# Typified Steel Connections STY+

## Table of contents



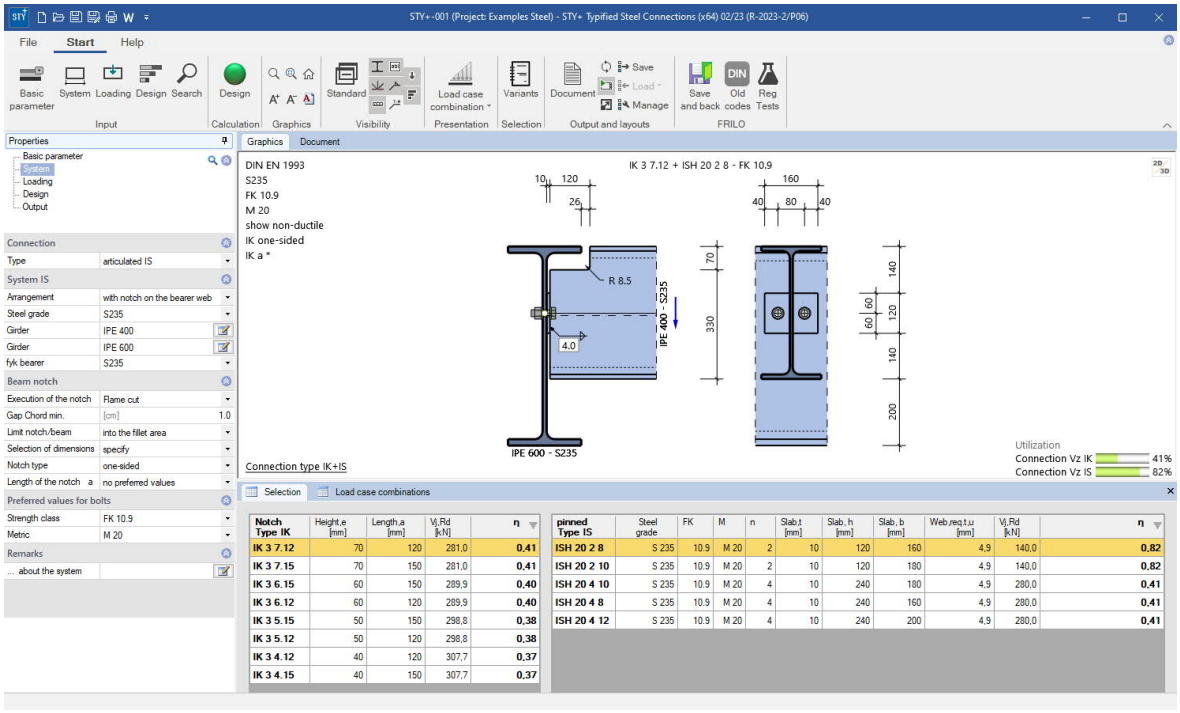
## Basic Documentation – Overview

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.

# Application options

The STY+ program can be used to design moment-bearing and pinned I-beam connections of the IH series and the IS series in conjunction with IK beam notches according to the DSTV ring book "Typisierte Anschlüsse im Stahlhochbau“ (Typified connections in structural steelwork), 2013 edition.

All connections from the DSTV catalog that are permitted for the entered system are listed. This list can be further restricted to the required connection types by specifying connection type, material, bolt strength or metrics. The degree of utilization is determined for each listed connection type and a clear representation of the details including a 3D model and 2D plan is provided.

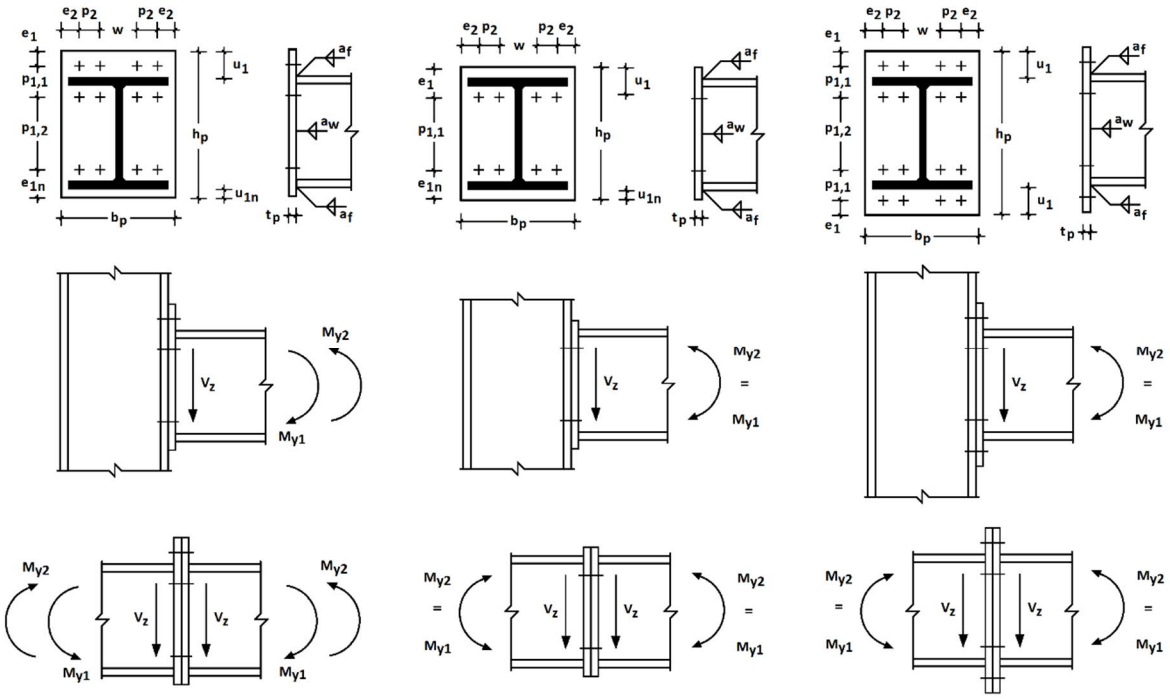



## Standards

Type test TP-12-0001 based on the regulations of DIN EN 1993 (DSTV ring binder)

## IH – connection

Excerpt of possible connections - representative for vertical four-row configurations.



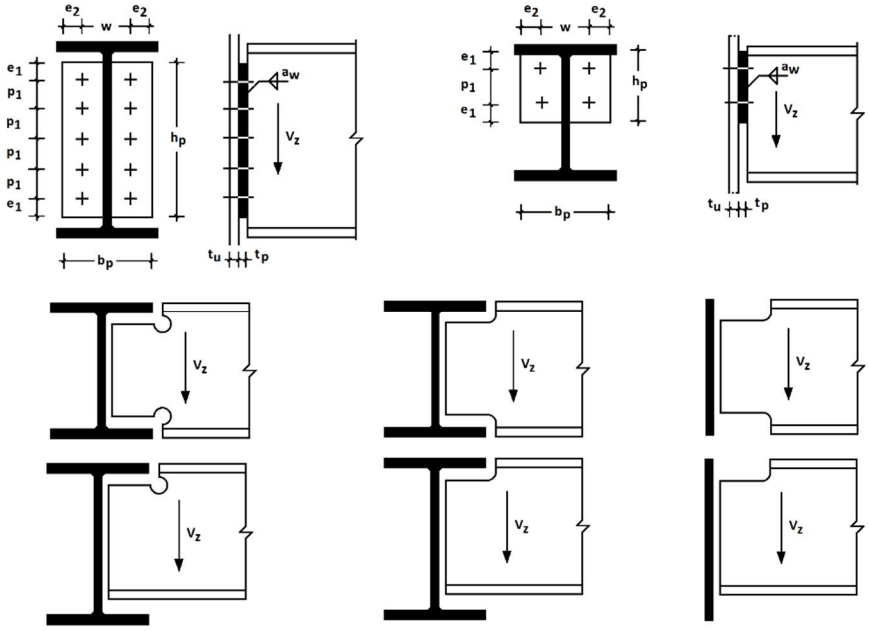

### System

- moment-bearing I-beam connections
- connection types as
  - beam joint
  - column connection as a beam to a continuous column with design of the column cross-section
  - column connection as a column to a continuous beam with design of the beam cross-section
- Material S235 or S355
- Beams and supports from the section series IPE, HEA, HEB and HEM as well as from IPEa, IPEo and HEAA for the member to be connected
- Connection with flush end plate protruding on one or both sides and two or four vertical rows of bolts
- Bolts of strength class 8.8 or 10.9 with a shear plane in the shank of the bolt and a nominal hole clearance of 2 mm or 3 mm for M27 and M30
- the bolts can be preloaded or unloaded
- washers are to be provided under the bolt head and nut
- the weld seam is to be carried out circumferentially with a lateral overhang > 1.41 $a_f$
- same beam heights and positions with two-sided beam-column connection
- bearing members marked with "St" in the catalog must be stiffened over the entire width at the height of the connecting flange, with $t_{stiffness} = t_{flange}$ , $b_{stiffness} \geq b_{flange}$ and $a_{stiffness} = a_f$

### Loading (effect)

- design values of internal forces $M_y$ and $V_z$
- if necessary, reversal torque to $M_y$
- small normal force N in the beam in compliance with the condition $N/N_{pl} < 0,05$
- predominantly static loading
- transmission parameter β = 1
- compressive stress in the column web ≤ $075\ f_{y,wc}$

## IS - connection




### System

- pinned I-beam connections with welded end plate
- types of connection as arrangement carrier
  - without notch
    - to sheet metal (as a connection to an unspecified member)
    - to a column web
    - to a joist web (connected to the center of the beam in the web)
  - with notch
    - to a joist web (in the same design as the ceiling and, if necessary, notched on both sides)
    - to sheet metal (as a connection to an unspecified member)
- Material S235 or S355
- Beams from the section series IPE, HEA, HEB, HEM and IPEo
- the end plate welded on can be carried out in the middle or, in the case of non-notched beams, at the top of the chord and web
- the weld seam is also applied to the fillet in the version with end plate on the chord
- bolts of strength class 4.6 or 10.9 with a shear plane in the shank of the bolt, not preloaded and a nominal hole clearance of up to 2 mm
- thickness of the load-bearing member $t_u$ with a two-sided connection $t_u = t_{u,\,left} + t_{u,\,right}$

### Loading (effect)

- design values of internal force $V_z$
- predominantly static loading

# Calculation bases

For the design, the program uses the stored catalog from the DSTV, which corresponds to the ring binder "Typified Connections in Steel Structures", Edition 2013.

The load-bearing capacities of the connections shown therein were calculated using the component method, in which the connection is broken down into its individual basic components and the load capacity of each of these components, such as column web under tension or bolts under tension, etc., is determined. The overall strength then results from the assembly of the individual members.

For a more detailed explanation of the detection methods used, reference is made to the ring binder mentioned.

## Significance of the reported limit states

IH - connection

| | |
|---|---|
| EPB | (end plate in bending) |
| BT | (bolts in tension) |
| BFC | (beam flange in compression) |
| BWT | (beam web in tension) |
| WELD | (weld) |
| * | (elastic distribution of bolt forces) |
| St | (horizontal stiffeners in column web) |

IS - connection

| | |
|---|---|
| B | (beam) |
| BT | (bolts) |
| EP | (end plate) |
| b | (hole bearing) |
| s | (shear or shear failure) |
| bd | (bending) |
| st | (shear fracture) |

## Explanation of the designation (code) of the connection

IH V.V PP HH MM

it says in detail

| | |
|---|---|
| IH | for the group moment-capable I-end plate connections |
| V.V. | replaced by (end plate type) |
| | 1.1 for end plate flush, vertical two rows of bolts |
| | 2.1 for end plate flush, vertical four rows of bolts |
| | 3.1 for end plate protruding, two rows of bolts vertically |
| | 4.1 for end plate protruding, four rows of bolts vertically |
| | with 1 as the revision number after the point |

PP replaced by (section series)
- E for IPE
- Ea for IPEa
- Eo for IPEo
- A for HEA
- AA for HEAA
- B for HEB
- M for HEM

HH replaced by beam height in cm

MM replaced by bolt size in mm (thread diameter outside)

IS(H) MM N WW

it says in detail

IS for the group of pinned I-end plate connections

H with bolt strength of 10.9

MM replaced by bolt size in mm (thread diameter outside)

N replaced by number of bolts

WW replaced by horizontal bolt spacing in cm

IK T E.AA

it says in detail

IK for the notches group

T replaced by the notch type
- 1 for one-sided with bore
- 2 for both sides with bore
- 3 for one-sided flame cut
- 4 for flame cut on both sides

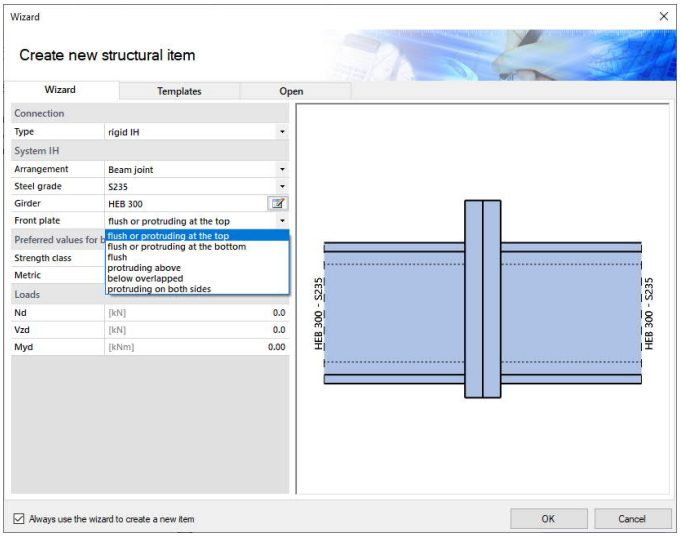
E replaced by the notch height e in cm

WW replaced by the notch length a in cm

# Input and basic parameters

## Wizard

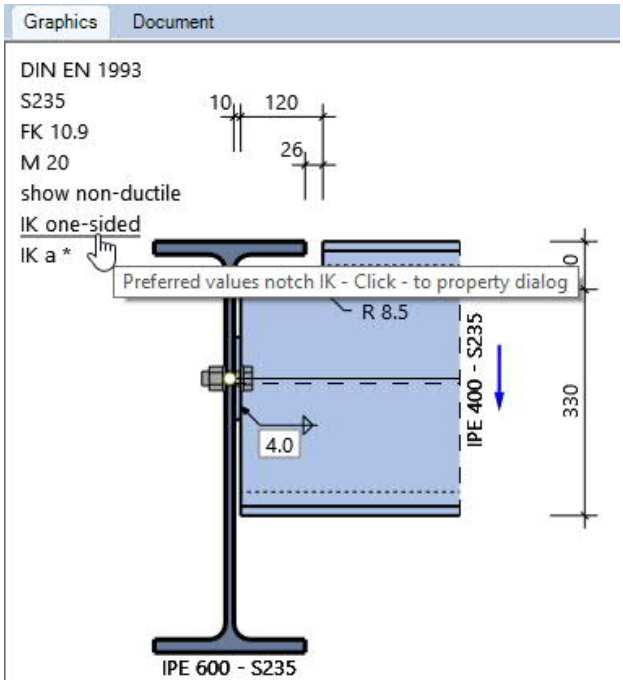
After starting the program, the Wizard is displayed first. Here you define the most necessary/most important parameters so that you already have an initial, calculable basic system for further adjustments.




## Interactive graphic

You can make the entries in the left menu or directly in the graphic (click on objects or use the right mouse button).

See the Interactive graphics chapter in the Basics of Operation.



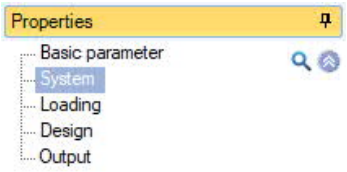

## Basic parameters

Here you can restrict the cataloged connections listed via the load η.

Default is 100%.

# IH - rigid connection

## System - IH

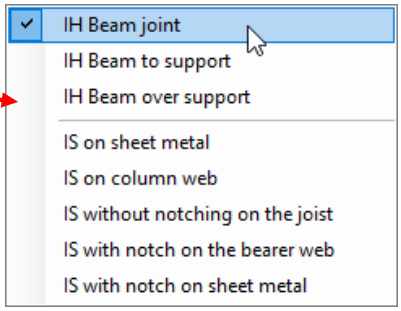



### Connection type selection

The connection type IH or IS to be modeled is selected either in the assistant or via ▸ System ▸ Type in the left menu.

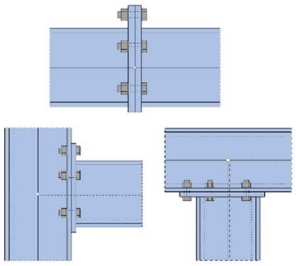
Alternatively, a quick selection can be achieved by means of graphical interaction by clicking on the display for the selected connection type.

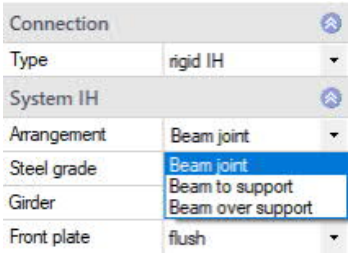





### System IH

Arrangement — Selection of arrangement
- beam joint
- beam on continuous column or
- column to continuous beam.

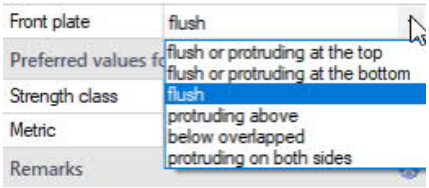





Steel grade — Selection of steel grade S235 or S355 for the entire connection.

Beam/column — Cross-section selection for the beam, or if available for the column, with the section series described in the Application options. The selection adapts to the selected arrangement. Further explanations can be found in the document Cross-section selection PLUS

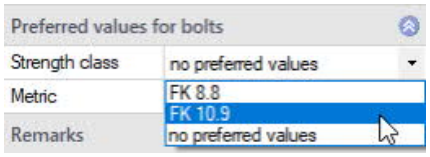
End plate — Specification for the design of the end plate - see picture on the right...




### Preferred values for bolts

Strength class — Specification for selecting strength class 8.8 or 10.9.

Metric — Specification for selecting the bolt metric from M16 to M30.




### Remarks

Calling up the Remarks editor. The remarks are listed in the output with the system data.

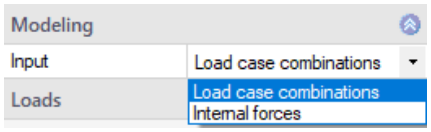
# Loading - IH

## Modelling

Input

The loading can be entered as a list of load case combinations with the associated design values of the internal forces.

As an alternative, the direct specification of the decisive component of all internal forces is possible.




## Load case combinations

You can open the load case table via the "Load case combinations" tab below the graphic.

Alternative input via the load case toolbar in the left menu:

see Table entry (Basic Operations).

You can add table rows using the various icons ( ) or delete - also via the "Load case combination" icon in the ribbon.

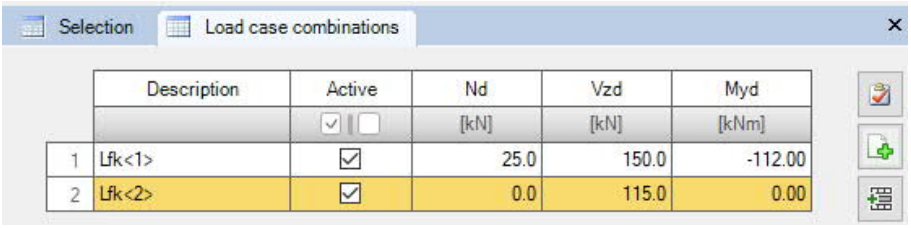
You can enter a designation for each load case combination.

Nd — Design value of the axial force at the cutting edge of the member positive as a tensile force away from the node.

Vzd — Design value of the shear force at the cutting edge of the member.

Myd — Design value of the moment at the cutting edge of the member (see also dashed fiber in the system representation).

Active — Sets the load case combination(s) active / inactive




| | Description | Active | Nd | Vzd | Myd |
|---|---|---|---|---|---|
| | | | [kN] | [kN] | [kNm] |
| 1 | Lfk<1> | ☑ | 25.0 | 150.0 | -112.00 |
| 2 | Lfk<2> | ☑ | 0.0 | 115.0 | 0.00 |

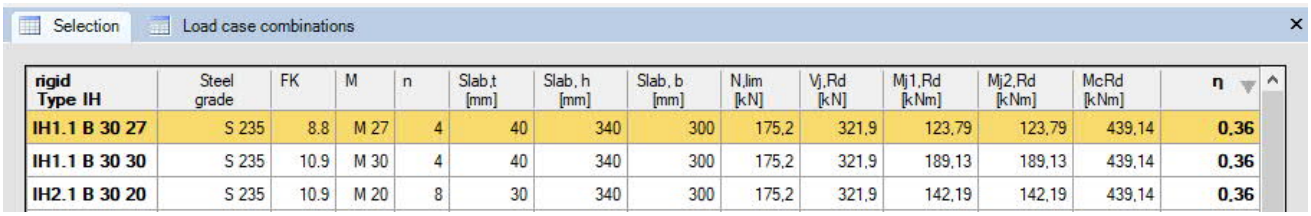
## Internal forces

Specification of the relevant members of the internal forces. The sign rule corresponds to the input for the load case combinations.

*Myd,1* creates tension at the upper edge of the beam (or at the left edge of the column, depending on the connection type) and must be negative. The reversing moment *Myd,2* generates tension at the bottom edge of the beam (or at the right edge of the column, depending on the connection type) and must be positive.

## Design - IH

After each change in geometry or load, the program determines all connections permitted for the given model from the DSTV catalog and presents them in a table, sorted according to the degree of utilization.




| rigid Type IH | Steel grade | FK | M | n | Slab,t [mm] | Slab, h [mm] | Slab, b [mm] | N,lim [kN] | Vj,Rd [kN] | Mj1,Rd [kNm] | Mj2,Rd [kNm] | McRd [kNm] | η |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IH1.1 B 30 27 | S 235 | 8.8 | M 27 | 4 | 40 | 340 | 300 | 175,2 | 321,9 | 123,79 | 123,79 | 439,14 | 0,36 |
| IH1.1 B 30 30 | S 235 | 10.9 | M 30 | 4 | 40 | 340 | 300 | 175,2 | 321,9 | 189,13 | 189,13 | 439,14 | 0,36 |
| IH2.1 B 30 20 | S 235 | 10.9 | M 20 | 8 | 30 | 340 | 300 | 175,2 | 321,9 | 142,19 | 142,19 | 439,14 | 0,36 |

There are various ways of displaying the selection table. A click on the "Selection" tab under the graphic opens it in such a way that it always remains visible when further entries are made for the model. Alternatively, a modal view can be opened that more variably adapts to a larger number of allowed variants.

By marking a line, its variant is adopted in the graphic and output document and saved as relevant in the position. Multiple markings are not permitted.

It is possible to sort the table according to different criteria by clicking on the column titles.

If variants with a utilization of more than 100% should also be displayed, this can be specified under the basic settings.

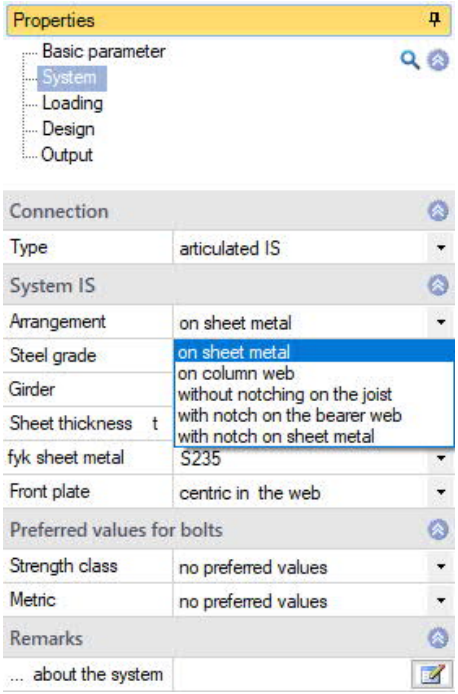
# IS – pinned connection

## System – IS

### Connection type selection

The connection type IH or IS to be modeled is selected either in the Wizard or via ▸ System ▸ Type in the left menu.

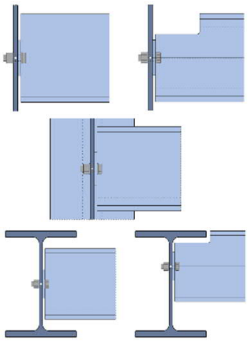
Alternatively, a quick selection can be achieved by means of graphical interaction by clicking on the display for the selected connection type.




### System IS

Arrangement — Selection of arrangement

- beam without notch on sheet metal,
- on column web or on joist web or
- beam with notch on sheet metal or beam.



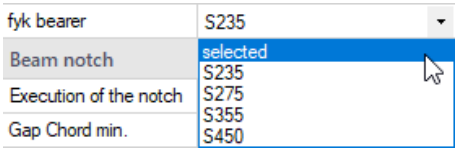
Steel grade — Selection of steel grade S235 or S355 for the entire connection.

Beam — Cross-section selection for the beam with the section series described in the possible applications. For more detailed explanations on profile selection, see Cross-section selection PLUS

Column/beam — Cross-section selection for the load-bearing member, depending on the selected arrangement. The selection is limited to geometrically possible profiles.

Sheet thickness — Thickness of the load-bearing member in the connection, depending on the selected arrangement. If the input is deactivated, the program cannot check the required member thickness "tu". It must be ensured that it is structurally complied with. Likewise, for variants that can only be used on one side, it is not possible to check the required ductility in the eroding member.

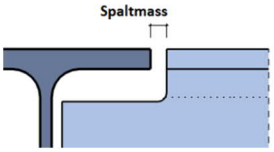
fyk — Characteristic yield strength of the load-bearing member for determining sufficient ductility afterwards. For easier entry, the usual structural steels are summarized in a selection list. It can be set differently under "selected" as a value.




End plate — Specification for positioning the end plate either in the middle of the beam web or adjacent to the top chord of the girder. If the beam is notched, the panel is always placed in the middle.

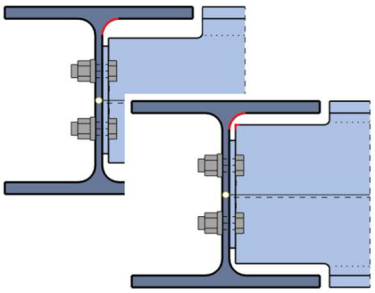
## Beam notch

Execution — Specification for execution with bore (types IK 1 and IK 2 as well as ∅17 mm) or with flame cutting (types IK 3 and IK 4 as well as r=8.5 mm).




Gap chord — Specification for the smallest required gap dimension between the flanges of the beam and girder.

Limitation — The possible notch height is based on the dimensions of the beam and is set at least with the sum of flange thickness and fillet, so that the beam is also in the non-rounded web area of the beam. In order to optimally utilize the available web height of the beam, the beam can alternatively be arranged up to the rounded area of this beam.



Selection of dimensions — The selection of the IK variants can be optimized in such a way that only notches with the smallest possible dimensions are suggested. Alternatively, the selection can be restricted individually using filters.

Notch type — Specification for selection as a connection notched on one side (IK 1 and IK3) or on both sides (IK 2 and IK4). Both types can also be included in the selection list at the same time.

Length of the notch — Possible limitation for the selection of the notch length a.

## Preferred values for bolts

Strength class — Specification for selecting strength class 4.6 or 10.9.

Metric — Default for selecting the bolt metric from M16 to M24.

## Remarks

Calling up the Remarks editor. The remarks are listed in the output with the system data.

# Loading - IS

## Modeling

Input — The loading can be entered as a list of load case combinations with the associated design values of the internal forces. As an alternative, the direct specification of the decisive member of all internal forces is possible.

## Load case combinations

You can open the load case table via the "Load case combinations" tab below the graphic.

Alternative input via the load case toolbar in the left menu:

see Table entry (Basic Operations).

You can add table rows using the various icons (  ) or delete - also via the "Load case combination" icon in the ribbon.

You can enter a designation for each load case combination.

Vzd — Design value of the shear force at the cutting edge of the member.

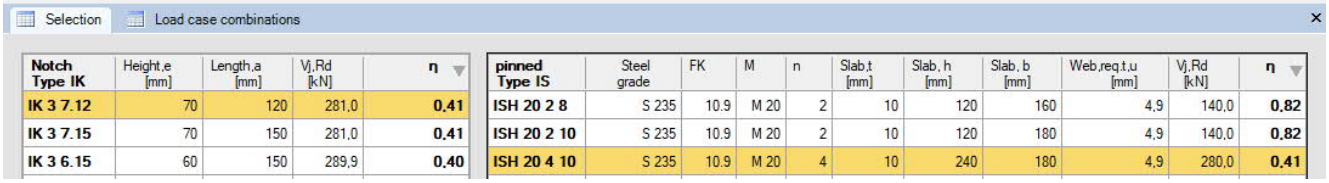
Active — sets the load case combination(s) active / inactive

## Internal forces

Direct input of the design-relevant shear force.

# Design - IS

The same applies as described under Design - IH.



Selection | Load case combinations

| Notch Type IK | Height,e [mm] | Length,a [mm] | Vj,Rd [kN] | η |
|---|---|---|---|---|
| IK 3 7.12 | 70 | 120 | 281,0 | 0,41 |
| IK 3 7.15 | 70 | 150 | 281,0 | 0,41 |
| IK 3 6.15 | 60 | 150 | 289,9 | 0,40 |

| pinned Type IS | Steel grade | FK | M | n | Slab,t [mm] | Slab, h [mm] | Slab, b [mm] | Web,req.t,u [mm] | Vj,Rd [kN] | η |
|---|---|---|---|---|---|---|---|---|---|---|
| ISH 20 2 8 | S 235 | 10.9 | M 20 | 2 | 10 | 120 | 160 | 4,9 | 140,0 | 0,82 |
| ISH 20 2 10 | S 235 | 10.9 | M 20 | 2 | 10 | 120 | 180 | 4,9 | 140,0 | 0,82 |
| ISH 20 4 10 | S 235 | 10.9 | M 20 | 4 | 10 | 240 | 180 | 4,9 | 280,0 | 0,41 |

### The following also applies:

For arrangements with a notch in the beam, the standardized variant IK is selected first. The program then determines the typed end plate connections IS that are possible for the selected variant IK and displays them in the adjacent table. After changing the IK variant, the table of the IS variants is rebuilt and the previous selection is discarded.

## Ductility

Connections whose type designation states "only on one side" show insufficient ductility of the end plate. The ductility must then be provided by the load-bearing member. This means that the connection cannot be made on two sides.

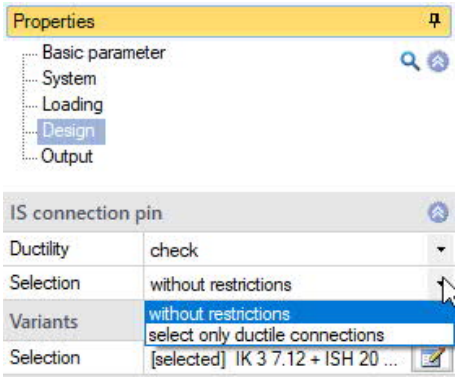
If the thickness and the characteristic yield strength of the load-bearing member are known, the program also verifies sufficient ductility for the load-bearing side:

it must apply

$$\frac{d}{t_u} \geq 2.8 \sqrt{\frac{f_{yu}}{f_{ub}}}$$

With

| | |
|---|---|
| d | nominal bolt diameter |
| $t_u$ | sheet thickness of the load-bearing member |
| $f_{yu}$ | characteristic yield strength of load-bearing member |
| $f_{ub}$ | characteristic tensile strength of the bolt |



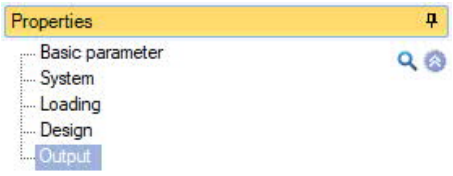

In the "Design" node of the input tree, various options for the behavior regarding the verification of required ductility can be adjusted. For example, whether insufficiently ductile variants are displayed in the selection table or not.

# Output

Use the "Document" tab to switch to the display of the output.

See also

Output and printing




The scope of output is selectable.

| | |
|---|---|
| Screen | Display of the values in a text window |
| Print | Starts output to the printer |