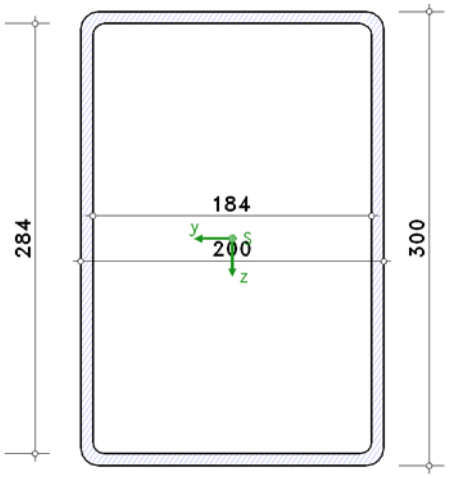
POS. 29: KINDMANN/FRICKEL 10.6.5

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

1. input report

scale 1:5.0



steel
steel parameters:
char. yield strength ($t \le 40$ mm) $f_{y,40}$ = 360.0 N/mm²
char. tensile strength ($t \le 40$ mm) $f_{u,40}$ = 490.0 N/mm²
char. yield strength (40 mm < $t \le 80$ mm) $f_{y,80}$ = 335.0 N/mm²
char. tensile strength (40 mm < $t \le 80$ mm) $f_{u,80}$ = 470.0 N/mm²
char. yield strength (t > 80 mm) $f_{y,\infty}$ = 335.0 N/mm²
char. tensile strength (t > 80 mm) $f_{u,\infty}$ = 470.0 N/mm²
elastic modulus E = 210000.0 N/mm²
material safety factor
resistance of cross-sections γ_{M0} = 1.10
geometry
section RR 300 x 200 x 8.0(w)
resistance
elastic verification, calculation as thin-walled cross-section
plastic verification acc. to EC 3-1-1, 6.2
valid normal, shear-, equivalent stress: $\sigma_{x,Rd}$ = 327.3 N/mm², τ_{Rd} = 189.0 N/mm², $\sigma_{v,Rd}$ = 327.3 N/mm²
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: $M_{y,Ed}$ = -24000.00 kNcm, $V_{z,Ed}$ = 48.00 kN, $T_{t,Ed}$ = 2400.00 kNcm

notes
buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: M_y = -24000.00 kNcm, V_z = 48.00 kN, T_t = 2400.00 kNcm

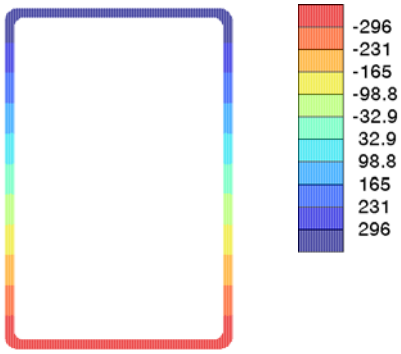
2.1.1. elastic verification

elastic verification for M_y = -240.00 kNm, V_z = 48.00 kN, T_t = 24.00 kNm
elastic stresses: max $|\sigma_x|$ = 370.48 N/mm², max τ = 40.58 N/mm², max σ_v = 375.14 N/mm²

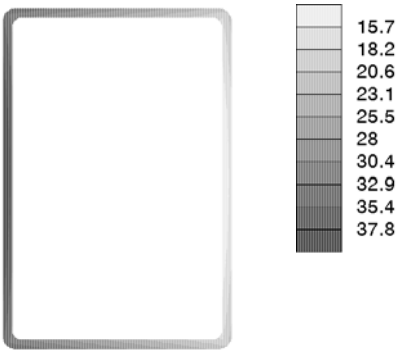
max σ_x	bei y = -80.0 mm, z = -150.0 mm:	σ_x = 370.48 N/mm², τ = 23.12 N/mm², σ_v = 372.64 N/mm²
min σ_x	bei y = 80.0 mm, z = 150.0 mm:	σ_x = -370.48 N/mm², τ = 34.03 N/mm², σ_v = 375.14 N/mm²
max τ	bei y = 100.0 mm, z = 0.0 mm:	σ_x = -0.00 N/mm², τ = 40.58 N/mm², σ_v = 70.28 N/mm²
max σ_v	bei y = 80.0 mm, z = 150.0 mm:	σ_x = -370.48 N/mm², τ = 34.03 N/mm², σ_v = 375.14 N/mm²

valid equivalent stress: $\sigma_{v,Rd}$ = 327.3 N/mm²
verification: σ_v = 375.14 N/mm² > $\sigma_{v,Rd}$ = 327.27 N/mm² $\Rightarrow$ U_σ = 1.146 > 1 **fault !!**

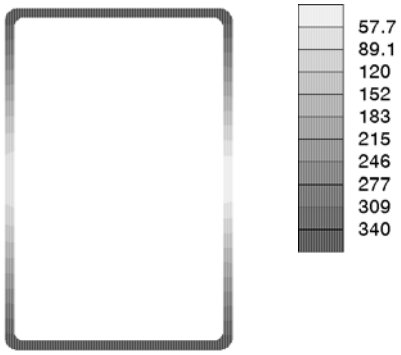
normal stresses σ_x [N/mm²]
min σ_x = -370.6, max σ_x = 370.6



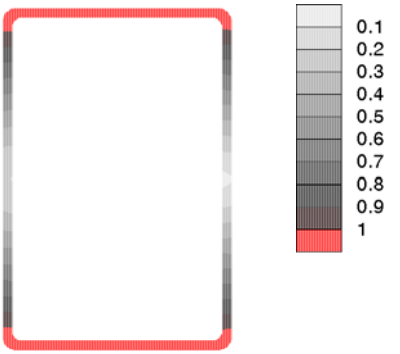
shear stresses τ [N/mm²]
max τ = 40.6



equivalent stresses σ_v [N/mm²]
max σ_v = 375.4



utilization U_σ
max U_σ = 1.147



stresses, utilizations

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
-12.0	300.0	-370.56	34.83	375.44	1.147 > 1
-11.5	300.0	-370.56	34.84	375.44	1.147 > 1
-188.0	0.0	370.56	22.33	372.57	1.138 > 1
0.0	150.0	0.00	40.59	70.30	0.215

y,z: node coordinates; σ_x,τ,σ_v: stresses; U_σ: stress utilization

2.1.2. plastic verification

plastic verification for M_y = -240.00 kNm, V_z = 48.00 kN, T_t = 24.00 kNm
plastic values: $M_{pl,y,Rd} = W_{pl,y} \cdot f_y/\gamma_{M0}$ = 255.00 kNm, $V_{pl,z,Rd} = A_{vz} \cdot f_y/(3^{1/2} \cdot \gamma_{M0})$ = 870.16 kN

torsion
$\tau_{t,Ed} = |T_{t,Ed}|/\min W_t$ = 26.80 N/mm², min W_t = 895.65 cm³

shear force and torsion
deduction V_z: $\tau_{t,z,Ed} = |T_{t,Ed}|/W_{t,z}$ = 26.80 N/mm², $W_{t,z}$ = 895.65 cm³
$f_{T,z} = 1 - \tau_{t,z,Ed}/\tau_{Rd}$ = 0.858 ⇒ $V_{pl,T,z,Rd} = V_{pl,z,Rd} \cdot f_{T,z}$ = 746.75 kNm

shear force
reduction factors:
z-Ri: $0.5 \cdot V_{pl,T,z,Rd}$ = 373.38 kN > $|V_{z,Ed}|$ = 48.00 kN: ρ_z = 0 (no deduction)
$|V_{y,Ed}|$ = 0: ρ_y = 0 (no deduction)

bending
verification: $|M_{y,Ed}|/M_{pl,y,Rd}$ = 0.941 < 1 ok

3. final result

maximum utilization: resistance max U = 1.146 > 1 fault !!

resistance not ensured !!