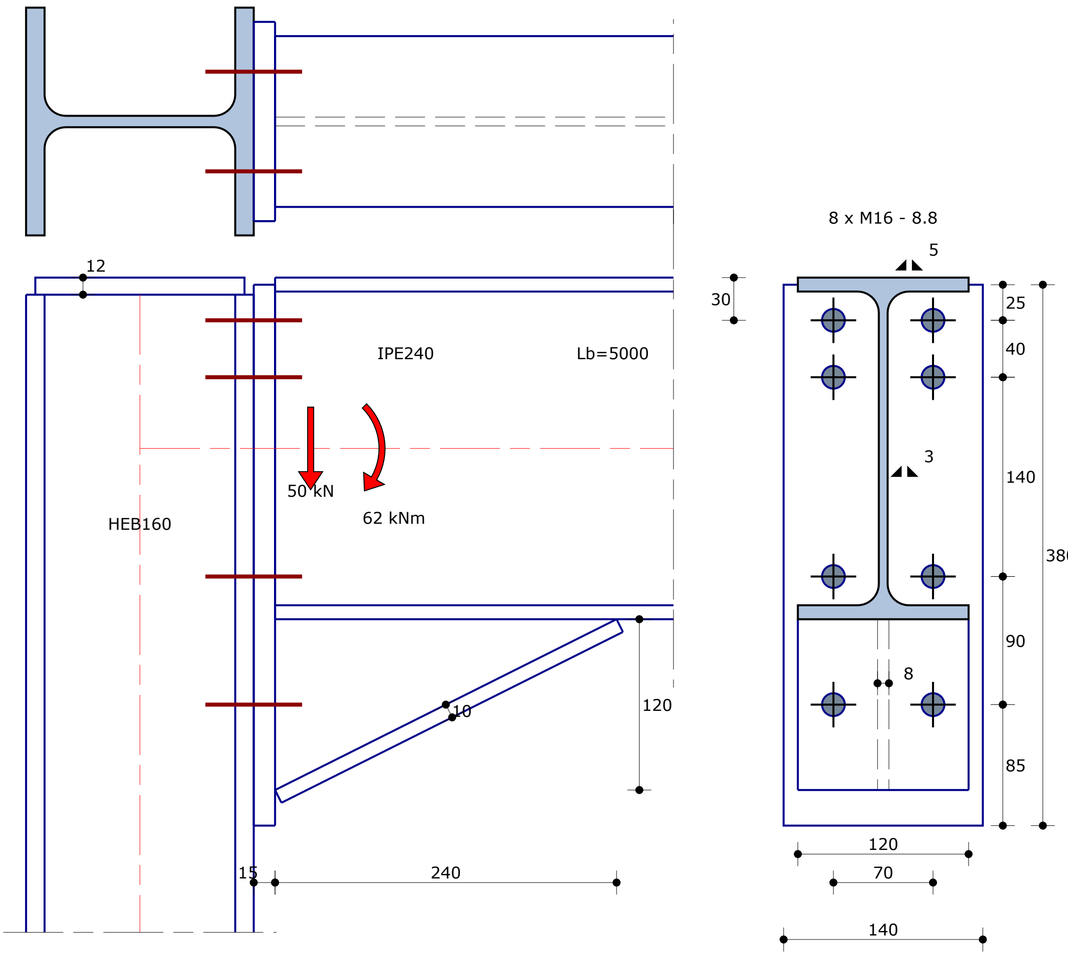
GENERAL

File : ....Struct4U\website\voorbeeld uitdraai\XConstructVoorbeeldenDutch.xcst

Consequence class : CC2

BEAM-TO-COLUMN JOINTS: Moment connection

INPUT DATA



Classification construction		Unbraced
Steel grade		S235
Tthe maximum longitudinal compressive stress	$\sigma_{com,Ed}$	0 N/mm ^{2}

CALCULATION according to Eurocode 3

Applied standards: : NEN-EN 1993-1-8 + C2:2011/NB:2011 (nl)

$M_{j,b1,Ed} = 62{,}00$ kNm

$V_{j,b1,Ed} = 50{,}00$ kN

Column flange in tranverse bending **art. 6.2.6.4**

Bolt-row 1

End bolt-row adjacent to a stiffener;Bolt-row considered as part of a group of bolt-row

$e = 0{,}5(b - w) = 0{,}5 \times (160 - 70) = 45$ mm

$m = 0{,}5w - 0{,}5t_w - 0{,}8r = 0{,}5 \times 70 - 0{,}5 \times 8 - 0{,}8 \times 15 = 19$ mm

$m_2 = dy - 0{,}5t - 0{,}8a_{ef}\sqrt{2} = 24 - 0{,}5 \times 12 - 0{,}8 \times 5 \times \sqrt{2} = 12{,}3$ mm

$\lambda_1 = \frac{m}{m + e} = \frac{19}{19 + 45} = 0{,}297$ $\lambda_2 = \frac{m_2}{m + e} = \frac{12{,}3}{19 + 45} = 0{,}193$ $\alpha = 10{,}296$ (Fig. 6.11)

$l_{eff,cp} = 2\pi m = 2 \times \pi \times 19 = 119{,}4$ mm (T6.5)

Tension resistance **(T3.4)**

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = \frac{0{,}9 \times 800 \times 157}{1{,}25} \times 10^{-3} = 90{,}4 \text{ kN}$$

$$M_{pl,Rd} = \frac{1}{4} l_{eff} t_{fc}^2 f_y = \frac{1}{4} \times 119{,}4 \times 13^2 \times 235 \times 10^{-6} = 1{,}185 \text{ kNm}$$

$$F_{T,1,Rd} = \frac{4 M_{pl,Rd}}{m} = \frac{4 \times 1{,}185}{19 \times 10^{-3}} = 249{,}537 \text{ kN}$$

$$F_{T,2,Rd} = \frac{2 M_{pl,Rd} + n \Sigma F_{t,Rd}}{m + n} = \frac{2 \times 1{,}185 + 23{,}8 \times 10^{-3} \times 2 \times 90{,}4}{(19 + 23{,}8) \times 10^{-3}} = 155{,}933 \text{ kN} \quad \text{(decisive)}$$

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 2 \times 90{,}4 = 180{,}864$ kN

Bolt-row 2

End bolt-row;Bolt-row considered as part of a group of bolt-row

$e = 0{,}5(b - w) = 0{,}5 \times (160 - 70) = 45$ mm

$m = 0{,}5w - 0{,}5t_w - 0{,}8r = 0{,}5 \times 70 - 0{,}5 \times 8 - 0{,}8 \times 15 = 19$ mm

$l_{eff,cp} = 2\pi m = 2 \times \pi \times 19 = 119{,}4$ mm (T6.4)

$l_{eff,nc} = 4m + 1{,}25e = 4 \times 19 + 1{,}25 \times 45 = 132{,}3$ mm

$l_{eff,cp} = \pi m + p = \pi \times 19 + 40 = 99{,}7$ mm

$l_{eff,nc} = 2m + 0{,}625e + 0{,}5p = 2 \times 19 + 0{,}625 \times 45 + 0{,}5 \times 40 = 86{,}1$ mm

$$M_{pl,Rd} = \frac{1}{4} l_{eff} t_{fc}^2 f_y = \frac{1}{4} \times 86{,}1 \times 13^2 \times 235 \times 10^{-6} = 0{,}855 \text{ kNm}$$

$$F_{T,1,Rd} = \frac{4 M_{pl,Rd}}{m} = \frac{4 \times 0{,}855}{19 \times 10^{-3}} = 180{,}024 \text{ kN}$$

$F_{T,2,Rd} = \frac{2 M_{pl,Rd} + n \Sigma F_{t,Rd}}{m + n} = \frac{2 \times 0{,}855 + 23{,}8 \times 10^{-3} \times 2 \times 90{,}4}{(19 + 23{,}8) \times 10^{-3}} = 140{,}485$ kN (decisive)

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 2 \times 90{,}4 = 180{,}864$ kN

End-plate in bending **art. 6.2.6.5**

Bolt-row 1

First bolt-row below tension flange of beam;Bolt-row considered as part of a group of bolt-row

$e = 0{,}5(b - w) = 0{,}5 \times (140 - 70) = 35$ mm

$m = 0{,}5w - 0{,}5t_w - 0{,}8a_{ew}\sqrt{2} = 0{,}5 \times 70 - 0{,}5 \times 6{,}2 - 0{,}8 \times 3 \times \sqrt{2} = 28{,}5$ mm

$m_2 = dy - 0{,}5t - 0{,}8a_{ef}\sqrt{2} = 25{,}1 - 0{,}5 \times 9{,}8 - 0{,}8 \times 5 \times \sqrt{2} = 14{,}5$ mm

$\lambda_1 = \frac{m}{m + e} = \frac{28{,}5}{28{,}5 + 35} = 0{,}449$ $\lambda_2 = \frac{m_2}{m + e} = \frac{14{,}5}{28{,}5 + 35} = 0{,}229$ $\alpha = 7{,}485$ (Fig. 6.11)

$l_{eff,cp} = 2 \pi m = 2 \times \pi \times 28{,}5 = 179{,}1$ mm (T6.6)

$l_{eff,nc} = \alpha m = 7{,}485 \times 28{,}5 = 213{,}4$ mm

$l_{eff,cp} = \pi m + p = \pi \times 28{,}5 + 40 = 129{,}6$ mm

$l_{eff,nc} = 0{,}5p + \alpha m - (2m + 0{,}625e) = 0{,}5 \times 40 + 7{,}485 \times 28{,}5 - (2 \times 28{,}5 + 0{,}625 \times 35) = 154{,}5$ mm

$M_{pl,Rd} = \frac{1}{4} l_{eff} t_{fc}^2 f_y = \frac{1}{4} \times 129{,}6 \times 15^2 \times 235 \times 10^{-6} = 1{,}713$ kNm

$F_{T,1,Rd} = \frac{4 M_{pl,Rd}}{m} = \frac{4 \times 1{,}713}{28{,}5 \times 10^{-3}} = 240{,}307$ kN

$F_{T,2,Rd} = \frac{2 M_{pl,Rd} + n \Sigma F_{t,Rd}}{m + n} = \frac{2 \times 1{,}713 + 35{,}6 \times 10^{-3} \times 2 \times 90{,}4}{(28{,}5 + 35{,}6) \times 10^{-3}} = 153{,}882$ kN (decisive)

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 2 \times 90{,}4 = 180{,}864$ kN

Bolt-row 2

Other end bolt-row;Bolt-row considered as part of a group of bolt-row

$e = 0{,}5(b - w) = 0{,}5 \times (140 - 70) = 35$ mm

$m = 0{,}5w - 0{,}5t_w - 0{,}8a_{ew}\sqrt{2} = 0{,}5 \times 70 - 0{,}5 \times 6{,}2 - 0{,}8 \times 3 \times \sqrt{2} = 28{,}5$ mm

$l_{eff,cp} = 2 \pi m = 2 \times \pi \times 28{,}5 = 179{,}1$ mm (T6.6)

$l_{eff,nc} = 4m + 1{,}25e = 4 \times 28{,}5 + 1{,}25 \times 35 = 157{,}8$ mm

$l_{eff,cp} = \pi m + p = \pi \times 28{,}5 + 40 = 129{,}6$ mm

$l_{eff,nc} = 2m + 0{,}625e + 0{,}5p = 2 \times 28{,}5 + 0{,}625 \times 35 + 0{,}5 \times 40 = 98{,}9$ mm

$M_{pl,Rd} = \frac{1}{4} l_{eff} t_{fc}^2 f_y = \frac{1}{4} \times 98{,}9 \times 15^2 \times 235 \times 10^{-6} = 1{,}307$ kNm

$F_{T,1,Rd} = \frac{4 M_{pl,Rd}}{m} = \frac{4 \times 1{,}307}{28{,}5 \times 10^{-3}} = 183{,}423$ kN

$F_{T,2,Rd} = \frac{2 M_{pl,Rd} + n \Sigma F_{t,Rd}}{m + n} = \frac{2 \times 1{,}307 + 35 \times 10^{-3} \times 2 \times 90{,}4}{(28{,}5 + 35) \times 10^{-3}} = 140{,}846$ kN (decisive)

$F_{T,3,Rd} = \Sigma F_{t,Rd} = 2 \times 90{,}4 = 180{,}864$ kN

Column web in transverse tension **art. 6.2.6.3**

$$\omega_1 = \frac{1}{\sqrt{1 + 1,3(b_{eff,t,wc}\ t_{wc}\ / A_{vc})^2}} = \frac{1}{\sqrt{1 + 1,3 \times (205,5 \times 8 / 1762)^2}} = 0,68$$

$\beta = 1,00 \quad \omega = \omega_1 = 0,68$

$$F_{t,wc,Rd} = \frac{\omega\ b_{eff,t,wc}\ t_{wc}\ f_{y,wc}}{\gamma_{M1}} = \frac{0,68 \times 205,5 \times 8 \times 235}{1,00} = 264,6\ kN \qquad (6.15)$$

$(F_{t,wc,1,Rd} = 153,7\ kN \quad F_{t,wc,2,Rd} = 110,9\ kN)$

Beam web in tensiont **art. 6.2.6.8**

$$F_{t,wb,Rd} = \frac{b_{eff,t,wb}\ t_{wb}\ f_{y,wc}}{\gamma_{M1}} = \frac{228,4 \times 6,2 \times 235}{1,00} \times 10^{-3} = 332,8\ kN \qquad (6.22)$$

Column web panel in shear **art. 6.2.6.1**

$A_{vc} = A_a - 2\ b\ t_{fc} + (t_{wc} + 2\ r)\ t_{fc} = 5428 - 2 \times 160 \times 13 + (8 + 2 \times 15) \times 13 = 1762\ mm^2$

$$V_{wp,Rd} = \frac{0.90\ f_{y,wc}\ A_{vc}}{\sqrt{3}\ \gamma_{M0}} = \frac{0.90 \times 235 \times 1762}{\sqrt{3} \times 1,00} \times 10^{-3} = 215,1\ kN \qquad (6.7)$$

Column web in transverse compression **art. 6.2.6.2**

$$b_{eff,c,wc} = t_{fb} + 2\sqrt{2}\ a_b + 5(t_{fc} + r_c) + s_p = 9,8 + 2\sqrt{2} \times 5 + 5 \times (13 + 15) + 30 = 193,9\ mm \qquad (6.11)$$

$$\lambda_p = 0,932\sqrt{\frac{b_{eff,c,wc}\ d_{wc}\ f_{y,wc}}{E\ t_{wc}^2}} = 0,932 \times \sqrt{\frac{193,9 \times 104 \times 235}{210000 \times 8^2}} = 0,55 \qquad (6.13c)$$

$\lambda_p < 0,72 \quad \rho = 1,0$ (6.13a)

$$\omega_1 = \frac{1}{\sqrt{1 + 1,3(b_{eff,c,wc}\ t_{wc}\ / A_{vc})^2}} = \frac{1}{\sqrt{1 + 1,3 \times (193,9 \times 8 / 1762)^2}} = 0,71$$

$\beta = 1,00 \quad \omega = \omega_1 = 0,71$

$\sigma_{com,Ed} = 0\ N/mm^2 < 0,7\ f_{y,wc} \qquad k_{wc} = 1,00$

$$F_{c,wc,Rd} = \frac{\omega\ k_{wc}\ \rho\ b_{eff,c,wc}\ t_{wc}\ f_{y,wc}}{\gamma_{M1}} = \frac{0,71 \times 1,00 \times 1,00 \times 193,9 \times 8 \times 235}{1,00} \times 10^{-3} = 257,3\ kN \qquad (6.9)$$

Beam flange and web in compression **art. 6.2.6.7**

$$M_{c,Rd} = M_{pl,Rd} = \frac{W_{pl}\ f_y}{\gamma_{M0}} = \frac{366897 \times 235}{1,00} \times 10^{-6} = 86,221\ kNm \qquad (6.13)$$

$F_{c,fb,Rd} = M_{c,Rd} / (h - t_{fb}) = 86,221 / (240 - 9,8) \times 10^3 = 374,5\ kN$ (6.21)

Beam web in transverse compression **art. 6.2.6.2**

$$b_{eff,c,wb} = t_{f,cons} + 2\sqrt{2}\ a_b + 5(t_{fb} + r_b) = 10 + 2\sqrt{2} \times 5 + 5 \times (9,8 + 15) = 148,1\ mm \qquad (6.11)$$

$$\lambda_p = 0,932\sqrt{\frac{b_{eff,c,wb}\ d_{wb}\ f_{y,wb}}{E\ t_{wb}^2}} = 0,932 \times \sqrt{\frac{148,1 \times 190,4 \times 235}{210000 \times 6,2^2}} = 0,84 \qquad (6.13c)$$

$\lambda_p < 0,72 \quad \rho = (\lambda_p - 0,2)/\lambda_p^2 = (0,84 - 0,2)/ 0,84^2 = 0,90$ (6.13b)

$$\omega_1 = \frac{1}{\sqrt{1 + 1{,}3(b_{eff,c,wb}\ t_{wb}\ / A_{vb})^2}} = \frac{1}{\sqrt{1 + 1{,}3 \times (148{,}1 \times 6{,}2 / 1917)^2}} = 0{,}88$$

$\beta = 1{,}00 \qquad \omega = \omega_1 = 0{,}88$

$\sigma_{com,Ed} = 191\ N/mm^2 > 0{,}7\ f_{y,wb} \qquad k_{wb} = 1{,}7 - \sigma_{com,Ed} / f_{y,wb} = 0{,}89$ (6.14)

$$F_{c,wb,Rd} = \frac{\omega\ k_{wb}\ \rho\ b_{eff,c,wb}\ t_{wb}\ f_{y,wb}}{\gamma_{M1}} = \frac{0{,}88 \times 0{,}89 \times 0{,}90 \times 148{,}1 \times 6{,}2 \times 235}{1{,}00} \times 10^{-3} = 151{,}8\ kN \quad (6.9)$$

$$F_{c,wb,Rd,h} = F_{c,wb,Rd} \frac{l_{cons}}{h_{cons}} = 151{,}8\ kN \times \frac{240}{120} = 303{,}7\ kN$$

Beam-to-column joints with bolted end-plate connections **art. 6.2.7.2**

Bolt-row	Ftr,Rd,c [kN]	Ftr,Rd,e [kN]	after redistribution Ftr,Rd,c [kN]	Ftr,Rd,e [kN]	Ftr,Rd [kN]	hr [m]	Mj,Rd [kNm]
1	153,7	153,9	153,9	153,9	153,9	0,330	50,781
2	110,9	140,8	110,7	140,8	61,2	0,290	17,754
					215,1		68,535

$M_{j,b1,Rd} = \Sigma h_r\ F_{tr,Rd} = 68{,}535\ kNm$ (6.25)

Moment is limitted by: Column web panel in shear

$$\frac{M_{j,b1,Ed}}{M_{j,b1,Rd}} = \frac{62{,}000}{68{,}535} = 0{,}90 < 1{,}0 \qquad \text{complies}$$

Check shear force

Shear resistance per shear plane **(T3.4)**

$$F_{v,Rd} = \frac{\alpha_v\ f_{ub}\ A_s}{\gamma_{M2}} = \frac{0{,}6 \times 800 \times 157}{1{,}25} \times 10^{-3} = 60{,}3\ kN$$

Bearing resistance **(T3.4)**

$$k_1 = \min[\ 2{,}8 \frac{e_2}{d_0} - 1{,}7\ ;\ 1{,}4 \frac{p_2}{d_0} - 1{,}7\ ;\ 2{,}5\ ] = \min[\ 2{,}8 \times \frac{35}{18} - 1{,}7\ ;\ 1{,}4 \times \frac{70}{18} - 1{,}7\ ;\ 2{,}5\ ] = 2{,}5$$

$$\alpha_d = \frac{e_1}{3\ d_0} = \frac{210}{3 \times 18} = 3{,}889$$

$$\alpha_b = \min[\ \alpha_d\ ;\ \frac{f_{ub}}{f_u}\ ;\ 1{,}0\ ] = \min[\ 3{,}889\ ;\ \frac{800}{360}\ ;\ 1{,}0\ ] = 1$$

$$F_{b,Rd} = \frac{k_1\ \alpha_b\ f_u\ d\ t}{\gamma_{M2}} = \frac{2{,}5 \times 1 \times 360 \times 16 \times 15}{1{,}25} \times 10^{-3} = 172{,}8\ kN$$

Bearing resistance **(T3.4)**

$$k_1 = \min[\ 2{,}8 \frac{e_2}{d_0} - 1{,}7\ ;\ 1{,}4 \frac{p_2}{d_0} - 1{,}7\ ;\ 2{,}5\ ] = \min[\ 2{,}8 \times \frac{45}{18} - 1{,}7\ ;\ 1{,}4 \times \frac{70}{18} - 1{,}7\ ;\ 2{,}5\ ] = 2{,}5$$

$$\alpha_d = \frac{e_1}{3\ d_0} = \frac{210}{3 \times 18} = 3{,}889$$

$$\alpha_b = \min[\ \alpha_d\ ;\ \frac{f_{ub}}{f_u}\ ;\ 1{,}0\ ] = \min[\ 3{,}889\ ;\ \frac{800}{360}\ ;\ 1{,}0\ ] = 1$$

$$F_{b,Rd} = \frac{k_1\ \alpha_b\ f_u\ d\ t}{\gamma_{M2}} = \frac{2,5 \times 1 \times 360 \times 16 \times 13}{1,25} \times 10^{-3} = 149,8 \text{ kN}$$

Bearing resistance **(T3.4)**

$$k_1 = \min[\ 1,4 \frac{p_2}{d_0} - 1,7 \ ;\ 2,5\ ] = \min[\ 1,4 \times \frac{70}{18} - 1,7 \ ;\ 2,5\ ] = 2,5$$

$$\alpha_d = \frac{p_1}{3\ d_0} - \frac{1}{4} = \frac{300}{3 \times 18} - \frac{1}{4} = 5,306$$

$$\alpha_b = \min[\ \alpha_d \ ;\ \frac{f_{ub}}{f_u} \ ;\ 1,0\ ] = \min[\ 5,306 \ ;\ \frac{800}{360} \ ;\ 1,0\ ] = 1$$

$$F_{b,Rd} = \frac{k_1\ \alpha_b\ f_u\ d\ t}{\gamma_{M2}} = \frac{2,5 \times 1 \times 360 \times 16 \times 15}{1,25} \times 10^{-3} = 172,8 \text{ kN}$$

Bearing resistance **(T3.4)**

$$k_1 = \min[\ 1,4 \frac{p_2}{d_0} - 1,7 \ ;\ 2,5\ ] = \min[\ 1,4 \times \frac{70}{18} - 1,7 \ ;\ 2,5\ ] = 2,5$$

$$\alpha_d = \frac{p_1}{3\ d_0} - \frac{1}{4} = \frac{300}{3 \times 18} - \frac{1}{4} = 5,306$$

$$\alpha_b = \min[\ \alpha_d \ ;\ \frac{f_{ub}}{f_u} \ ;\ 1,0\ ] = \min[\ 5,306 \ ;\ \frac{800}{360} \ ;\ 1,0\ ] = 1$$

$$F_{b,Rd} = \frac{k_1\ \alpha_b\ f_u\ d\ t}{\gamma_{M2}} = \frac{2,5 \times 1 \times 360 \times 16 \times 13}{1,25} \times 10^{-3} = 149,8 \text{ kN}$$

$$\frac{V_{1,Ed}}{V_{1,Rd}} = \frac{50,000}{241,152} = 0,21 < 1,0$$ complies

Check of fillet welds

$a_{ef} = 5 \text{ mm} > 0,46\ t_f = 0,46 \times 9,8 = 4,5 \text{ mm}$ complies

$a_{ew} = 3 \text{ mm} > 0,46\ t_w = 0,46 \times 6,2 = 2,9 \text{ mm}$ complies

Rotational stiffness **art. 6.1.2.3**

Bolt-row 1

$$k_3 = \frac{0,7\ l_{eff}\ t_w}{d_c} = \frac{0,7 \times 119,4 \times 8}{134} = 4,99 \text{ mm} \qquad k_4 = \frac{0,9\ l_{eff}\ t_{fc}^3}{m^3} = \frac{0,9 \times 119,4 \times 13^3}{19^3} = 34,41 \text{ mm} \quad (T6.11)$$

$$k_{10} = \frac{1,6\ A_s}{L_b} = \frac{1,6 \times 157}{39,8} = 6,32 \text{ mm} \qquad k_5 = \frac{0,9\ l_{eff}\ t_p^3}{m^3} = \frac{0,9 \times 129,6 \times 15^3}{28,5^3} = 16,99 \text{ mm}$$

$$\frac{1}{k_{eff,1}} = \frac{1}{k_3} + \frac{1}{k_4} + \frac{1}{k_{10}} + \frac{1}{k_5} = \frac{1}{4,99} + \frac{1}{34,41} + \frac{1}{6,32} + \frac{1}{16,99} = 0,447 \qquad k_{eff,1} = 2,24 \text{ mm} \quad (6.30)$$

Bolt-row 2

$$k_3 = \frac{0,7\ l_{eff}\ t_w}{d_c} = \frac{0,7 \times 86,1 \times 8}{134} = 3,60 \text{ mm} \qquad k_4 = \frac{0,9\ l_{eff}\ t_{fc}^3}{m^3} = \frac{0,9 \times 86,1 \times 13^3}{19^3} = 24,83 \text{ mm} \quad (T6.11)$$

$$k_{10} = \frac{1,6\ A_s}{L_b} = \frac{1,6 \times 157}{39,8} = 6,32 \text{ mm} \qquad k_5 = \frac{0,9\ l_{eff}\ t_p^3}{m^3} = \frac{0,9 \times 98,9 \times 15^3}{28,5^3} = 12,97 \text{ mm}$$

$$\frac{1}{k_{eff,2}} = \frac{1}{k_3} + \frac{1}{k_4} + \frac{1}{k_{10}} + \frac{1}{k_5} = \frac{1}{3,60} + \frac{1}{24,83} + \frac{1}{6,32} + \frac{1}{12,97} = 0,553 \qquad k_{eff,2} = 1,81 \text{ mm} \qquad (6.30)$$

$$z_{eq} = \frac{\Sigma k_{eff,r}\ h_r^2}{\Sigma k_{eff,r}\ h_r} = \frac{2,24 \times 330^2 + 1,81 \times 290^2}{2,24 \times 330 + 1,81 \times 290} = 313 \text{ mm} \qquad (6.31)$$

$$k_{eq} = \frac{\Sigma k_{eff,r}\ h_r}{z_{eff}} = \frac{2,24 \times 330 + 1,81 \times 290}{313} = 4,03 \text{ mm} \qquad (6.29)$$

$$k_1 = \frac{0,38\ A_{vc}}{\beta\ z} = \frac{0,38 \times 1762}{1 \times 310} = 2,16 \text{ mm} \qquad k_2 = \frac{0,7\ b_{eff}\ t_w}{d_c} = \frac{0,7 \times 193,9 \times 8}{134} = 8,11 \text{ mm} \qquad (T6.11)$$

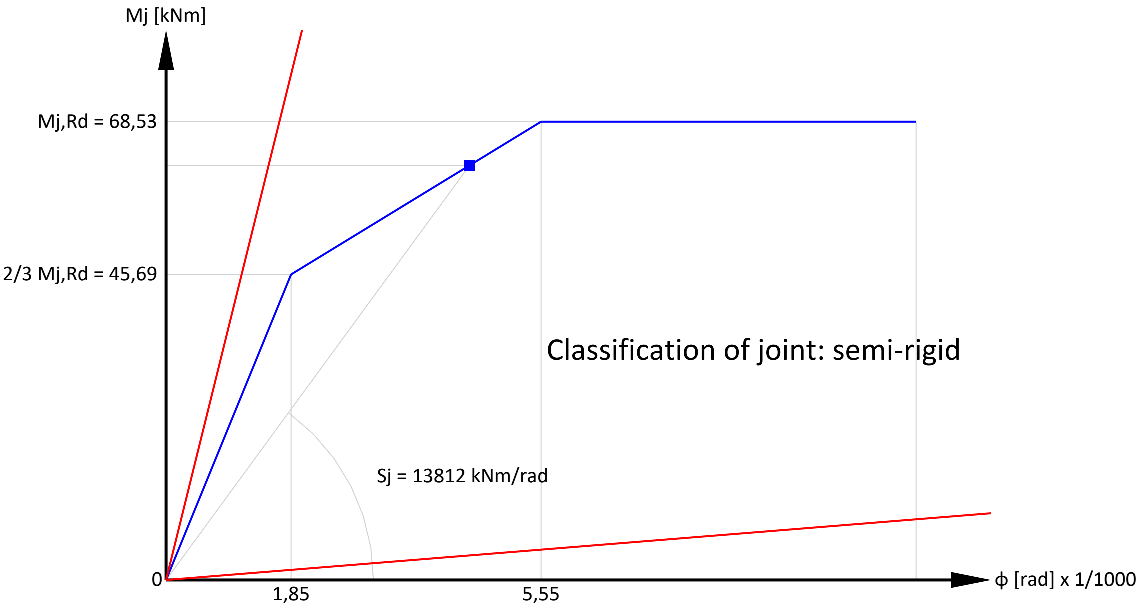
$$S_{j,ini} = \frac{E\ z_{eq}^2}{\frac{1}{k_{eq}} + \frac{1}{k_2} + \frac{1}{k_1}} = \frac{210000 \times 313^2}{\frac{1}{4,03} + \frac{1}{8,11} + \frac{1}{2,16}} .10^{-6} = 24713 \text{ kNm/rad} \qquad (6.27)$$

$$S_{j,ini} > \frac{0,5\ E\ I_b}{L_b} = \frac{0,5 \times 210000 \times 38942643}{5000} = 818 \text{ kNm/rad} \qquad (F5.4)$$

$$S_{j,ini} < \frac{k_b\ E\ I_b}{L_b} = \frac{25 \times 210000 \times 38942643}{5000} = 40890 \text{ kNm/rad} \rightarrow \text{Zone 2: semi-rigid}$$

$$\phi_1 = \frac{2/3\ M_{j,Rd}}{S_{j,ini}} = \frac{45,69}{24713} = 1,85.10^{-3} \text{ rad} \qquad \phi_2 = \frac{M_{j,Rd}}{\frac{S_{j,ini}}{\eta}} = \frac{68,53}{\frac{24713}{2}} = 5,55.10^{-3} \text{ rad}$$

$$S_j = \frac{M_{j,Ed}}{\phi} = \frac{62,00}{4,49.10^{-3}} = 13812 \text{ kNm/rad}$$



Rotational stiffness to be used in elastic global analysis

Conclusion: Beam-to-column joints complies.