

# Steel Frame Corner SRE+

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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](http://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

Depending on the licensed option, bolted (option SRE-1) or welded (option SRE-2) flexurally rigid frame nodes can be designed in steel structures.

The software performs the required verifications in regard to structural safety and the welded connections.

### Available standards

- DIN EN 1993
- ÖNORM EN 1993

### Structural system

The beam can either be connected to a continuous column (T-joint) or end above the column (knee joint) or continue above the column (rotated T-joint). Double-T sections are available.

Variants:

- T-joint with haunch on one or both sides (corner reinforcement) and inclined beam.
- Knee joint with haunch on one side (corner reinforcement) and inclined beam.
- Knee joint with additional tension plate in the bolted connection, optionally also bolted to a top plate.

For a welded frame corner

- Additional field joint in the beam as flexurally rigid end plate joint in flush or projecting design.

You can increase the bearing capacity of the shear panel by applying diagonal stiffeners or a web reinforcement to one side. Web stiffeners can be fitted opposite adjacent flanges in the load-transferring component. In the welded joint, stiffeners on the outer flanges of the joint are automatically set and cannot be removed.

### Loading (actions)

You have to enter the design values of the internal forces  $N$ ,  $M_y$  and  $V_z$ . The internal forces must result for the biggest part from static loading.

Alternating moments can be included.

You can enter multiple combinations of actions via dedicated tables.

### Output

You can document the results in a well-structured brief or extensive output with the help of a customisable output profile.

The two-dimensional or three-dimensional graphical representation of the structural system and user-defined comments on the system can optionally be included in the output.

## Calculation

### Prerequisites for the application of the different calculation methods

All methods assume a mainly static loading.

The verification of the weld seam limit stresses is performed using the simplified method.

The permissible weld seam limit stresses are provided as a basis.

### Bolted frame corner

Various calculation methods are available depending on the configuration of the structural system:

- In accordance with the component method for optionally pre-tensioned bolts fitted in two vertical rows and distributed variably over the connection height (EN 1993)
- as well as for four vertical rows of bolts distributed on both sides of the outer beam flange under tension in accordance with the AiF model in "DASt Forschungsbericht 3/2009" [13] and Gerd Wagenknecht, "Stahlbau-Praxis nach Eurocode 3", 2017 [14] (EN 1993).

### Component method

Component model in accordance with the method stipulated in EN 1993-1-8.

The design resistance of the connection is determined under the assumption of a plastic distribution of the bolt forces. The internal forces can be determined with the help of the rotational stiffness of the connection calculated by the software.

Specific application restrictions for the methods:

→ see [calculation basis for steel connections with the component method according to EN 1993-1-8](#)

(german).

### Welded frame corner

Subject to verification are the weld seams, the shear panel as well as the transverse stiffeners or the load application points and the field joint, if applicable.

The minimum thicknesses of the weld seams required for constructive reasons are checked by the program and adjusted if necessary.

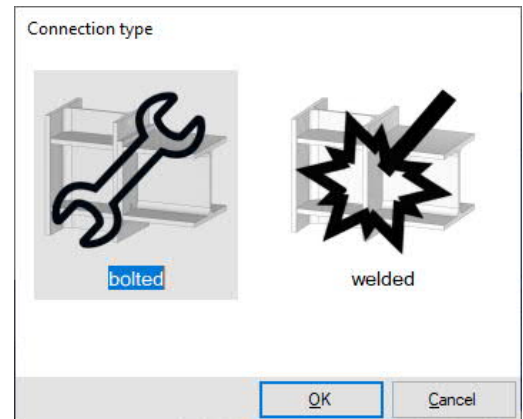
The software assumes a braced connection with stiffeners on the outer flanges of the connection.

The field joint is verified only when loads apply that generate tension in one flange and compression in the opposite flange.

## Data entry

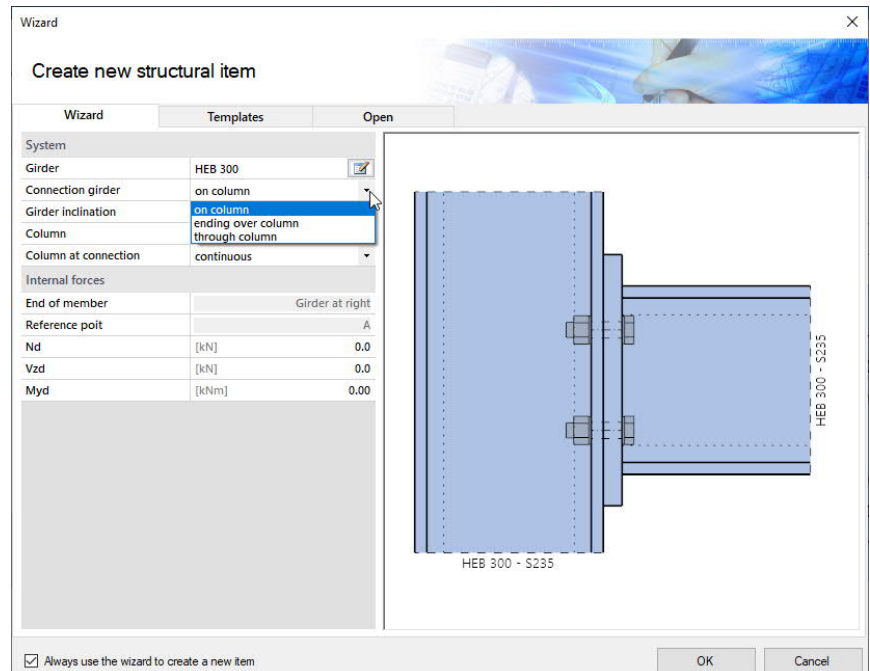
When starting the program, first select the type of joint

- bolted or
- welded connection



### Wizard

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



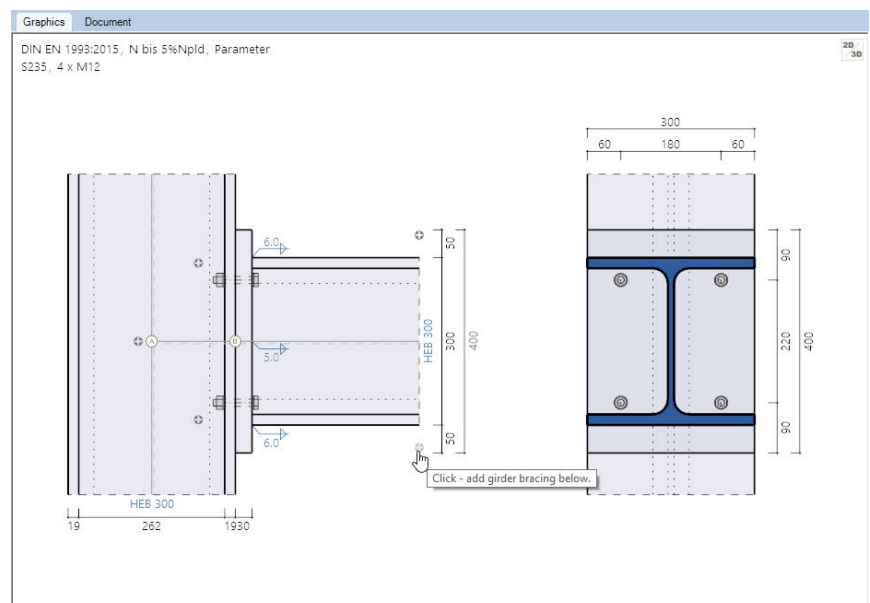
### Interactive graphical user interface (GUI)

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.
- Stiffeners / shear field reinforcement / built-up joint can be added using the "+" symbols.
- You can make changes to the dimensions directly in the dimension chains.
- The text links (top left) are also interactive.



## Basic parameters

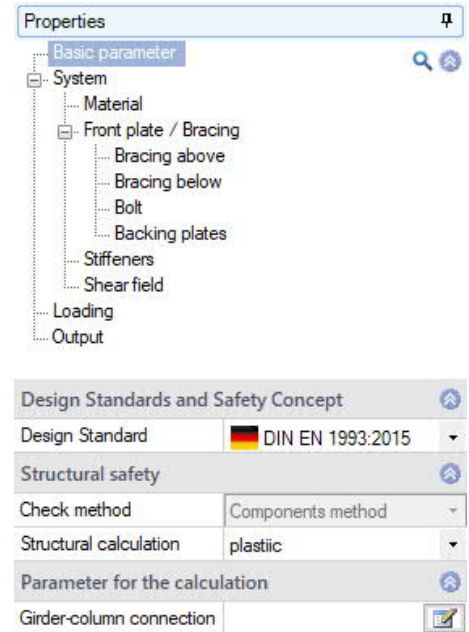
Depending on the selected type of connection - bolted or welded - the corresponding data-entry fields are displayed. The data to enter are described below, partly for both joint types together and partly separately for each type.

Design standard     DIN EN 1993  
                           ÖNORM EN 1993

### Bolted frame corner

Verification method     [Component method](#)

Structural calculation     the structural calculation is based either on the plastic method (decisive MaRd,pl - classification according to load-bearing capacity and stiffness) or the elastic method (decisive MaRd,el - classification according to stiffness).



### Girder-to-column connection

#### Parameters for the component method

Parameter		
<b>Parameter for component method</b>		
Great axial forces		without
Bolts for NRd-tension		without
Reactions in the T-stub		N-M Interaction are being investigated
Longitudinal pressure in column flange		disregarded
RtRd failure type 1		Standard
Check of stiffness at all		<input type="checkbox"/>
Tensile area factor	f	0.50
Transfer factor	$\beta$	1.00
<b>Parameter for the classification</b>		
Frames laterally		displaceable
System length	l [m]	10.00
ly for rigidity		Average bracing
<b>Parameter for lateral force check</b>		
Vz transfer with		tension-free bolts
VRd limitation		to 50% Qs load capacity
<b>Parameters for the shear panel check</b>		
with check according to Petersen		<input type="checkbox"/>
<b>Parameter for weld seam check</b>		
CHeck on the connection		Partial inner forces
Test constructive limits		<input checked="" type="checkbox"/>
Connection fully load-bearing		<input type="checkbox"/>
<b>Parameter for the tension plate check</b>		
Check of the flange below the tension plate		<input checked="" 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.
Reaction in the T-stub	you can either examine these supporting forces or generally assume their generation. 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.
Longitudinal pressure in column flange	you define whether a reduction due to longitudinal compressive stresses caused by pressure and bending moment in the column shall be considered within the component 'column flange in bending' analogous to J.3.5.4.2(4) ENV 1993-1-1:1992/A2:1998.
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.
Check of stiffness at all	check this option if the verification of the stiffeners should be considered as successful in all cases. The corresponding pressure component is then omitted in the verification of the connection (e. g. column web in compression analogous to ENV 1993-1-1:1992/A2:1998 J.3.3.2).
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.
Transfer factor $\beta$	transfer parameter for the component method as per table 5.4 (influence of shear on the column web panel) for the type of connection.

### Parameters for the classification

Frames laterally	non-sway/sway: criterion for the classification of stiffness of the connection.
System length	length of the adjoining component (system axis - system axis) for the classification of the stiffness of the connection.
$I_y$ for rigidity	classification of the stiffness from $I_y$ of the basic component without bracing or from the mean value of $I_y$ at the contact face of the bracing and $I_y$ of the basic component.

### Parameters for the lateral force check

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 force. See also factor $f$ for the tension area in the component method. If bolts are loaded by tensile and shear forces, a reduction due to the N-V interaction is applied in the verification of the shear force resistance.
VRd limitation	you can limit the design shear force resistance to 50 % of the design shear resistance of the connected component. 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 be required as a separate calculation.

### Parameters for the shear panel check

With check according to Petersen

If the option is ticked, an additional verification of the shear panel in accordance with Petersen is provided.

See Petersen, Ch., Stahlbau, 2nd edition, 1990; Vieweg & Sohn, Braunschweig/Wiesbaden.

### Parameters for the weld seam check

Check on 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 specifies whether the constructive limit values of the weld seam thickness are checked by the program.

Connection fully load bearing the weld seams at the connection are verified as to whether 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)

### Parameters for the tension plate check

Check of flange below tension plate if the option is ticked, a simplified verification of the component flange underneath the tension plate is performed in addition.

## Welded frame corner

### Girder-to-column connection

#### Parameters for the weld seam check

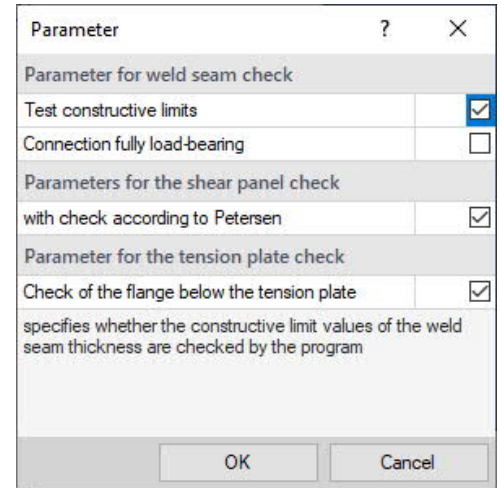
**Test constructive limits** If the option is ticked, the design limit values of the weld seam thickness are checked by the program.

**Connection fully load-bearing** if the option is ticked, the weld seams at the connection are verified as to whether 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



Parameter	
<b>Parameter for weld seam check</b>	
Test constructive limits	<input checked="" type="checkbox"/>
Connection fully load-bearing	<input type="checkbox"/>
<b>Parameters for the shear panel check</b>	
with check according to Petersen	<input checked="" type="checkbox"/>
<b>Parameter for the tension plate check</b>	
Check of the flange below the tension plate	<input checked="" type="checkbox"/>
specifies whether the constructive limit values of the weld seam thickness are checked by the program	
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

#### Parameter for the shear panel check

**according to Petersen** if the option is ticked, an additional verification of the shear panel in accordance with Petersen is provided.

See Petersen, Ch., Stahlbau, 2nd edition, 1990; Vieweg & Sohn, Braunschweig/Wiesbaden

#### Parameter for the tension plate check

**Check of the flange below the tension plate**

if the option is ticked, a simplified verification of the component flange underneath the tension plate is performed in addition.

## Built-up joint

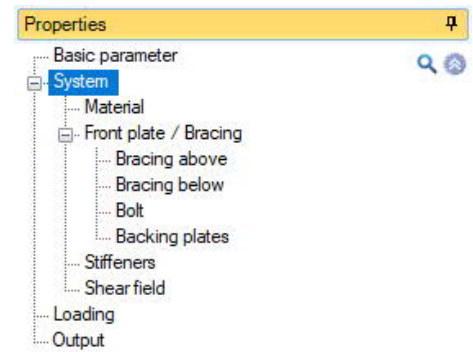
The parameters correspond to the options for the end plate already described in the "[Bolted frame corner](#)" section. The structural calculation is carried out either plastically or elastically.

See also system [built-up joint](#).



## Structural system

Girder	accesses the profile selection for the beam - see the document <a href="#">Cross-section selection-PLUS</a> .
Connection girder	the beam can either be connected to a continuous column (T-joint) or end above the column (knee joint) or continue above the column (rotated T-joint).
Girder inclination	inclination of the beam in degrees, mathematically positive (-45° ... 45°)
Column	accesses the profile selection for the column - see the document <a href="#">Cross-section selection-PLUS</a> .
Column at connection	the beam can either be connected to a continuous column (T-joint) or to the end of a column (knee joint).
Material	see chapter „Material“ below.
Input geometry	“general” means that all values are determined on both sides of the connection, “symmetrical” means that the values are determined only on one side of the component and are then automatically applied to the other side.
Remarks	launches the <a href="#">Remarks Editor</a> . The comments are included in the output with the system data.



System	
Girder	HEB 300
Connection girder	on column
Girder inclination	[°] 0.0
Column	HEB 300
Column at connection	continuous
Material	
Beam/Column	S235 / S235
Configuration of input	
Input geometry	general
Remarks	
... about the system	

## Material

In all members	the material can be identical for all members or different for each one. If you select "different", the corresponding input fields are displayed.
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.

Material	
in all members	different
Girder material	identical / different
Type	Structural steel
Grade	S235
Characteristic values	
Column material	
Type	Structural steel
Grade	S235
Characteristic values	

## Bolted frame corner: End plate/bracing

Enter the dimensions of the end plate and the weld seam.

The following options are available for bracing at the top or bottom:

- without,
- haunch from I-section,
- haunch from corner sheet metalprofile with flange,
- haunched I-section.

For the types 'haunch at component', sufficient projection of the plate must be provided.

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
Bracing above			
Type	haunched I-profile		
Bracing below			
Type	without bracing		
Selection Connection mean			
Screw	M24 - 10.9 (Black bolt)		
Bolt arrangement			
cross x long	2 x 2		

## Fastener selection / bolt

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.

The internal hole clearance of black bolts is between 0.3 and 2.0 mm,

whereas that of fit bolts is between 0.0 and 0.3 mm based on the regular hole diameter.

The shear joint might take effect in the thread or in the bolt shaft.

### Controlled pre-tensioning

Select a category for the 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

### Hole diameter

After having entered the bolt type, the hole diameter is set to the regular hole diameter of the corresponding bolt size.

It can be edited and adjusted within the permitted range in the dialog associated to the bolt pattern.

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

*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.  $F-5.6$   $f_{ybk} = 300 \text{ N/mm}^2$   
 $f_{ubk} = 500 \text{ N/mm}^2$

## Bolt arrangement on the end plate

Values to define the bolt pattern on the end plate in the beam-to-column connection.

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 bolt rows in transverse direction - they are arranged symmetrically on each side of the web, i. e. always 2 or 4.
w	enter the distances of the bolt rows in transverse direction, measured from the end plate edge to the centre. w, w1 etc. are shown in the graphical representation.
Per row	number of bolts within a row - in longitudinal direction, one behind the other.
e	data-entry table for the spacing of the bolts in longitudinal direction, measured from the upper edge of the end plate, with end plate at knee joint, from the outer edge of the component flange in the contact face. e1, e2 etc. are shown in the graphical representation.

It depends on the connection configuration and the calculation method which bolts are actually considered - see the chapter "[Application options](#)" and also [Calculation](#).

## Bracing on top / bottom

Options: without bracing, haunch of I-section or gusset plate with flange or haunched I-section.

If bracing is selected, the corresponding profiles are offered for selection as well as the dimensions.

## Bolts

See [Selection of fasteners](#).

## Backing plates

You can define the position of the backing plate on the tension-loaded flange:






- without,
- for all bolts in the connection,
- only for bolts under tensile load - optionally with tension in the connection on top or on bottom.

## Welded frame corner: Connection / bracing

You can define the weld seam thickness at the flange top/bottom and at the web.

For the bracing, the same [options](#) are available for selection as for the bolted frame corner.

Inner flange    consider the inner flange in the structural model as effective or neglect it.

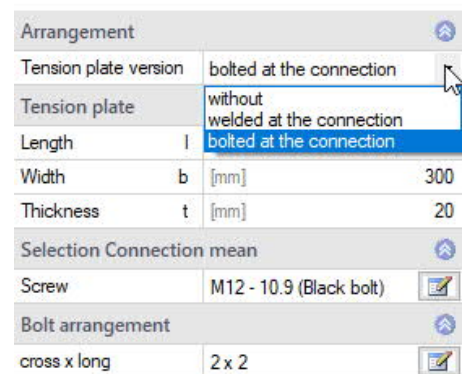
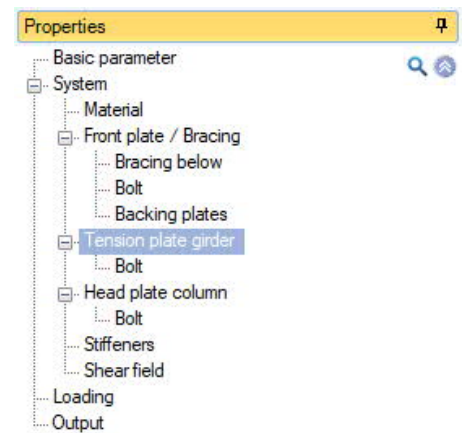
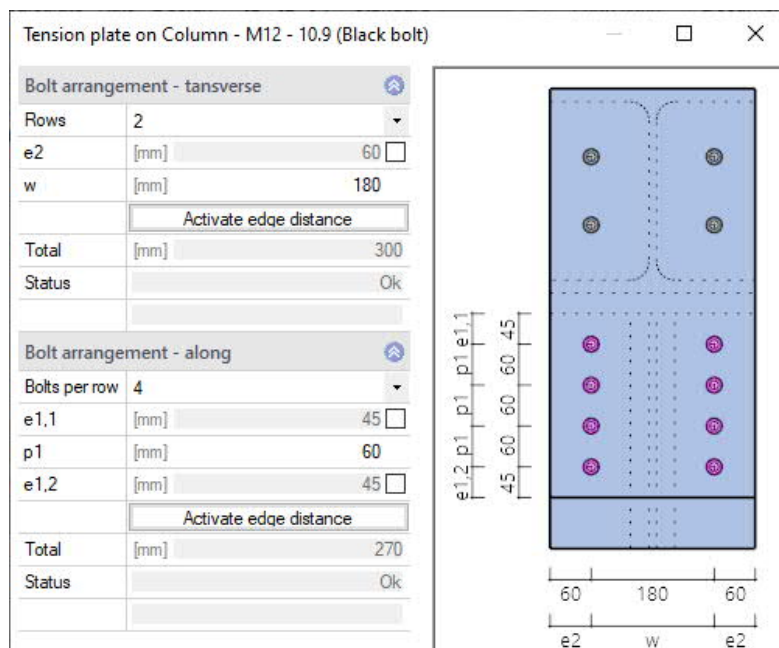
<b>Connection</b> 			
Flange above	aw,fo	[mm]	6.0
Web	aw,s	[mm]	5.0
Flange below	aw,fb	[mm]	6.0
<b>Bracing above</b> 			
Type	haunched I-profile		
<b>Bracing below</b> 			
Type	without bracing		

## Bolted frame corner: Tension plate

In order to transfer greater forces in a bolted knee joint, a tension plate can be positioned, if required.

Define the geometry of the tension plate by specifying its length, width, and thickness. It is either welded to the web of the load-bearing component at the connection ( $aw,s$ ) or bolted to a top plate attached there.

The selection of the bolts and their arrangement is made separately for the connections "tension plate at component flange" and "tension plate at top plate".



The bolt spacing is defined via parameters:

Rows	number of bolt rows in transverse direction - they are arranged symmetrically on each side of the web
w	centre-to-centre distance in transverse direction, above the web area
p2	hole spacing in transverse direction
e2	edge distance in transverse direction
Per row	number of bolts within a row - in longitudinal direction, one behind the other
e1,1	edge distance in longitudinal direction, at the beginning of the bolt pattern
p1	hole spacing in longitudinal direction
e1,2	edge distance in longitudinal direction, at the end of the bolt pattern

## Bolted frame corner: Head plate

In knee joints, the load-bearing component is terminated with a top plate, unless it is connected to a welded-on tension plate.

The geometry results from the dimensions in the component's contact face. You simply need to specify the thickness of the plate and the dimensions of the weld seams at the web and the flange. Without a screwed-on tension plate, the plate is orthogonal to the component or, optionally, adopts the inclination of the transferring component.

If a configuration with a tension plate bolted to a top plate is selected, details of the bolts used and the bolt arrangement are also queried (see the chapter Tension plate).

Arrangement		
Position of the head plate		inclined
Head plate		orthogonal inclined
Thickness	t [mm]	20
Welding seam		
Web	aw,s [mm]	5.0
Flange	aw,fu [mm]	6.0

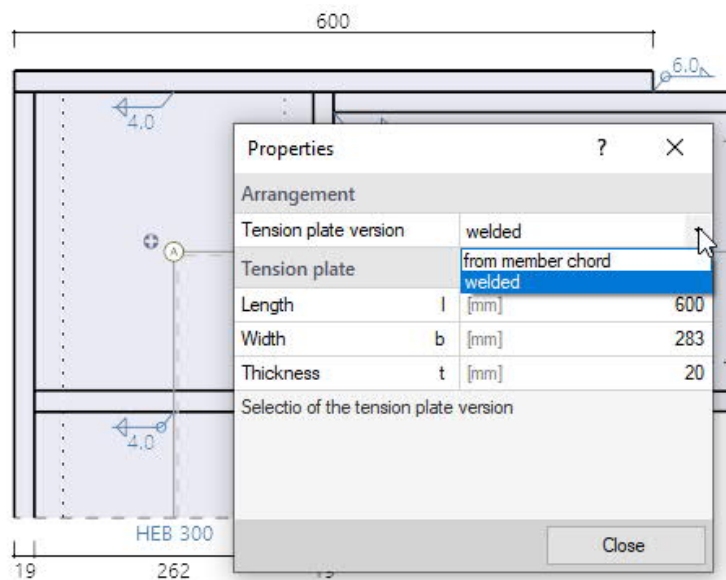
Head plate		
Thickness	t [mm]	20
Welding seam		
Web	aw,s [mm]	5.0
Flange	aw,fu [mm]	6.0
Selection Connection mean		
Screw		M12 - 10.9 (Black bolt)
Bolt arrangement		
cross x long		2 x 2

## Welded frame corner: Tension plate

In a knee joint, the upper flange of the adjoining component is pulled over the load-transferring component as a tension plate and welded to its web (aw,s).

Alternatively, this connection can be made with a welded-on tension plate.

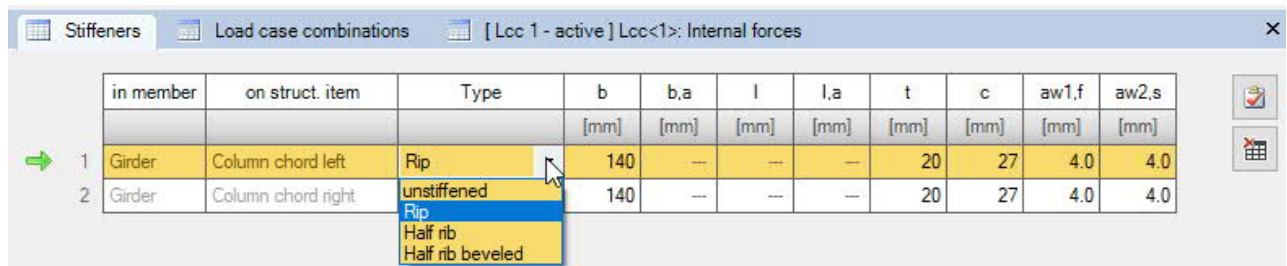
Length	length of the tension plate
Width	width of the tension plate
Thickness	thickness of the tension plate
aw,s	thickness of the weld seam on the web of the connected steel section
aw,f	thickness of the weld seam on the flange along the steel section with the welded-on tension plate.



## Stiffeners

The possible stiffener positions are displayed by the program in tabular form. By selecting the "type", a stiffening rib is positioned at the selected position. Templates can be defined for the thickness, the flange and web seam values, which are then automatically applied to all selected stiffeners. This facilitates the data entry.

In symmetrical systems, you can optionally define the values for the stiffeners only for one side of the component. The program then automatically provides for the symmetrical arrangement of the stiffeners on both sides.



in member	on struct. item	Type	b	b,a	l	l,a	t	c	aw1,f	aw2,s	
			[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	
1	Girder	Column chord left	Rip	140	---	---	---	20	27	4.0	4.0
2	Girder	Column chord right	unstiffened	140	---	---	---	20	27	4.0	4.0

Type depending on the component and type of connection: without stiffeners, stiffening rib, half-rib, bevelled half-rib.

b width of the stiffener (flange direction)

b,a width of stiffener at the outer edge (flange direction)

l length of the stiffener at the web (web direction)

l,a length of stiffener at the outer edge (web direction)

t thickness of the stiffener

c recess of the stiffener at the curvature of the basic component.

aw1,f weld seam thickness at the flange.

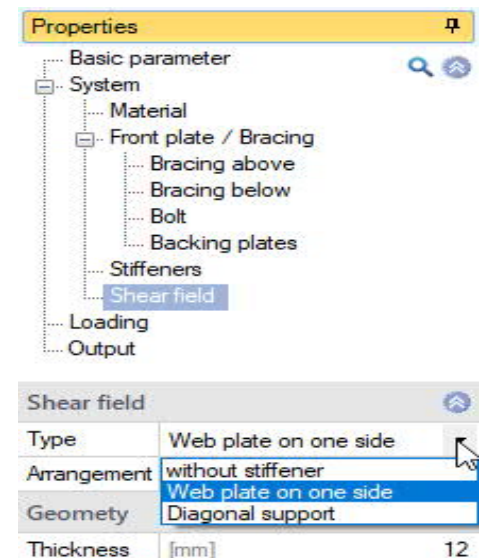
aw2,s weld thickness at the web.

## Shear field

You can select additional bracing for the shear field.

For additional bracing, define the thickness  $t$  for single-sided web plates or the width and thickness for the diagonal stiffener. The required weld seam thickness of the reinforcement is automatically selected by the program according to the standard and cannot be changed by the user.

Arrangement define whether the web reinforcement (single sided) is only applied in load case combinations with tension at the top (or on the left), in load case combinations with tension at the bottom (or on the right) or in both situations.

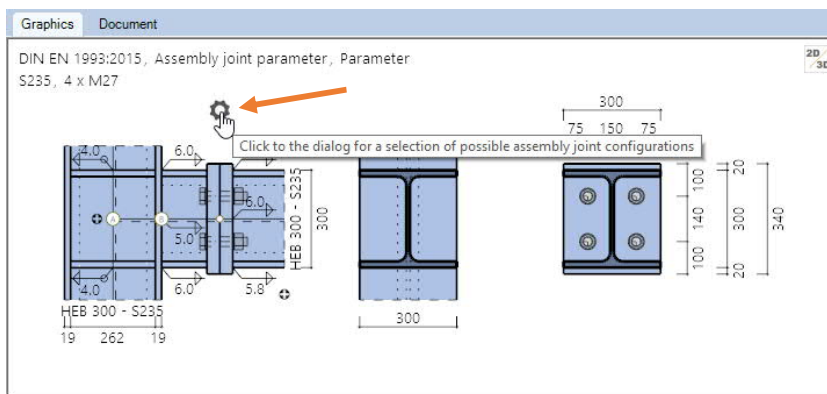


## Built-up joint

An built-up joint can be defined for the welded frame corner.  
The corresponding parameters are then displayed.

### Suggestion function for suitable typical designs of the built-up joint

Click on the gear symbol to display the suggestion dialog. You can then choose from a list of typical designs of the built-up joint as part of the welded connection of the frame corner.



**Properties**

- Basic parameter
- System
  - Material
  - Connection/Bracing
    - Bracing above
    - Bracing below
  - Stiffeners
  - Shear field
  - Built-up joint**
    - Bolt
- Loading
- Output

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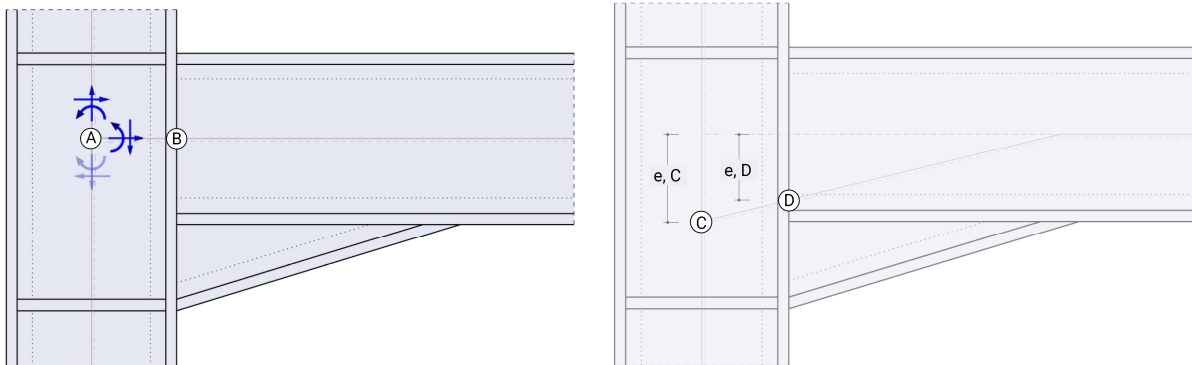
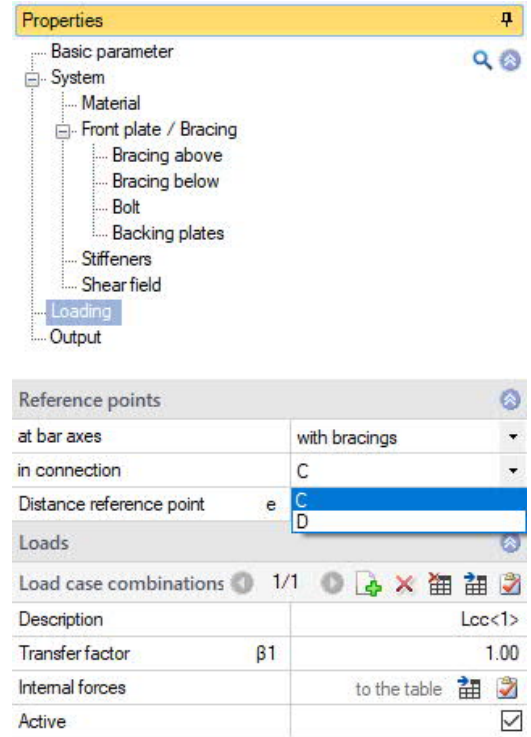
**Built-up joint**

Arrangement	in girder on the right	
Distance in girder e,r	without	
Front plate	in girder on the right	
Excess	o [mm]	20
Height	h [mm]	340
Width	b [mm]	300
Thickness	t [mm]	40
<b>Welding seam</b>		
Flange above	aw.fo [mm]	5.8
Web	aw.s [mm]	6.0
Flange below	aw.fu [mm]	5.8
<b>Selection Connection mean</b>		
Screw	M27 - 10.9 (Black bolt)	
<b>Bolt arrangement</b>		
cross x long	2 x 2	

## Loading

### Reference points

Based on the modelling in a frame structure, the internal forces can be applied at different reference points. For members with or without bracing on both sides, they are always on the member axes, without consideration of a local bracing in points A or B. Only with one-sided bracing, you can also define them in the points C or D if the distance  $e$  is transferred from a framework calculation with consideration of the local bracing in the member axes.



- A intersection of the member axes without consideration of the local bracing.
  - B intersection of the member axis and the contact face to the load-transferring component - adjoining component without consideration of the local bracing.
  - C intersection of the member axes with consideration of the local bracing - defined by the distance  $e$ .
  - D intersection of the member axis and the contact face of the load-transferring component - adjoining component with consideration of the local bracing.
- Distance  $e$  distance of the reference point to the member axis without consideration of the bracing. With a value of zero, points C and A or D and B are identical. Positive upwards or to the right.

Sign convention: in the graphical representation, the positive direction of the internal forces is displayed.



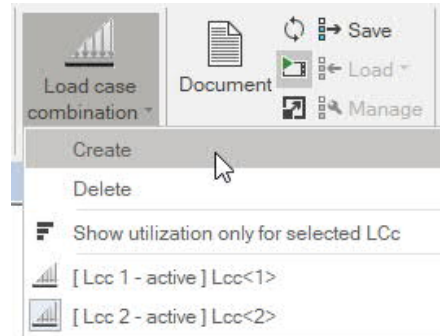
### Load case combinations

For each load case combination, you can enter a designation and, in the bolted connection with  $\beta_1$ , set the transfer parameter for the component method (shear influence column web panel) according to Tab. 5.4 EN 1993-1-8 ( $\beta_1 = 1.0$  for the one-sided beam-column connection).

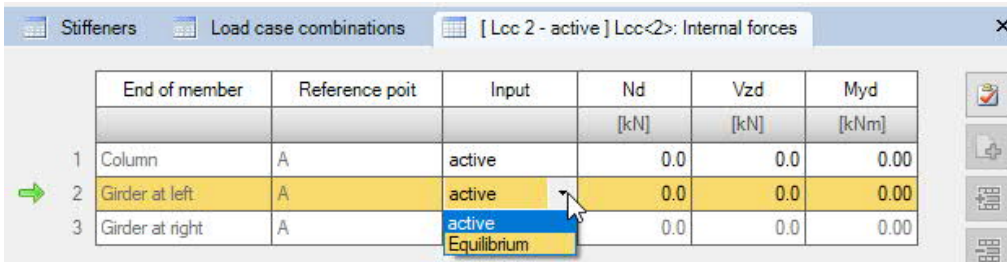
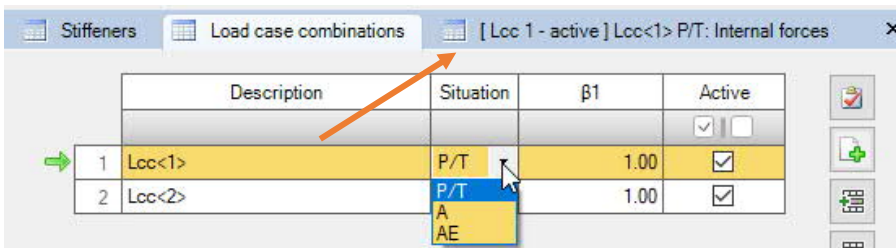
- Situation Design situation of the load combination
- P/T : persistent/transient design situation
- A : accidental design situation
- AE : seismic design situation

The load case combinations can be enabled or disabled individually.

Via the icons on the right, you can add or delete table rows - as well as via the "Load case combination" icon in the menu ribbon.



To enter the design values of the associated internal forces, click on the corresponding item in the load combination menu and then on the tab "Internal forces" to display the corresponding table.



- Input** set to "active" to enter the internal force at this end of a member. If the end of a member is disabled in all cases, the corresponding values are determined by the equilibrium.
- 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 representation of the node).

# Output

## Scope of the output and options

The output scope is selectable. By checking the desired options, you can determine the scope of data to be put out. Activate the desired output options.

Brief, Standard, Detailed are predefined profiles.

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

See also

[Output and printing](#)

