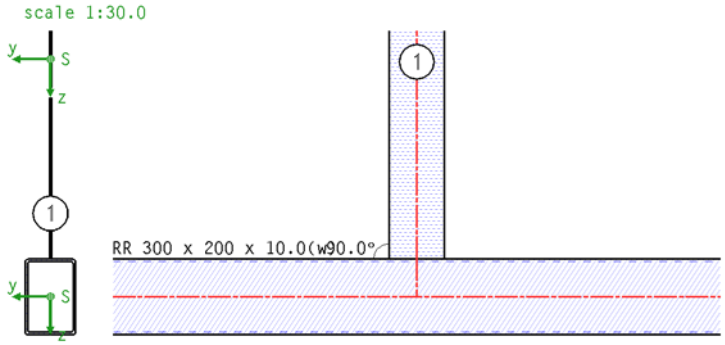
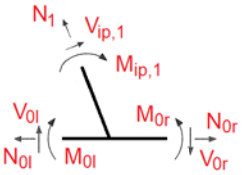
verification of a welded hollow section joint EC 3-1-8 (12.10), NA: Deutschland 4H-EC3HK version: 5/2014-3z

1. input report



steel
steel grade S235
material safety factor
resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
resistance of hollow section joints γ_{M5} = 1.00
geometry
T/Y joint
chord: section RR 300 x 200 x 10.0(w)
brace 1: connection angle Θ = 90.00°, longitudinal plate, section parameters (flat steel):
height h = 220.0 mm, thickness t = 8.0 mm
welds
fillet weld, weld thickness a = 4.0 mm
verifications
verification of hollow section joint (chord and brace)
verification of welds with the directional method
plastic verification of joining sections
internal forces and moments
Lk 1: $N_{0l,Ed}$ = -95.00 kN, $M_{0l,Ed}$ = 55.00 kNm, $N_{0r,Ed}$ = -270.00 kN, $M_{0r,Ed}$ = 89.13 kNm
$M_{ip,1,Ed}$ = 7.88 kNm, $V_{ip,1,Ed}$ = 175.00 kN



note
equilibrium is not checked.

check of data
brace 1: plate thickness t_1 = 10.0 mm > 4 mm ok
brace 1: plate thickness t_2 = 8.0 mm > 4 mm ok
brace 1: NA-DE: plate thickness $t_{max} \geq$ 3 mm: weld thickness a = 4.0 mm > $a_{min} = t_{max}^{1/2}$ - 0.5 = 2.66 mm ok
brace 1: weld thickness a = 4.0 mm < $a_{max} = 0.7 \cdot t_{min}$ = 5.6 mm (welding technology, s. DIN 18800) ok
brace 1: weld thickness a = 4.0 mm > a_{min} = 3 mm ok
coefficient $\beta = t_1/b_0$ = 0.040
coefficient $\eta = h_1/b_0$ = 1.100

2. Lk 1

2.1. verification of a welded hollow section joint

design values: $N_{0,Ed}$ = -270.00 kN, $M_{0,Ed}$ = 89.13 kNm, $M_{ip,1,Ed}$ = 7.88 kNm
range of validity (table 7.8, T/Y joint)
chord: 0.5 < h_0/b_0 = 1.500 < 2 ok
chord: b_0/t_0 = 20.000 < 35 ok
chord: h_0/t_0 = 30.000 < 35 ok
chord: section class 1 < 2 ok
additional limits (table 7.13+7.14):
η = 1.100 < 4 ok
chord: b_0/t_0 = 20.00 < 30 ok
resistance (table 7.13+7.14, T/Y joint)
brace 1:
coefficient $k_m = 1.3 \cdot (1 - n)$ = 0.517 with $n = \sigma_0/(f_{y0} \cdot \gamma_{M5})$ = 0.602, $\sigma_0 = -N_0/A_0 + M_0/W_{el,0}$ = 141.6 N/mm²
chord face failure for β = 0.040 ≤ 0.2
resistance: $N_{1,Rd} = (k_m \cdot f_{y0} \cdot t_0^2) \cdot (2 \cdot h_1/b_0 + 4 \cdot (1-\beta)^{1/2}) / \gamma_{M5}$ = 74.33 kN
moment resistance: $M_{ip,1,Rd} = k_m \cdot (1-\beta) \cdot f_{y0} \cdot t_0^2 \cdot h_1 \cdot (1/(2 \cdot \eta) + 2/(1-\beta)^{1/2} + \eta/(1-\beta)) / \gamma_{M5}$ = 9.34 kNm
utilisation: $U_1 = N_{1,Ed}/N_{1,Rd} + |M_{ip,1,Ed}|/M_{ip,1,Rd}$ = 0.843 < 1 ok
punching shear failure (analogical table 7.3)
$n_{1,Rd} = f_{y0}/3^{1/2} \cdot 2 \cdot t_0 / \gamma_{M5}$ = 2713.55 kN/m

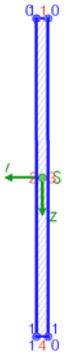
$n_{1,Ed} = \sigma_{max} \cdot t_1 = 976.86$ kN/m with $\sigma_{max} = -N_1/A_1 + |M_1|/W_{el,1} = 122.1$ N/mm²
utilisation: $U_1 = |n_{1,Ed}|/n_{1,Rd} = 0.360 < 1$ ok

total: $U_{Lk1} = 0.843 < 1$ ok

2.2. weld verification

brace 1:

calculation section:



weld 1:	$a_w = 4.0$ mm	$l_w = 8.0$ mm
weld 2:	$a_w = 4.0$ mm	$l_w = 220.0$ mm
weld 3:	$a_w = 4.0$ mm	$l_w = 220.0$ mm
weld 4:	$a_w = 4.0$ mm	$l_w = 8.0$ mm

design values refering to centroid of the section:
$M_{y,Ed} = 7.88$ kNm, $V_{z,Ed} = 175.00$ kN
cross-sectional properties refering to centroid of the line cross-section:
$\Sigma A_w = 18.24$ cm², $A_{w,y} = 0.64$ cm², $A_{w,z} = 17.60$ cm², $\Sigma l_w = 45.6$ cm
$I_{w,y} = 787.31$ cm⁴, $I_{w,z} = 2.85$ cm⁴, $\Delta y_w = 0.0$ mm, $\Delta z_w = 0.0$ mm
distribution of internal forces and moments:
weld 1: $N_w = -3.52$ kN
weld 2: $M_{y,w} = 3.55$ kNm
weld 3: $M_{y,w} = 3.55$ kNm
weld 4: $N_w = 3.52$ kN
from conventionel distribution of shear force: $V_{z,w} = 175.00$ kN
verifications in weld edges:

weld 1,	pt. 0:	$\sigma_{w,x} = -110.10$ N/mm²		$\Rightarrow U_w = 0.433 < 1$ ok
	pt. 1:	$\sigma_{w,x} = -110.10$ N/mm²		$\Rightarrow U_w = 0.433 < 1$ ok
weld 2,	pt. 0:	$\sigma_{w,x} = -110.10$ N/mm²	$\tau_{w,z} = 99.43$ N/mm²	$\Rightarrow U_w = 0.645 < 1$ ok
	pt. 1:	$\sigma_{w,x} = 110.10$ N/mm²	$\tau_{w,z} = 99.43$ N/mm²	$\Rightarrow U_w = 0.645 < 1$ ok
weld 3,	pt. 0:	$\sigma_{w,x} = -110.10$ N/mm²	$\tau_{w,z} = 99.43$ N/mm²	$\Rightarrow U_w = 0.645 < 1$ ok
	pt. 1:	$\sigma_{w,x} = 110.10$ N/mm²	$\tau_{w,z} = 99.43$ N/mm²	$\Rightarrow U_w = 0.645 < 1$ ok
weld 4,	pt. 0:	$\sigma_{w,x} = 110.10$ N/mm²		$\Rightarrow U_w = 0.433 < 1$ ok
	pt. 1:	$\sigma_{w,x} = 110.10$ N/mm²		$\Rightarrow U_w = 0.433 < 1$ ok

Result:
weld 2, pt. 0: $\sigma_{w,x} = -110.10$ N/mm² $\tau_{w,z} = 99.43$ N/mm²
Max: $\sigma_{1,w,Ed} = 23.22$ kN/cm² $< f_{1w,d} = 36.00$ kN/cm²,
$\sigma_{2,w,Ed} = 7.79$ kN/cm² $< f_{2w,d} = 25.92$ kN/cm² $\Rightarrow U_w = 0.645 < 1$ ok

2.3. verification of cross-section

chord:
plastic verification for $N = -95.00$ kN, $M_y = 55.00$ kNm
plastic values: $N_{pl,Rd} = A \cdot f_y/\gamma_{M0} = 2230.78$ kN, $M_{pl,y,Rd} = W_{pl,y} \cdot f_y/\gamma_{M0} = 224.50$ kNm

bending and axial force
deduction M_y: $f_{N,y} = (1-n)/(1-0.5 \cdot a) = 1.277 > 1 \Rightarrow f_{N,y} = 1$, $n = |N_{Ed}|/N_{pl,,Rd} = 0.043$, $a = (A-A_f)/A = 0.500 \leq 0.5$
$A_f = 2 \cdot b_f \cdot t_f = 40.00$ cm², $A = 94.93$ cm² $\Rightarrow M_{pl,y,Rd} = M_{pl,y,Rd} \cdot f_{N,y} = 224.50$ kNm

bending
verification: $|M_{y,Ed}|/M_{pl,y,Rd} = 0.245 < 1$ ok

plastic verification for $N = -270.00$ kN, $M_y = 89.13$ kNm
plastic values: $N_{pl,Rd} = A \cdot f_y/\gamma_{M0} = 2230.78$ kN, $M_{pl,y,Rd} = W_{pl,y} \cdot f_y/\gamma_{M0} = 224.50$ kNm

bending and axial force
deduction M_y: $f_{N,y} = (1-n)/(1-0.5 \cdot a) = 1.172 > 1 \Rightarrow f_{N,y} = 1$, $n = |N_{Ed}|/N_{pl,,Rd} = 0.121$, $a = (A-A_f)/A = 0.500 \leq 0.5$
$A_f = 2 \cdot b_f \cdot t_f = 40.00$ cm², $A = 94.93$ cm² $\Rightarrow M_{pl,y,Rd} = M_{pl,y,Rd} \cdot f_{N,y} = 224.50$ kNm

bending
verification: $|M_{y,Ed}|/M_{pl,y,Rd} = 0.397 < 1$ ok

brace 1:
plastic verification for $M_y = 7.88$ kNm, $V_z = 175.00$ kN
plastic values: $M_{pl,y,Rd} = W_{pl,y} \cdot f_y/\gamma_{M0} = 22.75$ kNm, $V_{pl,z,Rd} = A_{vz} \cdot f_y/(3^{1/2} \cdot \gamma_{M0}) = 238.79$ kN

shear force
reduction factors:
z-Ri: $0.5 \cdot V_{pl,z,Rd} = 119.40$ kN $<$ $|V_{z,Ed}| = 175.00$ kN: $\rho_z = (2 \cdot |V_{z,Ed}|/V_{pl,z,Rd} - 1)^2 = 0.217$

bending and shear force
z-Ri: $W_{V,y} = (1-\rho_z) \cdot W_{pl,y} = 75.81$ cm³
$\Rightarrow$ $M_{pl,V,y,Rd} = W_{V,y} \cdot f_y/\gamma_{M0} = 17.81$ kNm

bending
verification: $|M_{y,Ed}|/M_{pl,V,y,Rd} = 0.442 < 1$ ok

3. final result

maximum utilisation: resistance max U = 0.843 < 1 ok

verification succeeded