

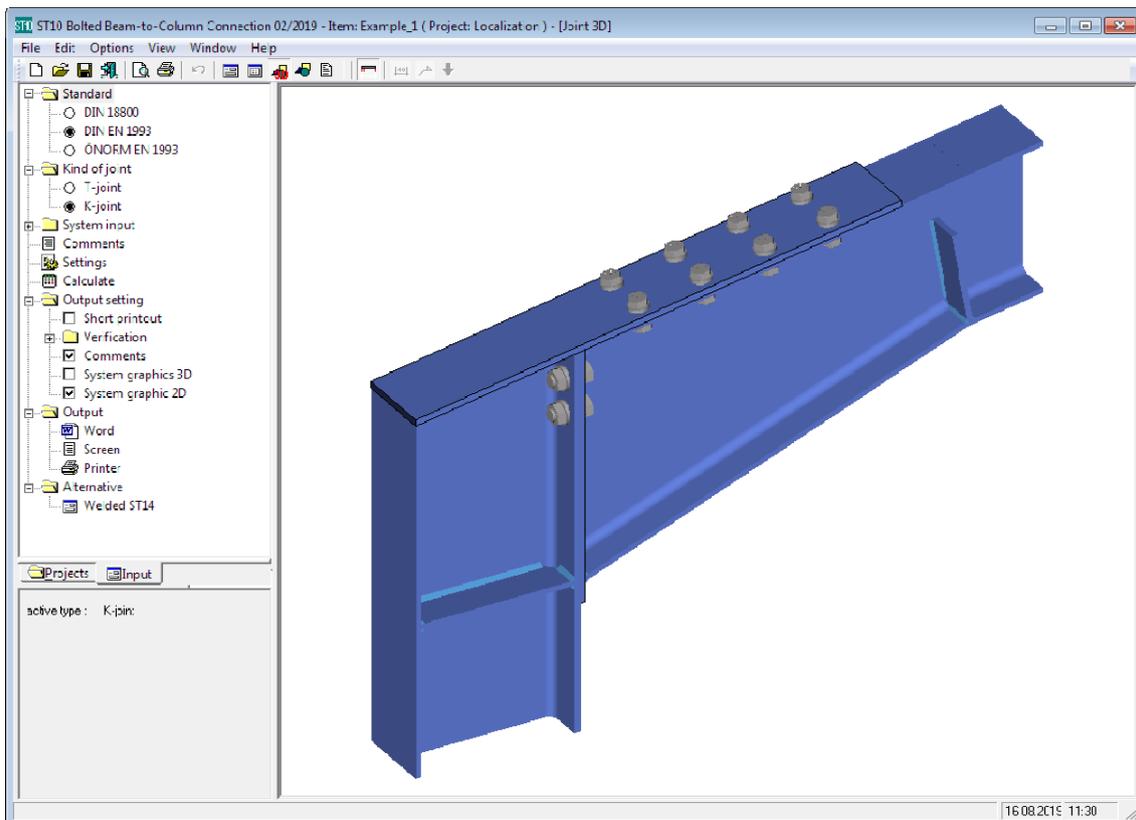
# ST10 - Bolted Beam-to-Column Connection

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As of 16/08/2019



# ST10 - Bolted Beam-to-Column Connection

## Contents

<b>Application options</b>	<b>3</b>
<b>Basis of calculation</b>	<b>4</b>
<b>Definition of the structural system</b>	<b>5</b>
Material	5
Actions	6
List of internal forces	7
Geometry	9
End plate with braces	10
Stiffeners	11
Shear field	12
Backing plates	12
Bolt selection	13
Bolt pattern on the end plate	13
Tension plate	14
Top plate	15
Calculation	16
Calculation options	16
<b>Output</b>	<b>19</b>
<b>Program settings</b>	<b>20</b>
<b>Direct data transfer to Frilo application programs</b>	<b>20</b>
<b>Application-specific icons</b>	<b>20</b>
<b>Reference literature</b>	<b>21</b>

## 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) ▶ Support ▶ Articles/Information ▶ Basic operating instructions.

## Application options

ST10 is a software application for the calculation of screwed steel frame joints resistant to bending.

The application program performs the required verifications concerning the structural safety and the welded connections in accordance with the following standards.

### Available standards

- DIN EN 1993
- ÖNORM EN 1993
- DIN 18800

### 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.

### Structural system

You can verify typical variants of single-sided beam-to-column connections as T-joint and knee joints of double-T sections:

- T-joint with haunch on one or both sides (joint bracing) and inclined beam
- Knee joint with haunch on one side (joint bracing) and inclined beam
- Knee joint with welded/bolted tension plate in addition

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 inside the column and also inside the beam, if joint braces have been defined.

### Calculation

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

- In accordance with the component method for optionally preloaded bolts fitted in two vertical rows and distributed variably over the connection height.
  - EN 1993
  - DIN 18800 (in accordance with DIN ENV 1993-1-1:1992 / A2; 1998)  
as well as for vertical four-row distributed screws around the outer beam chord under tension according to AiF model in DAST Research Report 3/2009 [13] and Wagenknecht in steel construction practice according to Eurocode 3, 2017 [14] for EN 1993
- As per DSTV guideline (1984)\* (only in combination with DIN 18800) for flush/projecting end-plates with two or four rows of high-strength, preloaded bolts.
- In accordance with Schineis (only in combination with DIN 18800): Simplified calculation of bolted beam-to-column connections in "Der Bauingenieur", Magazine 12/1969 (Jg. 44); for non-preloaded bolts, arranged in two or more vertical rows and distributed evenly over the connecting height. A sufficient stiffness of the flanges and the end-plate is a prerequisite to this. The calculation is based on the elastic-elastic method and the end-plate is assumed to maintain its evenness in the deformation. From a pure practical point of view, it is impossible to identify the internal forces exactly because panel, plate and bar-type components act together. Therefore, the calculation should be considered as an approximation in each case.

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

All methods assume a mainly static loading.

The verification of the welds follows the simplified method. The permissible limit weld seam stresses are used as the basis.

Specific application restrictions for the methods:

→ see Basis of calculation

### 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 loads.

Alternating moments can be included.

Multiple combinations of actions can be entered via tables.

### Output

The user can document the results in a well-structured, summarized or extensive output with the help of a customizable output profile.

Optionally, he/she can generate a graphic representation of the structural system and include additional text notes in the output.

## Basis of calculation

The basis of calculation in the ST10 application program is described in the document

→ [ST10 Basis of Calculation](#) (german).

## Definition of the structural system

First, select the standard and the type of connection, T-joint or knee joint.

**Note:** *A subsequent change of the connection involves the risk of data loss. The software takes over all suitable parameter settings, but when changing from T to knee, for instance, the upper joint bracing will be lost.*

After this, define the geometry of the frame joint, its material and the internal forces.

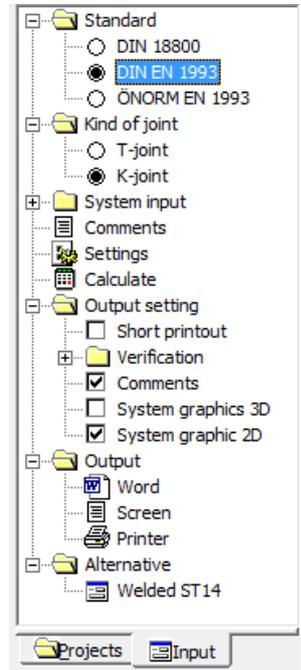
### Combinations of internal forces

If you want to calculate multiple combinations of internal forces in order to compare them, you can enter and handle them via the list of internal forces. To register the internal forces in the list, access the corresponding dialog via "Actions" ▶ [General...](#)

The [list of internal forces](#) is accessible via the to the list ... button or the



corresponding icon.



## Material

Select the structural steel grade or define a material via the "Free definition" option.

$\gamma_M$  partial safety factor of the resisting side.

**Material**

structural steel  $\gamma_{MO} = 1,00$

S235 ...

### Free definition / display of the material parameters



displays the material parameters allowing you to define the material parameters manually.

DIN 18800: the  $\alpha_w$  factor of the permissible limit weld seam stress as per DIN 18800 P. 1 is set to 0.95 for S235 and to 0.8 for S355. For other steel grades, it must be entered by the user.

material

steel

name

$f_y$  =  N/mm<sup>2</sup>

$f_u$  =  N/mm<sup>2</sup>

E-modulus =  N/mm<sup>2</sup>

G-modulus =  N/mm<sup>2</sup>

$\alpha_T$  =  1/K

$\beta_w$  =

$\mu$  =

$\gamma$  =  KN/m<sup>3</sup>

## Actions

The design values of the actions in the connection are entered in this section.

- Nd** axial force transmitted in the direction of the defined centre line (depends on the reference point), positive if it produces tension.
- Vzd** shear force perpendicular to the defined centre line (depends on the reference point).
- Myd** moment transmitted about the y-axis (positive, if it produces tension on the bottom side of the section)

<b>Action</b>	( 001 )	( point C )
Nd=	-45,00 kN	<a href="#">to the list ...</a> <a href="#">global ...</a>
Vzd=	62,00 kN	Myd= -178,00 kNm

### Advanced definition

Activating the “General ...” button accesses a dialog for advanced settings.

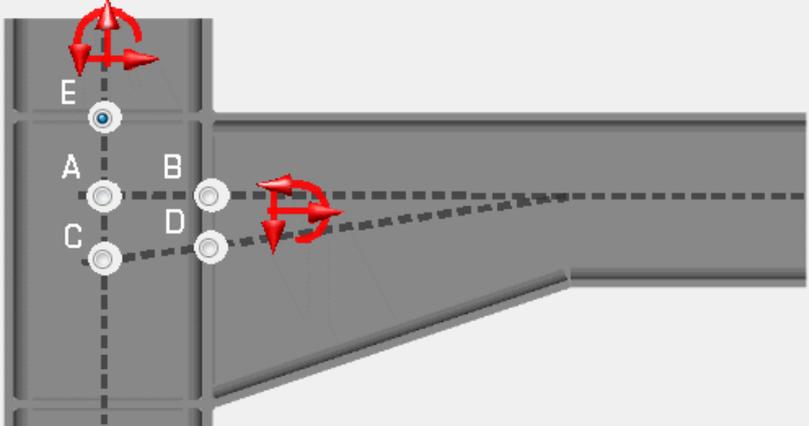
In order to take the internal forces in the shear panel into account in a T-joint, the internal forces in the column must also be defined.

Reference point depending on the pre-condition, internal forces can be assigned to different reference points in the frame joint.

T-joint internal forces in the column top apply in point A or E, internal forces in the beam act in one of the points A to D.

Knee joint internal forces applying to the frame joint act in one of the points A to D.

**Action ( 001 )**



top (column)		right (beam)	
Nd=	0,00 kN	Reference point:	E
Vzd =	0,00 kN	Myd=	0,00 kNm
Nd=	-45,00 kN	Reference point:	C
Vzd =	62,00 kN	Myd=	-178,00 kNm

Transmission parameter for Components Method acc. to J.2.3.3      Beta= 1,00

**Internal force (1)**

- A intersection of the column centre line with the beam centre line - without haunch
- B intersection of the beam contact face to the column with the beam centre line – without haunch

- C intersection of the column centre line with the beam centre line - with haunch
- D intersection of the beam contact face to the column with the beam centre line – with haunch
- E intersection of the column centre line with the contact face of the shear panel on top

*Note: "Beam centre line incl. haunch" refers to the angle bisector of the haunch outline.*

Sign convention:

In the dialog graph, the positive direction of the internal forces is displayed.

List of internal forces:

In the lower area of the dialog, the current number of given combinations of internal forces is indicated in brackets.

Add: inserts the entered internal forces directly into the list.

Display: display the list of internal forces (calculate, maximum value, find, delete)

## List of internal forces

The list of internal forces allows you to handle any number of combinations of internal forces for the defined structural system in a table.



Click on the list of internal forces icon or the "Display" button in the Actions

► [General...](#) dialog, to display the list.

**Internal force list (2)**

Id	Nd right	Myd right	Vzd right	Nd top	Myd top	Vzd top	beta	Eta max	
1	0,00	-5,00	10,00	0,00	0,00	0,00	1,00	0,27	✓
2	0,00	-85,00	60,00	0,00	0,00	0,00	1,00	1,79	!

Show all results  
 Show results with eta > 100%  
 Utilization:  % till  %

Delete      Output  
 Edit      Calculate      to the system

### Sorting the list

By clicking on the column title, you can sort each column in ascending or descending order.

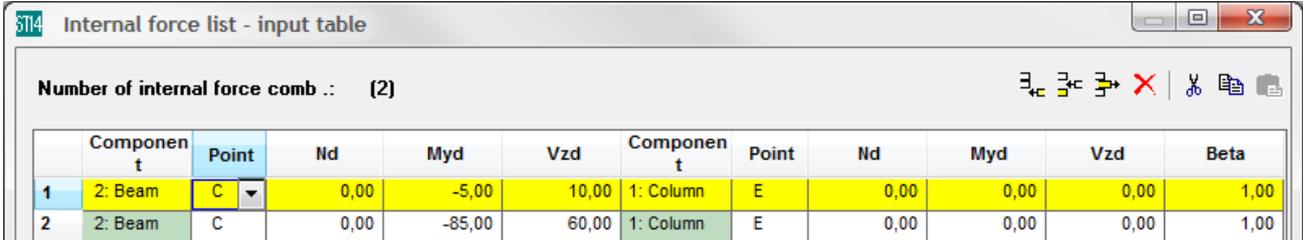
### Displaying results

Three options are available to customize the results and the combinations of internal forces to be displayed:

- all combinations of internal forces
- all combinations of internal forces with a utilization greater than 100 %
- all combinations of internal forces with a maximum utilization within user-defined limits (in per cent). Maximum utilization in this context means the maximum loading rate from all verifications. To display all sections with a utilization greater than the specified lower limit, enter 0.0 in the box for the upper limit (behind to).

### Editing of the list of internal forces - interactive table

Activate the "Edit" option to access the table listing the internal forces. You can edit the defined combinations of internal forces in the table and add additional ones.



	Component	Point	Id	Myd	Vzd	Component	Point	Id	Myd	Vzd	Beta
1	2: Beam	C	0,00	-5,00	10,00	1: Column	E	0,00	0,00	0,00	1,00
2	2: Beam	C	0,00	-85,00	60,00	1: Column	E	0,00	0,00	0,00	1,00

The available table columns (internal forces) depend on the defined structural system.

### Delete

Activating the "Delete" option deletes the currently selected combinations of internal forces.

*Multi-selection: Pressing the Shift or Ctrl key while selecting rows allows you to select several combinations of internal forces at a time.*

### Calculation

Activating the "Calculate" option launches the recalculation for all cross sections.

### Output

Click on the "Output" button to display the results of the selected sections on the screen. You can select several sections by using the functions described above.

If you make no further selections, the combinations of internal forces in the currently active row are put out - not to be confused with the combination of internal forces entered in the system definition section!

The number(s) of the combination(s) of internal forces is/are added to the output.

### Add to structural system

In order to transfer the selected internal forces (active row) to the definition dialog, click on "Transfer to structural system" or double-click on the corresponding combination of internal forces.

## Geometry

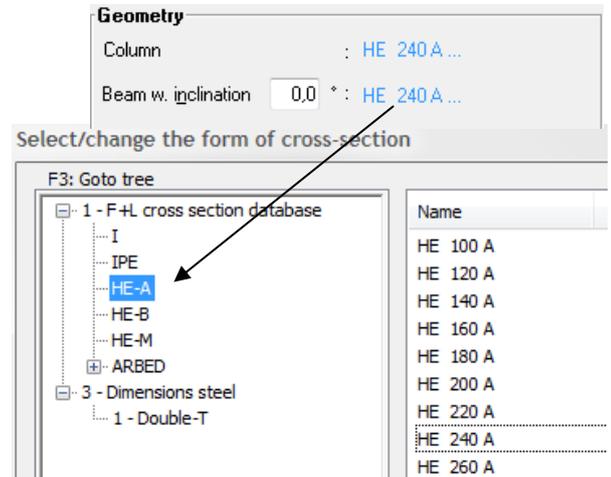
### Defining cross sections for columns/beams

Clicking on one of the section buttons (see ill. on the right) accesses the dialog for the selection or definition of a cross section.

You can define cross sections by specifying their dimensions or by selecting them from a list of standard steel shapes.

Available are double-T sections as per DIN and a series of special double-T sections make ARBED.

→ See also the document [Selecting/Defining Cross Sections](#)



**Beam inclination** angle between the centre line of the beam section and the horizontal line in degrees.

### End plate/bracing

Access the dialog for the definition of the end plate at the beam contract face as well as of the haunch or joint bracing.

→ See the chapter [End plate and braces](#).

A haunch can be defined with cranked chord or, in addition, with a continuous chord in the beam in the sense of a joint bracing. You can define additional stiffeners in the beam member at the chord end to ensure resistance against deflection forces.

**Stiffeners** column bracing by rib stiffeners at the upper and lower beam flanges, → see the chapter [Stiffeners](#).

**Shear panel** bracing of the shear panel → see the chapter [Shear field](#).

**Backing plates** reinforcement of the column flange → see the chapter [Backing plates](#).

### Only for knee joints:

**Tension plate** activate this option to connect the members with the help of a bolted or welded tension plate. The required data-entry fields are enabled, when you activate this option. Otherwise, the column is fitted with a top plate.

*With inactive tension plate (only top plate of column)*

**Inclined** activate this option if the top plate of the column shall have the same inclination as the beam. Otherwise, the column is connected orthogonally.

**dp** thickness of the top plate

**aws, awf** thickness of the fillet weld between the top plate and the column

*With active tension plate*

**lz** length of the tension plate

**tz** thickness of the tension plate

**aw** thickness of the fillet weld at the web of the column

**Details...** accesses the dialog for the detailed definition of the tension plate (width, bolt pattern, top plate on the column, if applicable) → see the chapter [Tension plate](#).

**Bolt geometry** [bolt selection](#) and definition of the [bolt pattern](#).



## Stiffeners

The illustration shows the stiffener dimensions as they are used in the software,  $t$  = stiffener thickness. A short description of each data-entry fields is displayed in the status line (on bottom left).

### Continuous stiffener

when you check this option, a three-sided stiffener connection is generated, i. e. the stiffener length  $h$  is equal to the clear distance of the flanges.

### Take over flange thickness

check this option if the stiffener thickness  $t$  should be matched to the flange thickness of the connected section.

### Width $b$

the stiffener width must not exceed the width of the corresponding section flange.

### Height $h$

the stiffener height must not exceed the clear chord distance in the section.

### Height $h1$

only for stiffeners that are not continuous:  $h1$  refers to the height of the non slanted area. The non-slanted width  $b1$  results from  $b * h1 / h$

### Thickness $t$

thickness of the stiffener

### Recess $c$

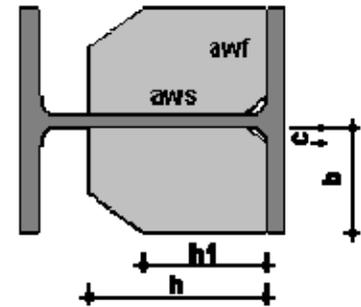
recess in the area of the rounding of the section

### Weld seam $awf$

thickness of the fillet welds in the area of the steel shape chords.

### Weld seam $aws$

thickness of the fillet welds in the area of the steel shape web.



Dimensions	
<input type="checkbox"/>	continuous rib
<input type="checkbox"/>	flange thickness accept
Width	$b =$ 116,3 mm
Height	$h =$ 100,0 mm
Height	$h1 =$ 100,0 mm
Thickness	$t =$ 15,0 mm
Cut-out	$c =$ 21,0 mm
Weld seams	
Flange	$awf =$ 4,0 mm
Web	$aws =$ 4,0 mm
<input type="button" value="Delete"/> <input type="button" value="Standard"/>	

## Buttons

### Delete

deletes the dimensions of the current stiffener(s).

### Standard

sets the values of the stiffeners to defaults (in the area of the bracing, this applies to the outer stiffener). The stiffener is continuous; it fills the full width of the section and has the thickness of the connected chord.

## Shear field

Select the corresponding option to reinforce the shear field with a web plate on one side or diagonal stiffeners on both sides.

### Web reinforcing plate

**Thickness t** thickness of the web plate

**Weld seam aw** thickness of weld seam on the web plate

For the calculation in accordance with the component method, the following options can be set:

#### For tension on top and bottom

The required height and projection of the web plate are determined for the design situation tension on top as well as for simultaneously applying tension on the bottom of the connection: typical for internal force combinations with positive and negative moments.

#### Only for tension on top

The required height and the required projection of the web plate are calculated for the design situation 'tension on top of the connection' (negative moment  $M_y$ ). With a positive  $M_y$ , i.e. tension on bottom, the web plate is not used!

#### Only for tension on bottom

Similar to "Only for tension on top", but for the design situation with a positive  $M_y$ , i.e. tension on bottom.

### Diagonal stiffeners on both sides

**Thickness t** thickness of the stiffeners

*Tip: to delete a reinforcement, just untick the corresponding checkbox.*

**Shear field input**

**Web plate strength.**

Thickness t= 10,0 mm

Sw-seam aw= 4,0 mm

ONLY at Components Method :

for tension top and bot.

for tension bot. ( $M_y$  neg.) only

for tension bot. ( $M_y$  pos.) only

**Diagonal stiff. double-s.**

Thickness t= 0,0 mm

## Backing plates

Backing plates are fitted under all relevant tension-loaded bolts over the full available chord width.

Only the method based on the component mode takes these backing plates into account in the calculation. With other methods, backing plates have only a constructive function!

**All bolts** the required height and projection of the backing plates are determined for the design situation tension on top as well as for simultaneously applying tension on bottom of the connection: typical for combinations of internal forces with positive and negative moments.

#### Only bolts with tension on top

the required height and projection of the backing plates are calculated for the design situation 'tension on top of the connection' (negative moment  $M_y$ ). With a positive  $M_y$ , i.e. tension on bottom, the backing plate is not used!

#### Only bolts with tension on bottom

similar to "Only for tension on top", but for the design situation with a positive  $M_y$ , i.e. tension on bottom.

The required height is determined in the calculation in accordance with the component model, or, with other methods, by the projection of  $2 \cdot$  the bolt diameter over the outer bolt rows under tension.

## Bolt selection

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

You can distinguish between raw bolts and fit bolts.

The internal hole clearance of raw 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.

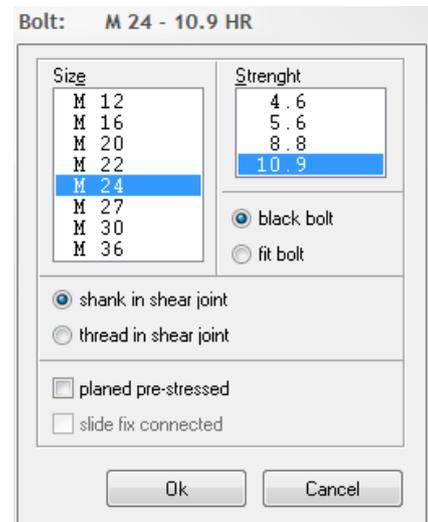
The shear joint might take effect in the thread or in the bolt shaft.

*Note: When selecting the calculation model, you should consider the restrictions and limits of the applied method.*

After you have 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 raw 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  $f_{yb}$  and the tensile strength  $f_{ub}$  are indicated by the strength class:*

$$f_{yb} = (\text{digit in front of the point}) \cdot (\text{digit behind the point}) \cdot 10 \text{ N/mm}$$

$$f_{ub} = (\text{digit in front of the point}) \cdot 100 \text{ N/mm}^2$$

e.g.      F-5.6       $f_{yb} = 300 \text{ N/mm}^2$   
    $f_{ub} = 500 \text{ N/mm}^2$

## Bolt pattern on the end plate

### Parameters to define for the bolt pattern on the end plate in the beam-to-column connection

- dL**      hole diameter, depends on the selected bolt type and size. The bolts can be selected in the dialog for the [end plate and the braces](#).
- H. rows**      number of horizontal bolt rows (in the direction of the beam web).
- V. rows**      number of vertical bolt rows on one side (in the direction of the beam flange)
- e**      data-entry table for the spacing of the horizontal bolt rows in the direction of the beam web, measured from the top edge of the end plate downwards (vertical screw spacing). The currently active data-entry field is marked in the graphical representation.
- e**      data-entry table for the spacing of the vertical bolt rows in the direction of the beam flange, measured from the edge of the end plate towards the centre (horizontal screw spacing). The currently active data-entry field is marked in the graphical representation.

The arrangement of bolts that is actually considered depends on the connection configuration and the calculation method → see the chapters [Application options](#) and also [Basis of calculation](#).

## Tension plate

### Tension plate geometry

<b>lz</b>	length of the tension plate
<b>bz</b>	width of the tension plate
<b>tz</b>	thickness of the tension plate
<b>aw</b>	thickness of the weld seam on the column web, if the option "Tension plate welded to column" has been checked.

**Top plate ...** accesses the dialog for the detailed definition of the top plate on the column, when the option "Tension plate bolted to column" has been checked → see the chapter [Top plate](#).

### Bolts

**dL** hole diameter, depends on the selected bolt type and size. The bolts are selected in the knee joint system.

### Bolt pattern

<b>nR</b>	number of horizontal bolt rows (in the direction of the beam web) in the area of the tension plate on the beam. The permissible maximum number is indicated by the software.
<b>nR</b>	number of vertical bolt rows, on one side (in the direction of the beam flange) in the area of the tension plate on the beam. The permissible maximum number is indicated by the software.
<b>Distance to edge e1</b>	distance to the edge of the tension plate on the beam side in the tension direction.
<b>Hole spacing e</b>	spacing of the bolts on the tension plate in the tension direction. Two bolt rows are assumed as a minimum in this direction.
<b>Distance to edge e2</b>	distance to the edge of the tension plate perpendicular to the tension direction.
<b>Hole spacing e3</b>	spacing of the bolts on the tension plate perpendicular to the tension direction. Two bolt rows are assumed as a minimum in this direction.

**Tension plate geometry**

lz=  mm  with column welded

bz=  mm  bolted with column

tz=  mm      aw=  mm

---

Selected bolt      M 24 - 10.9 HVR

Hole diameter      dL=  mm

---

**Bolt pattern**

max. nR= 12      nR=

max. nS= 2      nS=

————— distances direction web —————

edge distance      e1=  mm

Hole spacing      e=  mm

————— distances dir. flange —————

Edge distance      e2=  mm

Hole spacing      e3=  mm

### Explanations / permissible values

Each value that you enter is checked for plausibility in regard to the following conditions:

- The permissible minimum bolt spacing must satisfy the following conditions:
  - $e_1 \geq 1.2 \cdot d_L$
  - $e \geq 2.2 \cdot d_L$
  - $e_2 \geq 1.2 \cdot d_L$
  - $e_3 \geq 2.4 \cdot d_L$
- The total of all bolt distances perpendicular to the tension direction must be equal to the tension plate width bz.
 
$$e_2 + (\text{number of bolt rows} - 1) \cdot e_3 + e_{2,Rest} = bz$$

- The length of the tension plate must comply with the geometric parameter setting in the force direction:

$$e_1 + (nR - 1) \cdot e + hs + dp = lz$$

with:  $lz$  length of the tension plate

$hs$  height of the column section (outer edge of flange)

$dp$  thickness of the end plate between the column and the beam

**Note:** *When you enter a value for  $e_1$  ( $e$ ), compliance with this condition is checked and non-compliant values are adjusted automatically.*

*When you change the length  $lz$  subsequently, the difference is distributed evenly on the distances  $e_1$  and  $e$ .*

- When defining  $d_v$ , an internal hole clearance of 0.3 to 2.0 mm for raw bolts and of 0.0 to 0.3 mm for fit bolts should be considered.

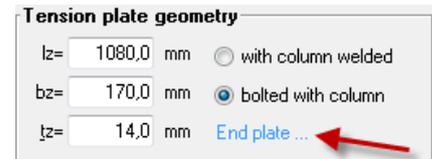
## Top plate

### Top plate geometry

**dp** thickness of the top plate

**aw** thickness of the fillet weld on the column web

**hp** and **bp** are determined by the cross section of the column.



### Bolts

The parameters of the bolt and the hole diameter correspond to the general parameters of the tension plate.

### Bolt pattern

**nR** number of horizontal bolt rows (in the direction of the column web).

**nS** number of vertical bolt rows, on one side (in the direction of the column flange)

**Distance to edge e1** distance to the edge in the tension direction (in direction of the web).  $e_1$  at the front end and  $e_1$  at the rear end are equated.

**Hole spacing e** spacing of the bolts in tension direction. Two bolt rows are assumed as a minimum in this direction.

**Distance to edge e2** distance to the edge of the tension plate perpendicular to the tension direction.

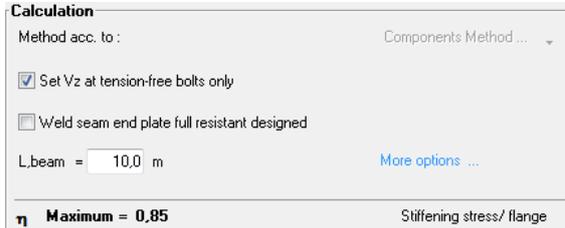
**Hole spacing e3** spacing of the bolts on the tension plate perpendicular to the tension direction. Two bolt rows are assumed as a minimum in this direction.

### Explanations / permissible values

→ See the chapter [Tension plate](#)

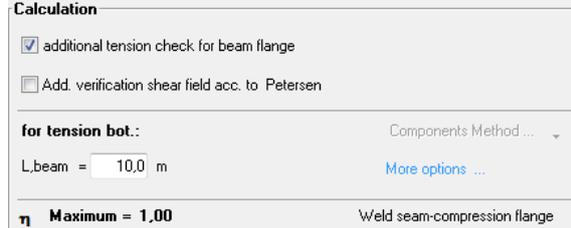
## Calculation

The available options depend on the selected standard: selection of the calculation method (component method; in combination with DIN 18800: DSTV and Schineis in addition) and the most important [calculation options](#) (click on "Further settings" to display all available calculation options).



**Calculation**  
 Method acc. to: Components Method ...  
 Set Vz at tension-free bolts only  
 Weld seam end plate full resistant designed  
 L.beam = 10,0 m [More options ...](#)  
**η** Maximum = 0,85 Stiffening stress/ flange

EN 1993: T-joint dialog



**Calculation**  
 additional tension check for beam flange  
 Add. verification shear field acc. to Petersen  
**for tension bot.:** Components Method ...  
 L.beam = 10,0 m [More options ...](#)  
**η** Maximum = 1,00 Weld seam-compression flange

Knee joint dialog

## Knee joint

If the members are connected with a tension plate, always the calculation model "knee joint with tension plate" is used if a negative  $M_y$  occurs. This calculation model is based on M. Schineis: "Vereinfachte Berechnung geschraubter Rahmenecken", in "Der Bauingenieur" Magazine 12/1969 (Jg. 44), see ST10 [Basis of Calculation](#). Only for a loading situation with a positive  $M_y$ , i.e. tension on bottom, the calculation method selected in the design options is applied (EN 1993: component method, DIN 18800: component method or Schineis) with the associated calculation options.

## Utilization $\eta$

When you activate the 'Calculate' option in the Main menu or the Edit menu, the decisive utilization  $\eta$  is calculated for structural system in the current state. This might be required after changes of the defined system or the definition of a new system.

Areas where  $\eta > 1$  are colour marked in the system graph.

If the utilization of the structural system should be displayed immediately after each change in geometry, activate the option 'Recalculate after each change' in the menu *Options* ▶ *Bolted beam-to-column connection settings*.

## Calculation options

To access all calculation options of the component method, click on "Further settings".

### Axial force / EN 1993

AF-M interaction... consideration of axial forces  $> 0.05 N_{pl,Rd}$  in accordance with equation 6.24 EN 1993-1-8

NRd-tension projection bolts in the projection are not taken into account if only tension applies.

NRd-tension haunch bolts in the haunch area are not taken into account if only tension applies.

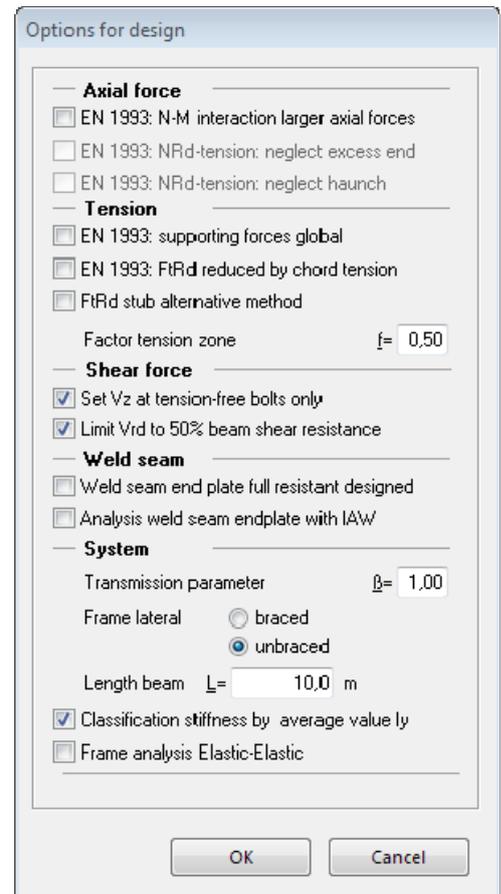
## Tension

**supporting forces global** Extended option: hereby it is assumed that there will be always support forces with bolted connections of the beam-column (there is no check by the program !, so always  $L_b \leq L_b \cdot \text{Table 6.2}$ ) - only with EN 1993

**FtRd ...chord tension** only with EN 1993:  
Reduction of the component column flange on bending FtRd for large longitudinal compressive stresses in the column flange due to pressure and bending moments in the column analogous to J.3.5.4.2 (4) in ENV 1993-1-1: 1992 / A2: 1998

**FtRd stub ...** Alternative method (method 2) for the verification in the first failure mode in the equivalent T-stub model. The more accurate consideration of the bolts provides for lower supporting reserves.

**Tension factor f** This factor is referenced to the height of the connection and specifies the area in which the bolts are in tension. Default is  $f = 0.5$ .  
*Effect:* Bolts that are closer to the compression zone can be neglected in the calculation of the moment design resistance. They contribute to the load transfer with their full limit shear strength in such a way that the shear resistance of the connection is increased under particular conditions. In general, the moment design resistance is only slightly underestimated. It is assumed 15 % for connections in which at least 50 % of the bolts are in tension and the neglected bolts are located within the 0.4-fold distance of the outer bolts in tension to the compression centre.



## Shear force

**Vz ...** Shear force is only transmitted by bolts that are not in tension. See also the factor f for the tension.

**Limit of Vrd...** The design shear force resistance is limited to 50 % of the design shear resistance of the beam. It is included in the calculation of the utilization by the limit shear force  $V_{aRd}$ .

## Weld seams

**Full design resistance...** The weld seams on the end plate are verified under the assumption that they can transmit the limit moment and the limit shear force of the connection. 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.

## Verification ... with IAW

The weld seams on the end plate are verified via the structural calculation of the global weld seam pattern, otherwise with the help of the respective partial internal forces.

**Structural system**

- $\beta$**  transformation parameter for the component method as per table 5.4 (influence of shear on the column web panel) for the type of connection.
- Frame lateral** non-sway/sway: criterion for the classification of the joint by stiffness.
- L** length of the beam (column centre line to column centre line) for the classification of the joint by stiffness.
- ...mean value  $l_y$**  classification of the joint by stiffness based on the mean value of the beam's  $l_y$  and  $l_y$  at the contact face of the beam and the end plate, i.e. with inclusion of the bracing. This is only reasonable for beams with joint braces and chords.
- ...elastic-elastic** the structural calculation shall only be performed in accordance with the elastic-elastic method.  $M_{a,Rd,el}$  is decisive, classification only by stiffness.
- ...verification of the shear panel**  
the shear panel's design resistance is verified in accordance with Petersen independently of the modelled transformation parameter  $\beta$ .

**As per DIN 18800: Schineis (T-joint and key joint without tension plate)**

**Compression zone as per...** the compression zone is calculated with the help of the more accurate calculation method as per Schineis. Otherwise, the centre of compression is assumed in the web stiffener. The height of the compression zone between the end plate and the column is calculated by the software. The bolts must be distributed evenly over the height of the connection.

**Additional tension resistance verification...**

an additional simplified verification of the tension design resistance is performed in the beam chord and underneath the tension plate.

**Transversal struts**

**Verification stiffeners ...** Extended option: The stiffener check is considered as global valid. The corresponding pressure component is thus eliminated in the check of the connection.

## Output

### Output profile

The output profile allows you to define the scope and contents of data to be put out. Only the activated options are considered in the output scope. Depending on the context of the currently active connection variant, particular options might be disabled.

The scope of the output might be restricted by the selected calculation method.

**Summary print** the standard output scope does not include any intermediate results. To include intermediate result uncheck this option.

### Verifications

**Shear panel** output of the shear panel resistance verifications.

**Stiffeners** output of the stiffener verifications as well as the verifications concerning the load application.

**Tension plate** output of the verifications in the tension plate, if applicable.

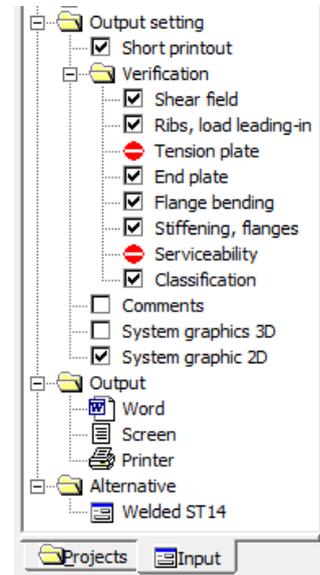
**End plate** output of verifications concerning the end plate

**Flange bending** output of the verifications as per Schineis concerning bending of the column flanges

**Bracing** output of the verifications in the (hauch-)braced areas.

**Serviceability** only with the method as per DSTV/DAST.

**Classification** output of the connection classification (rigid, deformable, ...), only in combination with the component method.



### Comments and graphical representation

**Item text** comments on the system.

**System graph 2d** two-dimensional representation of the frame joint with details (dimensions and/or legends).

**System graph 3d** three-dimensional view of the frame joint in isometric mode.

**Word** double-clicking on this option launches the text editor Word if it is installed on your computer. An rtf file named according to the item is created and opened, e.g. Item1.rtf. It contains the all data selected in the output profile. You can edit the data in word and print them.

**Screen** view of the output texts on the screen (without graphs).

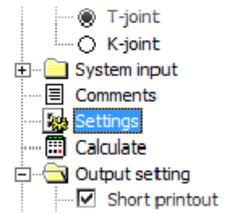
**Printer** all data, verifications and graphics selected in the output profile are put out on the printer.

→ See also the document "[Output and Printing](#)".

## Program settings

Any changes of the settings in this dialog have an immediate effect on the defined structural system. If you set up a new item, however, the software goes back to the default settings.

In order to set user-defined settings as defaults activate the button "As default".



### Always recalculate

Activate this option to make sure that the system is recalculated immediately after each change.

### Advanced options for component method

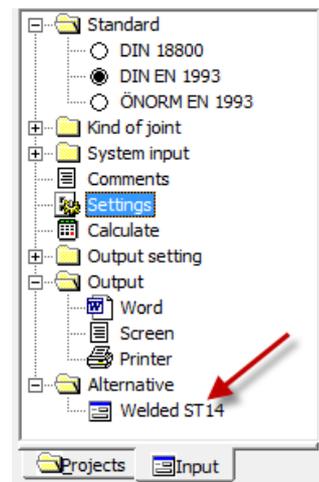
The options under "Settings" are supplemented by the following calculation options:

- Tension – EN 1993 – supporting forces global.
- Transversal struts – stiffener check is considered as global valid.

## Direct data transfer to Frilo application programs

You can transfer the defined structural system to the ST14 application to further process it as a welded connection.

To do this, activate the corresponding menu item in the main menu (sub-item of "Alternative") or the option "Welded ST14" in the "Edit" menu.



## Application-specific icons

In addition to the standard icons, each software application offers application-specific functions via additional icons and tool bars.

In these application program, the following icons are available in addition to the standard ones:



[List of internal forces](#). The list of internal forces allows you to handle any number of combinations of internal forces for the defined structural system in a table.



3d representation of the column-to-beam connection (illuminated solid model). You can rotate the system in any direction with the help of the left mouse button.



representation of the dimension lines, the legends and the internal forces. The icons are only enabled if the graphic view is shown in full-screen mode, i.e. if the graphic icon is active.



## Reference literature

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- [ 2] Typisierte Verbindungen im Stahlhochbau, 2. Auflage. Deutscher Stahlbau – Verband DSTV in Zusammenarbeit mit dem Deutschen Ausschuss für Stahlbau (DASt),. Stahlbau – Verlags GmbH, Köln 1984.
- [ 3] M. Schineis: Vereinfachte Berechnung geschraubter Rahmenecken, in „Der Bauingenieur“ Heft 12/1969 (Jg. 44)
- [ 4] Petersen, Ch., Stahlbau, 2. Auflage, 1990, Vieweg & Sohn, Braunschweig/Wiesbaden
- [ 5] Petersen, Ch., Statik und Stabilität der Baukonstruktionen, 2. Auflage, 1982, Vieweg & Sohn, Braunschweig/Wiesbaden
- [ 6] J. LINDNER; J. SCHEER; H. SCHMIDT (HRSG.): *Stahlbauten. Erläuterungen zu DIN 18800 Teil 1 bis Teil 4 (Beuth Kommentare)*. Beuth, Berlin, Köln; Ernst & Sohn, Berlin 1993.
- [ 7] R.KINDMANN; M.STRACKE: Verbindungen im Stahl- und Verbundbau. 1. Auflage. Ernst & Sohn, Berlin 2003.
- [ 8] DIN ENV 1993-1-1:1992 / A2; 1998
- [ 9] Stahlbau Kalender 2005; 7. Jahrgang; Ernst & Sohn, Berlin 2005.
- [ 10] DIN ENV 1993 Teil 1-1: EuroCode 3: Bemessung und Konstruktion von Stahlbauten, Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; Ausgabe April 1993
- [ 11] DIN EN 1993, Dezember 2010
- [ 12] ÖNORM B 1993, Februar 2007
- [ 13] Forschungsbericht 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
- [ 14] WAGENKNECHT: Stahlbau-Praxis nach Eurocode 3, Band 3 Komponentenmethode, 2. Auflage; Beuth Verlag GmbH, Berlin, Wien, Zürich 2017