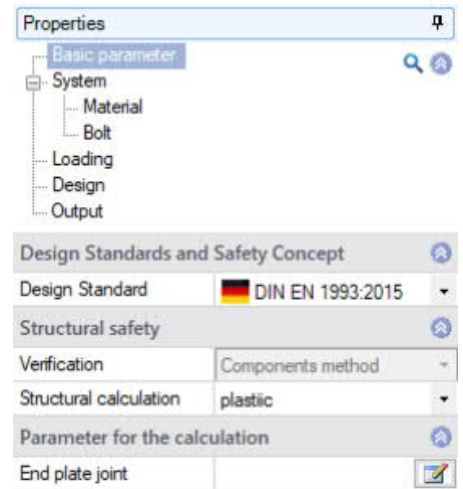
Colored marking of critical components

If the utilization is greater than 1.0, the critical component is highlighted in the 2D graphic.



Basic parameters

Design standard	DIN EN 1993 ÖNORM EN 1993
Verification method	Component method (in German)
Structural calculation	the structural calculation is based either on the plastic method (decisive MaRd,pl - classification according to load-bearing capacity and stiffness) or on the elastic method (decisive MaRd,el - classification according to stiffness).



Parameters for the calculation / end plate joint

Parameters for the component method

Parameter		
Parameter for component method		
Great axial forces		without
Bolts for NRd-tension		without
Reactions in the T-stub		N-M Interaction are being investigated
FtRd failure type 1		Standard
Tensile area factor	f	0.50
Parameter for lateral force verification		
Vz transfer with		tension-free bolts
VRd limitation		to 50% Qs load resistance
Parameter for weld seam verification		
Verification type of the connection		Partial inner rforces
Test constructive limits		<input checked="" type="checkbox"/>
Connection fully load-bearing		<input type="checkbox"/>

Great axial forces	without or with N-M interaction. Consideration of the axial forces through a verification against NRd and interaction N-M according to equation 6.24 of EN 1993-1-8.
Bolts for NRd tension	include without restriction, neglect in the projection: Allows you to define whether the bolts in the projection or in the haunch should be neglected for the determination of the NRd tension.
Reactions in the T-stub	you can either examine them or assume their generation in general. You define whether it is generally assumed that supporting forces can build up in the joint (Tab. 6.2, $L_b < L_b^*$ NOTE 1) or whether the generation of these supporting forces is examined by the program.
FtRd failure type 1	select whether the standard or the alternative verification of the bending resistance is used for determining failure type 1 in the equivalent T-stub of the component flange/plate.
Tensile area factor	this factor allows you to define which bolts absorb tensile stress for MRd: with $f = 1.0$ all bolts in the connection area up to the pressure point act in tension, with $f = 0.5$ only those bolts in the half of the joint that is away from the pressure point act in tension.

Parameters for the shear force verification

Vz transfer via	the shear force is either transferred by all bolts in the valid connection area or exclusively by bolts that do not absorb tensile forces. See also factor f for the tension area in the component method. If bolts are subjected to tensile and shear forces, the shear capacity is reduced by the N-V interaction.
VRd limitation	you can limit the design shear force resistance to 50 % of the design shear resistance of the crossbeam. This limitation is used in the calculation of the utilization by VRd. This dispenses with the examination of the interaction with VRd, which would otherwise have been required as a separate calculation.

Parameters for the welding seam verification

Verification type of the connection	the verification of the weld seams in the connection is performed optionally - with the respective partial internal forces - via the structural analysis of the overall weld seam pattern (IAW*)
Test constructive limits	If the option is selected, the design limit values of the weld seam thickness are checked by the program.
Connection fully load bearing	the weld seams at the connection are verified in such manner that they are able to transmit the limit moment and limit shear force of the joint. The ductility of weld seams is limited. Therefore, they should be dimensioned in such a way that they are not relevant for the design, i. e. that another component fails first. NOT with activated interaction of N and M according to equation 6.24 of EN 1993-1-8

*IAW = Institut für Arbeitswissenschaft (German Institute for Labour Science)

Structural system

Girder accesses the profile selection for the beam - see the document [Cross-section selection-PLUS](#)

Girder inclination inclination of the beam in degrees, mathematically positive (-45° ... 45°)

End plate

Enter the end plate dimensions.

o distance of the top edge of the plate to the top edge of the adjoining component.

h height of the plate.

b width of the plate.

t thickness of the plate.

Weld seam

aw,fo thickness of weld seam plate to flange on top

aw,s thickness of weld seam plate to web

aw,fb thickness of weld seam plate to flange bottom

Fasteners

Accesses the data-entry fields for the bolts. See the chapter [Bolts](#).

Bolt arrangement

Klick the edit button to enter the values for the bolt pattern .

Transverse means transverse to the direction of the main loading (i. e. in the flange direction, seen from the joint) and longitudinal means in the direction of the main loading (i. e. in the web direction, seen from the joint).

Rows number of rows of bolts in the transverse direction - these are arranged symmetrically on each side of the web, i. e. always 2 or 4.

w distance of the bolt axes in the transverse direction (in the web area).

w1 hole spacing of the bolts in the transverse direction.

w2 distance of the bolts to the edge in the transverse direction.

w, w1, w2 are shown in the GUI.

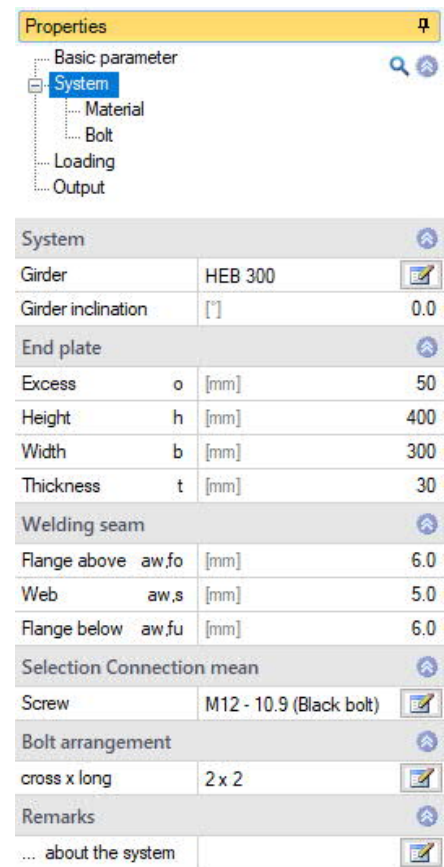
Per row number of bolts within a row - in longitudinal direction, one behind the other.

e a data-entry table for the distances of the bolts in longitudinal direction, measured from the upper edge of the end plate is displayed. e1, e2 etc. are shown in the GUI.

Conflict the program tries to solve the conflict by arranging the bolts with valid distances.

Remarks

Call up the [Remarks Editor](#). The comments are included in the output with the system data.



Properties			
Basic parameter			
System			
Material			
Bolt			
Loading			
Output			
System			
Girder		HEB 300	
Girder inclination		[°]	0.0
End plate			
Excess	o	[mm]	50
Height	h	[mm]	400
Width	b	[mm]	300
Thickness	t	[mm]	30
Welding seam			
Flange above	aw,fo	[mm]	6.0
Web	aw,s	[mm]	5.0
Flange below	aw,fb	[mm]	6.0
Selection Connection mean			
Screw		M12 - 10.9 (Black bolt)	
Bolt arrangement			
cross x long		2 x 2	
Remarks			
... about the system			

Material

Steel type/grade structural steel, fine-grained structural steel or user-defined (entry of the characteristic values). The corresponding steel grades are offered for selection.

Bolts

The bolt sizes M12 to M36 are available for selection in the strength classes 4.6 to 10.9.

You can select among black bolts and fit bolts.

Black bolts with an internal hole clearance between 0.3 and 2.0 mm and fit bolts with an internal hole clearing between 0.0 and 0.3 mm can be used.

Controlled pre-tensioning of the bolt:

Category A or D only for qualitative improvement of the serviceability by applying the controlled pre-tensioning force F_{pc}^* .

Category B, C or E to increase the structural safety by applying the full pre-tensioning force F_{pc} .

Category A - shear/bearing stress joint

Category B - non-slip connection in the SLS

Category C - non-slip connection in the ULS

Category D - tensile connection, not pre-tensioned

Category E - pre-tensioned tensile connection

You can select whether the thread or shank of the bolt should be in the shear joint.

After having defined the bolt type, the hole diameter is set to the nominal hole diameter of the corresponding bolt size.

It can be adjusted within the permissible range.

The nominal hole diameter of M16 is 18 mm for black bolts (internal hole clearance of 1.0 mm) and 17 mm for fit bolts (internal hole clearance of 0.0 mm), for example.

Note: The characteristic values of the yield strength f_{ybk} and the tensile strength f_{ubk} are indicated by the strength class:

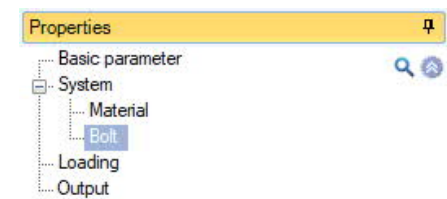
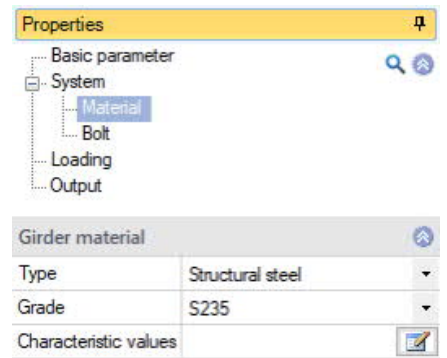
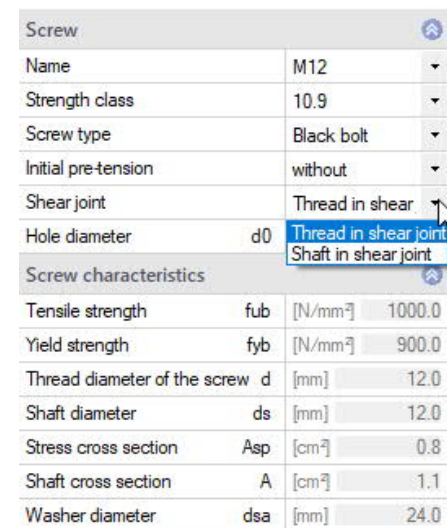
$$f_{ybk} = (\text{digit preceding the dot}) * (\text{digit following the dot}) * 10 \text{ N/mm}^2$$

$$f_{ubk} = (\text{digit preceding the dot}) * 100 \text{ N/mm}^2$$

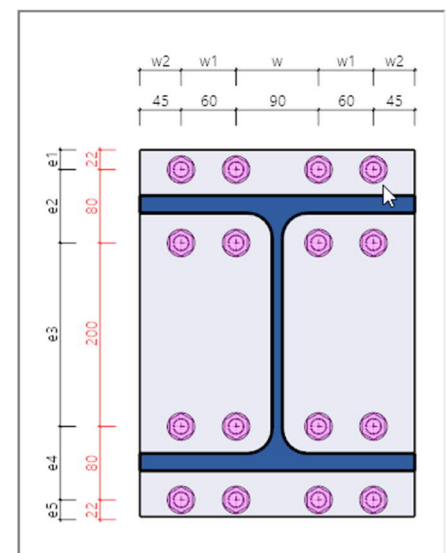
e. g. $F-5.6 \quad f_{ybk} = 300 \text{ N/mm}^2$

$$f_{ubk} = 500 \text{ N/mm}^2$$

Bolt arrangement: see [System](#)

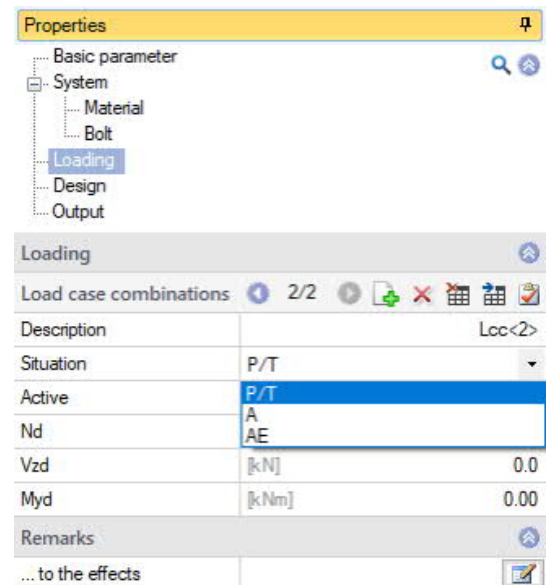
Screw		
Name	M12	
Strength class	10.9	
Screw type	Black bolt	
Initial pre-tension	without	
Shear joint	Thread in shear	
Hole diameter	d0	
Screw characteristics		
Tensile strength	f_{ub} [N/mm ²]	1000.0
Yield strength	f_{yb} [N/mm ²]	900.0
Thread diameter of the screw	d [mm]	12.0
Shaft diameter	d_s [mm]	12.0
Stress cross section	A_{sp} [cm ²]	0.8
Shaft cross section	A [cm ²]	1.1
Washer diameter	d_{sa} [mm]	24.0



Loading

To access the table of the load case combinations, click on "to the table" or on the tab "Load combinations" below the GUI.

You can add or delete [table rows](#) via the icons on the right - as well as via the "Load case combination" icon in the menu ribbon.



Properties

- Basic parameter
- System
 - Material
 - Bolt
 - Loading
 - Design
 - Output

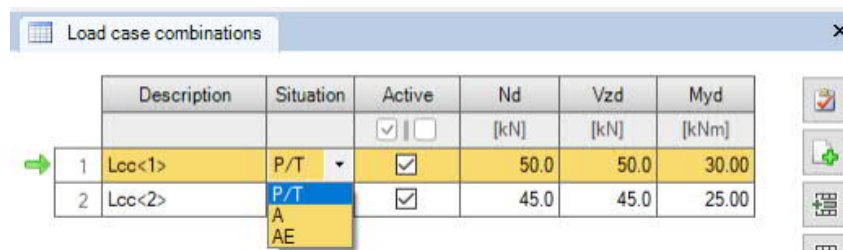
Loading

Load case combinations 2/2

Description	Situation	Active	Nd	Vzd	Myd
Lcc<1>	P/T	<input checked="" type="checkbox"/>	50.0 [kN]	50.0 [kN]	30.00 [kNm]
Lcc<2>	P/T	<input checked="" type="checkbox"/>	45.0 [kN]	45.0 [kN]	25.00 [kNm]

Remarks

... to the effects



Load case combinations

Description	Situation	Active	Nd	Vzd	Myd
Lcc<1>	P/T	<input checked="" type="checkbox"/>	50.0 [kN]	50.0 [kN]	30.00 [kNm]
Lcc<2>	P/T	<input checked="" type="checkbox"/>	45.0 [kN]	45.0 [kN]	25.00 [kNm]

You can assign a name to each load case combination.

Situation Design situation of the load combination
 P/T : persistent/transient design situation
 A : accidental design situation
 AE : seismic design situation

Active enables/disables the corresponding load case combination.

Nd design value of the axial force at the cut face of the member positive as tension force away from the node.

Vzd design value of the shear force at the cut face of the member.

Myd design value of the moment at the cut face of the member (see also dashed fibre in the system diagram).

Output

The "Document" tab displays the data to be put out.

See also

[Output and printing](#)

The output scope is selectable.

Properties

- Basic parameter
- System
 - Material
 - Bolt
 - Loading
 - Design
 - Output**

Global

Output scope	Standard
System graphics 3D	Brief
System graphics 2D	Standard
Scale	User defined
Sheet metal excerpt	<input type="checkbox"/>
Detail graphic end plate	<input checked="" type="checkbox"/>
Loading	
Only relevant LCc	<input checked="" type="checkbox"/>
Graphic decisive Lfk	<input type="checkbox"/>

The screenshot shows the software interface with the 'Document' tab active. On the left, a 'Pages' sidebar shows thumbnails for Page 1, Page 2, Page 3, and Page 4. The main window displays technical drawings for a 'Butt Plate Joint SPS+ 01/22 (FRILO R-2022-1/P02)'. The drawings include a front view of the joint, a detail of the front plate, and a cross-section of the girder. The 'Properties' panel on the right is open to the 'Output' section, showing the 'Output scope' set to 'Standard' and 'System graphics 2D' set to 'Standard'. The 'Detail graphic end plate' checkbox is checked.

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 12/13/2021 Page: 1

Item: (New item)
 Butt Plate Joint SPS+ 01/22 (FRILO R-2022-1/P02)

Basic parameters

Design code : DIN EN 1993-1-1/NA:2015-08
 Check method : Components method
 Structural calculation : plastic
 Components method : vertical - 2 rows
 without considering large normal forces
 Apply bolts for N_{Ed} tension without restriction
 Investigate reactions in the T-stub
 $F_{t,Rd}$ failure type 1 standard method
 Tension area factor for M ω connection height $f = 0.50$

Shear force : transfer only by tension-free bolts
 V_{Ed} limited to 50% by the girder

Welding seam : simplified check of partial internal forces

System
 System graphics 2D

Model : End plate joint
Bolts : 4 x M24 - 10.9 (Black bolt)
 Girder inclination 0.0°

Member	Name	Material	h mm	b _w mm	t _w mm	t _f mm	r mm	b _f mm	t _f mm
Girder	HEB 300	S235	300	300	19	11	27	300	19