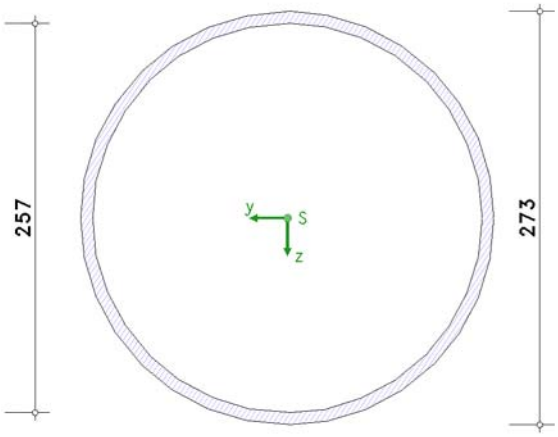
POS. 28: KINDMANN/FRICKEL 10.5.5

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) $f_{y,40} = 240.0$ N/mm²
char. tensile strength ($t \le 40$ mm) $f_{u,40} = 360.0$ N/mm²
char. yield strength (40 mm $< t \le 80$ mm) $f_{y,80} = 215.0$ N/mm²
char. tensile strength (40 mm $< t \le 80$ mm) $f_{u,80} = 360.0$ N/mm²
char. yield strength ($t > 80$ mm) $f_{y,\infty} = 215.0$ N/mm²
char. tensile strength ($t > 80$ mm) $f_{u,\infty} = 360.0$ N/mm²
elastic modulus $E = 210000.0$ N/mm²
material safety factor
resistance of cross-sections $\gamma_{M0} = 1.10$
geometry
section R 273.0 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: $\sigma_{x,Rd} = 218.2$ N/mm², $\tau_{Rd} = 126.0$ N/mm², $\sigma_{v,Rd} = 218.2$ 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: $M_{y,Ed} = 100.00$ kNm, $V_{z,Ed} = 116.00$ kN, $T_{t,Ed} = 40.00$ kNm

notes
buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: $M_y = 100.00$ kNm, $V_z = 116.00$ kN, $T_t = 40.00$ kNm

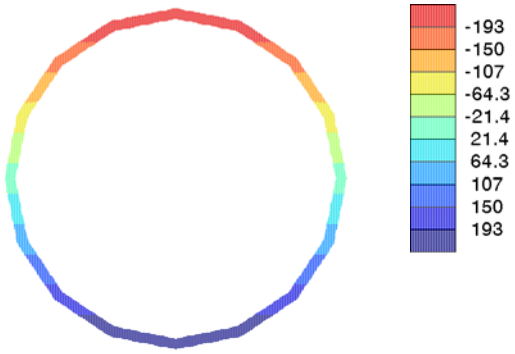
2.1.1. elastic verification

elastic verification for $M_y = 100.00$ kNm, $V_z = 116.00$ kN, $T_t = 40.00$ kNm
elastic stresses: max $|\sigma_x| = 233.39$ N/mm², max $\tau = 84.53$ N/mm², max $\sigma_v = 248.49$ N/mm²

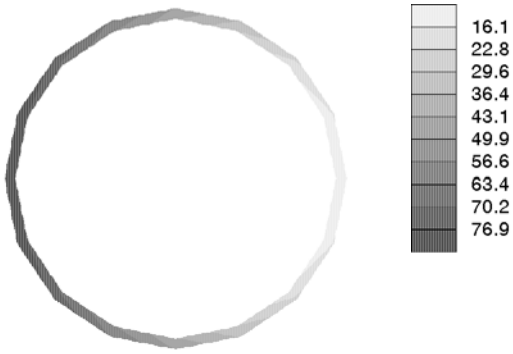
max σ_x	bei y = 0.0 mm, z = 136.6 mm:	$\sigma_x = 233.39$ N/mm², $\tau = 49.25$ N/mm², $\sigma_v = 248.49$ N/mm²
min σ_x	bei y = -0.0 mm, z = -136.6 mm:	$\sigma_x = -233.39$ N/mm², $\tau = 49.25$ N/mm², $\sigma_v = 248.49$ N/mm²
max τ	bei y = 136.6 mm, z = -0.0 mm:	$\sigma_x = -0.00$ N/mm², $\tau = 84.53$ N/mm², $\sigma_v = 146.41$ N/mm²
max σ_v	bei y = 0.0 mm, z = 136.6 mm:	$\sigma_x = 233.39$ N/mm², $\tau = 49.25$ N/mm², $\sigma_v = 248.49$ N/mm²

valid equivalent stress: $\sigma_{v,Rd} = 218.2$ N/mm²
verification: $\sigma_v = 248.49$ N/mm² > $\sigma_{v,Rd} = 218.18$ N/mm² $\Rightarrow$ $U_\sigma = 1.139 > 1$ fault !!

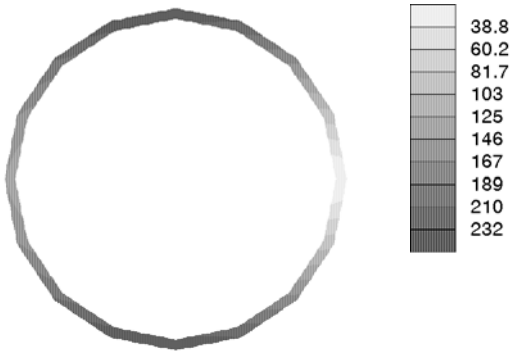
normal stresses σ_x [N/mm²]
min σ_x = -241.0, max σ_x = 241.0



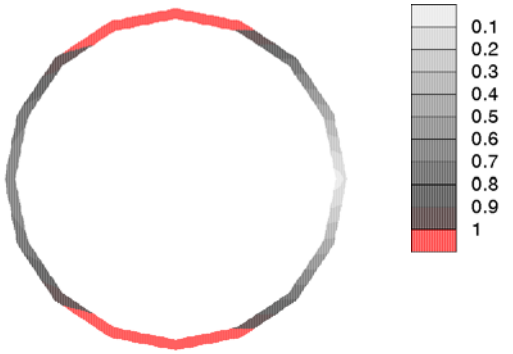
shear stresses τ [N/mm²]
max τ = 84.5



equivalent stresses σ_v [N/mm²]
max σ_v = 255.8



utilization U_σ
max U_σ = 1.172



stresses, utilizations

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
-136.6	273.2	241.00	49.46	255.77	1.172 > 1
-136.6	0.0	-241.00	49.46	255.77	1.172 > 1
0.0	136.6	0.00	84.52	146.39	0.671

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

2.1.2. plastic verification

plastic verification for M = 100.00 kNm, V = 116.00 kN, T_t = 40.00 kNm
plastic values: $M_{pl,Rd} = W_{pl} \cdot f_y/\gamma_{M0}$ = 120.23 kNm, $V_{pl,Rd} = A_v \cdot f_y/(3^{1/2} \cdot \gamma_{M0})$ = 534.10 kN

torsion
$\tau_{t,Ed} = |T_{t,Ed}|/W_t$ = 45.33 N/mm², W_t = 882.47 cm³

shear force and torsion
deduction: $\tau_{t,Ed} = |T_{t,Ed}|/W_t$ = 45.33 N/mm², W_t = 882.47 cm³
$f_T = 1 - \tau_{t,Ed}/\tau_{Rd}$ = 0.640 ⇒ $V_{pl,T,Rd} = V_{pl,Rd} \cdot f_T$ = 341.91 kNm

shear force
reduction factor: $\rho = (2 \cdot V_{Ed}/V_{pl,T,Rd} - 1)^2$ = 0.103

bending and shear force/torsion
$M_{pl,V,Rd} = W_{pl} \cdot (1-\rho) \cdot f_y/\gamma_{M0}$ = 107.80 kNm

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

3. final result

maximum utilization: resistance max U = 1.139 > 1 fault !!

resistance not ensured !!