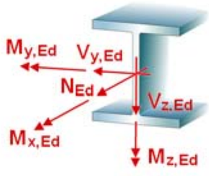
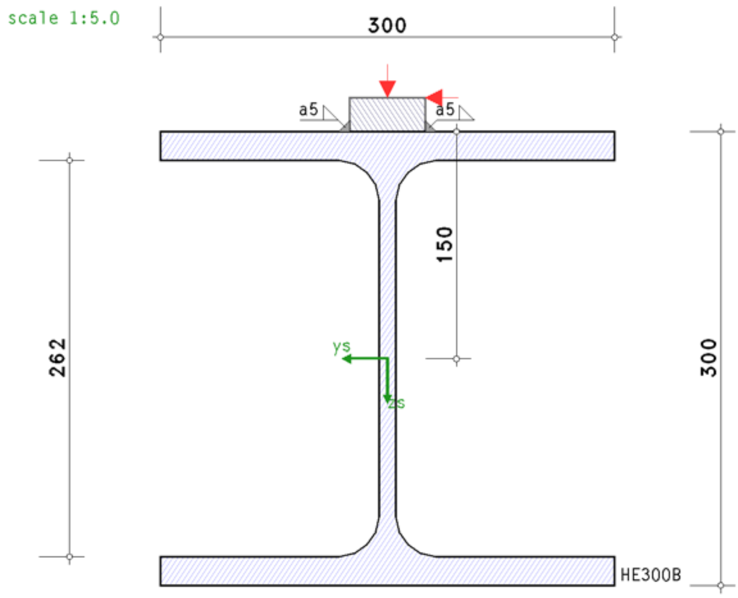
POS. 159: SEESSELBERG, 11.7.1-3, ULS

detailed problems acc. to Eurocode 3

EC 3-6 (12.10), NA: Deutschland

steel grade
steel grade S 235
cross-section
beam: section HE300B
crane gantry
crane rail of flat steel, shear-resistant joined with the girder
connection with fillet welds: weld thickness a_w = 5.0 mm, intermittent weld with section length l_w = 60.0 mm (staggered)
crane rail: width b_r = 50.0 mm, height of fretted rail h_r = 22.5 mm
moment of inertia, cross-sectional area of fretted rail I_{yr} = 4.75 cm⁴, A_r = 11.25 cm²
loading
Lk 1: $M_{y,Ed}$ = -129.8 kNm, $V_{z,Ed}$ = 175.5 kN
transverse loading on upper edge of cross-section:
design value of vertical wheel load $F_{z,Ed}$ = 113.70 kN
design value of horizontal wheel load H_{Ed} = 17.40 kN
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of bolts, welds, plates in bearing γ_{M2} = 1.25





Verification of Local Loading due to Crane Gantry

cross-sectional properties
A = 149.08 cm², z_s = 150.0 mm, I_y = 25165.90 cm⁴, y_s = 0.0 mm, I_z = 8562.83 cm⁴

effective loading length from crane gantry
effective width $b_{eff} = b_r+h_r+t_{fo}$ = 91.5 mm $\leq b_{fo}$
moment of inertia of crane rail with beam flange I_{rf} = 39.38 cm⁴
effective length $l_{eff} = 3.25\cdot(I_{rf}/t_w)^{1/3}$ = 107.1 mm

local stresses from crane gantry
refering to outer edge of flange $s_s = l_{eff} - 2\cdot t_f$ = 69.1 mm / auf den web $s_w = l_{eff} + 2\cdot r$ = 161.1 mm

permissible stresses
$\sigma_{Rd} = f_y/\gamma_{M0}$ = 235.0 N/mm², $\tau_{Rd} = f_y/(3^{1/2}\cdot\gamma_{M0})$ = 135.7 N/mm²

wheel pressure at top edge of the web
local normal stress $\sigma_{oz,Ed} = -F_{z,Ed}/(t_w\cdot s_w)$ = -64.2 N/mm²
$|\sigma_{oz,Ed}|$ = 64.2 N/mm² < σ_{Rd} = 235.0 N/mm² ⇒ U = 0.273 < 1 ok.

associated local shear stress $\tau_{oxz,Ed} = 0.2 \cdot \sigma_{oz,Ed} = -12.8$ N/mm²
$|\tau_{oxz,Ed}| = 12.8$ N/mm² $< \tau_{Rd} = 135.7$ N/mm² $\Rightarrow$ U = 0.095 < 1 ok.

stresses at top edge of the web
Lk 1:
normal stress $\sigma_{x,Ed} = 53.6$ N/mm²
$|\sigma_{x,Ed}| = 53.6$ N/mm² $< \sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ U = 0.228 < 1 ok.
shear stress $\tau_{xz,Ed} = 55.3$ N/mm²
$|\tau_{xz,Ed}|+|\tau_{oxz,Ed}| = 68.1$ N/mm² $< \tau_{Rd} = 135.7$ N/mm² $\Rightarrow$ U = 0.502 < 1 ok.
equivalent stress $\sigma_v = (\sigma_{x,Ed}^2+\sigma_{oz,Ed}^2-\sigma_{x,Ed}\cdot\sigma_{oz,Ed}+3\cdot(|\tau_{xz,Ed}|+|\tau_{oxz,Ed}|)^2)^{1/2} = 156.0$ N/mm²
$\sigma_v = 156.0$ N/mm² $< \sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ U = 0.664 < 1 ok.

welds of crane rail at outer edge of flange (intermittent welds, staggered arrangement)
$N_{Ed} = -56.9$ kN, $V_{Ed} = -20.0$ kN
stresses on the design area of the weld: $\sigma_s = -15.73$ kN/cm² $\tau_s = -7.53$ kN/cm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2} = 20.44$ kN/cm²
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w\cdot\gamma_{M2}) = 36.00$ kN/cm²
$\sigma_{1,w,Ed} = 20.44$ kN/cm² $< f_{1,w,Rd} = 36.00$ kN/cm² $\Rightarrow$ U = 0.568 < 1 ok.
$\sigma_{2,w,Ed} = |\sigma_s| = 15.73$ kN/cm²
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9\cdot f_u / \gamma_{M2} = 25.92$ kN/cm²
$\sigma_{2,w,Ed} = 15.73$ kN/cm² $< f_{2,w,Rd} = 25.92$ kN/cm² $\Rightarrow$ U = 0.607 < 1 ok.
$N_{Ed} = -56.9$ kN, $V_{Ed} = 20.0$ kN
stresses on the design area of the weld: $\sigma_s = -7.53$ kN/cm² $\tau_s = -15.73$ kN/cm²
$\sigma_{1,w,Ed} = (\sigma_s^2 + 3\cdot(\tau_s^2 + \tau_p^2))^{1/2} = 28.27$ kN/cm²
design resistance of the weld (req.1): $f_{1,w,Rd} = f_u / (\beta_w\cdot\gamma_{M2}) = 36.00$ kN/cm²
$\sigma_{1,w,Ed} = 28.27$ kN/cm² $< f_{1,w,Rd} = 36.00$ kN/cm² $\Rightarrow$ U = 0.785 < 1 ok.
$\sigma_{2,w,Ed} = |\sigma_s| = 7.53$ kN/cm²
design resistance of the weld (req.2): $f_{2,w,Rd} = 0.9\cdot f_u / \gamma_{M2} = 25.92$ kN/cm²
$\sigma_{2,w,Ed} = 7.53$ kN/cm² $< f_{2,w,Rd} = 25.92$ kN/cm² $\Rightarrow$ U = 0.291 < 1 ok.

Final Result

maximum utilization: max U = 0.785 < 1 ok.

verification succeeded