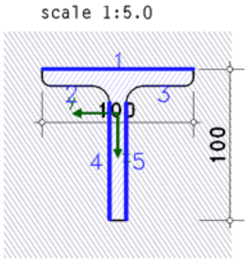
POS. 2: T-SECTION, EC3, AUSFÜHRLICH

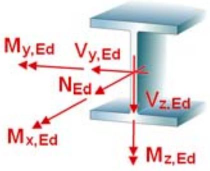
4H-EC3SA version: 10/2014-1m

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 T100
plate: thickness t_p = 35.0 mm
welds as fillet weld:
a_{w1} = 6.0 mm, l_{w1} = 100.0 mm a_{w1} = 3.0 mm, l_{w1} = 100.0 mm a_{w2} = 0.0 mm, l_{w2} = 28.0 mm
a_{w3} = 0.0 mm, l_{w3} = 28.0 mm a_{w4} = 6.0 mm, l_{w4} = 78.0 mm a_{w5} = 6.0 mm, l_{w5} = 78.0 mm
design resistance
plastic 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} = -8.40 kN $M_{y,Ed}$ = 5.84 kNm $V_{z,Ed}$ = -2.30 kN



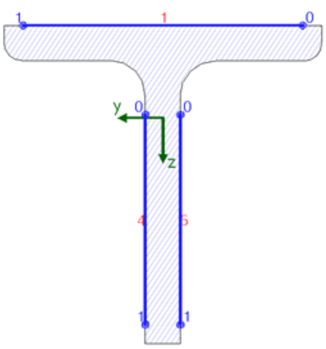
Lk 1:

cross-sectional check

design values: N_{Ed} = -8.40 kN, $M_{y,Ed}$ = 5.84 kNm, $V_{z,Ed}$ = -2.30 kN
elastic stresses: max σ_x = 232.8 N/mm², min σ_x = -93.4 N/mm², max τ = 3.0 N/mm², max σ_v = 232.8 N/mm²
utilizations: design resistance U_σ = 0.499 < 1 **ok.**, c/t-ratio $U_{c/t}$ = 0.125 < 1 **ok.**

verification of welds

calculation section:



weld 1: a_w = 6.0 mm l_w = 88.0 mm
weld 4: a_w = 6.0 mm l_w = 66.0 mm
weld 5: a_w = 6.0 mm l_w = 66.0 mm

design values:
N_{Ed} = -8.40 kN, $M_{y,Ed}$ = 5.84 kNm, $V_{z,Ed}$ = -2.30 kN

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

$\Sigma A_w = 13.20\ cm^2$, $\Sigma l_w = 22.0\ cm$
$I_{w,y} = 146.79\ cm^4$, $I_{w,z} = 36.71\ cm^4$, $\Delta y_w = 0.0\ mm$, $\Delta z_w = 7.6\ mm$

member forces distributed to the individual welds:

weld 1: $N_w = -80.24\ kN$ $M_{y,w} = 0.01\ kNm$ $V_{z,w} = -0.01\ kN$
weld 4: $N_w = 35.92\ kN$ $M_{y,w} = 0.57\ kNm$ $V_{z,w} = -1.14\ kN$
weld 5: $N_w = 35.92\ kN$ $M_{y,w} = 0.57\ kNm$ $V_{z,w} = -1.14\ kN$

stresses in the edge points of the individual welds:

weld 1, pt. 0: $\sigma_{w,x} = -151.98\ N/mm^2$ $\tau_{w,z} = -0.02\ N/mm^2$
pt. 1: $\sigma_{w,x} = -151.98\ N/mm^2$ $\tau_{w,z} = -0.02\ N/mm^2$
weld 4, pt. 0: $\sigma_{w,x} = -40.58\ N/mm^2$ $\tau_{w,z} = -2.89\ N/mm^2$
pt. 1: $\sigma_{w,x} = 222.00\ N/mm^2$ $\tau_{w,z} = -2.89\ N/mm^2$
weld 5, pt. 0: $\sigma_{w,x} = -40.58\ N/mm^2$ $\tau_{w,z} = -2.89\ N/mm^2$
pt. 1: $\sigma_{w,x} = 222.00\ N/mm^2$ $\tau_{w,z} = -2.89\ N/mm^2$

verifications in the edge points of the individual welds:

verification of weld 1, pt. 0:

stresses on the design area of the weld ($\alpha = 45°$, $\sigma_w = \sigma_{w,x}$, $\tau_w = \tau_{w,z}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) - \tau_w \cdot \sin(\alpha) = -107.5\ N/mm^2$
$\tau_s = \sigma_w \cdot \sin(\alpha) + \tau_w \cdot \cos(\alpha) = -107.4\ N/mm^2$
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 21.49\ kN/cm^2$
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w \cdot \gamma_{M2}) = 36.00\ kN/cm^2$
$\sigma_{1,w,Ed} = 21.49\ kN/cm^2 < f_{1,w,Rd} = 36.00\ kN/cm^2 \Rightarrow$ utilization U = 0.597 < 1 ok.
$\sigma_{2,w,Ed} = \sigma_s = 10.75\ kN/cm^2$
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9 \cdot f_u / \gamma_{M2} = 25.92\ kN/cm^2$
$\sigma_{2,w,Ed} = 10.75\ kN/cm^2 < f_{2,w,Rd} = 25.92\ kN/cm^2 \Rightarrow$ utilization U = 0.415 < 1 ok.

verification of weld 1, pt. 1:

stresses on the design area of the weld ($\alpha = 45°$, $\sigma_w = \sigma_{w,x}$, $\tau_w = \tau_{w,z}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) - \tau_w \cdot \sin(\alpha) = -107.5\ N/mm^2$
$\tau_s = \sigma_w \cdot \sin(\alpha) + \tau_w \cdot \cos(\alpha) = -107.4\ N/mm^2$
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 21.49\ kN/cm^2$
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w \cdot \gamma_{M2}) = 36.00\ kN/cm^2$
$\sigma_{1,w,Ed} = 21.49\ kN/cm^2 < f_{1,w,Rd} = 36.00\ kN/cm^2 \Rightarrow$ utilization U = 0.597 < 1 ok.
$\sigma_{2,w,Ed} = \sigma_s = 10.75\ kN/cm^2$
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9 \cdot f_u / \gamma_{M2} = 25.92\ kN/cm^2$
$\sigma_{2,w,Ed} = 10.75\ kN/cm^2 < f_{2,w,Rd} = 25.92\ kN/cm^2 \Rightarrow$ utilization U = 0.415 < 1 ok.

verification of weld 4, pt. 0:

stresses on the design area of the weld ($\alpha = 45°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = -28.7\ N/mm^2$
$\tau_s = \sigma_w \cdot \sin(\alpha) = -28.7\ N/mm^2$
$\tau_p = \tau_{w,z} = 2.9\ N/mm^2$
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 5.76\ kN/cm^2$
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w \cdot \gamma_{M2}) = 36.00\ kN/cm^2$
$\sigma_{1,w,Ed} = 5.76\ kN/cm^2 < f_{1,w,Rd} = 36.00\ kN/cm^2 \Rightarrow$ utilization U = 0.160 < 1 ok.
$\sigma_{2,w,Ed} = \sigma_s = 2.87\ kN/cm^2$
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9 \cdot f_u / \gamma_{M2} = 25.92\ kN/cm^2$
$\sigma_{2,w,Ed} = 2.87\ kN/cm^2 < f_{2,w,Rd} = 25.92\ kN/cm^2 \Rightarrow$ utilization U = 0.111 < 1 ok.

verification of weld 4, pt. 1:

stresses on the design area of the weld ($\alpha = 45°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = 157.0\ N/mm^2$
$\tau_s = \sigma_w \cdot \sin(\alpha) = 157.0\ N/mm^2$
$\tau_p = \tau_{w,z} = 2.9\ N/mm^2$
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 31.40\ kN/cm^2$
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w \cdot \gamma_{M2}) = 36.00\ kN/cm^2$
$\sigma_{1,w,Ed} = 31.40\ kN/cm^2 < f_{1,w,Rd} = 36.00\ kN/cm^2 \Rightarrow$ utilization U = 0.872 < 1 ok.
$\sigma_{2,w,Ed} = \sigma_s = 15.70\ kN/cm^2$
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9 \cdot f_u / \gamma_{M2} = 25.92\ kN/cm^2$
$\sigma_{2,w,Ed} = 15.70\ kN/cm^2 < f_{2,w,Rd} = 25.92\ kN/cm^2 \Rightarrow$ utilization U = 0.606 < 1 ok.

verification of weld 5, pt. 0:

stresses on the design area of the weld ($\alpha = 45°$, $\sigma_w = \sigma_{w,x}$):
$\sigma_s = \sigma_w \cdot \cos(\alpha) = -28.7\ N/mm^2$
$\tau_s = \sigma_w \cdot \sin(\alpha) = -28.7\ N/mm^2$
$\tau_p = \tau_{w,z} = 2.9\ N/mm^2$
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2} = 5.76\ kN/cm^2$
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w \cdot \gamma_{M2}) = 36.00\ kN/cm^2$
$\sigma_{1,w,Ed} = 5.76\ kN/cm^2 < f_{1,w,Rd} = 36.00\ kN/cm^2 \Rightarrow$ utilization U = 0.160 < 1 ok.
$\sigma_{2,w,Ed} = \sigma_s = 2.87\ kN/cm^2$
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9 \cdot f_u / \gamma_{M2} = 25.92\ kN/cm^2$
$\sigma_{2,w,Ed} = 2.87\ kN/cm^2 < f_{2,w,Rd} = 25.92\ kN/cm^2 \Rightarrow$ utilization U = 0.111 < 1 ok.

verification of weld 5, pt. 1:

stresses on the design area of the weld (α = 45°, $\sigma_w = \sigma_{w,x}$):

$\sigma_s = \sigma_w \cdot \cos(\alpha)$ = 157.0 N/mm²

$\tau_s = \sigma_w \cdot \sin(\alpha)$ = 157.0 N/mm²

$\tau_p = \tau_{w,z}$ = 2.9 N/mm²

$\sigma_{1,w,Ed} = (\sigma_s^2 + 3 \cdot (\tau_s^2 + \tau_p^2))^{1/2}$ = 31.40 kN/cm²

design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w \cdot \gamma_{M2})$ = 36.00 kN/cm²

$\sigma_{1,w,Ed}$ = 31.40 kN/cm² < $f_{1,w,Rd}$ = 36.00 kN/cm² ⇒ utilization U = 0.872 < 1 ok.

$\sigma_{2,w,Ed} = \sigma_s$ = 15.70 kN/cm²

design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9 \cdot f_u / \gamma_{M2}$ = 25.92 kN/cm²

$\sigma_{2,w,Ed}$ = 15.70 kN/cm² < $f_{2,w,Rd}$ = 25.92 kN/cm² ⇒ utilization U = 0.606 < 1 ok.

Result:

weld 4, pt. 1: $\sigma_{w,x}$ = 222.00 N/mm² $\tau_{w,z}$ = 2.89 N/mm²

$\sigma_{1,w,Ed}$ = 31.40 kN/cm² < $f_{1,w,Rd}$ = 36.00 kN/cm²,

$\sigma_{2,w,Ed}$ = 15.70 kN/cm² < $f_{2,w,Rd}$ = 25.92 kN/cm² ⇒ U_w = 0.872 < 1 ok.

Final result

maximum utilization: design resistance max U = 0.872 < 1 ok.

c/t-ratio max U = 0.125 < 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