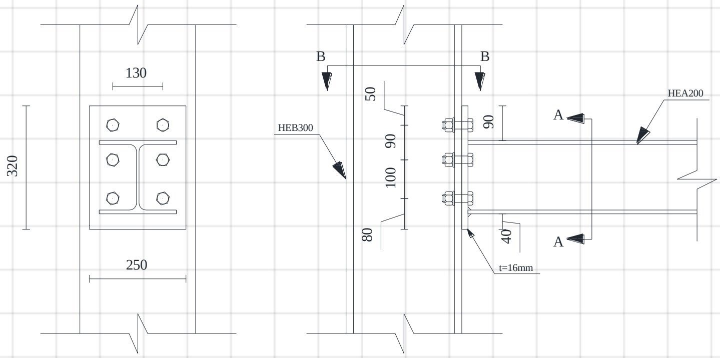
This [playlist]() series focuses on the rigid connection calculation according to EN 1993-1-8. A comparison is made with Ansys at the end of the series after hand calculation. Finally, tips for applying the semi-rigid connection to RFEM are presented.

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.

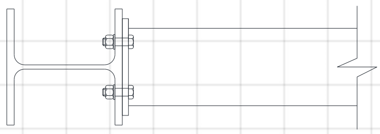
This [video]() shows the resistance calculation of a column web in transverse tension according to EN 1993-1-8. The contents are as follows:

a) Table 6.1 Item 3 explanation.
b) Column Web in transverse tension according to 6.2.6.3.
c) Reduction factor for the interaction with shear in the column web panel.
d) Transformation parameters exact and approximation calculation.
e) Tension resistance of the column web in transverse tension.

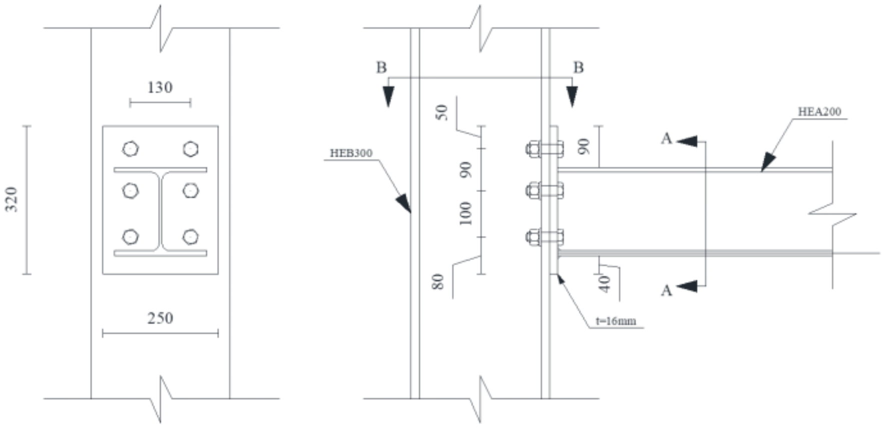
All dimensions are in mm unless otherwise specified.



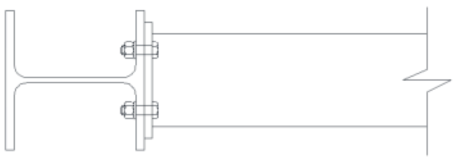
Sec A-A



Sec B-B

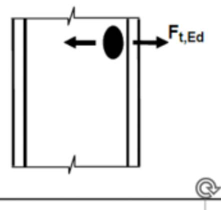


Sec A-A



Sec B-B

Table 6.1: Basic joint components

Component			Reference to application rules		
			Design Resistance	Stiffness coefficient	Rotation capacity
3	Column web in transverse tension		6.2.6.3	6.3.2	6.4.2 and 6.4.3

6.2.6.3 Column web in transverse tension

(1) The design resistance of an unstiffened column web subject to transverse tension should be determined from:

$$F_{t,wc,Rd} = \frac{\omega b_{eff,t,wc} t_{wc} f_{y,wc}}{\gamma_{M0}} \qquad \text{... (6.15)}$$

where:

ω is a reduction factor to allow for the interaction with shear in the column web panel.

(3) For a bolted connection, the effective width $b_{eff,t,wc}$ of column web in tension should be taken as equal to the effective length of equivalent T-stub representing the column flange, see 6.2.6.4.

(4) The reduction factor ω to allow for the possible effects of shear in the column web panel should be determined from Table 6.3, using the value of $b_{eff,t,wc}$ given in 6.2.6.3(2) or 6.2.6.3(3) as appropriate.

$l_{eff,r1,r2,cp} = 238\,mm$

$l_{eff,r1,r2,nc} = 258\,mm$

$l_{eff,r1,r2,cp} = 348\,mm$

$l_{eff,r1,r2,nc} = 348\,mm$

6.2.6.3 Column web in transverse tension

(1) The design resistance of an unstiffened column web subject to transverse tension should be determined from:

$$F_{t,wc,Rd} = \frac{\omega b_{eff,t,wc} t_{wc} f_{y,wc}}{\gamma_{M0}} \quad \text{... (6.15)}$$

where:

ω is a reduction factor to allow for the interaction with shear in the column web panel.

(3) For a bolted connection, the effective width $b_{eff,t,wc}$ of column web in tension should be taken as equal to the effective length of equivalent T-stub representing the column flange, see 6.2.6.4.

(4) The reduction factor ω to allow for the possible effects of shear in the column web panel should be determined from Table 6.3, using the value of $b_{eff,t,wc}$ given in 6.2.6.3(2) or 6.2.6.3(3) as appropriate.

$r1 \rightarrow b_{eff,t,wc} = 238mm$

$r2 \rightarrow b_{eff,t,wc} = 238mm$

$r_1, r_2 \rightarrow b_{eff,t,wc} = 348\ mm$

$t_{wc} = 11mm$

$f_{y,wc} = 355\ MPa$

$\gamma_{M_0} = 1$

Table 6.3: Reduction factor ω for interaction with shear

Transformation parameter β	Reduction factor ω
$0 \leq \beta \leq 0{,}5$	$\omega = 1$
$0{,}5 < \beta < 1$	$\omega = \omega_1 + 2(1-\beta)(1-\omega_1)$
$\beta = 1$	$\omega = \omega_1$
$1 < \beta < 2$	$\omega = \omega_1 + (\beta - 1)(\omega_2 - \omega_1)$
$\beta = 2$	$\omega = \omega_2$
$\omega_1 = \dfrac{1}{\sqrt{1+1{,}3(b_{eff,c,wc}\, t_{wc} / A_{vc})^2}}$	$\omega_2 = \dfrac{1}{\sqrt{1+5{,}2(b_{eff,c,wc}\, t_{wc} / A_{vc})^2}}$
A_{vc} is the shear area of the column, see 6.2.6.1; β is the transformation parameter, see 5.3(7).	

6.2.6.1 Column web panel in shear

A_{vc} is the shear area of the column, see EN 1993-1-1.

$\boxed{A_{vc} = 4743\ mm^2}$

5.3 Modelling of beam-to-column joints

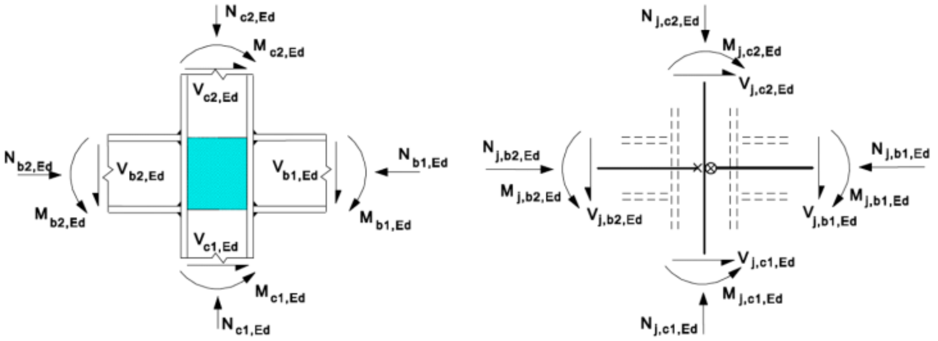
(7) When determining the design moment resistance and rotational stiffness for each of the joints, the possible influence of the web panel in shear should be taken into account by means of the transformation parameters β_1 and β_2, where:

β_1 is the value of the transformation parameter β for the right-hand side joint;

β_2 is the value of the transformation parameter β for the left-hand side joint.

NOTE: The transformation parameters β_1 and β_2 are used directly in 6.2.7.2(7) and 6.3.2(1). They are also used in 6.2.6.2(1) and 6.2.6.3(4) in connection with Table 6.3 to obtain the reduction factor ω for shear.

(8) Approximate values for β_1 and β_2 based on the values of the beam moments $M_{b1,Ed}$ and $M_{b2,Ed}$ at the periphery of the web panel, see Figure 5.6(a) may be obtained from Table 5.4.

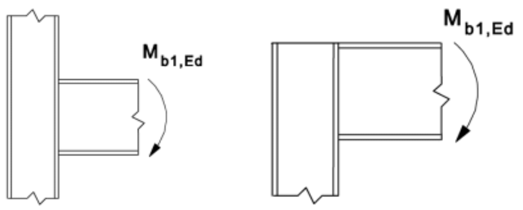
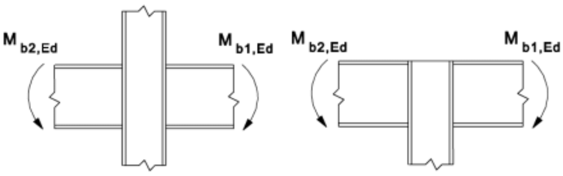


a) Values at periphery of web panel b) Values at intersection of member centrelines

Direction of forces and moments are considered as positive in relation to equations (5.3) and (5.4)

Figure 5.6: Forces and moments acting on the joint

Table 5.4: Approximate values for the transformation parameter β

Type of joint configuration	Action	Value of β
	$M_{b1,Ed}$	$\beta \approx 1$
	$M_{b1,Ed} = M_{b2,Ed}$	$\beta = 0$ *)
	$M_{b1,Ed} / M_{b2,Ed} > 0$	$\beta \approx 1$
	$M_{b1,Ed} / M_{b2,Ed} < 0$	$\beta \approx 2$
	$M_{b1,Ed} + M_{b2,Ed} = 0$	$\beta \approx 2$
*) In this case the value of β is the exact value rather than an approximation.		

5.3 Modelling of beam-to-column joints

(9) As an alternative to 5.3(8), more accurate values of β_1 and β_2 based on the values of the beam moments $M_{j,b1,Ed}$ and $M_{j,b2,Ed}$ at the intersection of the member centrelines, may be determined from the simplified model shown in Figure 5.6(b) as follows:

$$\beta_1 = \left|1 - M_{j,b2,Ed} / M_{j,b1,Ed}\right| \leq 2 \qquad \text{... (5.4a)}$$

$$\beta_2 = \left|1 - M_{j,b1,Ed} / M_{j,b2,Ed}\right| \leq 2 \qquad \text{... (5.4b)}$$

where:

$M_{j,b1,Ed}$ is the moment at the intersection from the right hand beam;

$M_{j,b2,Ed}$ is the moment at the intersection from the left hand beam.

Table 6.3: Reduction factor ω for interaction with shear

Transformation parameter β	Reduction factor ω
$0 \leq \beta \leq 0{,}5$	$\omega = 1$
$0{,}5 < \beta < 1$	$\omega = \omega_1 + 2(1-\beta)(1-\omega_1)$
$\boxed{\beta = 1}$	$\boxed{\omega = \omega_1}$
$1 < \beta < 2$	$\omega = \omega_1 + (\beta - 1)(\omega_2 - \omega_1)$
$\beta = 2$	$\omega = \omega_2$
$\boxed{\omega_1 = \dfrac{1}{\sqrt{1+1{,}3(b_{eff,c,wc}\, t_{wc} / A_{vc})^2}}}$	$\omega_2 = \dfrac{1}{\sqrt{1+5{,}2(b_{eff,c,wc}\, t_{wc} / A_{vc})^2}}$
A_{vc} is the shear area of the column, see 6.2.6.1;	
β is the transformation parameter, see 5.3(7).	

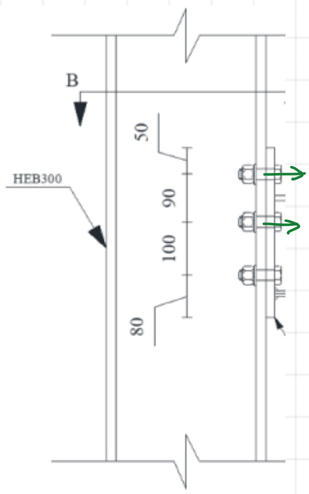
$b_{eff,c,wc} \rightarrow$
- $r_1 \rightarrow 238\ mm \rightarrow \omega_1 = \dfrac{1}{\sqrt{1+1.3\left(\dfrac{238\ mm \times 11\ mm}{4743\ mm^2}\right)^2}} = 0.85$
- $r_2 \rightarrow 238\ mm \rightarrow \omega_1 = 0.85$
- $r_1\ \&\ r_2 \rightarrow 348\ mm \rightarrow \omega_1 = 0.74$

$$F_{t,wc,Rd} = \frac{\omega\, b_{eff,t,wc}\, t_{wc}\, f_{y,wc}}{\gamma_{M0}}$$

$\rightarrow F_{t,wc,Rd,r1} = \dfrac{0.85 \times 238\ mm \times 11\ mm \times 355\ MPa}{1} = 790\ kN$

$F_{t,wc,Rd,r_2} = 790\ kN$

$F_{t,wc,Rd,r_1\&r_2} = 1006\ kN$



$\rightarrow 790\ kN$
$\rightarrow 790\ kN$
$\Big\}$ 1006 kN

Column flange in transverse bending

kN
$\rightarrow 282$
$\rightarrow 282$
$\Big\} \leq 564$ kN