

5. Lc 7 (decisive)

5.1. verification of cross-section

flange top: section class 1, utilization $U_{c/t} = 0.064$

flange below: section class 1, utilization $U_{c/t} = 0.133$

webs: section class 1, utilization $U_{c/t} = 0.398$

total: section class 1, c/t -utilization $U_{c/t} = 0.398 < 1$ **ok** (reg. section class 2)

plastic verification for $N_{Ed} = -14.61$ kN, $M_{y,Ed} = -4.49$ kNm, $V_{z,Ed} = 6.38$ kN, $M_{z,Ed} = -17.29$ kNm

$V_{y,Ed} = -11.92$ kN, $T_{t,Ed} = 12.00$ kNm

plastic values: $N_{pl,Rd} = A \cdot f_y / \gamma_{M0} = 1020.74$ kN, $M_{pl,y,Rd} = W_{pl,y} \cdot f_y / \gamma_{M0} = 39.26$ kNm

$V_{pl,z,Rd} = A_{vz} \cdot f_y / (3^{1/2} \cdot \gamma_{M0}) = 353.60$ kN, $M_{pl,z,Rd} = W_{pl,z} \cdot f_y / \gamma_{M0} = 29.30$ kNm, $V_{pl,y,Rd} = A_{vy} \cdot f_y / (3^{1/2} \cdot \gamma_{M0}) = 235.73$ kN

torsion

$\tau_{t,Ed} = I T_{t,Ed} / \min W_t = 94.01$ N/mm²

verification: $\tau_{t,Ed} / \tau_{Rd} = 0.459 < 1$ **ok**

shear force and torsion

deduction V_z : $f_{T,z} = 1 - \tau_{t,z,Ed} / \tau_{Rd} = 0.541 \Rightarrow V_{pl,T,z,Rd} = V_{pl,z,Rd} \cdot f_{T,z} = 191.42$ kNm

deduction V_y : $f_{T,y} = 1 - \tau_{t,y,Ed} / \tau_{Rd} = 0.541 \Rightarrow V_{pl,T,y,Rd} = V_{pl,y,Rd} \cdot f_{T,y} = 127.61$ kNm

shear force

verification: $|V_{z,Ed}| / V_{pl,T,z,Rd} = 0.033 < 1$ **ok**

verification: $|V_{y,Ed}| / V_{pl,T,y,Rd} = 0.093 < 1$ **ok**

reduction factors:

z -Ri: $0.5 \cdot V_{pl,T,z,Rd} = 95.71$ kN $> |V_{z,Ed}| = 6.38$ kN: $\rho_z = 0$ (no deduction)

y -Ri: $0.5 \cdot V_{pl,T,y,Rd} = 63.81$ kN $> |V_{y,Ed}| = 11.92$ kN: $\rho_y = 0$ (no deduction)

axial force

verification: $|N_{Ed}| / N_{pl,Rd} = 0.014 < 1$ **ok**

bending and axial force

deduction M_y : $M_{pl,y,Rd} = M_{pl,y,Rd} \cdot f_{N,y} = 39.26$ kNm, $f_{N,y} = 1.314$

deduction M_z : $M_{pl,z,Rd} = M_{pl,z,Rd} \cdot f_{N,z} = 29.30$ kNm, $f_{N,z} = 1.249$

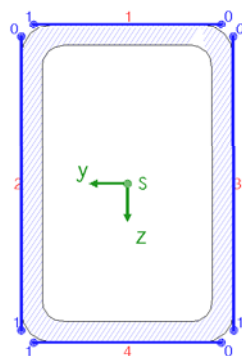
bending

verification: $(|M_{y,Ed}| / M_{pl,y,Rd})^\alpha + (|M_{z,Ed}| / M_{pl,z,Rd})^\beta = 0.027 + 0.417 = 0.444 < 1$ **ok**

with $\alpha = 1.66$, $\beta = 1.66$

5.2. verification of welds

calculation section:



weld 1:	$a_w = 6.0$ mm	$l_w = 70.6$ mm
weld 2:	$a_w = 7.0$ mm	$l_w = 110.6$ mm
weld 3:	$a_w = 7.0$ mm	$l_w = 110.6$ mm
weld 4:	$a_w = 6.0$ mm	$l_w = 70.6$ mm

design values referring to centroid of the section:

$N_{Ed} = -14.61$ kN, $M_{y,Ed} = -4.49$ kNm, $V_{z,Ed} = 6.38$ kN, $M_{z,Ed} = -17.29$ kNm, $V_{y,Ed} = -11.92$ kN, $M_{x,Ed} = 12.00$ kNm

cross-sectional properties referring to centroid of the line cross-section:

$\Sigma A_w = 23.95$ cm², $A_{w,y} = 8.47$ cm², $A_{w,z} = 15.48$ cm², $\Sigma l_w = 36.2$ cm

$I_{w,y} = 462.62$ cm⁴, $I_{w,z} = 282.84$ cm⁴, $W_{w,t} = 134.40$ cm³, $\Delta y_w = 0.0$ mm, $\Delta z_w = 0.0$ mm

distribution of internal forces and moments:

weld 1: $N_w = 22.06$ kN, $M_{z,w} = -1.07$ kNm

weld 2: $N_w = 184.58$ kN, $M_{y,w} = -0.76$ kNm

weld 3: $N_w = -194.02$ kN, $M_{y,w} = -0.76$ kNm

weld 4: $N_w = -27.22$ kN, $M_{z,w} = -1.07$ kNm

from conventional distribution of shear force: $V_{y,w} = -11.92$ kN, $V_{z,w} = 6.38$ kN

verifications in weld edges:

30% decrease of stress by pressure contact

due to torsion: $\tau_{w,T} = 89.29$ N/mm²

weld 1,	pt. 0:	$\sigma_{w,x} = -114.57$ N/mm ²	$\tau_{w,y} = 75.21$ N/mm ²	$\Rightarrow U_w = 0.477 < 1$	ok
	pt. 1:	$\sigma_{w,x} = 267.84$ N/mm ²	$\tau_{w,y} = 75.21$ N/mm ²	$\Rightarrow U_w = 0.920 < 1$	ok
weld 2,	pt. 0:	$\sigma_{w,x} = 292.09$ N/mm ²	$\tau_{w,z} = 93.41$ N/mm ²	$\Rightarrow U_w = 1.019 > 1$	not ok !!
	pt. 1:	$\sigma_{w,x} = 184.85$ N/mm ²	$\tau_{w,z} = 93.41$ N/mm ²	$\Rightarrow U_w = 0.706 < 1$	ok
weld 3,	pt. 0:	$\sigma_{w,x} = -137.93$ N/mm ²	$\tau_{w,z} = -85.16$ N/mm ²	$\Rightarrow U_w = 0.561 < 1$	ok
	pt. 1:	$\sigma_{w,x} = -213.00$ N/mm ²	$\tau_{w,z} = -85.16$ N/mm ²	$\Rightarrow U_w = 0.770 < 1$	ok
weld 4,	pt. 0:	$\sigma_{w,x} = -196.03$ N/mm ²	$\tau_{w,y} = -103.37$ N/mm ²	$\Rightarrow U_w = 0.758 < 1$	ok
	pt. 1:	$\sigma_{w,x} = 151.47$ N/mm ²	$\tau_{w,y} = -103.37$ N/mm ²	$\Rightarrow U_w = 0.641 < 1$	ok

Result:

weld 2, pt. 0: $\sigma_{w,x} = 292.09$ N/mm², $\tau_{w,z} = 93.41$ N/mm²

Max: $\sigma_{1,w,Ed} = 443.63 \text{ N/mm}^2 > f_{1w,d} = 435.56 \text{ N/mm}^2$,
 $\sigma_{2,w,Ed} = 206.54 \text{ N/mm}^2 < f_{2w,d} = 352.80 \text{ N/mm}^2 \Rightarrow U_w = 1.019 > 1$ **not ok !!**