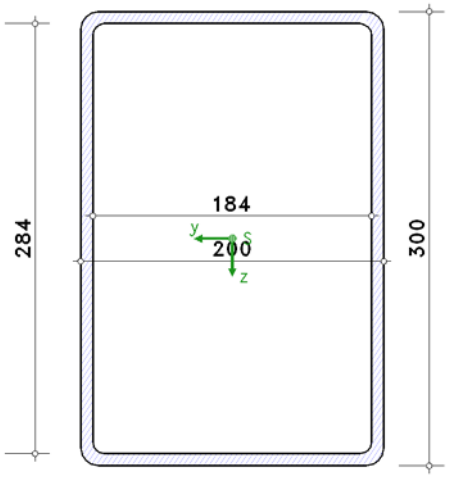
POS. 26: KINDMANN/KRÜGER 2.9.6

verification of cross-section EC 3-1-8 (12.10), NA: Deutschland

1. input report

scale 1:5.0



steel
steel grade S235
material safety factor
resistance of cross-sections $\gamma_{M0} = 1.00$
geometry
section RR 300 x 200 x 8.0(w)
resistance
plastic verification acc. to EC 3-1-1, 6.2
internal forces and moments refering to local axes of cross-section
σ-generating forces (N, M) work at centroid, τ-generating forces (V, T_t) work at shear center
Lk 1: a)
$N_{Ed} = 400.00$ kN, $M_{y,Ed} = 170.00$ kNm, $V_{z,Ed} = 250.00$ kN
Lk 2: b)
$M_{y,Ed} = 154.00$ kNm, $V_{z,Ed} = 250.00$ kN, $M_{z,Ed} = 60.00$ kNm, $V_{y,Ed} = 150.00$ kN
Lk 3: c)
$N_{Ed} = 200.00$ kN, $M_{y,Ed} = 154.00$ kNm, $V_{z,Ed} = 250.00$ kN, $M_{z,Ed} = 60.00$ kNm, $V_{y,Ed} = 150.00$ kN

notes
buckling is not investigated.

2. Lk 1: a)

2.1. verification of cross-section

internal forces and moments: $N = 400.00$ kN, $M_y = 170.00$ kNm, $V_z = 250.00$ kN

2.1.1. plastic verification

plastic verification for $N = 400.00$ kN, $M_y = 170.00$ kNm, $V_z = 250.00$ kN
plastic values: $N_{pl,Rd} = A \cdot f_y/\gamma_{M0} = 1803.70$ kN, $M_{pl,y,Rd} = W_{pl,y} \cdot f_y/\gamma_{M0} = 183.11$ kNm
$V_{pl,z,Rd} = A_{vz} \cdot f_y/(3^{1/2} \cdot \gamma_{M0}) = 624.82$ kN

shear force
reduction factors:
z-Ri: $0.5 \cdot V_{pl,z,Rd} = 312.41$ kN $>$ $|V_{z,Ed}| = 250.00$ kN: $\rho_z = 0$ (no deduction)
$|V_{y,Ed}| = 0$: $\rho_y = 0$ (no deduction)

bending and axial force
deduction M_y: $f_{N,y} = (1-n)/(1-0.5 \cdot a) = 1.038 > 1 \Rightarrow f_{N,y} = 1$, $n = |N_{Ed}|/N_{pl,,Rd} = 0.222$, $a = (A-A_f)/A = 0.500 \leq 0.5$
$A_f = 2 \cdot b_f \cdot t_f = 32.00$ cm², $A = 76.75$ cm² $\Rightarrow$ $M_{pl,y,Rd} = M_{pl,y,Rd} \cdot f_{N,y} = 183.11$ kNm

bending
verification: $|M_{y,Ed}|/M_{pl,y,Rd} = 0.928 < 1$ ok

3. Lk 2: b)

3.1. verification of cross-section

internal forces and moments: M_y = 154.00 kNm, V_z = 250.00 kN, M_z = 60.00 kNm, V_y = 150.00 kN

3.1.1. plastic verification

plastic verification for M_y = 154.00 kNm, V_z = 250.00 kN, M_z = 60.00 kNm, V_y = 150.00 kN
plastic values: $M_{pl,y,Rd} = W_{pl,y} \cdot f_y / \gamma_{M0}$ = 183.11 kNm, $V_{pl,z,Rd} = A_{vz} \cdot f_y / (3^{1/2} \cdot \gamma_{M0})$ = 624.82 kN
$M_{pl,z,Rd} = W_{pl,z} \cdot f_y / \gamma_{M0}$ = 138.43 kNm, $V_{pl,y,Rd} = A_{vy} \cdot f_y / (3^{1/2} \cdot \gamma_{M0})$ = 416.55 kN

shear force
reduction factors:
z-Ri: $0.5 \cdot V_{pl,z,Rd}$ = 312.41 kN > $|V_{z,Ed}|$ = 250.00 kN: ρ_z = 0 (no deduction)
y-Ri: $0.5 \cdot V_{pl,y,Rd}$ = 208.27 kN > $|V_{y,Ed}|$ = 150.00 kN: ρ_y = 0 (no deduction)

bending
verification: $(|M_{y,Ed}|/M_{pl,y,Rd})^{\alpha} + (|M_{z,Ed}|/M_{pl,z,Rd})^{\beta}$ = 0.750 + 0.250 = 1.000 < 1 ok
with α = 1.66, β = 1.66
utilization: $U = 1.000^{1/2}$ = 1.000

4. Lk 3: c)

4.1. verification of cross-section

internal forces and moments: N = 200.00 kN, M_y = 154.00 kNm, V_z = 250.00 kN, M_z = 60.00 kNm, V_y = 150.00 kN

4.1.1. plastic verification

plastic verification for N = 200.00 kN, M_y = 154.00 kNm, V_z = 250.00 kN, M_z = 60.00 kNm
V_y = 150.00 kN
plastic values: $N_{pl,Rd} = A \cdot f_y / \gamma_{M0}$ = 1803.70 kN, $M_{pl,y,Rd} = W_{pl,y} \cdot f_y / \gamma_{M0}$ = 183.11 kNm
$V_{pl,z,Rd} = A_{vz} \cdot f_y / (3^{1/2} \cdot \gamma_{M0})$ = 624.82 kN, $M_{pl,z,Rd} = W_{pl,z} \cdot f_y / \gamma_{M0}$ = 138.43 kNm, $V_{pl,y,Rd} = A_{vy} \cdot f_y / (3^{1/2} \cdot \gamma_{M0})$ = 416.55 kN

shear force
reduction factors:
z-Ri: $0.5 \cdot V_{pl,z,Rd}$ = 312.41 kN > $|V_{z,Ed}|$ = 250.00 kN: ρ_z = 0 (no deduction)
y-Ri: $0.5 \cdot V_{pl,y,Rd}$ = 208.27 kN > $|V_{y,Ed}|$ = 150.00 kN: ρ_y = 0 (no deduction)

bending and axial force
deduction M_y: $f_{N,y} = (1-n)/(1-0.5 \cdot a)$ = 1.185 > 1 ⇒ $f_{N,y}$ = 1, $n = |N_{Ed}|/N_{pl,,Rd}$ = 0.111, $a = (A-A_f)/A$ = 0.500 ≤ 0.5
$A_f = 2 \cdot b_f \cdot t_f$ = 32.00 cm², A = 76.75 cm² ⇒ $M_{pl,y,Rd} = M_{pl,y,Rd} \cdot f_{N,y}$ = 183.11 kNm
deduction M_z: $f_{N,z} = (1-n)/(1-0.5 \cdot a)$ = 1.117 > 1 ⇒ $f_{N,z}$ = 1, $n = |N_{Ed}|/N_{pl,,Rd}$ = 0.111, $a = (A-A_w)/A$ = 0.408 ≤ 0.5
$A_w = 2 \cdot h_w \cdot t_w$ = 45.44 cm², A = 76.75 cm² ⇒ $M_{pl,z,Rd} = M_{pl,z,Rd} \cdot f_{N,z}$ = 138.43 kNm

bending
verification: $(|M_{y,Ed}|/M_{pl,y,Rd})^{\alpha} + (|M_{z,Ed}|/M_{pl,z,Rd})^{\beta}$ = 0.747 + 0.245 = 0.992 < 1 ok
with α = 1.68, β = 1.68
utilization: $U = 0.992^{1/2}$ = 0.996

5. final result

maximum utilization [Lk 2]: resistance max U = 1.000 < 1 ok

verification succeeded