

Steel Column Base ST3

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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.friilo.com in the Campus-download-section.

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

Application options

The ST3 application allows the verification of unbraced base plates subjected to the internal forces N in the connection, the moment M_y and the shear force V_z .

- The permissible column cross sections are I-shaped steel profiles.
For the verifications referred to EN1993, the base plate will also be calculated for pipes and hollow profiles, if only compression load is present.
- The base plate is fixed to the foundation with anchor bolts located outside and/or inside of the profile area.
- The shear forces are transferred from the base plate to the foundation via friction, flat steel dowels or profile dowels - V_y can also be taken into account in the transfer of the shear forces.
- The base plate is supported by a mortar joint on concrete.

Available standards

- DIN EN 1993
- ÖNORM EN 1993
- DIN 18800

Interfaces

Loads can be forwarded to ST3 from the programs STS+ and S7+.

Basis of calculation

The cross sections of the column shape and the shear connectors are verified in accordance with EN 1993-1-1, para. 6.2.

The base plate is verified in accordance with the component model as per EN 1993-1-8, para. 6.2.8.

Base plate mainly under compression load

Full surface pressure might apply below both column flanges.

The load bearing capacity results from the sum of the load bearing capacities of the three equivalent T-stubs (2*flange, 1*web) that do not overlap (in accordance with para. 6.2.5).

The load-bearing capacity of the T-stub flange under compression is determined by:

$$F_{C,Rd} = f_{jd} \cdot b_{eff} \cdot l_{eff} \quad \text{Eq. (6.4)}$$

b_{eff} = effective width of the T-stub flange

l_{eff} = effective length of the T-stub flange

f_{jd} = design value of the concrete or mortar strength under bearing stress

$$f_{jd} = \beta_j \cdot f_{cd} \cdot F_{ac,A1/A0}$$

$$f_{cd} = \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_c} \quad (\text{EN 1992-1-1, Eq. (3.15)})$$

$F_{ac,A1/A0}$ = factor to increase the permissible compressive concrete strength under partial area loading (EN 1992-1-1, Eq. (6.63) $F_{ac,A1/A0} < 3$)

j = the connection coefficient φ can be included with the value of 2/3, if the characteristic strength of the mortar is not smaller than 0.2 times the characteristic strength of the foundation concrete and the thickness of the mortar is not greater than 0.2 times the smallest dimension of the steel plate.

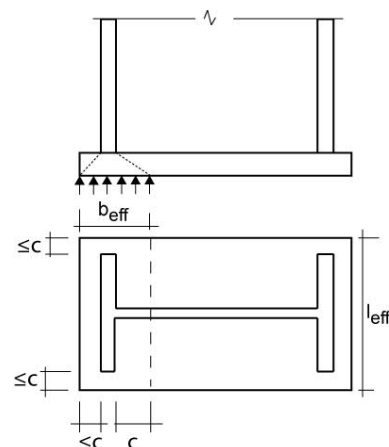
The maximum propagation width c is determined under the assumption of a uniform stress distribution below the T-stub while the permissible bearing pressure f_{jd} is observed:

$$c = t \cdot \left[f_y / (3f_{jd} \cdot \gamma_{M0}) \right]^{0.5} \quad \text{EN 1993-1-8 (6.5)}$$

t = thickness of the T-stub flange

f_y = yield point of the T-stub flange

Illustration on the right: system sketch in accordance with EN 1993-1-8, illustration 6.4 a)



If anchor bolts are present in the contact surfaces of the T-stubs, the area of the anchor holes is deducted from A_{eff} .

Base plate mainly under tension load

Full tension force might apply below both column flanges.

A T-stub consists of a tension-loaded web and a bending-loaded flange. The screw axes are subjected to tension that is counteracted by supporting forces at the outer edges, which are idealised as rigid supports.

The T-stub model distinguishes three different failure modes:

Failure mode 1: full yielding of the flanges

Failure mode 2: failure of the bolts and yielding of the flanges

Failure mode 3: failure of the bolts

For projecting base plates with anchor bolts outside of the flange area, the equivalent T-stub is assumed at the flange. To calculate the bolt row force, the T-stub is assumed symmetrical to the flange (below and above). The tension-loaded web of the T-stub is the column flange in this case. The load-bearing capacity is subsequently divided in order to be able to calculate F_T only for the outer bolt row.

The bolts in the area of the flanges are calculated as an equivalent T-stub at the web with stiffeners. If tension load applies exclusively, also the yield patterns occurring simultaneously are examined. The simultaneous action of all bolt rows together produces the maximum tension resistance of the base plate.

Base plate under axial force and bending loading

This case is handled in accordance with table 6.7. For the compression load only the equivalent T-stub on the flange is taken into consideration for reasons of simplification.

The tension loading is limited to the bolt row outside of the flange area and the first bolt row in the area of the flange.

The ratio of the acting forces $e = M_{Ed} / N_{Ed}$ influences the load-bearing capacity.

Anchor bolts

Anchor bolts are available in the sizes M12 to M36 and the strength classes FK 4.6 to 10.9.

The shear joint could be in the thread or in the shank.

Anchor arrangement in the base plate

You can optionally arrange a bolt row outside and/or two bolt rows inside the area of the steel shape. A bolt row consists of two bolts each.

Shear transfer below the base plate via friction

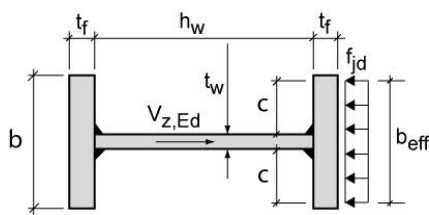
Friction resistance is determined in accordance with Eq. 6.1.

$$F_{f,Rd} = C_{f,d} \cdot N_{c,Ed}$$

A friction coefficient of 0.2 (sand cement mortar) is taken into account.

$N_{c,Ed}$ is the design value of the acting compressive force.

Shear transfer below the base plate via profile dowels



V_z is transferred in the web direction of the profile dowel. In this calculation, the compressive loading on the front flange is determined, the rear flange is not considered.

$F_{c,Rd}$ = load-bearing capacity due to concrete compression:

The propagation width b_{eff} is calculated in dependence of c (Eq. (6.5)) and the compressive concrete strength.

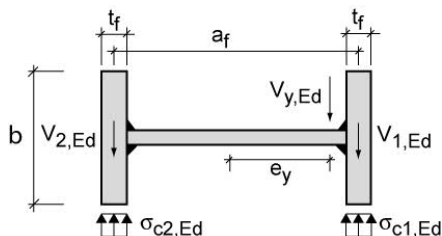
A factor to consider a possibly greater design value with partial area loading as per EN 1992-1-1, Eq. (6.63) can optionally be applied to the maximum concrete compression f_{jd} .

$V_{c,Rd}$ = load-bearing capacity of the web of the profile dowel

$V_{w,1,Rd}$ = load-bearing capacity of the weld seam between the dowel web and the base plate

$V_{c,Rd}$ = load-bearing capacity of the weld seams between the web and the flanges of the profile dowel

The smallest of these values corresponds to the load-bearing capacity of V_z .



V_y is transferred perpendicularly to the web direction of the profile dowel. The compression loading at the outer flange edges is determined in this connection.

Circumferential fillet welds are verified with the help of the simplified method as per EN 1993-1-8, para. 4.5.3.3.

Shear transfer below the base plate via flat-steel connectors

Flat-steel connectors should be arranged in such a manner that shear force acts orthogonally to the width.

Two versions of flat-steel connectors are available for the base plate,

→ see also [Basis of calculation](#):

t for reasons of manufacturing, the thickness of the base plate is to be defined first.
 $t_D \geq 4 \text{ mm}$ and $\leq 80 \text{ mm}$.

b the width b_D of the flat-steel connector should be as great as possible (\leq associated base plate width/length)

t_F the engagement depth t_F of the connector is the partial length of the connector engaged in the support.
 Compressive stresses are calculated only for this length.

a_w thickness of the connecting weld seam between the connector and the base plate

u_e distance of the connecting weld seam (connector to base plate) measured from the top edge of the base plate to the top edge of the connector. Only required if "Variant 2" was selected. This distance must be greater than or equal to the weld seam thickness and smaller than the thickness of the base plate.

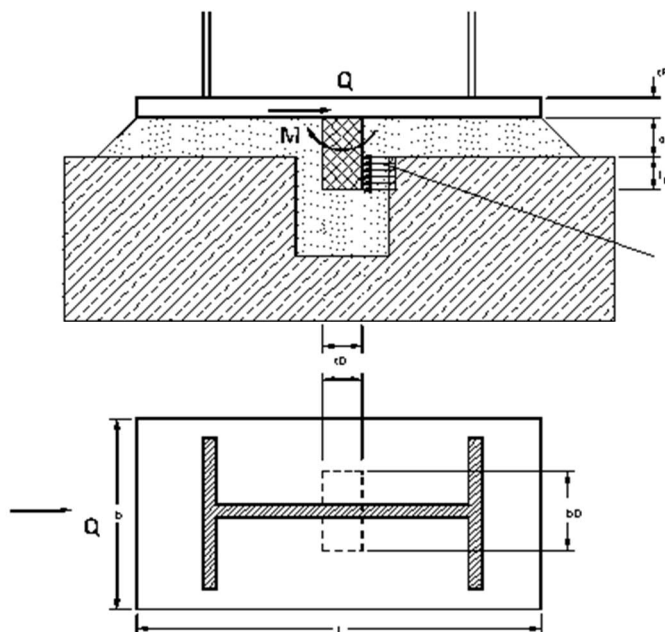
The dialog box 'Input flat steel dowel' contains the following controls:

- for shear force**:
 - Dowel position below the base plate:
 - central
 - outside
 - without
- Vzd**:
 - central
 - outside
 - without
- Vyd**:
 - central
 - outside
 - without
- Arrangement:
 - Single arrangement
 - Rectangel dowel centric
 - Cross dowel
- Parameters (all with input fields):

Thickness [mm]	t =	0,0	t =	0,0
Width [mm]	b =	0,0	b =	0,0
Depth [mm]	t _F =	0,0	t _F =	0,0
Weld thickness [mm]	a _w =	0,0	a _w =	0,0
Distance OK base plate/dowel [mm]	u _e =	0,0	u _e =	0,0

Variant 1

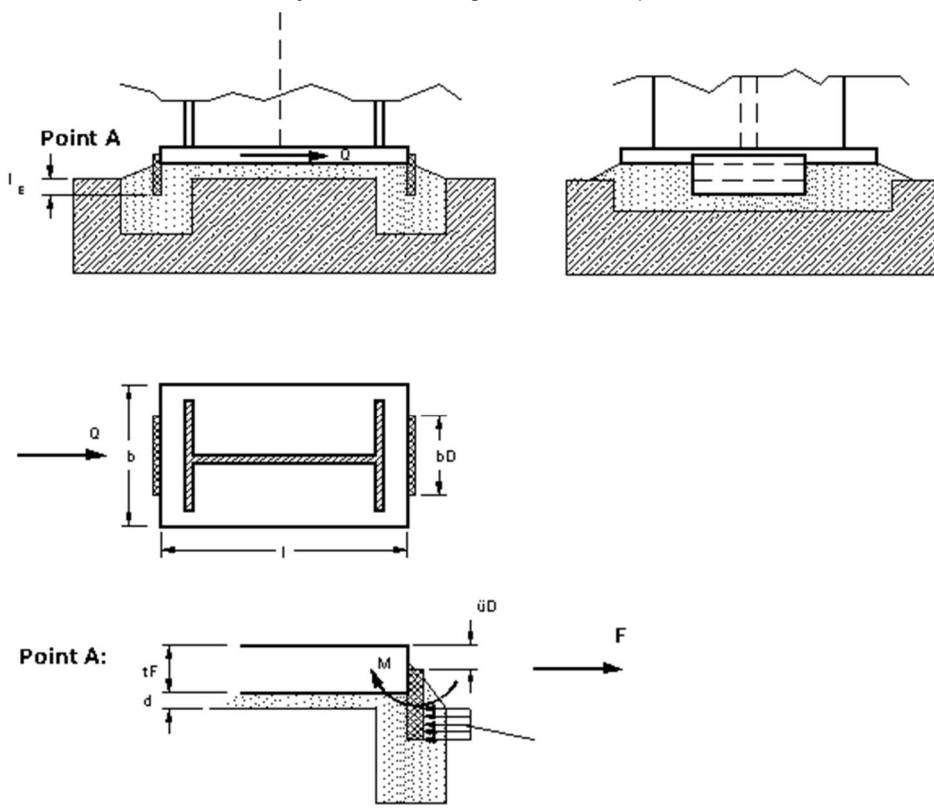
Flat-steel connector centrally underneath the base plate.



Compressive stress due to Q
 M: resulting moment

Variant 2

Flat-steel connectors centrally at the outer edges of the base plate.



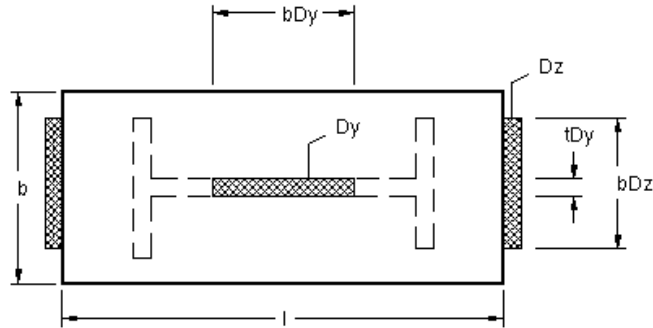
Compressive stress due to $Q/2$

M : resulting moment

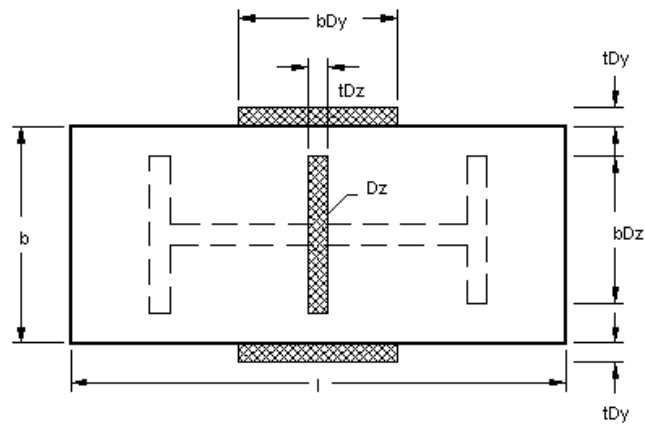
F : tension force acting on the weld seam

The two options for the location of the connectors allow three possible combination variants in regard to different directions:

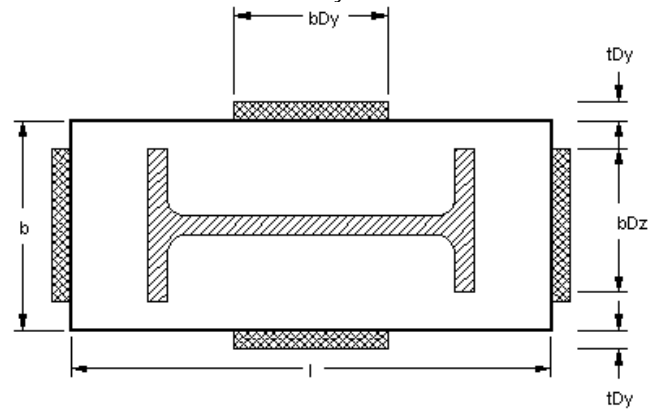
Combination 1 variant 1 for the z-direction and variant 2 for the y-direction



Combination 2 variant 1 for the y-direction and variant 2 for the z-direction



Combination 3 variant 2 for the z-direction and y-direction



Definition of the system

Material

Select the material from the available lists or define the properties manually.

GammaM0 partial safety factor of the material

Action

You can choose between design loads and characteristic loads.



provides access to the load definition table to define the load values (Nd, Myd ...) for the superpositions.

Nd axial force in [kN] must be entered with a positive sign (times gammaF) if it is a compressive force

Myd moment around the y-axis in [kNm] (times gammaF)

Vzd shear force in direction of the z-axis (times gammaF)

Vyd shear force in direction of the y-axis (times gammaF)

Cross sections of the column

Activating the Column button accesses the [Cross section dialog](#) to define or select the corresponding cross section.

Base plate

The base plate can be selected via the [Cross section dialog](#) or directly via the input fields Length, Thickness and Width of the base plate in [mm]. The thickness of the base plate should not exceed 60 mm, if possible. The software application checks compliance with the minimum values (min. B = profile width, min. L = profile height) and adjusts the values if required.

Weld seam between the column and the base plate

awS / awF thickness of the weld seam at the column web or flange.

A thickness between min aw and max aw is proposed. If you enter a value beyond these limits, min aw and max aw are displayed in an information window to make sure that you are aware of the non-conformity.

$$\min a_w = \sqrt{\max t} - 0.5$$

$$\max a_w = 0.7 \cdot \min t$$

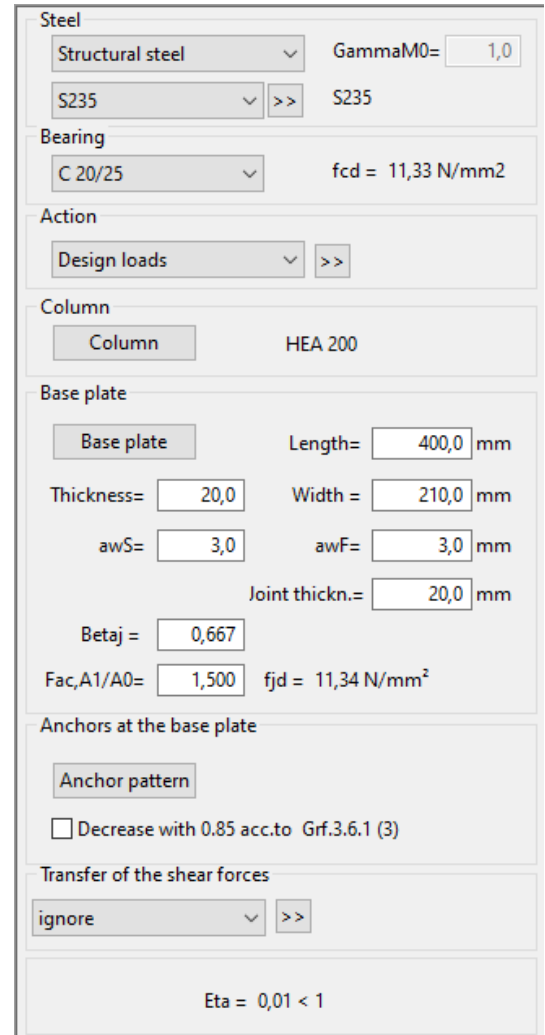
min t is the smaller value of either the flange/web or the base plate thickness.

Joint thickness thickness of the joint underneath the base plate (20 to 50 mm).

Betaj connecting coefficient as per EN 1993-1-8, para. 6.2.5 → see [Basis of calculation](#)

Fac,A1/A0 factor to increase the compressive concrete strength with partial area loading as per EN 1992-1-1, eq. (6.63) → see [Basis of calculation](#).

fjd design value f_{jd} of the concrete or mortar strength under bearing pressure.



The screenshot shows a software dialog box with the following sections and values:

- Steel:** Structural steel (dropdown), GammaM0 = 1,0 (input), S235 (dropdown), >> (button), S235 (input).
- Bearing:** C 20/25 (dropdown), fcd = 11,33 N/mm2 (input).
- Action:** Design loads (dropdown), >> (button).
- Column:** Column (button), HEA 200 (input).
- Base plate:** Base plate (button), Length = 400,0 mm (input), Thickness = 20,0 (input), Width = 210,0 mm (input), awS = 3,0 (input), awF = 3,0 (input), Joint thckn. = 20,0 mm (input), Betaj = 0,667 (input), Fac,A1/A0 = 1,500 (input), fjd = 11,34 N/mm² (input).
- Anchors at the base plate:** Anchor pattern (button), Decrease with 0.85 acc.to Grf.3.6.1 (3) (checkbox).
- Transfer of the shear forces:** ignore (dropdown), >> (button).
- Bottom:** Eta = 0,01 < 1 (input).

Tension anchors at the base plate

Input of anchors

Anchor M 16 - 4.6 R
dL = 17,0 mm

Anchor outside the cross-sect. flange
 Anchor between the flanges
 Two anchors in height of web center

Distances longitudinal to the base plate

e e1 = 55,0 mm 20,4 bis 96,5
e2 = 90,0 mm 68,5 bis 114,6

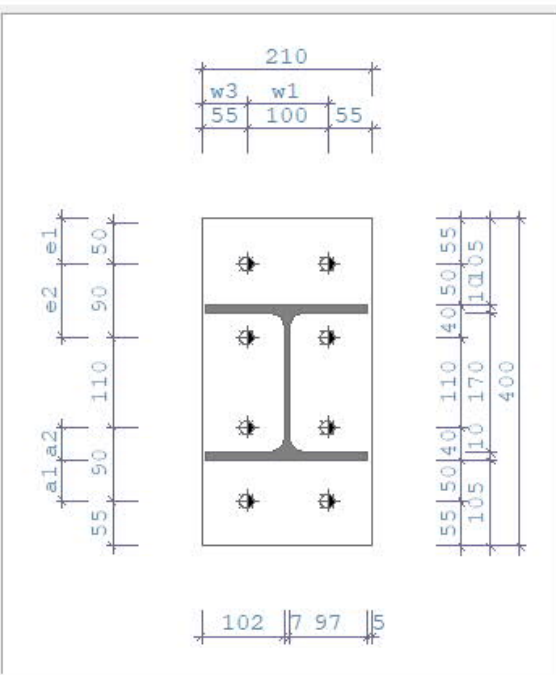
a a1 = 50,0 mm 8,5 bis 84,6
a2 = 40,0 mm 18,5 bis 64,6

Distance perpendicular to the base plate
w1 = 100,0 mm 23,5 bis 169,2

Base plate
L = 400,00 mm B = 210,00 mm

Weld thickness at the distance considered

OK Cancel



Activating the Anchor button accesses a selection dialog.

The description of the input fields is self-evident.

Optionally, there is a reduction with a factor of 0.85 according to Section 3.6.1 (3).

Transfer of the shear forces

Three transfer options are available for selection, if you have defined shear force.

Friction

The friction resistance is calculated using Eq. 6.1

→ see "[Shear transfer below the base plate via friction](#)".

Transfer of the shear forces

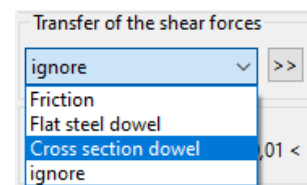
ignore >>

Friction

Flat steel dowel

Cross section dowel 01 <

ignore



Flat-steel connectors

Accesses the dialog for the definition of the flat-steel connectors,

→ see [Shear transfer underneath the base plate via flat-steel connectors](#)

Profile dowels

Accesses the dialog for the definition of the profile dowels.
Only I profiles are permissible.

See [Profile dowel cross section](#)

Optionally, the shear transfer with profile dowels is possible for both flanges proportionally.

The engagement depth l_e is the partial length of the dowel engaged in the support. The default value is 100 mm.

Input section dowel

90 grade rotated

Concrete compressive strength

Betaj =

Fac,A1/A0 =

SigmaRd = N/mm²

Distribution of concrete stress on the flanges

1.flange (outside) / 2.flange (inside)

2/3 and 1/3 (acc. to Thiele / Lohse)

1/2 and 1/2

1 and 0 (acc. to Kahlmeyer)

Depth (from lower edge mortar joint):

l_e = mm

Thickness circumferential weld base plate-dowel:

3,0 <= aw = mm <= 14,0

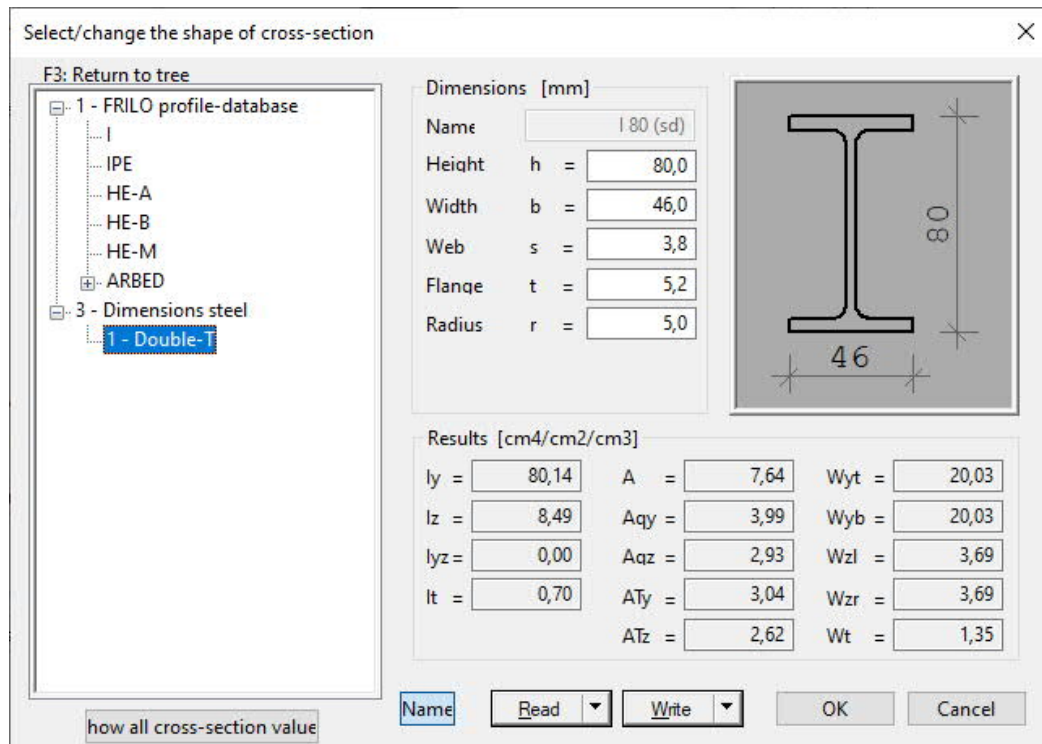
Neck seam aw = mm

Cross sections and profile selection

The profile selection window is displayed when you define a new cross section or edit an existing one.

This software application allows the calculation of I-shaped cross sections (and hollow sections and pipes in combination with DIN 18800). For profile dowels, only I-shaped cross sections are available.

The selection, definition and editing of cross sections is described in the general document "[Selecting or defining cross sections](#)".



Output

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

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

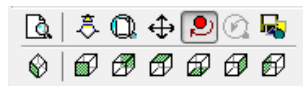
Screen	displays the values in a text window on the screen
Page view	accesses the PDF print preview
Print	starts the output on the Printer
Word	if installed on your computer, the text editor MS Word is launched and the output data are transferred. You can edit the data in Word as required.
Output profile	allows you to define the scope of data to be put out by checking the desired options.

3D-graphical screen



Launches the 3D graphical representation

Toolbar of the 3D graphical screen



Zoom window. Allows you to zoom in (enlarge) the desired screen section with the help of the mouse.



Zoom using the mouse. The mouse cursor is transformed to a hand. Moving the mouse while keeping the mouse button pressed changes the size of the representation.



Zoom full screen. The entire graphical representation is shown on the screen.



Move. An enlarged section can be moved while keeping the mouse button pressed.



Rotate using the mouse. Keep the mouse button pressed to rotate the represented object.



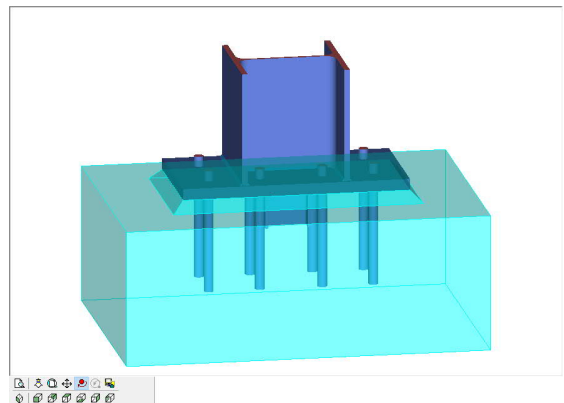
Previous section. The previously displayed section is shown.



Saves the graphical representation in a BMP or WMF file.



Displays the view of the system as shown on the button.



Reference literature

[1] Beispiele zur Bemessung von Stahltragwerken nach DIN EN 1993 Eurocode 3, bauforumstahl e.V., Ernst & Sohn „bauforumstahl“