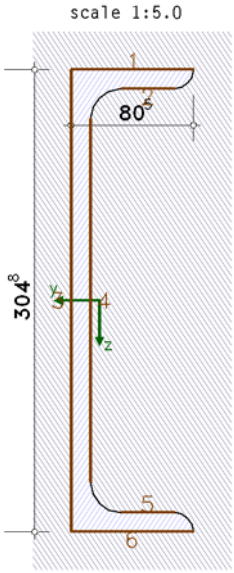
POS. 3: U-SECTION, EC3, STANDARD

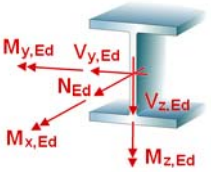
4H-EC3SA version: 10/2014-1m

Welded connection

EC 3-1-8 (12.10), NA: Deutschland



material
steel grade S 235
partial safety factors for material
resistance of cross sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25
geometry
section C310X76X45
plate: thickness t_p = 35.0 mm
welds as butt weld (partial penetrated, HY-weld):
a_{w1} = 4.8 mm, l_{w1} = 80.5 mm a_{w2} = 4.8 mm, l_{w2} = 34.9 mm a_{w3} = 4.9 mm, l_{w3} = 304.8 mm
a_{w4} = 4.9 mm, l_{w4} = 239.4 mm a_{w5} = 4.8 mm, l_{w5} = 34.9 mm a_{w6} = 4.8 mm, l_{w6} = 80.5 mm
design resistance
elastic cross-sectional check
weld verification with the directional method
resolution of shear force is made by the stiffness of the single weld.
internal forces and moments (sign definition of statics)
Lk 1: N_{Ed} = -19.39 kN $M_{y,Ed}$ = -0.01 kNm $V_{z,Ed}$ = -18.62 kN $M_{z,Ed}$ = 2.65 kNm $V_{y,Ed}$ = 14.95 kN
Lk 2: N_{Ed} = -19.09 kN $V_{z,Ed}$ = -0.17 kN $M_{z,Ed}$ = 5.14 kNm $V_{y,Ed}$ = 11.53 kN



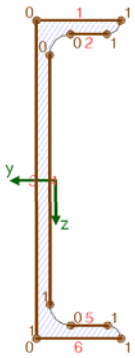
Lk 1:

cross-sectional check

design values:	N_{Ed} = -19.39 kN, $M_{y,Ed}$ = -0.01 kNm, $V_{z,Ed}$ = -18.62 kN, $M_{z,Ed}$ = 2.65 kNm, $V_{y,Ed}$ = 14.95 kN
elastic stresses:	max σ_x = 74.1 N/mm², min σ_x = -24.7 N/mm², max τ = 13.7 N/mm², max σ_v = 74.1 N/mm²
valid stresses:	σ_{Rd} = 235.0 N/mm², τ_{Rd} = 135.7 N/mm²
utilizations:	design resistance U_σ = 0.315 < 1 **ok.**, c/t-ratio $U_{c/t}$ = 0.125 < 1 **ok.**

verification of welds

calculation section:



weld 1: a_w = 4.8 mm l_w = 80.5 mm
weld 2: a_w = 4.8 mm l_w = 34.9 mm
weld 3: a_w = 4.9 mm l_w = 304.8 mm
weld 4: a_w = 4.9 mm l_w = 239.4 mm
weld 5: a_w = 4.8 mm l_w = 34.9 mm
weld 6: a_w = 4.8 mm l_w = 80.5 mm

design values:
N_{Ed} = -19.39 kN, $M_{y,Ed}$ = -0.01 kNm, $V_{z,Ed}$ = -18.62 kN, $M_{z,Ed}$ = 2.65 kNm, $V_{y,Ed}$ = 14.95 kN
cross-sectional properties refering to centroid of the line cross section:
ΣA_w = 38.13 cm², Σl_w = 77.5 cm
$I_{w,y}$ = 4208.52 cm⁴, $I_{w,z}$ = 171.58 cm⁴, Δy_w = 1.9 mm, Δz_w = 0.0 mm
member forces distributed to the individual welds:

weld 1:	N_w = 12.21 kN	$M_{z,w}$ = 0.33 kNm	$V_{y,w}$ = 6.83 kN		
weld 2:	N_w = 7.93 kN	$M_{z,w}$ = 0.03 kNm	$V_{y,w}$ = 0.56 kN		
weld 3:	N_w = -46.61 kN	$M_{y,w}$ = -0.00 kNm	$M_{z,w}$ = 0.00 kNm	$V_{y,w}$ = 0.10 kN	$V_{z,w}$ = -12.54 kN
weld 4:	N_w = -13.02 kN	$M_{y,w}$ = -0.00 kNm	$M_{z,w}$ = 0.00 kNm	$V_{y,w}$ = 0.08 kN	$V_{z,w}$ = -6.08 kN
weld 5:	N_w = 7.92 kN	$M_{z,w}$ = 0.03 kNm	$V_{y,w}$ = 0.56 kN		
weld 6:	N_w = 12.18 kN	$M_{z,w}$ = 0.33 kNm	$V_{y,w}$ = 6.83 kN		

verifications in the edge points of the individual welds:
a partial penetrated butt weld (HY-weld) is verified as a fillet weld.

weld 1,	pt. 0:	$\sigma_{w,x}$ = -30.86 N/mm²	$\tau_{w,y}$ = 17.49 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.148 < 1	ok.
	pt. 1:	$\sigma_{w,x}$ = 93.40 N/mm²	$\tau_{w,y}$ = 17.49 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.376 < 1	ok.
weld 2,	pt. 0:	$\sigma_{w,x}$ = 19.92 N/mm²	$\tau_{w,y}$ = 3.29 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.080 < 1	ok.
	pt. 1:	$\sigma_{w,x}$ = 73.79 N/mm²	$\tau_{w,y}$ = 3.29 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.290 < 1	ok.
weld 3,	pt. 0:	$\sigma_{w,x}$ = -30.86 N/mm²	$\tau_{w,y}$ = 0.07 N/mm²	$\tau_{w,z}$ = 8.31 N/mm²	⇒ U_w = 0.128 < 1	ok.
	pt. 1:	$\sigma_{w,x}$ = -30.93 N/mm²	$\tau_{w,y}$ = 0.07 N/mm²	$\tau_{w,z}$ = 8.31 N/mm²	⇒ U_w = 0.128 < 1	ok.
weld 4,	pt. 0:	$\sigma_{w,x}$ = -10.96 N/mm²	$\tau_{w,y}$ = 0.07 N/mm²	$\tau_{w,z}$ = 5.13 N/mm²	⇒ U_w = 0.049 < 1	ok.
	pt. 1:	$\sigma_{w,x}$ = -11.01 N/mm²	$\tau_{w,y}$ = 0.07 N/mm²	$\tau_{w,z}$ = 5.13 N/mm²	⇒ U_w = 0.050 < 1	ok.
weld 5,	pt. 0:	$\sigma_{w,x}$ = 19.85 N/mm²	$\tau_{w,y}$ = 3.29 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.080 < 1	ok.
	pt. 1:	$\sigma_{w,x}$ = 73.72 N/mm²	$\tau_{w,y}$ = 3.29 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.290 < 1	ok.
weld 6,	pt. 0:	$\sigma_{w,x}$ = -30.93 N/mm²	$\tau_{w,y}$ = 17.49 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.148 < 1	ok.
	pt. 1:	$\sigma_{w,x}$ = 93.32 N/mm²	$\tau_{w,y}$ = 17.49 N/mm²	$\tau_{w,z}$ = 0.00 N/mm²	⇒ U_w = 0.376 < 1	ok.

Result:
weld 1, pt. 1: $\sigma_{w,x}$ = 93.40 N/mm² $\tau_{w,y}$ = 17.49 N/mm² $\tau_{w,z}$ = 0.00 N/mm²
$\sigma_{1,w,Ed}$ = 13.54 kN/cm² < $f_{1,w,Rd}$ = 36.00 kN/cm²,
$\sigma_{2,w,Ed}$ = 6.60 kN/cm² < $f_{2,w,Rd}$ = 25.92 kN/cm² ⇒ U_w = 0.376 < 1 ok.

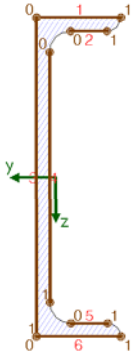
Lk 2:

cross-sectional check

design values: N_{Ed} = -19.09 kN, $V_{z,Ed}$ = -0.17 kN, $M_{z,Ed}$ = 5.14 kNm, $V_{y,Ed}$ = 11.53 kN
elastic stresses: max σ_x = 147.0 N/mm², min σ_x = -44.5 N/mm², max τ = 8.5 N/mm², max σ_v = 147.0 N/mm²
valid stresses: σ_{Rd} = 235.0 N/mm², τ_{Rd} = 135.7 N/mm²
utilizations: design resistance U_σ = 0.626 < 1 ok., c/t-ratio $U_{c/t}$ = 0.165 < 1 ok.

verification of welds

calculation section:



weld 1: a_w = 4.8 mm l_w = 80.5 mm
weld 2: a_w = 4.8 mm l_w = 34.9 mm
weld 3: a_w = 4.9 mm l_w = 304.8 mm
weld 4: a_w = 4.9 mm l_w = 239.4 mm
weld 5: a_w = 4.8 mm l_w = 34.9 mm
weld 6: a_w = 4.8 mm l_w = 80.5 mm

design values:
N_{Ed} = -19.09 kN, $V_{z,Ed}$ = -0.17 kN, $M_{z,Ed}$ = 5.14 kNm, $V_{y,Ed}$ = 11.53 kN
cross-sectional properties refering to centroid of the line cross section:
ΣA_w = 38.13 cm², Σl_w = 77.5 cm
$I_{w,y}$ = 4208.52 cm⁴, $I_{w,z}$ = 171.58 cm⁴, Δy_w = 1.9 mm, Δz_w = 0.0 mm
member forces distributed to the individual welds:

weld 1:	N_w = 25.56 kN	$M_{z,w}$ = 0.63 kNm	$V_{y,w}$ = 5.27 kN	
weld 2:	N_w = 16.20 kN	$M_{z,w}$ = 0.05 kNm	$V_{y,w}$ = 0.43 kN	
weld 3:	N_w = -83.13 kN	$M_{z,w}$ = 0.01 kNm	$V_{y,w}$ = 0.08 kN	$V_{z,w}$ = -0.11 kN
weld 4:	N_w = -19.50 kN	$M_{z,w}$ = 0.01 kNm	$V_{y,w}$ = 0.06 kN	$V_{z,w}$ = -0.05 kN
weld 5:	N_w = 16.20 kN	$M_{z,w}$ = 0.05 kNm	$V_{y,w}$ = 0.43 kN	
weld 6:	N_w = 25.56 kN	$M_{z,w}$ = 0.63 kNm	$V_{y,w}$ = 5.27 kN	

verifications in the edge points of the individual welds:
a partial penetrated butt weld (HY-weld) is verified as a fillet weld.

weld 1,	pt. 0:	$\sigma_{w,x}$ = -55.10 N/mm²	$\tau_{w,y}$ = 13.49 N/mm²		$\Rightarrow U_w = 0.226 < 1$ ok.
	pt. 1:	$\sigma_{w,x}$ = 186.05 N/mm²	$\tau_{w,y}$ = 13.49 N/mm²		$\Rightarrow U_w = 0.734 < 1$ ok.
weld 2,	pt. 0:	$\sigma_{w,x}$ = 43.46 N/mm²	$\tau_{w,y}$ = 2.54 N/mm²		$\Rightarrow U_w = 0.171 < 1$ ok.
	pt. 1:	$\sigma_{w,x}$ = 148.01 N/mm²	$\tau_{w,y}$ = 2.54 N/mm²		$\Rightarrow U_w = 0.582 < 1$ ok.
weld 3,	pt. 0:	$\sigma_{w,x}$ = -55.10 N/mm²	$\tau_{w,y}$ = 0.05 N/mm²	$\tau_{w,z}$ = 0.07 N/mm²	$\Rightarrow U_w = 0.216 < 1$ ok.
	pt. 1:	$\sigma_{w,x}$ = -55.10 N/mm²	$\tau_{w,y}$ = 0.05 N/mm²	$\tau_{w,z}$ = 0.07 N/mm²	$\Rightarrow U_w = 0.216 < 1$ ok.
weld 4,	pt. 0:	$\sigma_{w,x}$ = -16.45 N/mm²	$\tau_{w,y}$ = 0.05 N/mm²	$\tau_{w,z}$ = 0.05 N/mm²	$\Rightarrow U_w = 0.065 < 1$ ok.
	pt. 1:	$\sigma_{w,x}$ = -16.45 N/mm²	$\tau_{w,y}$ = 0.05 N/mm²	$\tau_{w,z}$ = 0.05 N/mm²	$\Rightarrow U_w = 0.065 < 1$ ok.
weld 5,	pt. 0:	$\sigma_{w,x}$ = 43.46 N/mm²	$\tau_{w,y}$ = 2.54 N/mm²		$\Rightarrow U_w = 0.171 < 1$ ok.
	pt. 1:	$\sigma_{w,x}$ = 148.01 N/mm²	$\tau_{w,y}$ = 2.54 N/mm²		$\Rightarrow U_w = 0.582 < 1$ ok.
weld 6,	pt. 0:	$\sigma_{w,x}$ = -55.10 N/mm²	$\tau_{w,y}$ = 13.49 N/mm²		$\Rightarrow U_w = 0.226 < 1$ ok.
	pt. 1:	$\sigma_{w,x}$ = 186.05 N/mm²	$\tau_{w,y}$ = 13.49 N/mm²		$\Rightarrow U_w = 0.734 < 1$ ok.

Result:
weld 1, pt. 1: $\sigma_{w,x}$ = 186.05 N/mm² $\tau_{w,y}$ = 13.49 N/mm²
$\sigma_{1,w,Ed}$ = 26.42 kN/cm² < $f_{1,w,Rd}$ = 36.00 kN/cm²,
$\sigma_{2,w,Ed}$ = 13.16 kN/cm² < $f_{2,w,Rd}$ = 25.92 kN/cm² $\Rightarrow U_w = 0.734 < 1$ ok.

Final result

maximum utilization [Lk 2]: design resistance max U = 0.734 < 1 ok.
c/t-ratio max U = 0.165 < 1 ok.

verification succeeded

Regulations

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

DIN EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-1/NA, Nationaler Anhang zur DIN EN 1993-1-1, Ausgabe Dezember 2010

DIN EN 1993-1-8, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-8: Bemessung von Anschlüssen;
Deutsche Fassung EN 1993-1-8:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-8/NA, Nationaler Anhang zur DIN EN 1993-1-8, Ausgabe Dezember 2010