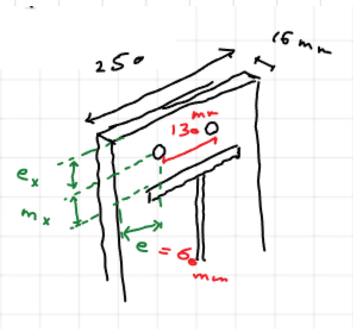
This playlist series focuses on the rigid connection calculation according to EN 1993-1-8. A comparison is made with Ansys at the end of the series after hand calculation. Finally, tips for applying the semi-rigid connection to RFEM are presented.

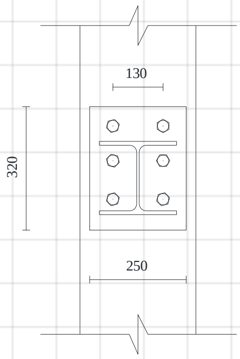
An Endplate welded to a beam, HEA200, is bolted to a HEB300 column with 6M20 class 8.8, as shown in the figures below. Steel material is S355 for all parties. The flange and web of the beam are welded to the end plate with a fillet weld, leg 8mm, and 4mm, respectively. This is not practical; typically, they are welded with the same dimension. However, for education purposes, they are selected differently.

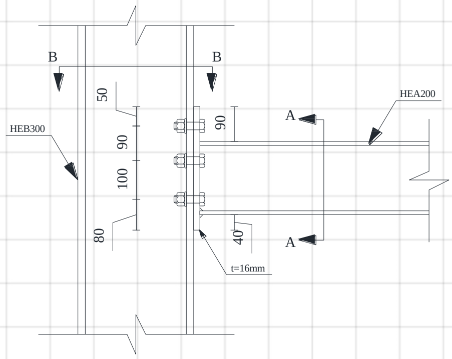
This video shows the resistance calculation of the Endplate in bending according to EN 1993-1-8. The contents are as follows:

a) Table 6.1 Item 5 explanation.
b) Endplate in bending according to 6.2.6.5.
c) Equivalent T-Stub effective length for Endplate table 6.6.
d) Failure patterns, circular and non-circular, and effective length for equivalent T-Stub for both outside and inside the beam flange.
e) The failure mode of the equivalent T-Stub.
f) Tension resistance of the Endplate in bending.

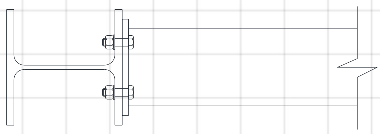
All dimensions are in mm unless otherwise specified.



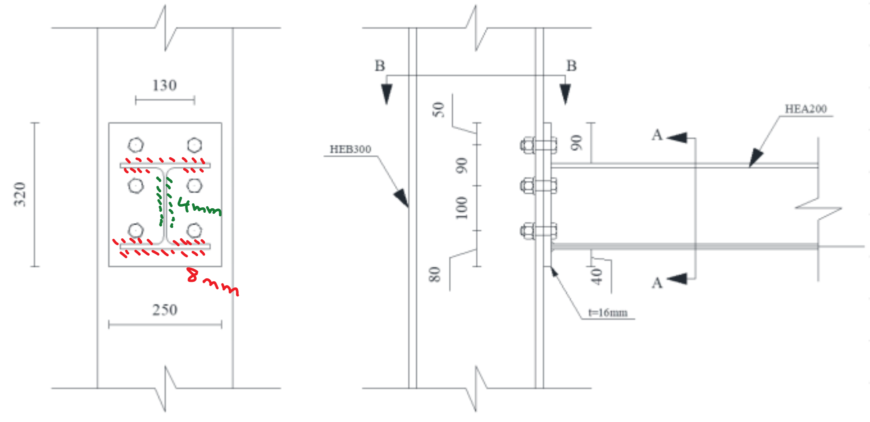




Sec A-A



Sec B-B



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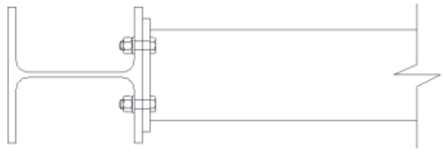

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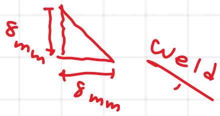
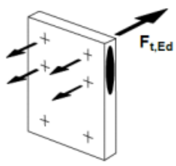


Table 6.1: Basic joint components

Component			Reference to application rules		
			Design Resistance	Stiffness coefficient	Rotation capacity
5	End-plate in bending		6.2.6.5	6.3.2	6.4.2

6.2.6.5 End-plate in bending

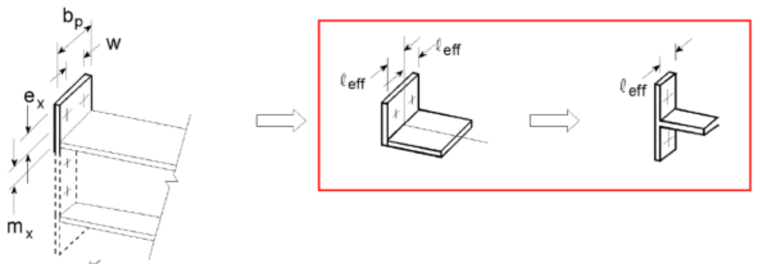
(1) The design resistance and failure mode of an end-plate in bending, together with the associated bolts in tension, should be taken as similar to those of an equivalent T-stub flange, see 6.2.4 for both:

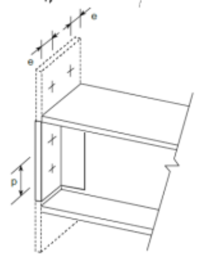
- each individual bolt-row required to resist tension;
- each group of bolt-rows required to resist tension.

(2) The groups of bolt-rows either side of any stiffener connected to the end-plate should be treated as separate equivalent T-stubs. In extended end-plates, the bolt-row in the extended part should also be treated as a separate equivalent T-stub, see Figure 6.10. The design resistance and failure mode should be determined separately for each equivalent T-stub.

(3) The dimension e_{min} required for use in 6.2.4 should be obtained from Figure 6.8 for that part of the end-plate located between the beam flanges. For the end-plate extension e_{min} should be taken as equal to e_x, see Figure 6.10.

(4) The effective length of an equivalent T-stub flange ℓ_{eff} should be determined in accordance with 6.2.4.2 using the values for each bolt-row given in Table 6.6.



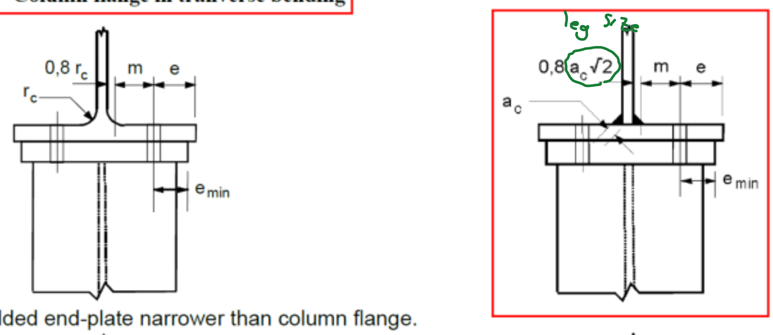


The extension of the end-plate and the portion between the beam flanges are modelled as two separate equivalent T-stub flanges.

For the end-plate extension, use e_x and m_x in place of e and m when determining the design resistance of the equivalent T-stub flange.

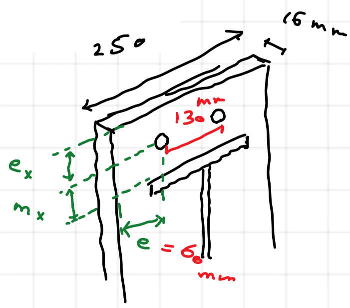
Figure 6.10: Modelling an extended end-plate as separate T-stubs

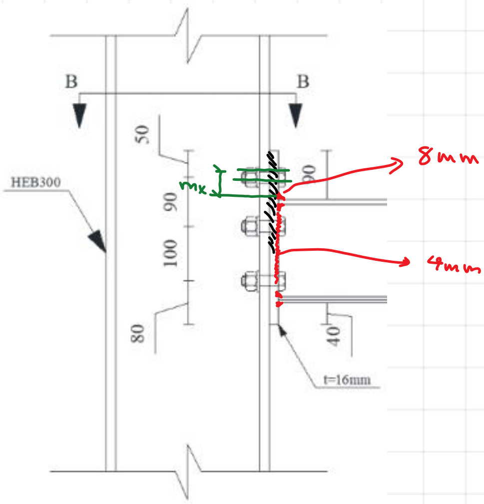
6.2.6.4 Column flange in tranverse bending

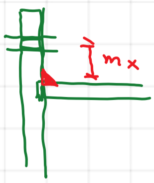


a) Welded end-plate narrower than column flange.

Figure 6.8: Definitions of e, e_{min}, r_c and m







$e_x = 50$ mm

$m_x = 40$ mm $- 0.8 \times 8$ mm $= 33.6$ mm

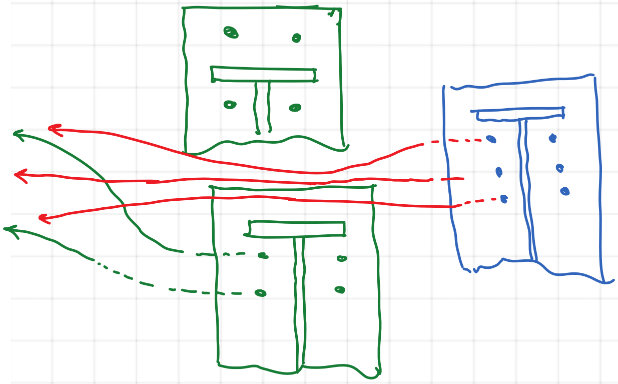
$e = 60$mm

$w = 130$mm, $b_p = 250$mm

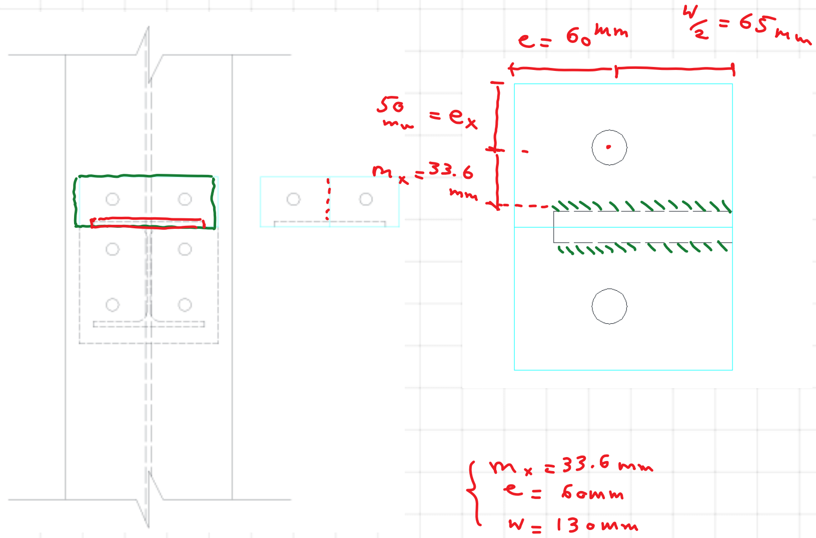
Table 6.6: Effective lengths for an end-plate

Bolt-row location	Bolt-row considered individually: Circular patterns $\ell_{eff,cp}$	Bolt-row considered individually: Non-circular patterns $\ell_{eff,nc}$	Bolt-row considered as part of a group of bolt-rows: Circular patterns $\ell_{eff,cp}$	Bolt-row considered as part of a group of bolt-rows: Non-circular patterns $\ell_{eff,nc}$
Bolt-row outside tension flange of beam	Smallest of: $2\pi m_x$; $\pi m_x + w$; $\pi m_x + 2e$	Smallest of: $4m_x + 1{,}25e_x$; $e+2m_x+0{,}625e_x$; $0{,}5b_p$; $0{,}5w+2m_x+0{,}625e_x$	—	—
First bolt-row below tension flange of beam	$2\pi m$	αm	$\pi m + p$	$0{,}5p + \alpha m - (2m + 0{,}625e)$
Other inner bolt-row	$2\pi m$	$4m + 1{,}25\,e$	$2p$	p
Other end bolt-row	$2\pi m$	$4m + 1{,}25\,e$	$\pi m + p$	$2m+0{,}625e+0{,}5p$
Mode 1:	$\ell_{eff,1} = \ell_{eff,nc}$ but $\ell_{eff,1} \le \ell_{eff,cp}$		$\sum\ell_{eff,1} = \sum\ell_{eff,nc}$ but $\sum\ell_{eff,1} \le \sum\ell_{eff,cp}$	
Mode 2:	$\ell_{eff,2} = \ell_{eff,nc}$		$\sum\ell_{eff,2} = \sum\ell_{eff,nc}$	

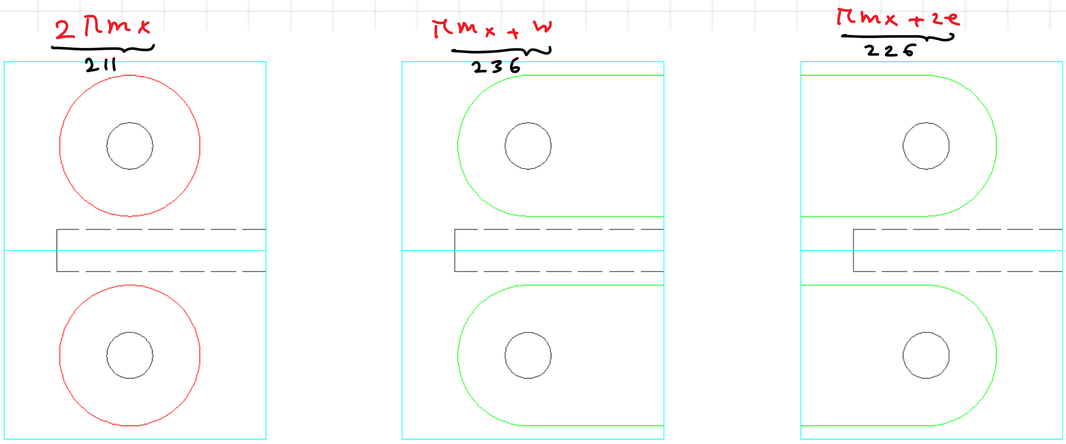
α should be obtained from Figure 6.11.



row #1:

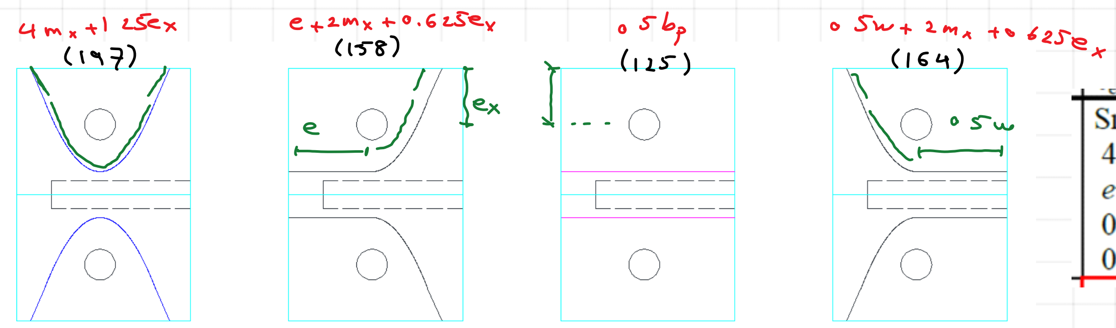


$m_x = 33.6$ mm
$e = 60$ mm
$w = 130$ mm



$\ell_{eff,cp}$
Smallest of: $2\pi m_x$; $\pi m_x + w$; $\pi m_x + 2e$

$l_{eff,cp} = 211$ mm



Smallest of:
$4m_x + 1{,}25e_x$
$e+2m_x+0{,}625e_x$
$0{,}5b_p$
$0{,}5w+2m_x+0{,}625e_x$

$m_x = 33.6$ mm
$e_x = 50$ mm
$e = 60$ mm
$b_p = 250$ mm
$w = 130$ mm

$$l_{eff,nc} = 125\text{ mm}$$

$l_{eff1,2} = 125$ mm

$$M_{pl,1,2,Rd} = 0.25\, l_{eff1,2} \cdot t^2 \cdot f_y / \gamma_{M0} \rightarrow M_{pl,1,2,Rd} = 2.84\text{ kN m}$$

($l_{eff1,2}$ = 125 mm; t = 16 mm (t_p); f_y = 355 MPa)

$$n = \min\{e_{min},\ 1.25m\} = 42.6\text{ mm}$$

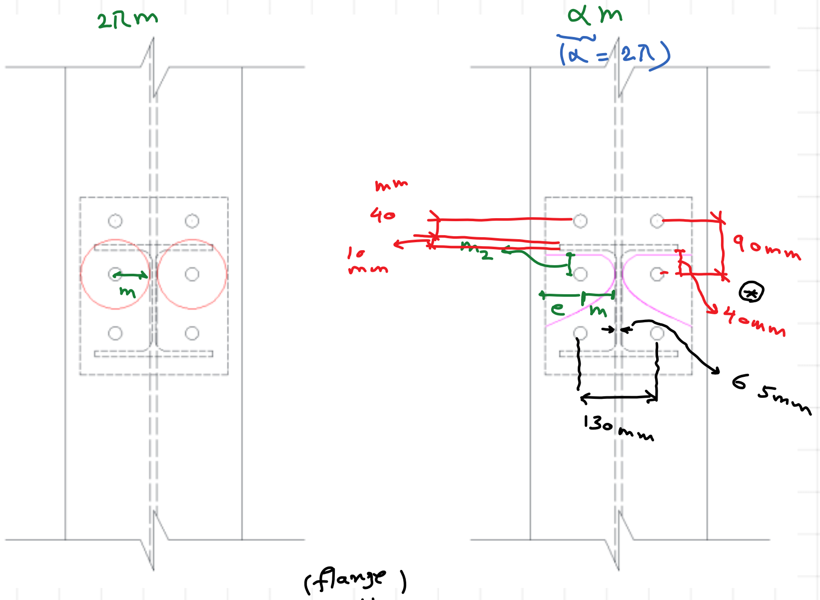
(e_{min} = 50 mm; m = 33.6 → 1.25m = 42 mm)

$$F_{T,1,Rd} = \frac{4 M_{pl,1,Rd}}{m} = 338\text{ kN}$$

$$F_{T,2,Rd} = \frac{2 M_{pl,2,Rd} + n \sum F_{t,Rd}}{m+n} = \frac{2 \times 2.84\text{ kN·m} + 42\text{ mm} \times 2 \times 141\text{ kN}}{33.6\text{ mm} + 42\text{ mm}} = 232\text{ kN}$$

$$F_{T,3,Rd} = \sum F_{t,Rd} = 2 \times 141\text{ kN} = 282\text{ kN}$$

row 1 → $F_T = 232$ kN



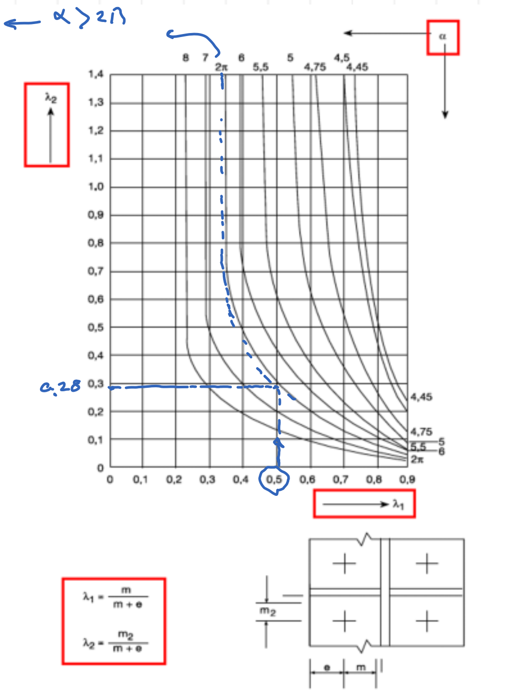


Figure 6.11: Values of α for stiffened column flanges and end-plates

(flange weld)

$$m_2 = 40\,mm - 0.8 \times 8\,mm = 33.6\,mm \quad (*)$$

$$m = \frac{130\,mm}{2} - \frac{6.5\,mm}{2} - 0.8 \times 4\,mm = 58.6\,mm$$

(web weld)

$$e = 60\,mm$$

$$\lambda_1 = \frac{m}{m+e} = 0.5$$

$$\lambda_2 = \frac{m_2}{m+e} = 0.28$$

$$l_{eff,cp} = 2\pi m = 368\,mm$$

$$l_{eff,nc} = \overset{(+)}{2\pi m} = 368\,mm$$

$$\begin{cases} l_{eff,1} = 368\,mm \\ l_{eff,2} = 368\,mm \end{cases}$$

$$M_{pl,1,2,Rd} = 0.25 \times 368\,mm \times (16\,mm)^2 \times \frac{355\,MPa}{1} = 8.36\,kN \cdot m$$

$$F_{T,1,Rd} = \frac{4 M_{pl,1,Rd}}{m} = 570\,kN$$

$$F_{T,2,Rd} = \frac{2 M_{pl,2,Rd} + n \sum F_{t,Rd}}{m+n} = 284\,kN$$

(8.36 kN m; 60 mm; 2×141 kN; m = 58.6 mm; n = 60 mm)

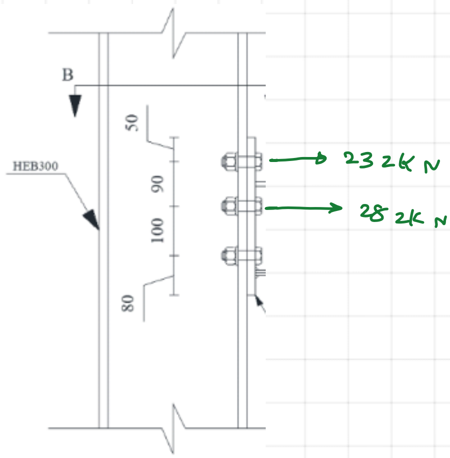
$$F_{T,3,Rd} = 2 \times 141\,kN = 282\,kN$$

$$n = \min\{60\,mm,\ 1.25\,m = 73\} = 60\,mm$$

$$\boxed{F_T = 282\,kN}$$

r. 1 → 232 kN

r. 2 → 282 kN



	Column flange bending (kN)	Column web T tension (kN)	End plate bending (kN)
r1	282	790	232
r2	282	790	282
r1, r2	564	1006	—