



STEEL CONNECTION
SC1 APPLICATION
for version AxisVM X6
April 2021

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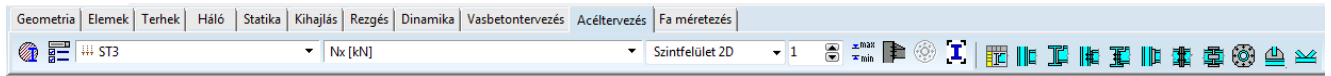
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1. APPLICATION OF STEEL CONNECTION (SC1) MODUL

1.1. In general about the module



Verification of steel connection

The SC1 module is suited for examination of steel connection. The steel connections have to be accordance with standard requirements.

The component method of standard is applied in the module, it means that the resistance of a joint should be determined on the basis of the resistances of its basic components.

Standards

The following standards are used in the module to verify the steel connection:

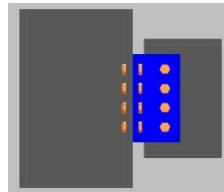
EN 1993-1-1 (2005): Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings

EN 1993-1-8 (2012): Eurocode 3: Design of steel structures - Part 1-8: Design of joints

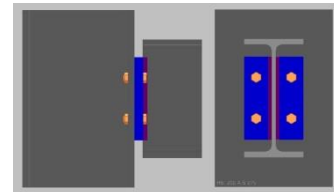
Furthermore the standards referred to in these standards.

Types of joints

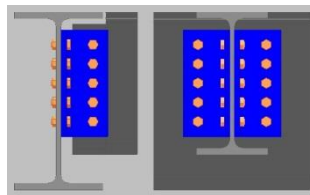
a) Column – Beam (semi-rigid)



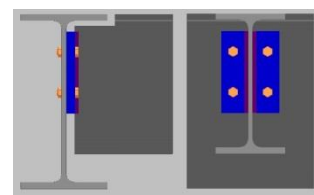
b) Column – Beam (nominally pinned)



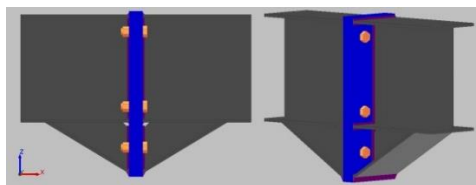
c) Girder – beam (semi-rigid)



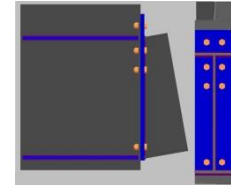
d) Girder – Beam (nominally pinned)



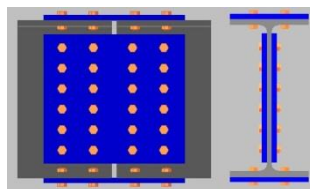
e) Beam – Beam (Endplate)



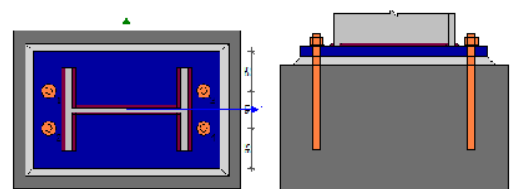
f) Beam – Column (Endplate)



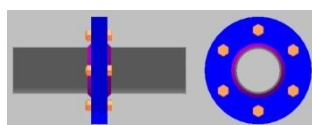
g) Beam splice



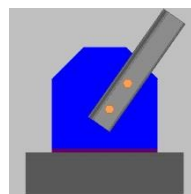
h) Column-Base



i) Pipe splice



j) Gusset plate (single truss)



k) Tube node



☞ The limitations and the scope of module are detailed by each type of joints (2. Type of).

1.2. Configuration of the joint

Getting started Select the required type of joints and then select the connecting members of the joint. Selection is considered when the OK button is pressed. After this the main dialog window appears. The main dialog window depends on the type of joint.

Multiselection Defining the same joint for multiply nodes is possible with selecting more structural members. In case of this the program check the joint for common internal forces. The multiselection feature finds all common nodes automatically taking into account only the valid nodes for the given connection (for beam-beam it will not take into account nodes between beam-column). SC1 looks at the end nodes of each selected beam.

Configuration The properties, as cross-section and material, of the members, which take part in the joint cannot be modified.

In the main window the type of and the geometrical and material properties of the components can be set. In some cases the proportions on multiple tabs can be set.

The default settings always satisfy the geometric requirements, but not certainly the ultimate limit state.

Bolted connection In case of bolted connection the arrangement of the bolts have to be set based on the figure in the dialog window. The additional parameters can be set or modified, as follow:

- Bolt grade
- Bolt diameter
- Type of shear part
- Categories of bolted connections, default category:
 - Shear connection: class „A“
 - Tension connections: class „D“

Welded connection In case of welded connection the type of welds (fillet weld, butt weld), and the length of them have to be defined, if it is necessary.

Starting dialog window (example)

The screenshot shows the 'Column-Beam (Semi-rigid) EN 1993-1-8' dialog window. The title bar indicates 'Utilization = 0.28' with a green checkmark. The window is organized into several functional areas:

- Angles [mm]:** Includes dropdowns for 'Section' (L 80x80x10) and 'Material' (S 235). There are checkboxes for 'One sided' and 'Central', and input fields for $I_a = 147.5$ and $d_a = 51.25$. A diagram shows the angle section with dimensions I_a and d_a .
- Node:** Features a 'Connection category' dropdown set to '2' and a 'Column setting' section with radio buttons for 'To flange' (selected) and 'To web'.
- Column - Angle:** Contains settings for 'Connected to column' (Bolted selected, Welded unselected), 'Database' (EN 1993-1-8), 'Grade' (4.6), 'Diameter' (d = 10), and 'Shear part' (Unthreaded). It also has input fields for 'Number of rows' (w = 4), 'Number of cols' (k = 1), and 'Center in vertical' (checked). A diagram shows the bolted connection layout with dimensions e_1, e_2, p_1, p_2, k, w .
- Angle - Beam:** Similar to the Column-Angle section, but for 'Connected to beam'. It has the same database, grade, diameter, and shear part settings, and input fields for rows, columns, and vertical centering.
- Connecting element:** A list of options: 'To plate', 'To angles' (highlighted in blue), 'To plates and flanges plates', and 'To angles and flanges plates'.
- Column:** Includes 'Section' (HE 260 A) and 'Material' (S 235) dropdowns, with a '1' in a box next to the material.
- Beam:** Includes 'Section' (HE 260 A) and 'Material' (S 235) dropdowns, with a '2' in a box next to the material and an input field for 's = 20'.
- Design calculations:** A button labeled 'v. 15.3.3'.
- Bottom:** A 'Connection name' text field, a '3D View' button, and 'Drawing' and 'Geometry' buttons. At the bottom right are 'OK' and 'Cancel' buttons.

1.2.1. File menu



A previously saved connection can be opened by *Open*. In this case just the same type of connection can be opened. All of the settings are loaded, even the cross-section. After opening always necessary check the configuration of the connection and the calculation. Usually this menu is used in *Standalone mode*.

1.2.2. Save

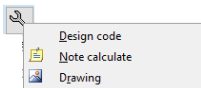


Applying *Save* menu the geometric and other settings can be saved and it can be opened later. This option save each connection type with different extensions. Otherwise on each node the defined/designed connection is saved to *axs* model file. This feature is automatic and available when the dialog window is closed by OK button after design.

The designed connections can be managed via Steel connection manager. [See... 1.5 Steel connection management](#).

If a previously saved connection is opened and in the meantime one of the connected member is changed the calculation cannot be carried out. It means, have to be careful if you open connection from file.

1.2.3. Settings



In Settings menu the following setup options can be found:

Design code

The standard cannot be changed. The safety factors can be modified manually.

Note calculate

The report can be detailed or short version, here can be set it. The type of the report as HTML or AxisVM also can be select. The place of report on disc and the units can be changed.

Drawing

The colours in case of drawing and 3D view can be modified, clicking on the colour it can be changed.

1.2.4. Exit

Exit option in file menu is out of work. Exit is possible in the following ways:

- on main dialog window press Cancel button (PAY ATTENTION: **without saving!**),
- close main dialog window (PAY ATTENTION: **without saving!**),
- on main dialog window press Cancel button (**saving!**).

1.3. Checking the design joint

- 3D View* Press *3D view* button and in a new window the connection can be seen, and it can be rotated. The settings can be checked with this option. The window has to be closed, without this cannot continue the verifying.
- Drawing* Press *Drawing* button and in a new window various drawings of the joint are displayed. Do not have to close the window, if some parameters are changed then press *Drawing* button again, the window will be updated.
- Geometry* The connection should satisfy geometric requirements specified by standard. The module checks them and shows **OK** if everything are in accordance with requirements. Otherwise the inadequate parameters are detailed. **It is important to note, that the program calculates even if the connection is not appropriate geometrically.**

1.4. The procedure of calculation

Calculations The program calculates automatically the utilization for the set load case, load combination, envelope, criticals. If we have changed the parameters we can recalculate the results by clicking the *Calculation* button in the upper right corner of the dialog.

We can check the details of the calculation by clicking the Design calculations button. [See... 1.4.1 Detailed report.](#)

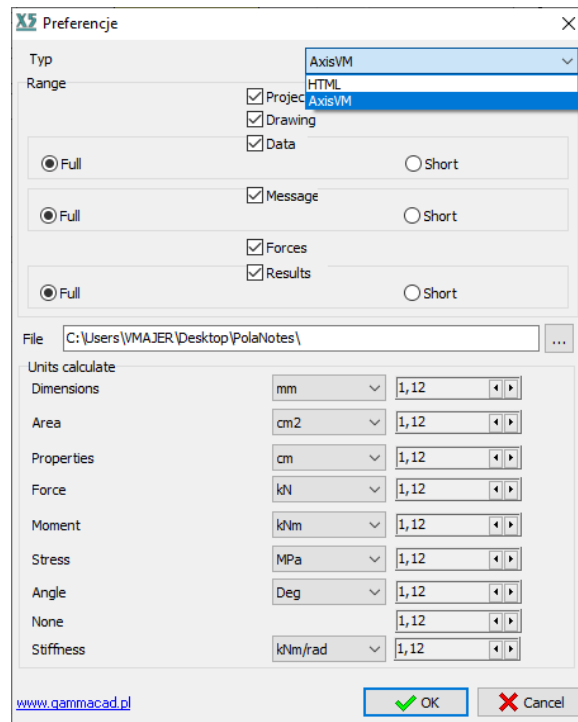
Analyses **The SC1 module calculates the resistances of the connection and the utilization associated with them.** In the following some ultimate resistances are listed.

Resistance of bolts In case of bolted connection depends on the type of the stresses the following resistances are calculated::

- $F_{t,Rd}$ - the design tension resistance per bolt
- $B_{p,Rd}$ - the design punching shear resistance of the bolt head and the nut
- $F_{v,Rd}$ - the design shear resistance per bolt (per shear plane)
- $F_{b,Rd}$ - the design bearing resistance per bolt
- $V_{eff,1,Rd}$ the design block tearing resistance
- $F_{s,Rd}$ - the design slip resistance per bolt at the *ultimate* limit state
- $F_{s,Rd,ser}$ - the design slip resistance per bolt at the *serviceability* limit state
- $\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4 \cdot F_{t,Rd}} \leq 1$ Interaction with tension and shear

1.4.1. Detailed report

In the *Note calculate* menu the type of the report can be selected, as HTML or AxisVM.



Clicking on the Design calculations button, detailed report displays about the connection, regardless of the type of report:

The report contains the following:

- View and section drawings about the connection and dimension lines
- Geometric and material properties of the elements
- Internal forces and moments at the node
- Results

The results are determined in case of ultimate limit states and serviceability case depends on the connection type. The program carries out the verifying even if the internal force is zero. The results are shown by highlighting. Green colour means it is passed, and the red means not passed.

Effective design capacity of a bolt

$$F_{t,Rd} = \min(F_{t,Rd1}; F_{t,Rd2}) = \min(39.68kN; 105.82kN) = 39.68kN$$

$$F_{t,Ed} \leq F_{t,Rd} \quad [5.49kN] \leq 39.68kN \quad 0.14 \quad \checkmark$$

Resultant shear force in a bolt

$$F_{s,Ed} = \sqrt{F_{s,Ed}^2 + F_{t,Ed}^2} = \sqrt{(220.93kN)^2 + (5.49kN)^2} = 221.00kN$$

$$F_{s,Ed} \leq F_{s,Rd} \quad 221.00kN > 30.16kN \quad 7.33 \quad \times$$



In case of HTML report type an IconBar can be found at the top of the window, which contains the print preview and type of the exporter software (MS Word). The latter can be used for exporting.



The AxisVM report type means the same format as the original report in AxisVM program. The report of the designed connection can be added to the full AxisVM report. It has to be noted, if the type of the report is AxisVM, **the report is not updated if something is changed in the model**. Therefore save the report at the last step.

Column-Beam (Semi-rigid) Node[23] Column[20] Beam[19]

Beam - column (front plate) EC3 1991-1-8: 2008 Ratio : 0.35 ✓

Structure node: 23
Structure bars: 20, 19

Connection category: D

HE 260 A
HE 260 A

Data

| Column HE 260 A | | | | | |
|-----------------|----------------------|-------------------------|------------------------|----------|----------|
| | h_c | b_{fc} | t_{fc} | t_{wc} | R_c |
| $\frac{b_f}{h}$ | 250.00mm | 260.00mm | 12.50mm | 7.50mm | 24.00mm |
| $\frac{R}{h}$ | A_c | J_{yc} | J_{zc} | y_{oc} | z_{oc} |
| | 86.84cm ² | 10457.44cm ⁴ | 3667.61cm ⁴ | 130.00mm | 125.00mm |
| Material | Grade | f_y | f_u | | |
| | S 235 | 235.00MPa | 360.00MPa | | |

| Beam HE 260 A | | | | | |
|-----------------|----------------------|-------------------------|------------------------|----------|----------|
| | h_b | b_{fb} | t_{fb} | t_{wb} | R_b |
| $\frac{b_f}{h}$ | 250.00mm | 260.00mm | 12.50mm | 7.50mm | 24.00mm |
| $\frac{R}{h}$ | A_b | J_{yb} | J_{zb} | y_{ob} | z_{ob} |
| | 86.84cm ² | 10457.44cm ⁴ | 3667.61cm ⁴ | 130.00mm | 125.00mm |
| Material | Grade | f_y | f_u | | |
| | S 235 | 235.00MPa | 360.00MPa | | |

| Front plate | | | |
|-------------|-------|-------|-------|
| b_p | l_p | h_p | t_p |
| | | | |

100% ✓

OK








1.5. Steel connection management



The steel connection management summarizes the designed connections. There is a possibility to delete connections. If something is changed in the model, the *Ratio* and the *Status* will be blank. The calculation can be easily done again by clicking the calculator icon. Double click on a row and the main window of the connection design appears.

The table contains the following:

- *Node* - place of connection
- *Type, Category, Connection name*
- *Created, modified*
- *Ratio*: Maximum utilization of the connection
- *Members*: Connecting elements

| Structure Standalone | | | | | | | | |
|--|-----------|---|----------|-----------------|------------------------|------------------------|-------------------|--------|
|   Delete | | | | | | | | |
| | Node | Type | Category | Connection name | Created | Modified | Ratio | Status |
| 1 | 23 |  | D | | 2020. 03. 25. 15:01:09 | 2020. 03. 25. 15:01:09 | 0.354882088924701 | ✓ |
| 2 | 11 |  | A | | 2020. 03. 25. 15:01:37 | 2020. 03. 25. 15:02:32 | 38,5895230102827 | ✗ |
| 3 | 27 |  | A | | 2020. 03. 25. 15:01:37 | 2020. 03. 25. 15:01:37 | 7,32763504576106 | ✗ |
| 4 | 3 |  | A | | 2020. 03. 26. 11:30:17 | 2020. 03. 26. 11:30:17 | 10,8411998486928 | ✗ |
| 5 | 6 |  | A | | 2020. 03. 26. 11:39:44 | 2020. 03. 26. 11:39:44 | 0,463093423855897 | ✓ |
| Members | | | | | | | | |
| | Beam name | Number | Section | Material | | | | |
| 1 | Column | 20 | HE 260 A | S 235 | | | | |
| 2 | Beam | 19 | HE 260 A | S 235 | | | | |
| www.gammacad.pl OK Cancel | | | | | | | | |

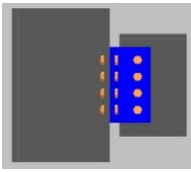


The node associated with the selected line can be displayed with the binoculars icon.

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2. Type of joints

2.1. Column-beam semi-rigid connection



This type of joint is suitable for rectangular column-beam connection. The angle cannot be different from perpendicular.

The place of connection (on the flange or web of the column) is automatically detected.

There is a full pinned option, where the internal forces from the moments are neglected. Just axial and shear forces are transmitted.

The applicable cross-sections:

Column: I-, H- shapes, RHS (Box shape)

Beam: I-, H-shapes



The rotational stiffness of connection and the value of $S_{j,ini}$ are not determined.

The moment resistance is not determined, but the internal forces from the bending moment are taken into account in the calculation.



The program does not check the fin plate and the angle member for bending moment and shear force. The checking of the beam web panel in shear have to be carried out by the user.



Fin plate connection

Optional one-sided fin plate, welded or bolted connection. Moment from the eccentricity of the bolt/weld arrangement is taken into account.



Double (angle) web cleats connection

Optional one angle web cleat, not necessary use double angle.

In both cases of column-angle and angle-beam connection the eccentricity is taken into account.

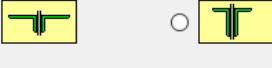


Fin plate connection and flanges plates

There is on option to apply stiffener for column web, the parameter of the stiffener can be specified on a separate tab. The program divides the axial forces into three parts proportionally according to the areas of flanges and web.

Column-Beam (Semi-rigid) EN 1993-1-8 Utilization = 0.28 ✓

Angles [mm]
 Section: L 80x80x10 Material: S 235
☐ One sided
☒ Central
 $l_a = 147.5$
 $d_a = 51.25$

Section position: 

Column - Angle
 Connected to column: ☒ Bolted ☐ Welded
 Database: EN 1993-1-8 Grade: 4.6 Diameter: $d = 10$ Shear part: Unthreaded

Angle - Beam
 Connected to beam: ☒ Bolted ☐ Welded
 Database: EN 1993-1-8 Grade: 4.6 Diameter: $d = 10$ Shear part: Unthreaded

Number of rows: $w = 4$
 Number of cols: $k = 1$
 $p_1 = 32.5$
☒ Center in vertical
 $e_1 = 25$
 $e_2 = 25$
☐ Full pinned

Number of rows: $w = 4$
 Number of cols: $k = 1$
 $p_1 = 32.5$
☒ Center in vertical
 $e_1 = 25$
 $e_2 = 25$
☐ Full pinned

Design calculations: **v. 15.3.3**

Connection name:

Node: 2
 Connection category: A
 Column setting: ☐ To flange ☐ To web
 Connecting element:
 To plate
 To angles
 To plates and flanges plates
 To angles and flanges plates
 Column: Section: HE 260 A Material: S 235
 Beam: Section: HE 260 A Material: S 235
 $s = 20$

3D View Drawing Geometry

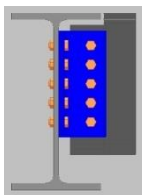
OK Cancel



Web cleat connection with flange plate

Specify the connection and the verifying of the connection are carried out in the same way as *fin plate connection and flanges plates*.

2.2. Girder-beam semi-rigid connection



The verifying is similar to column-beam semi-rigid connection.

There is no option to connect the flanges directly to the girder. The default setting is a flush girder-beam connection, but it can be modified by changing the parameters.



Fin plate connection

There is one- or double sided fin plates option.



Web (angle) cleat connection

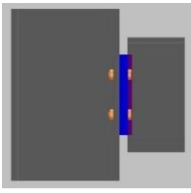
There is one- or double web cleats option.



Brace plate (stiffener) connection

Only one sided plate can be used which can be bolted or welded connection.

2.3. Column-beam nominally pinned connection

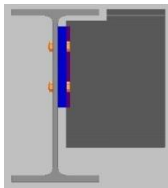


This is a header plate connection, actually a short endplate is used. In case of semi-rigid connections there is a check box for nominally pinned connection where fin plate or web cleat is used.



The program does not check the fin plate and the angle member for bending moment and shear force. The checking of the beam in shear have to be carried out by the user.

2.4. Girder-beam nominally pinned connection

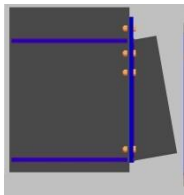


This is a header plate connection, actually a short endplate is used. In case of semi-rigid connections there a check box for nominally pinned connection where fin plate or web cleat is used.



The program does not check the fin plate and the angle member for bending moment and shear force. The checking of the beam in shear have to be carried out by the user.

2.5. Column-beam endplate connection



The column and the beam have to be selected to apply this type of connection. This type of connection is valid only for uniplanar connection. It is not suited for checking spatial connections.

The checking procedure is the same as in EN 1993-1-8 is specified. The design moment resistance, rotational stiffness and rotational capacity are determined based on basic components of joints.

The applicable shapes: I-, H-shapes and variable I-shapes.

Wedged I-shape defined in cross-section editor is not applicable. In the module there is an option to select and set haunched beam.

There is no flange cleat, just haunched beam or stiffener plate.

In the main window the following settings can be set:

- *Type of joint:*
 - *One-sided*
 - *Double-sided*
- *Type of component*
 - *Bolted (Endplate)*
 - *Welded*
- *Position of the connection on the column*
 - *Flange*
 - *Web*
- *Reinforcement of web*
 - *Horizontal stiffener plate*
- *Pitch/Inclination angle*
- *Reinforcement of flange, on the top or bottom, on both side*
 - *Stiffener plate*
 - *Haunched beam*

On various tab can be set the parameters of bolts, plates and etc.

On the *Bolts* tab beyond basic properties of the bolts, specifications are found:

- *Number of bolt in tension in both cases of positive and negative moment*
- *Head washer and nut washer*

It is important to check the changes with *Drawing* or *3D View*. See... 1.3 Checking the design joint

Beam-Column (Endplate) EN 1993-1-8 Utilization = 0.40 ✓

Bolts parameters [mm]

Database: EN 1993-1-8
 Grade: 4.6
 Diameter: d = 24
 Shear part: Unthreaded

Number of rows: w = 4
 Number of cols: k = 2
 Distance: $e_1 = 36$
 Horizontal spacing: $w_1 = 188$

| | | |
|-------|---|-------------------------------------|
| m_1 | 2 | <input checked="" type="checkbox"/> |
| m_2 | 2 | <input checked="" type="checkbox"/> |
| m_3 | 2 | <input checked="" type="checkbox"/> |
| m_4 | 2 | <input checked="" type="checkbox"/> |

| | |
|-------|------|
| p_1 | 84.5 |
| p_2 | 153 |
| p_3 | 84.5 |

☐ Equal spacings

☐ Number of tension bolts for moment

☒ Head washer
☒ Nut washer

Front plate | **Bolts** | Column web | Welds

Design calculations

v. 15.3.3 Connection name

Node 15

Type: One-sided

Connection category: D

Type: Bolted

Column Position: Flange

☒ Clipped $e_c = 0.00$

Section: HE 260 A
 Material: S 235

Reinforcement of web

Beam Section: HE 260 A
 Material: S 235

Angle: $\alpha = 0.00$ [deg]

Reinforcement of flange

Connection stiffness Parameters

3D View Drawing Geometry

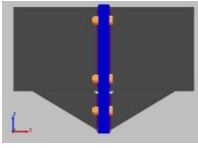
OK Cancel

The checking procedure can be followed in the report. The moment resistance of the joint is determined according to Tables 6.1 and 6.2 of EN 1993-1-8.

The directional method is used, the flange welds need to be designed to transmit part of axial, shear forces and bending moment. The web welds need to transmit part of shear force and bending moment. The rotational stiffness is determined based on Section 6.3 of EN 1993-1-8, it is detailed in report. More information about the report in Section 1.4.1 Detailed report are founded.

If an endplate is necessary for the joint, but the joint does not transmit moment, this kind of joint have to use.

2.6. Beam-beam endplate connection



The two connected beam have to be selected for the calculation.

Based on the relevant components, the moment resistance is determined the same way as by column-beam endplate connection. If the axial force exceeds the 5% of design resistance $N_{pl,Rd}$ the resistance of the joint should be satisfied using interaction formulae.

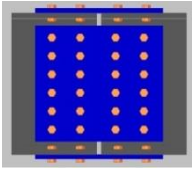
Only I-, H- shape can be used.

The following properties can be set:

- *Type of connection*
 - *Bolted (Endplate)*
 - *Welded*
- *Pitch/Inclination angle*
- *Reinforcement*
 - *Stiffener plate*
 - *Haunched beam*

To set and verify the joint is the same as in case of column-beam endplate connection. The report contains the detailed calculation.

2.7. Beam splice

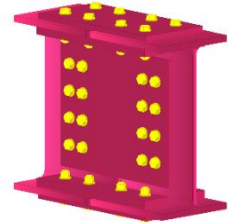


The resistance of the connection should be satisfied the internal forces.

Both sides (beam left, beam right) of the connection have to be specified. Among others the following properties can be set:

- One- or double sided plate
- With or without flange plates

In the case of a bolted connection, inner bolted cover plates are available .



Beam splice EN 1993-1-8 X

ST1 Utilization = 0.22 ✓

Splice plate | Top flange plate | Bottom flange plate

Plate parameters [mm]

☐ One sided ☒ Central

$l_{pw} = 270$ $h_{pw} = 147.5$ $d_{pw} = 51.25$

$t_{pw} = 10$

Material S 235

Connected to beam

☒ Bolted ☐ Welded

Database EN 1993-1-8

Grade 4.6

Diameter $d = 10$

Shear part Unthreaded

Number of rows $w = 4$

Number of cols $k = 2$

$p_1 = 32.5$

☒ Center in vertical

$e_1 = 25$

$e_2 = 25$

$p_2 = 32.5$

☐ Full pinned

Beam left | Beam right

Node 19

Connection category A

Beam left

Section HE 260 A

Material S 235

Beam right

Section HE 260 A

Material S 235

Space $s = 10$

☒ Flange plates

Design calculations

v. 15.3.3

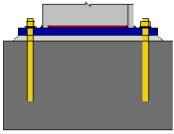
Connection name

3D View Drawing Geometry

OK Cancel

The web plates in bending have to be checked by the user own. Please check the report.

2.8. Column-base connection



The column and the node have to be selected for column-base connection. On the node have to be defined a support, otherwise it is invalid.

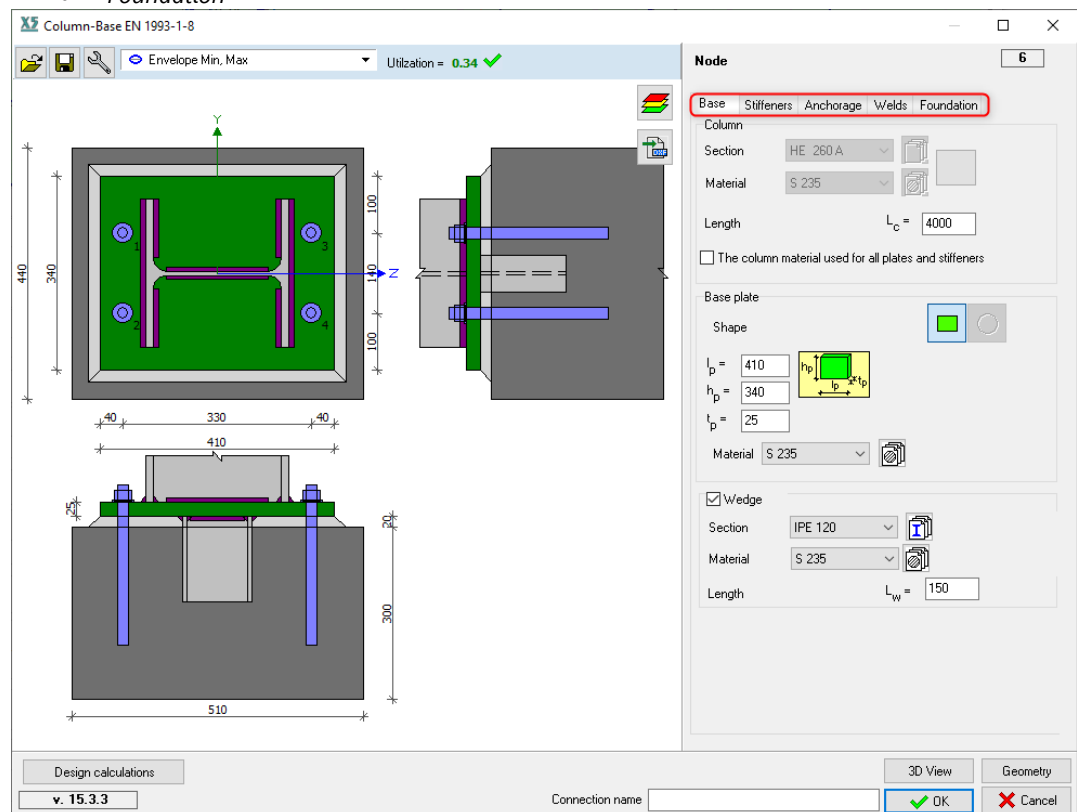
The column have to be vertical, parallel to z-axis. The checking procedure and the resistance components are the same as the standard (EN 1993-1-8) required.

Applicable shapes:

- *I-, H – shape*
- *Pipe and box shapes.*

The following properties can be set:

- *Base plate and wedge*
- *Stiffeners*
- *Anchorage*
- *Welds*
- *Foundation*



The stiffeners and the geometrical properties of them can be set.

Optional stiffeners:

- *Trapezoid plates*
 - *On direction Y-Y*
 - *On direction Z-Z*
- *Stiffeners*
 - *On perimeter (Pipes and box shapes)*
 - *On direction Y-Y*
 - *On direction Z-Z*

The type and properties of the anchorage can be set on *Anchorage* tab. *The defined pad footing on R.C. design tab is **not** imported to Foundation.* On *Foundation* tab have to set the parameters by the user.

Node 4

Base Stiffeners Anchorage Welds Foundation

Column stiffening

Trapezoid plates Direction Z-Z

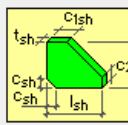
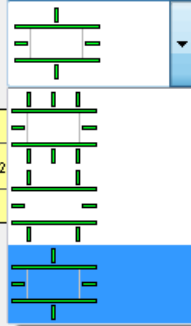
☐ Stiffeners on perimeter

☒ Stiffeners on direction Z-Z

☒ Stiffeners on direction Y-Y

Arrangement

$l_{sh} = 100$
 $h_{sh} = 100$
 $t_{sh} = 10$
 $c_{sh} = 20$
 $c_{1sh} = 10$
 $c_{2sh} = 15$
 Material S 355

Stiffeners on direction Z-Z Stiffeners on direction Y-Y

Trapezoid plate

Node 4

Base Stiffeners Anchorage Welds Foundation

Solid

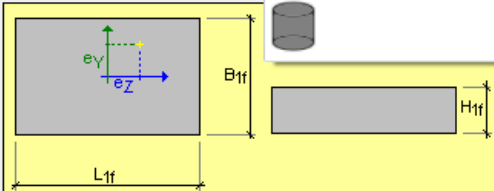
Length $L_{1f} = 600$

Width $B_{1f} = 600$

Height $H_{1f} = 600$

Eccentricity $e_z = 0$

Diameter



Concrete

Material C20/25

State Non-cracked

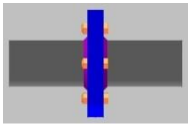
☒ Grout layer

Friction coefficient $C_{fg} = 0.2$

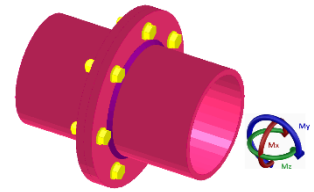
Thickness $t_g = 20$

Material C20/25

2.9. Pipe splice connection



From AxisVM X6 version in SC1 module in case of pipe splice taking into account bending moment is also available, such as like tension/compression.



The calculation method is the same as in CEDICT (<http://www.cidect.org/design-guides/>). The resistance of the joint is carried out based on a similar conception as the T-stub element analysis in EN 1993-1-8. The following component resistances are taken into account, in the parentheses there is the corresponding internal force:

- Bolt tension resistance (N)
- Resistance of welds (N, V)
- Member tension – compression resistance (N)
- Member shear resistance (V)
- Shear resistance per bolt (V)
- Bearing resistance (V)
- T-stub/Plate resistance (N):

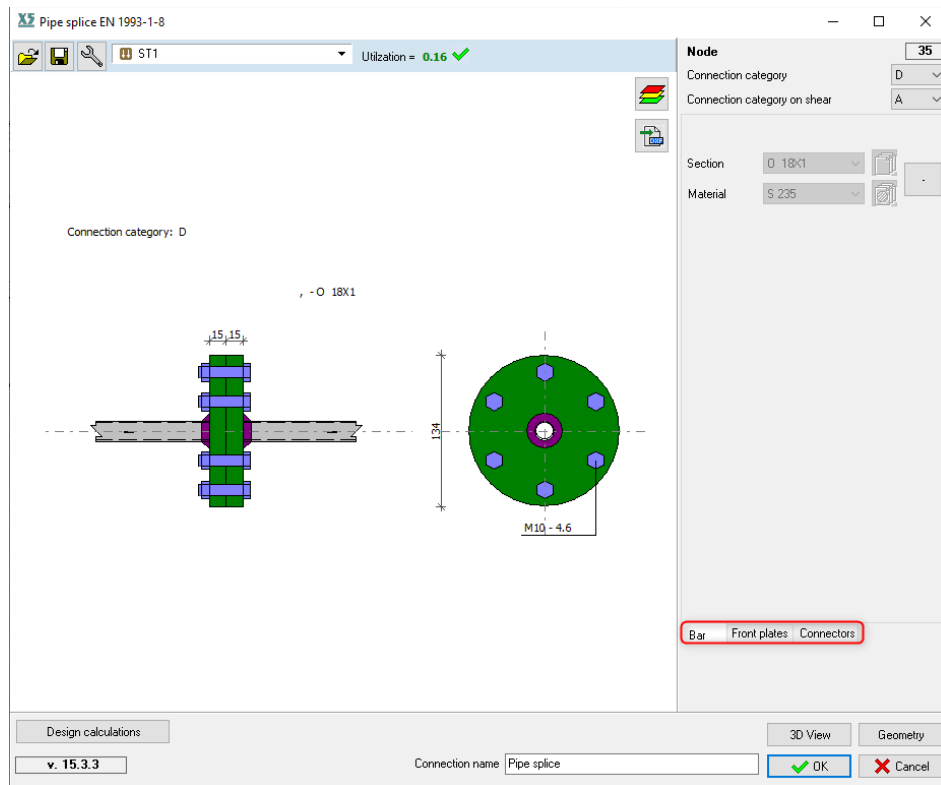
CHS (pipe) member:

1. $N_{T,Rd,1}$ – Complete yielding of the endplate
2. $N_{T,Rd,2}$ – Bolt failure with yielding of the endplate
3. $N_{T,Rd,3}$ – Bolt failure

RHS (box shape) member:

1. Complete yielding of the endplate – can be avoided by geometric requirements
2. $N_{T,Rd,2}$ – Bolt failure with yielding of the endplate
3. $N_{T,Rd,3}$ – Bolt failure

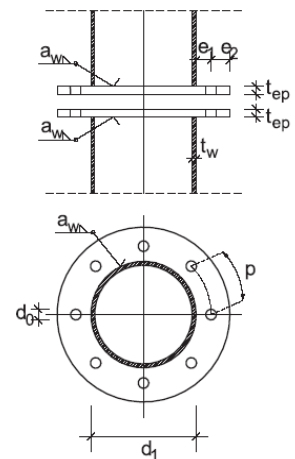
The selected pipes/boxes have to have the same cross-section.



Geometrical
requirements of
T-stub

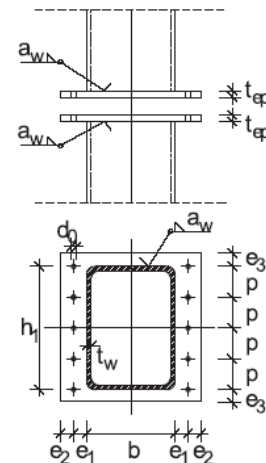
Pipes (CHS)

- $p_{\min} = 2,2d_0$; $p_{\max} = \min(14t_{ep}; 200 \text{ mm})$
- Number of bolts: $n_{\min} \geq 4$
- Recommended:
 - $e_2 = 1,5 d \sim 2,0d$
 - $e_2^* \geq 1,2 d_0$
 - $e_3^* \geq 1,2 d_0$

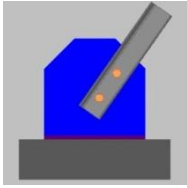


Boxes (RHS)

- Thickness of endplate: $12\text{mm} \leq t_{ep} \leq 26 \text{ mm}$
- $3d_0 \leq p \leq 5d_0$
- $p_{\min} = 2,2d_0$; $p_{\max} = \min(14t_{ep}; 200 \text{ mm})$
- Number of bolts: $n_{\min} \geq 4$ and $n \leq (2h_1/p+2)$
- Recommended
 - $e_2 \leq 1,25 e_1$
 - $e_2 \geq 1,2 d_0$
 - $e_3 \geq 1,2 d_0$



2.10. Gusset plate (single truss) connection



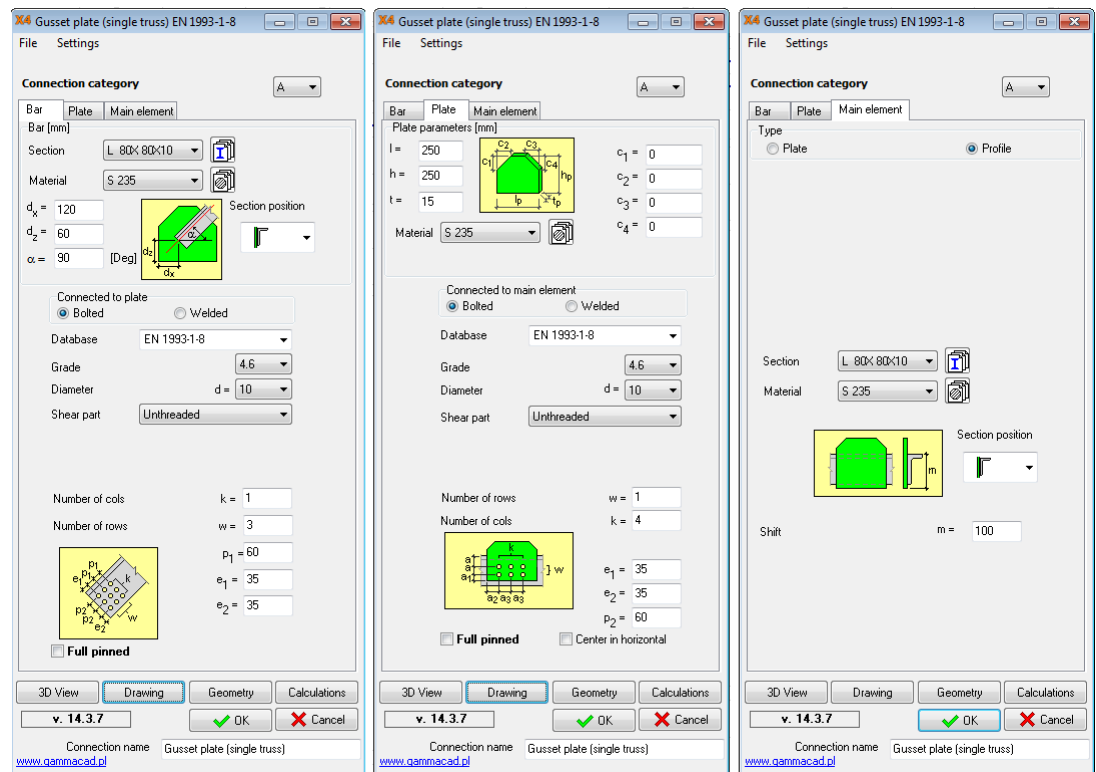
The geometrical arrangement have to be set by user. The main element is the chord member of truss or a column. In addition plate element can be set as main element on *Main element* tab.

By default settings the connecting members are perpendicular to each other.

It is important to check the geometry by using *Drawing* and/or *3D Views*.

Verifying of:

- Welds
- Bolts
- Angle member – additional bolts group failure, tension member failure



2.11. Tube node connection



The members, are involved in the connection, should be selected. If just one bracing member is selected in a K-joint, the program will calculate as the joint would be Y-joint.

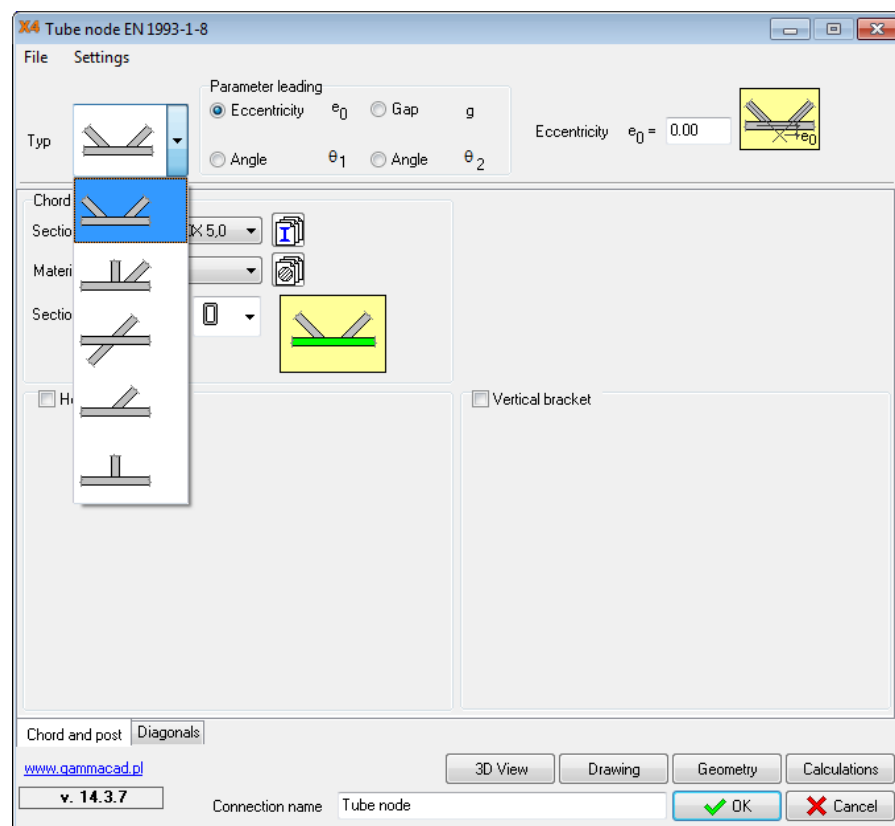
Just uniplanar connection can be verified, if the connection is spatial/3D or there are more than two bracing members, the user should be calculate manually.

There are various types of joints in lattice girders. User can applying different leading parameter and hereby change the geometry of the joint.

Leading parameters::

- Eccentricity (e_0)
- Gap (g)
- Angle of Diagonal 1 (θ_1)
- Angle of Diagonal 2 (θ_2)

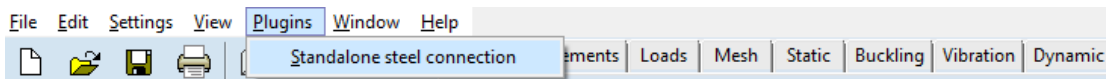
Stiffener can be used on chord member if it is necessary.



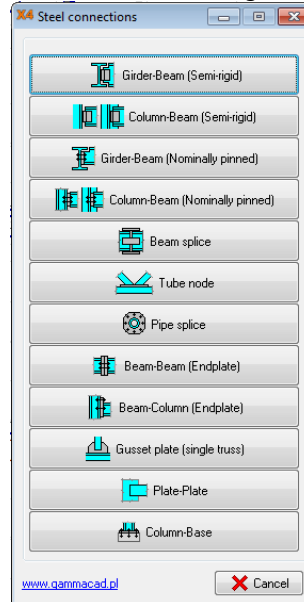
The geometrical parameters are verified based on Section 8.7 of EN 1993-1-8. Using *Geometry* button, the satisfaction of the geometrical requirements can be checked. Some ultimate failure mode can be avoid by compliance with geometrical criterions. The program checks the following ultimate failure modes if it relevant to the type of joint and to applied cross-sections:

- Chord face failure
- Chord side wall failure (or chord web failure)
- Chord shear failure
- Brace failure
- Punching shear failure
- Chord web yielding

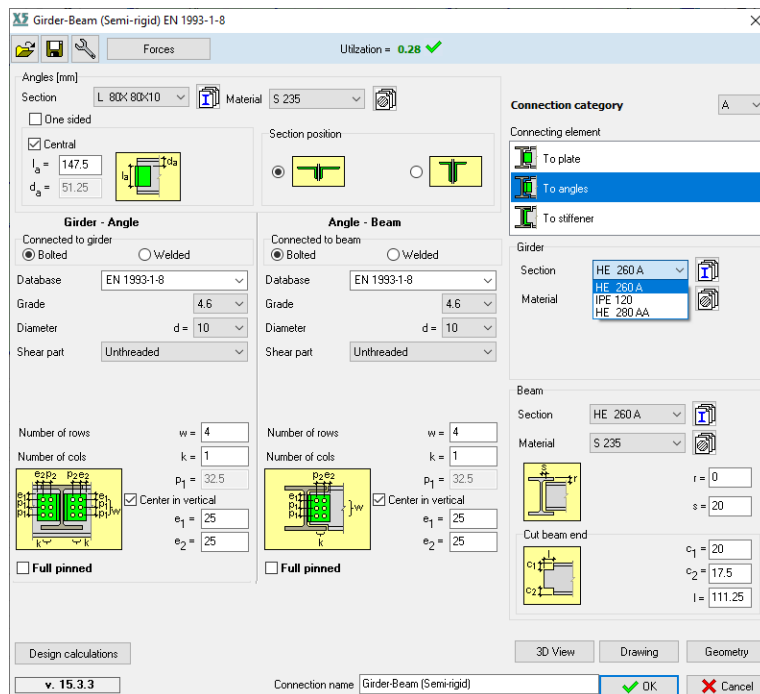
3. STANDALONE STEEL CONNECTION



Standalone steel connection plugin is available in AxisVM program. It can be used independently. The previously detailed types of connections are available through this.



There is no need to be selected nodes and elements. The elements can be selected from cross-section library or from combo-box, which contains the already selected cross-section in the model. The shapes of the applicable cross-sections are limited according to the type of joint.



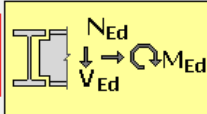
In the first step have to be set the elements and the geometry of the connection. Press button *Calculation* and the following dialog window appears:

X4 Forces

Design loads
Name: ULS

$N_{Ed} = 7$ [kN]
 $V_{Ed} = 9$ [kN]
 $M_{Ed} = 4$ [kNm]

Loads



| | N_{Ed} | V_{Ed} | M_{Ed} | Name |
|---|----------|----------|----------|------|
| 1 | 5.00 | 10.00 | 5.00 | ULS |
| 2 | 8.00 | 12.00 | 4.00 | ULS |
| 3 | 7.00 | 9.00 | 4.00 | ULS |

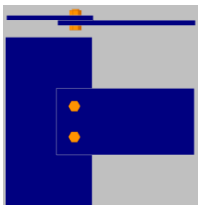
Add row (+)
 Delete row (-)
 Delete all (X)

www.gammacad.pl

OK Cancel

The internal forces have to be added in this dialog window. Results cannot be imported from model file. On the left side can be set the current highlighted internal forces. Press button OK and the calculation is carried out for the highlighted case.

3.1. Plate-plate connection



The plate-plate connection is available in standalone mode. Simply plate to plate bolted or welded connection can be verified. The plates may be perpendicular or parallel to each other. The set of the connection and the calculation method are the same as previous connections.

X5 Plate-Plate EN 1993-1-8

Utilization = 2.78 X

Connected to element
☒ Bolted ☐ Welded


Database: EN 1993-1-8
 Grade: 4.6
 Diameter: $d = 10$
 Shear part: Unthreaded

Number of rows: $w = 2$
 Number of cols: $k = 1$
 $p_1 = 60$
 $e_1 = 35$
 $e_2 = 35$
☒ Center in vertical

☐ Full pinned

Design calculations

Connection category: A

Type connection: 

Element Thickness: $t_2 = 10$
 Material: S 235

Plate
 $l_p = 270$
 $h_p = 130$
 $t_p = 10$
 Material: S 235
☒ One sided
 Length splice: $l_s = 70$

3D View Drawing Geometry

v. 15.3.3 Connection name: Plate-Plate

OK Cancel

NOTES