Bolted Steel Connection ST9

Contents

Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage www.frilo.com in the Campus-download-section.

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

Application options

The ST9 application is suitable for the design of screw connections in steel construction.

Available standards

- DIN EN 1993
- ÖNORM EN 1993
- DIN 18800, 1990 edition

Types of connections

- Tensile splice
- Beam connection
- Bending-resistant beam joint
- End-plate splice

Tensile splice

In a tensile splice, only tensile forces that apply in the gravity line of the bolt pattern are transferred.

The connection can be single-, double- or multi-shear.

The beam tie and the fish plate are either defined as metal plates or by selecting a standard shape from the Frilo Profile Selection File (rolled steel shapes).

In the latter case, fish plates can only be defined as plates whereas beam ties can also have an I-shape (one tie) or a U-channel shape (two ties).

As type of connection, a shear-resistant and embedding-pressure resistant joint has been realized. Friction-grip pre-loaded structural bolting assemblies are in preparation.

Drilled holes are assumed.

Beam connection

In a beam connection (shear force connection), only shear forces are transferred in the z-direction.

The permissible profile types for main and secondary beams are I-shaped profiles connected with two angle brackets with equal or unequal legs.

The dimensions are defined by selecting a standard shape from the Frilo Profile Selection file.

The secondary beam (SB) can be connected with an offset to the main beam (MB) and have a notch, on top, on bottom or on both sides.

As type of connection, a shear-resistant and embedding-pressure resistant joint has been realized. Friction-grip pre-loaded structural bolting assemblies are in preparation.

Drilled holes are assumed.

Bending-resistant beam joint

In a bending-resistant joint with fish plates, axial forces, shear forces and bending moments can be transferred.

You must define fish plates on the outer side of the web and the flanges.

You can optionally define fish plates on the inner sides.

I-shapes are permitted as profile types; their dimensions are defined by selecting a standard shape from the Frilo Profile Selection File.

As type of connection, a shear-resistant and embedding-pressure resistant joint has been realized. Friction-grip pre-loaded structural bolting assemblies are in preparation.

Drilled holes are assumed.

End-plate splice

In an end-plate splice, two beams are connected with a welded-on end plate either flush to the surface or projecting in the tension-loaded area. Two or four vertical bolt rows are used to create a moment-resistant connection. I-shapes are permitted as profile types.

DIN EN 1993

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

For the verification of vertically four-row end-plate splices, the design model listed 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, 2. Auflage; Beuth Verlag GmbH, Berlin, Wien, Zürich 2017.
  (Steel construction practice according to Eurocode 3, Volume 3 component method, 2nd edition; Beuth Verlag GmbH, Berlin, Vienna, Zurich 2017)

DIN 18800

The calculation in accordance with DIN 18800 is based on the method for the calculation of moment-resistant end-plate joints described in Kahlmeier, Stahlbau nach DIN 18800(11.90), published by Werner Verlag. It is derived from the explanations of standardized connections in steel construction “Typisierte Verbindungen im Stahlhochbau” published in the DSTV guidelines by Stahlbau-Verlagsgesellschaft mbH, Köln 1984.

This method assumes the internal forces to be transferred via equivalent loads in the flanges of the beam. To comply with this model, the beams to be connected must satisfy the condition $I_{flange}/I_{total} < 0.15$. Only low axial forces may apply. Only high-strength bolts of strength class 10.9 may be used. They shall be structurally pre-loaded. The material S235 is specified in the guideline.

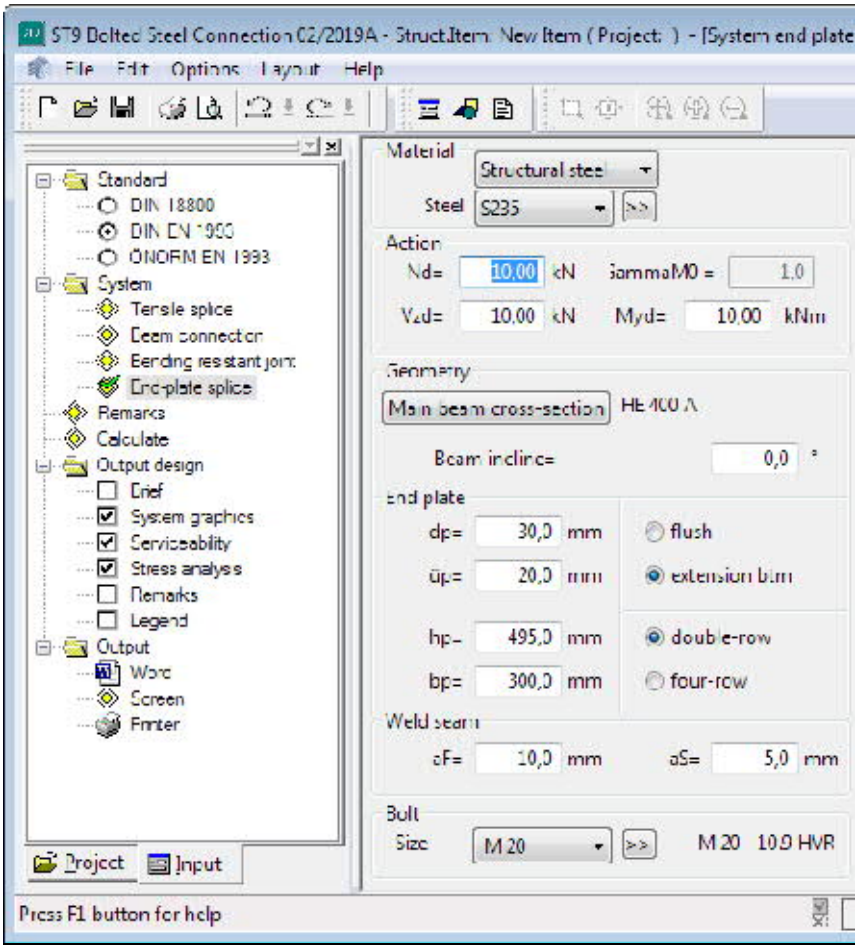
Double-symmetrical I shapes are assumed as beam cross sections.

Definition of the structural system

The “System” menu item in the main menu allows you to select the type of connection:

- Tensile splice
- Beam connection
- Bending-resistant joint
- End-plate splice

After selecting the desired type of connection, the corresponding input fields and options are displayed.



Remarks on the item

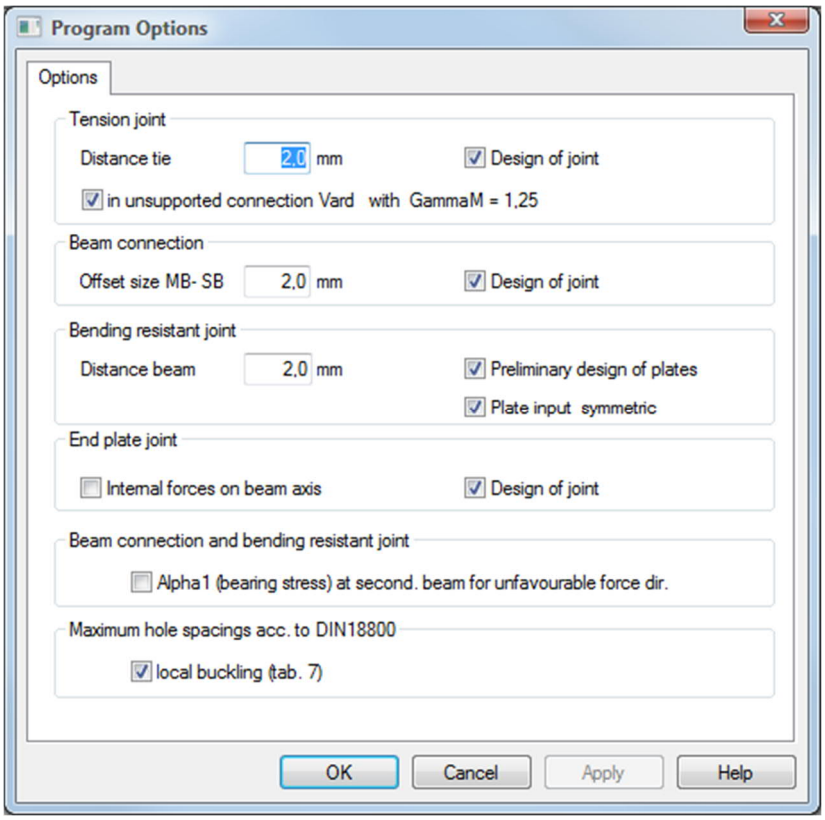
The “Remarks” button allows you to enter explanatory texts about the item. You can optionally put out these comments together with the results (Main menu - Output design - Remarks on the system).

Options/Settings

The menu item Options >> Settings - ST9 Bolted Steel Connection allows you to configure the following parameters:

Tensile splice

- Size of the offset between the beam ties in the direction of force (0.0 to 5.0 mm; default is 2.0).
- The design of the joint is performed automatically after you have entered the number of beam ties n1 when the corresponding option is checked ([✓]).
- For unsupported single-shear tensile splices, you can optionally reduce V_{ard} to element 804 in accordance with the Beuth comments (only in connection with DIN 18800).



Beam connection

- Offset dimension between the web of the main beam and the secondary beam (0.0 to 20.0 mm; default is 5.0).
- The design of the joint is performed automatically after you have defined the secondary beam when the corresponding option is checked ([✓]).

Bending-resistant joint

- Offset dimension between the beams in the N-direction (0.0 to 5.0 mm, default is 2.0).
- The pre-design of the fish-plate dimensions is performed automatically after you have defined or edited the beam cross section when the corresponding option is checked ([✓]).
- Fish plates symmetrical (values defined for the top fish plates are automatically assumed for the bottom fish plates).

End-plate splice

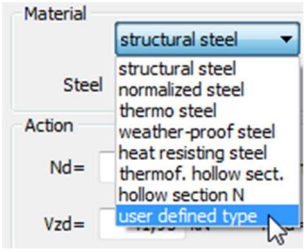
- The design of the splice joint is automatically performed when the option is checked ([✓]).

Beam connection and bending-resistant joint

For the verification of the embedding strength in the secondary beam/angle, you can optionally use the smallest coefficient alpha 1 of both directions of force (DIN 18800).

Note: *The settings are saved in an item-related manner.*

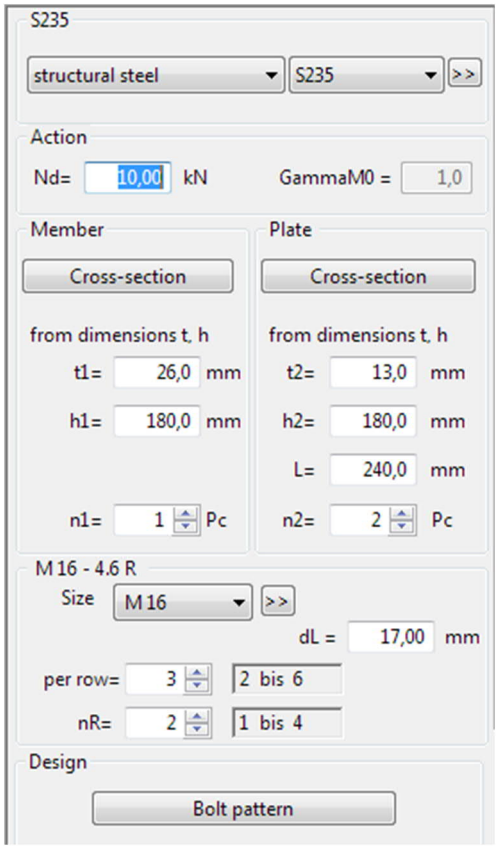
Material selection



You can select the material from the list or define the required values by selecting the option User-defined (click to >> button).

Tensile splice

In the "Tensile splice" dialog, you can define the structural system of a tensile splice and the action N_d as γ_f-fold internal force.



After each entry, a plausibility check of the entire joint is performed. If a calculation is permissible, the loading rate of the joint is displayed.

In addition, the required number of bolts is indicated for each row and each joint, for shear action as well as shear and embedding pressure.

You can check the defined values on the graphic screen on the right which is updated after each entry. This allows you to correct values in the event of deviations.

For each new splice, reasonable default values that allow the calculation of eta are displayed in the corresponding dialog.

Actions

Nd	axial force in the direction of the centre of gravity of the bolt pattern. Tension force is positive.
GammaM	material factor γ_M.

Member

Cross-section	see Cross-section
t1	thickness of the beam tie
h1	height of the beam tie
n	number of identical beam ties (n1)

Plate

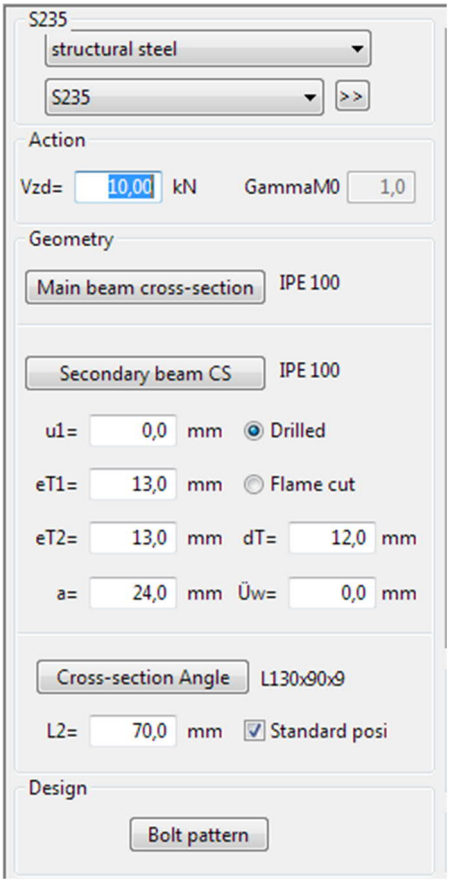
Cross-section	see Cross-section
t2	thickness of the fish plate
h2	height of the fish plate
L	length of the fish plate in one connection
n	number of identical fish plates (n2)

Bolt rows

Select the bolt size as well as other bolt parameters (strength, bolt type etc.) via selection lists.

nR	number of bolt rows parallel to the tensile force
perRow	number of bolts per row in one connection
dL	hole diameter

Beam connection



In the dialog “Beam connection”, you can define the structural system of a beam connection and the action V_{zd} as γ_f-fold internal force.

After each entry that you confirm with Return, a plausibility check of the entire connection is performed. If a calculation is permissible, the loading rates of the individual connections are displayed.

You can check the defined values on the graphic screen on the right which is updated after each entry. This allows you to correct values in the event of deviations.

To ensure a fluent workflow, checks and calculations are dispensed with when you enter values in the Geometry section (profile selection).

If you confirm an entered value in another section, a complete geometry check with recalculation is performed and you are prompted to correct values if required.

Exception: When modifying the shape of the main beam or the secondary beam, the notches e_{T1} and e_{T2} as well as a are set automatically to the required minimum values with consideration of U_1 and of the connection to the other beam.

If you enter values for the notches e_{T1} and e_{T2} or for a that are smaller than the minimum values, incorrect values are adjusted automatically.

For each new connection, reasonable default values that allow the calculation of eta are displayed in the corresponding dialog.

Actions

Vzd	shear force in the z-direction (downwards is positive).
GammaM	material factor γ_M.

Geometry

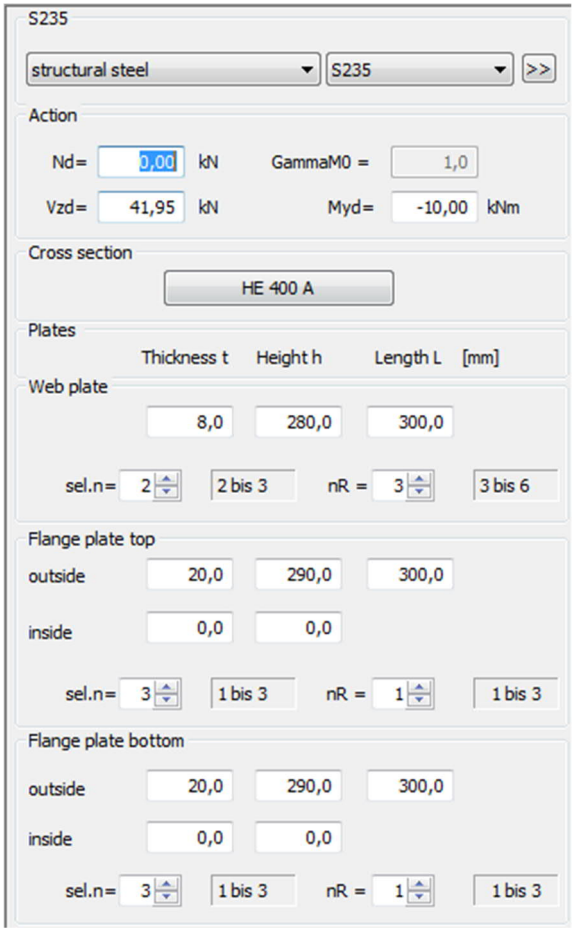
Main/Secondary beam	definition of the main beam and secondary beam by selecting standard shapes from the Frilo Profile Selection file or by entering user-defined “dimensions”. All I shapes are allowed.
u1	distance of the top edge of the secondary beam to the top edge of the main beam, downwards is positive.
eT1	height of the upper notch in the secondary beam, either zero or at least equal to the thickness of the flange on top + the top curvature. If an offset dimension for the beam connection was defined in the section ▸ Options ▸ Settings - Bolted Steel Connection, this value is taken into account for the determination of eT1.
eT2	height of the bottom notch in the secondary beam, either zero or at least equal to the thickness of the flange on bottom + the bottom curvature.
Notch type	- Drilled (typical for rolled shapes) - Flame cut (typical for welded shapes)
dT	diameter of the drilling (disabled if flame cut was selected). dT reduces the usable cross section in the verification of the notch.
a	length of the notch in the secondary beam.

Üw	position of the angle in the secondary beam. When you enter a value, the software checks whether there is any problem with notches or curvatures on the beams. Under normal conditions, Üw = 0, if Üw < 0 and a value is defined for L2, the angle is provided centrally in the possible positioning area.
Angle	selection of an angle profile from the Frilo Profile Selection file or by entering user-defined dimensions. All equal and unequal angle profiles are permitted.
L2	length of the connecting angle

Bolt rows for the main beam (MB) and the secondary beam (SB)

MB n	number of bolts per row in one main-beam-to-angle connection.
SB n	number of bolts per row in the angle-to-secondary-beam connection.

Bending-resistant joint



The dialog for the bending-resistant joint allows you to define the structural system of the joint, i.e. an I-shaped beam cross section, the fish-plate dimensions and the actions N_d, V_{zd} and M_{yd} as γ_f-fold internal forces.

After each data entry, a plausibility check is performed. If a calculation is permissible, the loading rate is displayed.

At the same time, you can check your settings on the graphic screen and correct deviations efficiently.

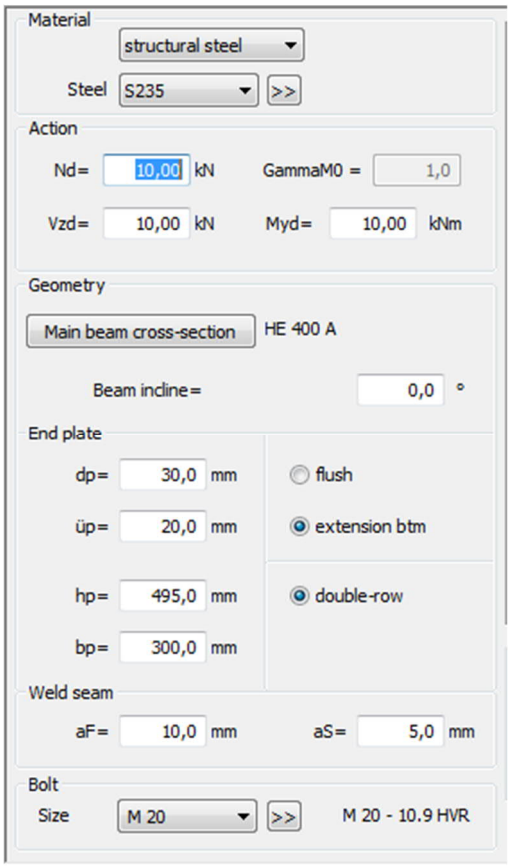
To ensure a fluent workflow, checks and calculations are dispensed with when you enter values in the Geometry section (this is indicated by the question marks "??.?" that are shown for eta).

If you confirm an entered value in another section, a complete geometry check with recalculation is performed and you are prompted to apply corrections, if required.

Nd	axial force in the x-direction (tension is positive).
Vzd	shear force in the z-direction (downwards is positive).
Myd	moment about the y-axis (positive, if it produces tension on the bottom side of the flange)
GammaM	material factor γ_M.
Cross section	definition of the main beam by selecting a standard shape from the Frilo Profile Selection file or by entering user-defined dimensions. All I shapes are allowed.
Plates	you must define plates on the outer side of the web and the flanges. You can optionally define fish plates on the inner side of the flange (if no inner fish plates have been defined the values for the thickness and the height are zero). The fish plates on the inner and the outer side of the flange have always the same length. The software checks the height of the plates for compliance with possible minimum and maximum values. A fish plate must have a minimum thickness of 3 mm. If you have set a symmetrical fish plate geometry in the Options section, the values entered for the top fish plates are proposed as defaults for the bottom fish plates of the flange.

t	thickness in mm
h	height in mm
L	length of the fish plate in the total connection in mm
sel. n	number of bolts per row in one connection
nR	number of bolt rows (parallel to the Nd force).

End-plate splice



The dialog for the end-plate slice allows you to define the structural system of the joint, i.e. a beam cross section, the dimensions of the end plate as well as the actions N_d, V_{zd} and M_{yd} as γ_f-fold internal forces.

Please note: *The software provides the projection of the end plate always in the tension area of the beam.*

After each data entry, a plausibility check is performed. If a calculation is permissible, the loading rate is displayed.

At the same time, you can check your settings on the graphic screen and correct deviations efficiently.

Nd	axial force in the x-direction (tension is positive).
Vzd	shear force in the z-direction (downwards is positive).
Myd	moment about the y-axis (positive, if it produces tension on the bottom of the flange)
GammaM	material factor γ_M.
Geometry	definition of the main beam by selecting a standard shape from the Frilo Profile Selection file or by entering user-defined dimensions. All double-symmetrical I shapes are permitted. Beam inclination: -45° - +45°, inclination to the right, clockwise, is positive

End plate

flush	flush to the surface with a projection *ü* on both sides for the fillet welds.
Extension btm	projecting in the tension area of the beam with a projection *ü* on the facing side for the fillet weld (btm = bottom).
double row	two bolt rows
Four rows	four bolt rows
dp	thickness of the end plate (the minimum thickness, which depends on the type of bolt, must be adhered to).
üp	projection of the end plate for the placement of the filled welds. You can set üp = 0; in this case, single-bevel groove welds are assumed at the outer sides of the beam flanges.
hp	height of the end plate, disabled if a flush type was selected; in this case hp is determined by the beam height + 2 üp.
bp	width of the end plate (the minimum spacing of the bolts must be complied with).
aF	thickness of the weld seam in the flange area.
aS	thickness of the weld seam in the web area.

Cross section

Click on the cross-section-button for the selection of the cross-section. In the cross-section window you can enter or edit the cross-sectional dimensions as desired.

See also the document Selecting/Defining Cross Sections

Profile selection - member

Select the member with the desired dimensions in the Frilo Profile Selection file. The dimensions of the selected profile are displayed in the input fields t_1 and h_1.

Permissible shapes are:

- Plates
- I-shape sections with only one beam tie
- U-channel sections with one/two beam tie/s.

For I-shapes and U-channels, t_1 is determined by the web thickness and h_1 by the parallel web area. Internally, the software uses t_1/h_1 (as a plate) in the calculation.

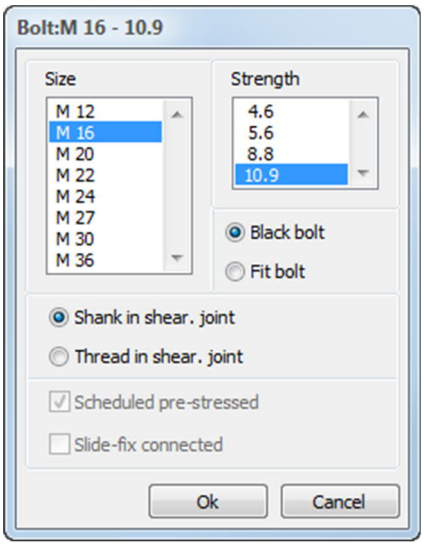
Profile selection - plate

Select the plate with the desired dimensions in the Frilo Profile Selection file. The dimensions of the selected profile are displayed in the input fields t_2 and h_2.

Permissible shapes are flat steel plates and wide flat steel plates.

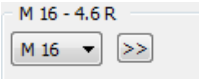
Bolts

Bolt selection



The dialog for the selection of the bolts allows you to define the type of bolts to be used.

To display the dialog, click on the >> button.



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

You can select among raw bolts and fit bolts.

The raw bolts may have an internal hole clearance between 0.3 and 2.0 mm and the fit bolts between 0.0 to 0.3 mm.

You can select whether the joints of a connection shall all be assumed in the bolt shafts or the bolt threads.

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 raw bolts (internal hole clearance of 1.0 mm) and 17 mm for fit bolts (internal hole clearance of 0.0 mm).

Pre-loaded structural bolts and friction-grip bolts will be available in a later software version.

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

f_{ybk} = (digit in front of the point) (digit behind the point) 10 N/mm²

f_{ubk} = (digit in front of the point) 100 N/mm²

e.g. *F-5.6* *f_{ybk} = 300 N/mm²*

f_{ubk} = 500 N/mm²

Bolt spacing

Each time you edit a defined value, the software automatically optimizes the bolt spacing before recalculating the structural system. This ensure a clearly defined state of the structural system after each modification (optimization aims at the lowest loading rate imposed by the connection).

The "Bolt pattern" dialog allows you to enter a user-defined bolt spacing. Subsequently, eta is calculated with the defined bolt spacing.

The thickness of the weld seams is not considered in the determination of the bolt spacing.

Tip: *Enter the user-defined bolt spacing always last!*

Bolt pattern of the tensile splice

The dialog “Bolt pattern of tensile splice” (Bolt pattern button) allows you to specify the number of bolt rows parallel to the tensile force, the bolt spacing and the hole diameter to be used.

The maximum number of possible bolt rows perpendicular to the tensile force is displayed. It is determined by the permissible minimum bolt spacing.

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

- The permissible minimum bolt spacing must be complied with.

  e1 >= 1.2 dL

  p1 >= 2.2 dL

  e2 >= 1.2 dL

  p2 >= 2.4 dL

- The total of all bolt distances perpendicular to the tensile force must be equal to the height of the beam tie or the fish plate.

  2 e_2 + (number of bolt rows - 1) p_2 = h

Note: *When you enter a value for e_2 (p_2), compliance with this condition is checked and the value of p_2 (e_2) is adjusted automatically.*

When you change the height h subsequently, the difference is proportionally allocated to e_2 and p_2 and the values are adjusted accordingly.

- The total of the bolt spacing in the direction of the tensile force must be equal to the length of the fish plate in a joint L.

  2 e_1 + (number of bolts per row - 1) p1 = L

  This condition is only verified when you close the bolt pattern dialog after having confirmed your settings. The length L is adjusted automatically if required.

  When defining d_L, 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 complied with.

The following values are to be defined:

n per Row	number of bolt rows parallel to the tensile force
e1	distance to the edge in the direction of force
p1	hole spacing in the direction of force (inner spacing of the bolts)
nR	number of bolt rows parallel to the tensile force
e2	distance to the edge perpendicular to the direction of force
p2	hole spacing perpendicular to the direction of force (inner spacing of the bolts)
dL	hole diameter, depends on the selected bolt type and size

Note: *Because* the different bolt spacings *p_1 and e_1 or e_2 and p_2* depend on each other, the software checks the specified values with respect to these relations.

Bolt pattern of the beam connection

This dialog allows you to specify the number of bolt rows parallel to the direction of force, the bolt spacing and the hole diameter to be used.

The possible maximum number of bolt rows parallel to the shear force is displayed. It depends on the permissible minimum bolt spacing for the main-beam-to-angle connection and the angle-to-secondary-beam connection.

When selecting DIN angle profiles from the Frilo Profile Selection file, please note that the number of bolts and their spacing e2/p2 as well as the maximum bolt diameter to be used in each angle arm is fixed.

You cannot edit these values. If you want to use other values for these angles, you must use the option user-defined.

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

- The permissible minimum bolt spacing must be complied with.

  e1 >= 1.2 d_L

  p1 >= 2.2 d_L

  e2 >= 1.2 d_L

  p2 >= 2.4 d_L

- The total of all bolt distances perpendicular to the force must be equal to the corresponding angle width.

  e2 + (number of bolt rows - 1) p2 + $e2_{rem.}$ = B

e2	distance of the edge to the vertex of the angle
B	width of the respective arm
$e2_{rem.}$	distance of the edge to the free end of the arm with e2 >= 1.2 d_L

- The total of the bolt spacing in the direction of force must be equal to the length of the angles in one connection L_2.

  2 e_1 + (number of bolts per row - 1) p1 = L_2

Note: *When you enter a value for e1 (p1), compliance with this condition is checked and the value of p1 (e1) is adjusted automatically.*

When you change the length L_2 subsequently, the difference is proportionally allocated to e1 and p1 and the values are adjusted accordingly.

- When defining d_L, 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 complied with.

The following parameters must be defined for each connection, main beam to angle and angle to secondary beam:

nR	number of bolt rows in the angle-to-secondary-beam connection
n	number of bolts per row in the angle-to-secondary-beam connection.
e1	distance to the edge in the direction of force
p1	hole spacing in the direction of force
e2	distance of the angle vertex to the edge perpendicular to the direction of force
p2	hole spacing perpendicular to the direction of force
dL	hole diameter, depends on the selected bolt type and size

Bolt pattern of the bending-resistant joint

This dialog allows you to specify the number of bolt rows parallel to the direction of force, the bolt spacing and the hole diameter dL to be used.

The maximum number of possible bolt rows is displayed. It is determined by the permissible minimum bolt spacing.

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

- The permissible minimum bolt spacing must be complied with.

  e_1 >= 1.2 d_L

  p_1 >= 2.2 d_L

  e_2 >= 1.2 d_L

  p_2 >= 2.4 d_L

- The total of all bolt distances perpendicular to the force must be equal to the corresponding fish plate height h.

  e_2 + (number of bolt rows - 1) p_2 + $e_{2,rem.}$ = h

e_2	distance to the edge
$e_{2,rem.} = e_2$	for web fish plates
$e_{2,rem.}$ >= 1,2 d_L	for flange fish plates

- The total of the bolt spacing in the direction of force must be equal to the length of the fish plates in one connection L_2.

  2 e_1 + (number of bolts per row - 1) $P_1 = L_2$

Note: *When you enter a value for e_1 (p_1), compliance with this condition is checked and the value of p_1 (e_1) is adjusted automatically.*

When you change the length L_2 subsequently, the difference is allocated proportionally to the distances e_1 and p_1 and the values are adjusted accordingly.

If there is only one bolt in each row, half the length L_2 is taken into account for e_2.

- When defining d_L, 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 complied with.

Values to be defined for each fish-plate type

nR	number of bolt rows parallel to the direction of force N (for flange fish plates this value refers to one half of the beam flange)
sel. n	selected number of bolts per row in the web fish plates
e1	distance to the edge in the direction of force N
p1	hole spacing in the direction of force N
e2	distance to the edge perpendicular to the direction of force N (for flange fish plates, this value refers to one half of the beam flange, distance to the outer edge of the fish plates)
p2	hole spacing perpendicular to the direction of force (for flange fish plates, this value refers to one half of the beam flange)
dL	hole diameter, depends on the selected bolt type and size

Bolt pattern of the end-plate splice

This dialog allows you to specify the bolt spacing and the hole diameter dL to be used.

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

- The permissible minimum bolt spacing must be complied with.
- The total of all bolt distances must be equal to the corresponding plate dimension.
- When defining d_L, 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 complied with.

Spacing in the direction of the beam web

First you need to select “a“ or “e“ (see graphic displayed in the dialog)

a1 distance of the bolt in the projection to the outer edge of the beam

If the input field is disabled, a_1 is determined as follows:
(a_2 - flange thickness) rounded to 5 mm

a2 distance of the inner bolt to the bottom edge of the beam

a3 distance of inner bolt to the top edge of the beam

e1 distance of the bolt to the outer edge of the end plate in the projection

e2 distance of the holes on the bottom edge of the flange, measured from the bottom edge of the end plate if it is fitted flush to the surface

e3 hole spacing in the in the centre of the beam

e4 distance of the holes on the top edge of the flange, measured from the top edge of the end plate if it is fitted flush to the surface

Spacing in the direction of the beam flanges

w1 central spacing (in the beam)

w2 inner spacing of the bolts on an end plate with four rows

w3 distance of the bolt to the outer edge

dL hole diameter, depends on the selected bolt type and size

Design

Design of the tensile splice

If you have enabled the automatic design in the Options menu, it is performed after you have defined the beam tie (number n1) in the system definition dialog.

The dialog is structured like the bolt selection dialog. In addition, you can select the method of optimization and edit the proposed bolt pattern.

After each data entry, the current system is recalculated; the loading rate of the connection and the loading rate caused by tensile stress as well as the number of required bolts are indicated.

The following design rules apply:

$t_{2,tot}$ = t1,tot

n2 = n1 + 1

L = $e_{1,des}$ + (sel.n - 1) e_{des} + $e_{1,des}$

(sel.n n_{row})$_{des}$ >= req. number of bolts due to shear

For the criterion of minimum dimensions, the following equations apply:

$e_{1,des}$ = max.perm.e_1

e_{des} = min.perm.e

For the criterion of the minimum number of screws, the following equations apply:

$e_{1,des}$ = max.perm.e_1

e_{des} = min.perm.e

The required minimum number of bolts per joint is determined by the combination of the bolt rows and the selected number of bolts per row.

Note: *You can customize the joint by editing the proposed values. The bolt spacing is optimized automatically (unless you have defined the spacing manually in the BOLT PATTERN DIALOG)*
→ see also Values to be defined for a tensile splice .

Design of the beam connection

If you have enabled the automatic design in the Options menu, it is performed after you have defined the shear force, the main beam and the secondary beam in the system definition dialog.

You can dimension 21 typical angle profiles that have proven their worth in practice. The results are displayed in a well-structured table.

Eta_V: loading rate of the connection

Eta_eT: loading rate of the notch

The connections are always flush to the surface and the required values for e_{T1}, e_{T2} and a (rounded to the next tens place) are taken into account.

The Üw value is assumed 0.0. The bolt spacing is aligned to practice, however, not to the optimized values.

Among all angle profiles the one with the utilization closest to 1.0 is automatically highlighted.

If no angle profile is highlighted, you can select the closest profile and adjust or optimize the joint by editing the angle length or the bolt spacing.

Design of the bending-resistant joint

If you have enabled the automatic design in the Options menu, it is performed after you have defined (edited) the beam cross section in the system definition dialog.

In this process, the required thickness and height of the web fish plates and the flange fish plates on the outside are determined in accordance with the beam cross section. No fish plates are provided at the inner sides of the flange.

The cross sectional areas of the fish plates have the following relations to the corresponding cross-sectional areas of the beam:

$t_{plate} = t_{beam} / n_{plate}$ rounded to the next standard plate thickness

$h_{plate} = A_{beam} / t_{plate}$ rounded to the next integer

Design of the end-plate splice

If you have enabled the automatic design in the Options menu, it is performed after you have defined (edited) the beam cross section in the system definition dialog.

The design is performed for the following profile types:

IPE, IPEa, IPEo, IPEv, IPEr, HEA, HEAA, HEB, HEM.

You must select the desired standard shape from the Frilo Profile Selection file first.

You can dimension typical end-plate splices that have proven their worth in practice in accordance with the selected beam. The results are displayed in a well-structured table.

Eta_V: loading rate of the bolts

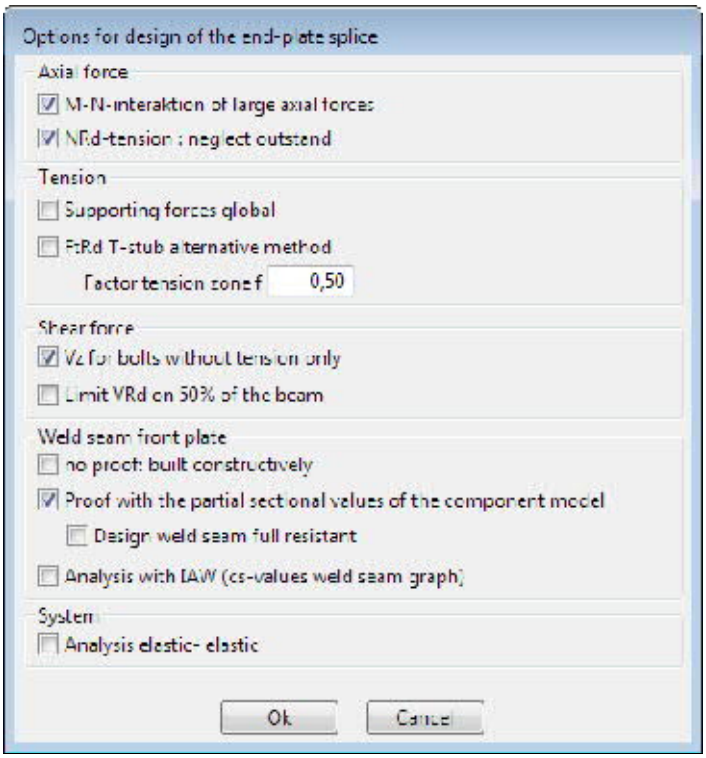
Eta_SP: loading rate of the end plate

Eta_SW: loading rate of the weld seam

In the design as per DIN EN 1993, the limit internal forces of the connection are calculated using the component method and are compared to the actions.

Settings End-plate splice according to EN 1993

To access the calculation options of the component model, click on "Settings" within the system input.



Axial force

N-M interaktion... Consideration of axial forces > 0.05 $N_{pl, Rd}$ according to equation 6.24 EN 1993-1-8

NRd-tension Screws in the outstand are neglected when determining the limit axial force N_{Rd}

Tension

Supporting forces global If the option is ticked, the program assumes that the bolted end plate connection always has supporting forces (there is no check by the program!), so it always applies Lb <= Lb * Table 6.2)

FtRd T-stub ... The use of the alternative method (method 2) for the verification of the failure mode 1 in the equivalent T-stubs opens up smaller bearing reserves by a more accurate approach of the screws

Factor tension zone f This factor related to the connection height gives the range in which the screws act on tension. Default value is f = 0.5.
Influence: Screws closer to the pressure zone can be neglected when calculating the moment resisting capacity. They then act with their full limit shearing force. This results, if applicable, in a higher shear resistance of the compound. The underestimation of the moment resisting capacity is generally low and is estimated to be 15% for joints where at least a minimum of 50% of the bolts act on tension and the neglected bolts are within 0.4 times the distance of the outermost tensioned bolt to the pressure point.

Shear force

Vz ...	The shear force is transmitted exclusively by screws, which take no tensile force. See also factor f for tension zone.
Limit Vrd...	The bearing capacity of the shear force is limited to 50% of the shear resitance of the beam. This is included in the calculation of the utilization of Va_{Rd}.

Weld seam front plate

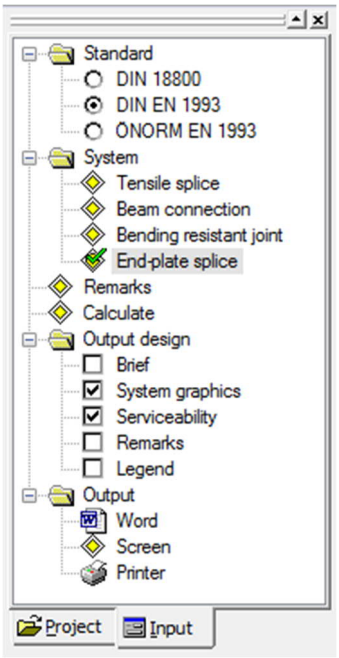
no proof ...	The welds of the front plate are designed according to the profile dimensions and are not explicitly proofed.
... partial sectional values ...	The welds of the front plate are proofed with the respective partial sectional values of the component model.
...full resistant...	The welds of the front plate are proofed in that way that they can transmit the limit moment and the limit shear force of the connection. Welds have only limited ductility and should therefore be dimensioned so that they are not relevant to the design, ie. one of the other components failed first.
Analysis ...with IAW	The welds of the front plate are verified by the statics of the overall weld seam pattern, otherwise with the respective partial section values.

System

...elastic-elastic	The structural calculation is to be done only elastic-elastic. Relevant is $Ma_{,Rd,\,el}$ - for classification, only the stiffness is used.

Output

The “Comments” button allows you to enter explanatory texts about the item.
You can optionally put out these comments together with the results (Main menu - Output profile - Comments).



Output of the system data, results and graphical representations on the screen or the printer.

The Output item in the Main menu allows you to start the output on a printer or the screen.

Output design	the dialog offers comprehensive options for the control of the output scope.
Screen	displays the values in a text window on the screen
Print er	starts the output on the printer
Word	if installed on your computer, the text editor MS Word is launched and the output data are transferred. You can edit the data in Word as required.

See also Output and printing

Output profile

You can define the scope of data to be printed in this section. Activate the desired output options.

Contents of verifications are only available if these verifications were actually performed.