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Anchorage of column with end plate

Introduction

This guide shows how to calculate resistance of column connection to the concrete base using detail with end plate and haunches. The column is loaded by the axial force N_x = 500kN and bending moment M_y = 60kNm. The steel class EN 10025:Fe360 and concrete class C20/25 are used.

Column:	b= 150mm, h= 300mm, t _w = 12mm, t _f = 16mm
Haunches:	t_w = 16mm, h_w = 90mm, L_w = 300mm, L_f = 50mm, a_w = 6mm
Concrete base:	b _b = 1600mm, a _b = 1600mm, h _b = 1000mm, t _g = 30mm
Welds:	a _{w,f} = 8mm; a _{w,w} = 6mm
End plate:	b _p = 180mm, h _p = 510mm, t _p = 30mm, a ₁ = -105mm
Bolts:	M24 10.9, w ₁ = 45mm, e= [50,410]mm

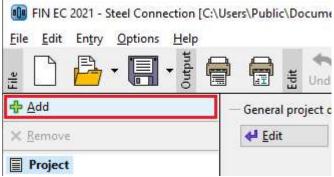
Starting a new task

We use a project created in previous tutorials.

IN EC 2021 - Steel Connection [C:\Us	ers\Public\Documents\Fine\FIN EC 2021	1 Examples\Steel_connection.sce]	<u></u>	×
<u>File Edit Entry Options Help</u>				
		3		
🕂 Add	General project data			
× <u>R</u> emove		1		
■ Project Þ¶s Joint 1 ÍS Joint 2 ÍS Joint 3	Perforated sectiv Capacity of bolt Capacity of trus	y : γ_{M0} = 1.00 ce when checking stability : γ_{M1} = 1.00		
수 Up	- Calculation parameters Structure type: Fra	Global material input structure elements Catalogue User defined Name: EN 10025 : Fe 360 Apply to all joints		

Main screen

We add a new task with the help of the button "Add" at the top of the tree menu



Insertion of a new task



We specify a name ("Column base 1") in the window "Add joint", that appears after the clicking on that button.

Name:	Column base 1
 Create new Copy existing 	

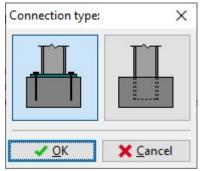
Input of task name

After the confirmation by the button "**OK**", the window with main joint types appears. We select column base (in the middle of the upper row).

Joint types:		×
	<mark>⇒ N</mark> ext	X Cancel

Choice of detail type

The choice of connection type follows. We select connection with end plate (left option) and confirm the choice by the button "**OK**".



Selection of connection type

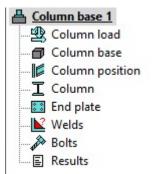
The initial geometry of the joint appears in the workspace.



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<u>File E</u> dit En <u>t</u> ry <u>O</u> ptions <u>H</u> elp		
<mark>∲</mark> <u>A</u> dd	€ column base: Stiff er	nd plate
× <u>R</u> emove	Q	
Project	Q 4 M20 - Bolt 10.9	
b <mark>l</mark> ⊄ <u>Joint 1</u> ji≅ <u>Joint 2</u>	IPE 220 - EN 10023 : FE 300	200
i Joint 3		8
Column base 1 Column load	Ş	² → ^{80.0} 3.0 × 5.0 ×
Column base	Q	
Column position	- P3D.0_140.0x380.0 -	EN 10025 : Fe 360
End plate	8	4 7 7
		8
Bolts		
	1400.0	700.0 700.0
		1400.0
	 • • • • • • • • • • • • • • • • • • •	1
	- Joint geometry	Bending capacity : M _{y,Rd} = 95.36 kNm
	🖾 Joint type 🔚 Connection type	Welds capacity : Max utilization (153.27%) Initial stiffness : S _{j.ini} = 28714.55 kNm/rad
	Loads	
	Add Number Name	_
	× <u>Remove</u>	
	네 Edit	
	Import 🔻	
		Error: 0 Warning: 0 Warning: 1
		(*) calculation without check of column section with respect to comb.
🔶 Up 🕹 Down		of moment and normal force.
EN 1993-1-8/Czech Rep.		
entrisso i of ezech hepi		

Fundamental geometry of column base

The following work is done with the help of the tree menu on the left side of the program. The structure of this menu is generated according to the specified joint geometry.



Inputs organized in the tree menu

We go through all parts from the top to the bottom and modify inputs. The connection to the left flange will be described in detail. The connection to the right flange would be solved in the same way.

On the main screen of the joint, it is possible to change the specified geometry of the joint (buttons "**Joint type**" and "**Connection type**") and specify list of loads. The load represents a set of internal forces that have to be defined for all members in the joint (column, beams). These internal forces should be resulting values of certain load combination. Therefore, they are considered as design values. Number of loads for the joint is not limited. We insert a new load with the help of the button "Add" in the toolbar on the left side of the loads table. The toolbar also contains buttons for editing and deletion of loads and also a tool for import of loads including internal forces from **.txt* or **.csv* file.



- Joint geomet	try	
	i॑॑॑॑♥ Joint type	Connection type
- Loads		
<mark>⊕ A</mark> dd	Number	Name
× <u>R</u> emove		
식 <u>E</u> dit		
Import Import	•	

Button for input of new load

The new is specified by a name. The input has to be confirmed by the button "Add".

New load				×
Descriptior	Load 1			
			∲ <u>A</u> dd	X Cancel
		Window "Ne	w load"	

As we want to add only one load, we close the window by the button "Cancel" after the input of first load.

Column load

If at least one load is entered, it is possible to switch to the part "Column load" in the tree menu and specify internal forces for the column. The axial force " N_x " should be 500kN and the bending moment " M_y " is 60kNm.

Load:	Lo	ad 1	÷
- Load val	ues		
N _x =	500.00	[kN]	
V _z =	0.00	[kN]	M _y \downarrow V _z
M _y =	60.00	[kNm]	
		Input of f	orces

Input of forces

Column base

This mode contains dimensions of concrete base (" b_b " - width, " a_b " - length, " h_b " - height) and thickness of grouting " t_g ". Choose the material of the column from the catalogue.



- Geometry -			— — Material —		
Column base:			Column base:		
b _b =	1600.0	[mm]	Catalogue	User defined	
a _b =	1600.0	[mm]	Name: C 2	0/25	
h _b =	1000.0	[mm]	Grouting:		
Grouting:			Catalogue	User defined	
t _g =	30.0	[mm]	Name: C	20/25	
		-			

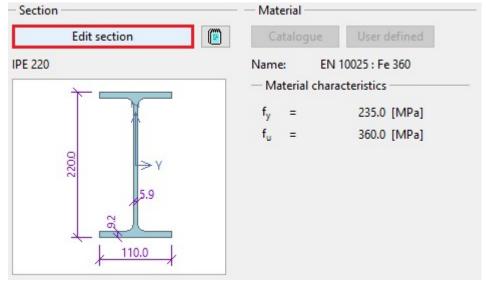
Dimensions

Column position

The position of the column relatively to the centre of concrete base and the column pitch can be specified here. We do not change default values and go to another part.

Column

We specify the column geometry (cross-section, haunches) with the help of the button "Edit section".



The button for edit of beam geometry

The window "**Column properties**" appears. Left part of the window contains input of cross-section, right part input of haunches. We change the cross-section with the help of the button "**New**".



Column properties		×
- Column cross-section	— — Column end — — — — — — — — — — — — — — — — — — —	
New Edit Name: IPE 220		
00022 7 5.9 5.9 110.0		
		<u>OK</u> <u>Cancel</u>

Buttons for editing cross-section and haunches

The window "**Steel section**" that appears after the clicking on the button contains an option to select type of crosssection. We select an option to specify arbitrary dimensions of welded cross-section (the option "**Solid welded**") and open the window "**Cross-section editor**" by pressing the button "**OK**".

Steel section	×
Section types:	
I Solid hot-rolled	
II Solid welded	
X Ca	ncel

Selection of cross-section type

We enter the cross-sectional dimensions and confirm the input by the button "OK".

name I-cross-section 150x300 comment	= 300.0 mm = 150.0 mm = 150.0 mm = 12.0 mm = 16.0 mm	name I-cross-section 150x300 comment f Cross-section dimension f cross-section height $h = 300.0 \text{ mm}$ top flange width $b_{ft} = 150.0 \text{ mm}$ bottom flange width $b_{fb} = 150.0 \text{ mm}$ stem thickness $t_w = 12.0 \text{ mm}$ top flange thickness $t_{ft} = 16.0 \text{ mm}$		Cross-section description				3	bft v
Cross-section dimension cross-section height h = 300.0 mm top flange width b _{ft} = 150.0 mm	= 300.0 mm = 150.0 mm = 150.0 mm = 12.0 mm = 16.0 mm	Cross-section dimension cross-section height h = 300.0 mm top flange width b _{ft} = 150.0 mm bottom flange width b _{fb} = 150.0 mm stem thickness tw = 12.0 mm top flange thickness tm = 16.0 mm bottom flange thickness tm = 16.0 mm	name	I-cross-section 150x300				1	
Cross-section dimension cross-section height h = 300.0 mm top flange width b _{ft} = 150.0 mm	= 300.0 mm = 150.0 mm = 150.0 mm = 12.0 mm = = 16.0 mm	Cross-section dimensioncross-section heighth =300.0 mmtop flange width b_{ft} =150.0 mmbottom flange width b_{fb} =150.0 mmstem thickness t_w =12.0 mmtop flange thickness t_{ft} =16.0 mmbottom flange thickness t_{fb} =16.0 mm	comment					1 2 1]
top flange width b _{ft} = 150.0 mm	= 150.0 mm = 150.0 mm = 12.0 mm = = 16.0 mm	top flange width $b_{ft} = 150.0 \text{ mm}$ bottom flange width $b_{fb} = 150.0 \text{ mm}$ stem thickness $t_w = 12.0 \text{ mm}$ top flange thickness $t_{ft} = 16.0 \text{ mm}$ bottom flange thickness $t_{fb} = 16.0 \text{ mm}$		Cross-section dimension				tt	
	= 150.0 mm = 12.0 mm = = 16.0 mm	bottom flange width $b_{fb} = 150.0 \text{ mm}$ stem thickness $t_w = 12.0 \text{ mm}$ top flange thickness $t_{ft} = 16.0 \text{ mm}$ bottom flange thickness $t_{f0} = 16.0 \text{ mm}$	cross-section hei	ght I	h =	300.0	mm		
	= 150.0 mm = 12.0 mm = = 16.0 mm	bottom flange width $b_{fb} = 150.0 \text{ mm}$ stem thickness $t_w = 12.0 \text{ mm}$ top flange thickness $t_{ft} = 16.0 \text{ mm}$ bottom flange thickness $t_{f0} = 16.0 \text{ mm}$	top flange width	b	ft =	150.0	mm		
	= 16.0 mm	top flange thickness t _{ft} = 16.0 mm bottom flange thickness t _{f0} = 16.0 mm	bottom flange wi			150.0	mm		
stem thickness t _w = 12.0 mm =	w tw	bottom flange thickness t _{fo} = 16.0 mm	stem thickness	t,	w =	12.0	mm		
top flange thickness t _{ft} = 16.0 mm	= 16.0 mm		top flange thickn	ess t	ft =	16.0	mm		22.20
bottom flange thickness t _{fb} = 16.0 mm			bottom flange th	ickness t _f	fib =	16.0	mm		Hew
L bfb	bfb							1	A



Dimensions of welded cross-section

The button in the part "**Column end**" opens the window "**Column haunches**". We select an option "**Haunch without** flange" and specify dimensions according to the following figure in the tab "Left haunch". As the column cross-section is symmetrical, we copy the haunch also to the right flange. We use the dedicated button "**Copy to "Right flange**" in the left bottom corner for this operation.

eft hau	nch Rigi	nt haunch		
— Haur	nch paran	neters		
haur	nch witho	ut flange		-occurrent
t _w	=	16.0	[mm]	
h _w	=	90.0	[mm] L _w	
L _w	=	300.0	[mm]	
t _f		0.0		
b _f	-	0.0	[mm] bf	t _w
L _f	=	50.0	(mm) t	u i tfhw
a _w	=	8.0	[mm]	C. STATE

The button for copying properties

The copy of haunch properties have to be confirmed in a new window.



Confirmation window for copy of haunch properties

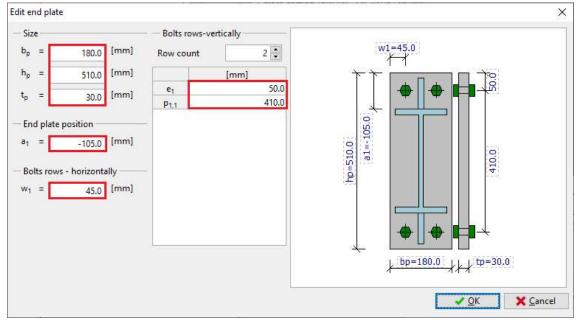
End plate

The input of end plate geometry follows. We open an appropriate window using the button "**Geometry adjustment**" in the bottom frame.



Ge	ometry		— — Material ——	Setter and
	Geome	try adjustment	Catalogue	User defined
Din	nensions —		Name: EN	10025 : Fe 360
bp	=	140.0 [mm]	— Material char	acteristics
hp	=	380.0 [mm]	f _y =	235.0 [MPa]
tp	=	30.0 [mm]	f _u =	360.0 [MPa]
- Op	enings - sing	gle row		
w ₁	=	35.0 [mm]		
		The button for	editing plate proper	ties

We specify end plate dimensions " $\mathbf{b}_{\mathbf{p}}$ ", " $\mathbf{h}_{\mathbf{p}}$ ", " $\mathbf{t}_{\mathbf{p}}$ ", position of end plate relatively to the beam edge " \mathbf{a}_{1} ", horizontal position of bolts " \mathbf{w}_{1} " and vertical positions of rows. Entered values are shown in the figure below. The input can be done with the help of input lines in the left part of the window or using active dimensions in the end plate figure in the right part of the window. The input has to be confirmed by the button "**OK**".



Properties of end plate

Welds

Fillet welds all round will be used for the connection of the end plate to the column. Therefore, we select weld type "**Weld all around**" and enter the throat thickness for flanges " $\mathbf{a}_{w,f}$ " and the throat thickness for the web " $\mathbf{a}_{w,w}$ ". Lengths are calculated automatically according to the geometry of the cross-section. Arbitrary lengths can be defined using weld type "**User defined weld**".



Weld type -		-	
Weld all aro	und	a _{w,f}	
Weld height	and length		
a _{w,f} =	8,0	[mm]	<u>a_{w,w}</u> L _{w,w}
L _W ,f =	150,0	[mm]	1 1 1 1 1 1 1 1 1 1
a _{w,w} =	6,0	[mm]	
L _{W,W} =	263,0	[mm]	L _{w,f}

Welds properties

Bolts

The part "**Bolts**" contains the input of bolt type, dimensions and material. The type and dimension can be specified with the help of the button "**Catalogue**" in the part "**Bolt type**" of the bottom frame. The material can be selected using the button "**Catalogue**" in the part "**Bolt material**".

Bolt type		— Bolt material —
	Catalogue	Catalogue User defined
Type:	M20	Name: Bolt 10.9
Standard:		
Bolts are n	not prestressed	
- Shank o	haracteristics	— Material characteristics — — — — — — — — — — — — — — — — — — —
A _b =	314.159 [mm ²]	f _{yb} = 900.0 [MPa]
A _s =	244.794 [mm ²]	f _{ub} = 1000.0 [MPa]
d =	20.0 [mm]	
d ₀ =	22.0 [mm]	

Buttons for input of bolt type and material

We select bolt type "Glued bolts in drilled sleeves" and the diameter "M24". The window has to be closed by the button "OK".



atalogue of anchorag	je bolts				×
Bolt type		Bolt Nu	t Washer		
Glued bolts in drille	ed <mark>sl</mark> eeves	•			
Unfinished hexago	nal nuts				
Bolt thread:	M24	-			
Shank length:	700.0	mm]			
Thread length:	100.0	mm]	8		
Bolt washer					
Consider washe	rs				
Unfinished washers		•			
itle: Glued b	olts in drilled sleeves	L1	Name of Stand	lard	
emark:					
Information				√ <u>о</u>к	X Cancel

Properties of anchoring bolts

We choose the material "Bolt 10.9" in the window "Materials catalogue" and confirm the input by the button "OK".

Materials catalogue - Bolt material		×
Bolt 4.6		
Bolt 4.8		
Bolt 5.6		
Bolt 5.8		
Bolt 6.8		
Bolt 8.8		
Bolt 10.9		
Information	🗸 OK	X Cancel

Selection of material

Results

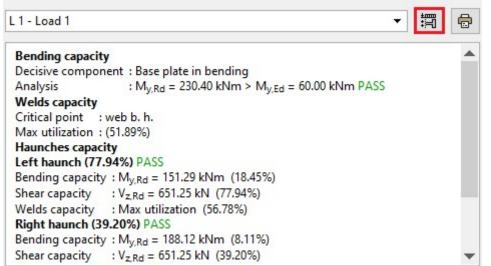
The total results are displayed in the right part of the bottom frame. They contain maximum utilization, the decisive load and connection and also brief results for decisive load.

Overall results



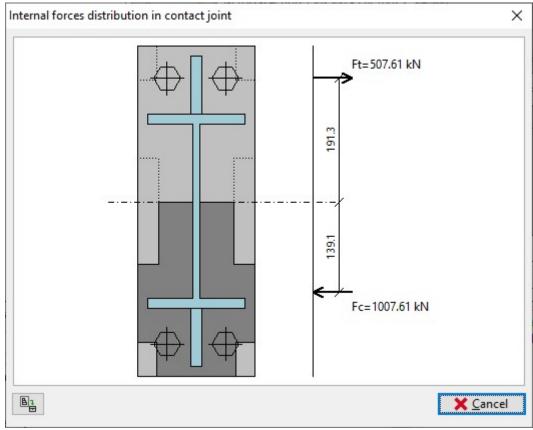
Th detailed results for particular components are displayed in the mode "**Results**". These results contain detailed bearing capacities and decisive components. The results can be displayed for all entered loads. Available is also an option "**Zero load**". In this case, maximum bearing capacities for all components are displayed.

Results for loads:



The button for scheme of forces in contact joint

The button on the right side of the load list (can be seen in the figure above) is able to open a scheme of contact joint with distribution of forces.



Distribution of forces in the contact joint



Steel column anchored in concrete footing

Introduction

Calculate the capacity of steel column - concrete footing connection. The steel column is anchored in the concrete footing. The depth of the anchorage is 600mm and the column is located in the centre of the footing. The values of internal forces acting in the connection are: $N_x = 694kN$, $M_y = 140kNm V_z = 80kN$. The material of the column is steel EN 10025: Fe360 and the footing is made of concrete grade C20/25.

Column: *HE* 240B Footing: b_b = 1600mm, a_b = 1600mm, h_b = 1000mm End plate: b_p = 280mm, h_p = 280mm, t_p = 30mm

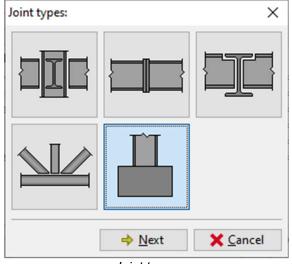
Creating new project

New connection to the project can be added by clicking the button "Add" in the main dialogue window. The "Add joint" dialogue window will appear, change the joint name to "Concrete footing 2" and confirm by clicking the button "OK".

Add joint	×
 Create new Copy existi 	
Name:	Column base 2
	✓ <u>O</u> K X Cancel

Creating new joint

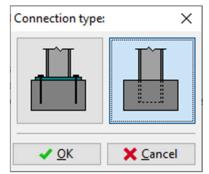
Next, the "**Joint types**" dialogue window will open automatically, choose the preferred type of joint. In this example, it is the column - footing joint.



Joint types

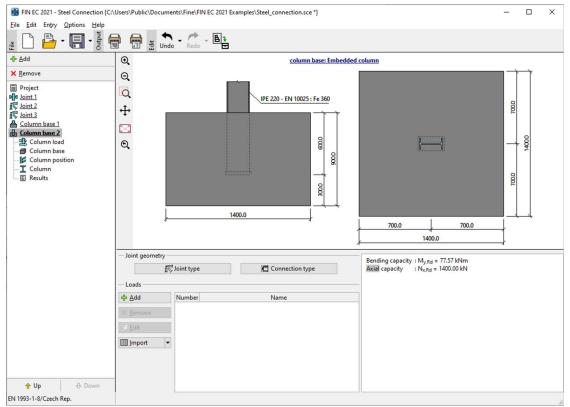
Continue by clicking the button "**Next**", the dialogue window with the types of connection will appear. Pick the option, where the column is anchored in the concrete footing.





Column - footing connections

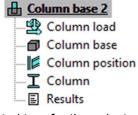
When this input is defined, the software will create new task named "**Concrete footing 2**" at the left side of the main dialogue window.



Main dialogue window for task "Concrete column 2"

Defining properties of the connection

The connection properties are defined in the control tree under the task "Concrete column 2". Every connection has it's own control tree.



Control tree for the selected task

Load cases

First, create new load case by clicking the button "Add" in the "Loads" section.



- Loads		
슈 <u>A</u> dd	Number	Name
× <u>R</u> emove	1	Load 1
<mark>≮⁴ E</mark> dit		
<u>Import</u> ▼		

Adding new load case to the task

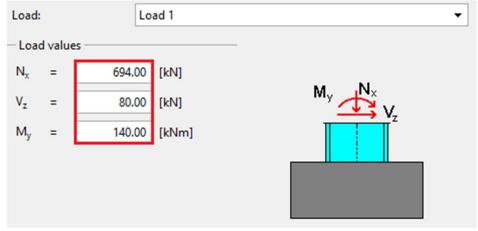
The dialogue window, with name of the new load case will appear. Keep the name "Load 1" and continue.

New load	×
Description Load 1	
	♣ <u>A</u> dd X Cancel

Name of the new load case

Column load

The column load values are defined in the "**Column load**" section in the control tree. The "**Load values**" are $N_x = 694kN$, $M_y = 140kNm V_z = 80kN$.



Defining load values

Column base

In this section, define the values of the concrete footing geometry and material. When the geometry is changed, the graphical preview of the footing will automatically re-generate its dimensions.

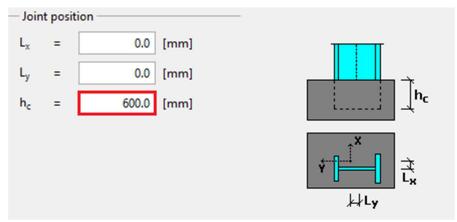


Geo	metry	(Material
Colu	mn ba	se:		Column base:
b _b	=	1600.0	[mm]	Catalogue User defined
ab	=	1600.0	[mm]	Name: C 20/25
h _b	=	1000.0	[mm]	Grouting:
Grou	ting:			Catalogue User defined
tg	=		[mm]	Name:

Geometry and material of the footing

Column position

Now, insert the anchorage depth of the steel column in the concrete footing, $h_c = 600mm$.



The joint position

Column

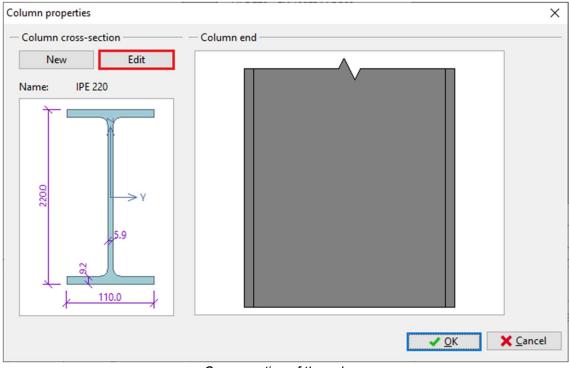
Define the cross-section of the column by clicking the button "**Edit section**" and the dialogue window "**Column properties**" will appear.

- Section	— — Material — — — — — — — — — — — — — — — — — — —
Edit section	Catalogue User defined
HE 240 B	Name: EN 10025 : Fe 360
000FZ 10.0 240.0	Base plate b_p = 280.0 [mm] h_p = 280.0 [mm] t_p = 30.0 [mm]

The column and the end plate dimensions

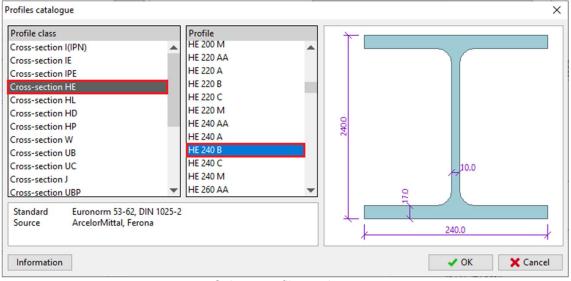


The dialogue window "**Column properties**" shows the preview of the cross-section. The supported types of steel columns are "**welded**" or "**hot-rolled**". The predefined type is "**hot-rolled**", therefore just click the "**Edit**" button and the catalogue with the cross-sections will appear.



Cross-section of the column

In the dialogue window "**Profile catalogue**" pick the profile class "**Cross-section HE**" and choose the profile "**HE 240 B**". Continue by clicking the "**OK**" button.



Column profile catalogue

Results

The overall results can be seen at the right-bottom section of the main dialogue window. It shows the capacity of the connection for the least favourable load case. The overall results show that the moment capacity of the connection is $M_{y,Rd}$ = 152,14kNm (utilization 92.02%) and normal force capacity $N_{x,Rd}$ = 2090,67kN (utilization 33.2%). The detailed results for every load case can be shown by selecting the section "**Results**" in the control tree.



🛞 FIN EC 2021 - Steel Connection [C:\Users\Public\Documents\Fine\FIN EC 2021 Examples\Steel_connection.sce *]			ו	×
<u>File Edit Entry Options Help</u>				
it				
<mark>♣</mark> <u>A</u> dd	Q column base: Embedded column			
× <u>R</u> emove	Q		T	
Project				
b <mark>l</mark> ⊄ <u>Joint 1</u> ji≅ <u>Joint 2</u>	HE 240 B - EN 10025 : Fe 360	0008		
i Joint 3		8		
Column base 1 Column base 2				
Column load				
Column base				
Column		Q		
E Kesuits	88	8000		
	1600.0		ſ	
	800.0 800.0	+		
	, 1600.0	\downarrow		
	Results for loads: Overall check : PASS (92.02%)			
	L 1 - Load 1			
	Bending capacity : N _{x,Rd} = 2090.67 kN (33.20%)			
	Decisive component : Column wall in shear Analysis : M _{V,Rd} = 152.14 kNm > M _{V,Ed} = 140.00 kNm PASS			
	Axial capacity Analysis : $N_{x,Ed} = 2090.67 \text{ kN} > N_{x,Ed} = 694.00 \text{ kN PASS}$			
🚹 Up 🕀 Down				
EN 1993-1-8/Czech Rep.				

The main dialogue window with results