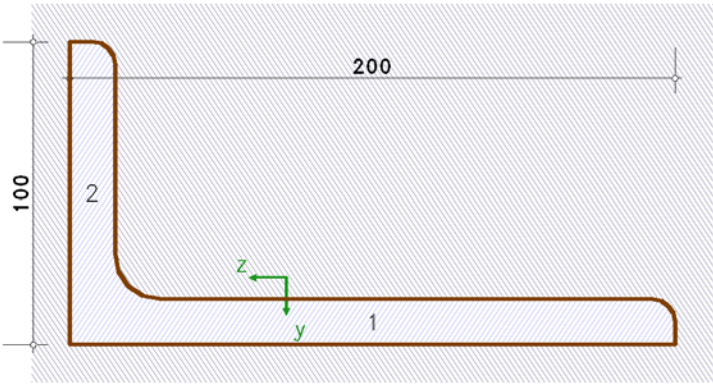
POS. 9: L-SECTION

Welded connection EC 3-1-8 (04.25), NA: Deutschland

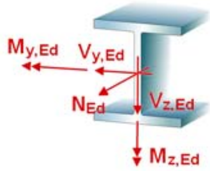
1. input report

scale 1:2.5



material
steel grade S620 Q/QL/QL1, high-strength steel
welds
filler metal at high-strength plates G42
material safety factors
resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
geometry
section L 200 X 100 X 15
plate: thickness t_p = 35.0 mm
full penetrated butt weld, 50% reduction of stress via compressive contact
resistance
plastic verification of cross-section
resolution of shear force is conventional by taking over V_y with the horizontal welds, V_z with the vertical welds.
internal forces and moments refering to local axes of cross-section

Lc 1: N_{Ed} = 3.53 kN, $M_{y,Ed}$ = -58.83 kNm, $V_{z,Ed}$ = -1.72 kN
$M_{z,Ed}$ = -12.06 kNm, $V_{y,Ed}$ = 1.55 kN



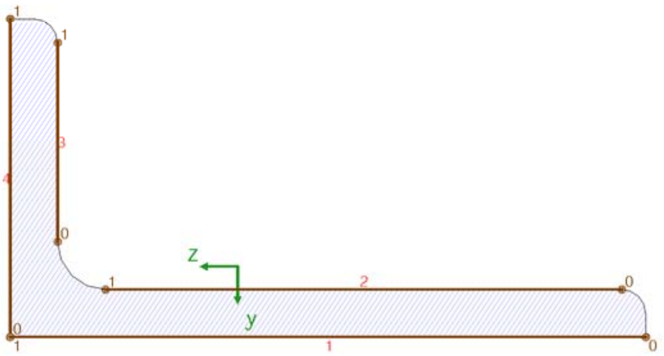
2. Lc 1

2.1. verification of cross-section

calculation acc. to EC 3-1-1, 8.2 not possible for this section !!
verification with TSV:
plastic verification for N = 3.53 kN, M_y = -58.83 kNm, V_z = -1.72 kN, M_z = -12.06 kNm
V_y = 1.55 kN
internal forces and moments reg. yz-direction in kN, m: My = -58.83, Mz = -12.06, Vy = 1.55, Vz = -1.72
partial internal forces and moments of lines of cross-section in kN, m:
1: N = 312.98, My = -29.25, Mz = 0.00, Vy = 0.00, Vz = -1.72, T = 0.00
2: N = -309.45, My = -0.00, Mz = 1.99, Vy = 1.55, Vz = 0.00, T = 0.00
utilizations of lines of cross-section
1: U_σ = 0.412, U_τ = 0.002, U = 0.412
2: U_σ = 0.410, U_τ = 0.003, U = 0.410
max. load factor (plastic): f_{pl} = 2.429
no equilibrium of warping at limit state: ΔB = -0.003 kNm^2
utilization (without equilibrium of warping): U_{pl} = 0.412
verification: U_{pl} = 0.412 < 1 ok
c/t-verification: utilization $U_{c/t}$ = 1.083 > 1 not ok !! (reg. section class 2)

2.2. verification of welds

calculation section:



weld 1: $a_w = 7.5$ mm $l_w = 200.0$ mm
weld 2: $a_w = 7.5$ mm $l_w = 162.5$ mm
weld 3: $a_w = 7.5$ mm $l_w = 62.5$ mm
weld 4: $a_w = 7.5$ mm $l_w = 100.0$ mm

design values refering to centroid of the section:

$N_{Ed} = 3.53$ kN, $M_{y,Ed} = -58.83$ kNm, $V_{z,Ed} = -1.72$ kN, $M_{z,Ed} = -12.06$ kNm, $V_{y,Ed} = 1.55$ kN

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

roots are not considered at surrounding welds.

$\Sigma A_w = 39.38$ cm², $A_{w,y} = 12.19$ cm², $A_{w,z} = 27.19$ cm², $\Sigma l_w = 52.5$ cm

$I_{w,y} = 1647.47$ cm⁴, $I_{w,z} = 287.23$ cm⁴, $I_{w,yz} = -384.41$ cm⁴, $\Delta y_w = 0.7$ mm, $\Delta z_w = -3.9$ mm

distribution of internal forces and moments:

weld 1: $N_w = 112.77$ kN $M_{y,w} = -18.84$ kNm
weld 2: $N_w = 175.93$ kN $M_{y,w} = -10.10$ kNm
weld 3: $N_w = -90.64$ kN $M_{z,w} = 0.13$ kNm
weld 4: $N_w = -194.53$ kN $M_{z,w} = 0.53$ kNm

from conventionel distribution of shear force: $V_{y,w} = 1.55$ kN $V_{z,w} = -1.72$ kN

stresses in weld edges:

weld 1,	pt. 0:	$\sigma_{w,x} = 451.94$ N/mm²		$\tau_{w,z} = -0.63$ N/mm²	
	pt. 1:	$\sigma_{w,x} = -150.79$ N/mm²		$\tau_{w,z} = -0.63$ N/mm²	(compressive contact)
weld 2,	pt. 0:	$\sigma_{w,x} = 436.35$ N/mm²		$\tau_{w,z} = -0.63$ N/mm²	
	pt. 1:	$\sigma_{w,x} = -87.95$ N/mm²		$\tau_{w,z} = -0.63$ N/mm²	(compressive contact)
weld 3,	pt. 0:	$\sigma_{w,x} = -109.87$ N/mm²	$\tau_{w,y} = 1.27$ N/mm²		(compressive contact)
	pt. 1:	$\sigma_{w,x} = -83.49$ N/mm²	$\tau_{w,y} = 1.27$ N/mm²		(compressive contact)
weld 4,	pt. 0:	$\sigma_{w,x} = -150.79$ N/mm²	$\tau_{w,y} = 1.27$ N/mm²		(compressive contact)
	pt. 1:	$\sigma_{w,x} = -108.58$ N/mm²	$\tau_{w,y} = 1.27$ N/mm²		(compressive contact)

verifications in weld edges:

50% decrease of stress by pressure contact

verification of weld 1, pt. 0:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = 451.9$ N/mm²
$\tau_p = \tau_{w,z} = -0.6$ N/mm²
$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 451.9$ N/mm²
loading $F_{w,Ed} = \sigma \cdot a = 6779.14$ kN/m
resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t/\gamma_{M2} = 7326.00$ kN/m
$F_{w,Ed} = 6779.14$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.925 < 1$ ok

verification of weld 1, pt. 1:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = -150.8$ N/mm²
$\tau_p = \tau_{w,z} = -0.6$ N/mm²
$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 150.8$ N/mm²
loading $F_{w,Ed} = \sigma \cdot a = 2261.96$ kN/m
resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t/\gamma_{M2} = 7326.00$ kN/m
$F_{w,Ed} = 2261.96$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.309 < 1$ ok

verification of weld 2, pt. 0:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = 436.3$ N/mm²
$\tau_p = \tau_{w,z} = -0.6$ N/mm²
$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 436.3$ N/mm²
loading $F_{w,Ed} = \sigma \cdot a = 6545.24$ kN/m
resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t/\gamma_{M2} = 7326.00$ kN/m
$F_{w,Ed} = 6545.24$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.893 < 1$ ok

verification of weld 2, pt. 1:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = -87.9$ N/mm²
$\tau_p = \tau_{w,z} = -0.6$ N/mm²
$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 88.0$ N/mm²
loading $F_{w,Ed} = \sigma \cdot a = 1319.30$ kN/m
resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t/\gamma_{M2} = 7326.00$ kN/m
$F_{w,Ed} = 1319.30$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.180 < 1$ ok

verification of weld 3, pt. 0:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):

$\sigma_s = \sigma_w \cdot \cos(\alpha) = -109.9$ N/mm²

$\tau_p = \tau_{w,y} = 1.3$ N/mm²

$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 109.9$ N/mm²

loading $F_{w,Ed} = \sigma \cdot a = 1648.41$ kN/m

resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t / \gamma_{M2} = 7326.00$ kN/m

$F_{w,Ed} = 1648.41$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.225 < 1$ ok

verification of weld 3, pt. 1:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):

$\sigma_s = \sigma_w \cdot \cos(\alpha) = -83.5$ N/mm²

$\tau_p = \tau_{w,y} = 1.3$ N/mm²

$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 83.5$ N/mm²

loading $F_{w,Ed} = \sigma \cdot a = 1252.76$ kN/m

resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t / \gamma_{M2} = 7326.00$ kN/m

$F_{w,Ed} = 1252.76$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.171 < 1$ ok

verification of weld 4, pt. 0:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):

$\sigma_s = \sigma_w \cdot \cos(\alpha) = -150.8$ N/mm²

$\tau_p = \tau_{w,y} = 1.3$ N/mm²

$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 150.8$ N/mm²

loading $F_{w,Ed} = \sigma \cdot a = 2262.14$ kN/m

resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t / \gamma_{M2} = 7326.00$ kN/m

$F_{w,Ed} = 2262.14$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.309 < 1$ ok

verification of weld 4, pt. 1:

stresses on the design area of the weld ($\alpha = 0°$, $\sigma_w = \sigma_{w,x}$):

$\sigma_s = \sigma_w \cdot \cos(\alpha) = -108.6$ N/mm²

$\tau_p = \tau_{w,y} = 1.3$ N/mm²

$\sigma = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 108.6$ N/mm²

loading $F_{w,Ed} = \sigma \cdot a = 1629.02$ kN/m

resistance of the weld: $F_{w,Rd} = f_{u,mod} \cdot t / \gamma_{M2} = 7326.00$ kN/m

$F_{w,Ed} = 1629.02$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U = 0.222 < 1$ ok

Result:

weld 1, pt. 0: $\sigma_{w,x} = 451.94$ N/mm² $\tau_{w,z} = -0.63$ N/mm²

Max: $F_{w,Ed} = 6779.14$ kN/m $<$ $F_{w,Rd} = 7326.00$ kN/m $\Rightarrow$ $U_w = 0.925 < 1$ ok

3. final result

maximum utilization:	resistance	max U = 0.925 < 1 ok
	c/t-ratio	max U = 1.083 > 1 not ok !!

verification succeeded

4. Regulations

EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2022, Ausgabe April 2025
EN 1993-1-1/NA, Nationaler Anhang zur EN 1993-1-1, Ausgabe April 2026

EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen; Deutsche Fassung EN 1993-1-8:2024, Ausgabe April 2025
EN 1993-1-8/NA, Nationaler Anhang zur EN 1993-1-8, Ausgabe April 2026