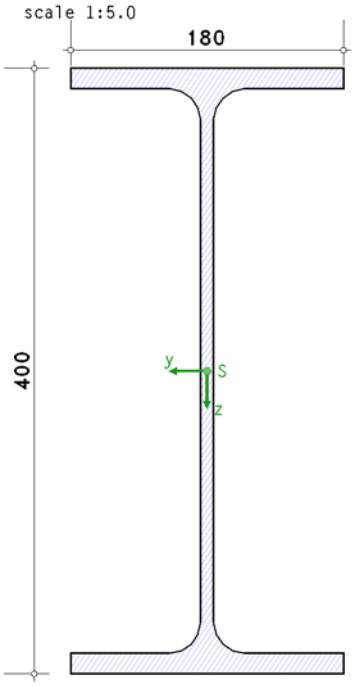
POS. 23: KINDMANN/KRÜGER 2.9.3

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

1. input report



steel
steel grade S235
material safety factor
resistance of cross-sections $\gamma_{M0} = 1.00$
geometry
section IPE400
resistance
elastic verification, calculation as thin-walled cross-section
plastic verification acc. to EC 3-1-1, 6.2
valid normal, shear-, equivalent stress: $\sigma_{x,Rd} = 235.0$ N/mm², $\tau_{Rd} = 135.7$ N/mm², $\sigma_{v,Rd} = 235.0$ 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: Mittelstütze
$M_{y,Ed} = -261.00$ kNm, $V_{z,Ed} = 217.50$ kN

notes
buckling is not investigated.

2. Lk 1: Mittelstütze

2.1. verification of cross-section

internal forces and moments: $M_y = -261.00$ kNm, $V_z = 217.50$ kN

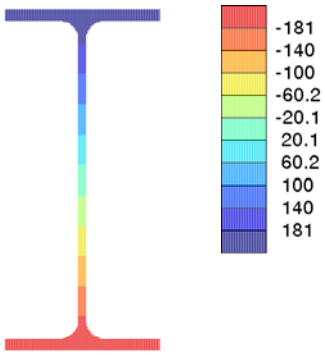
2.1.1. elastic verification

elastic verification for $M_y = -261.00$ kNm, $V_z = 217.50$ kN
elastic stresses: max $|\sigma_x| = 225.68$ N/mm², max $\tau = 71.51$ N/mm², max $\sigma_v = 236.79$ N/mm²

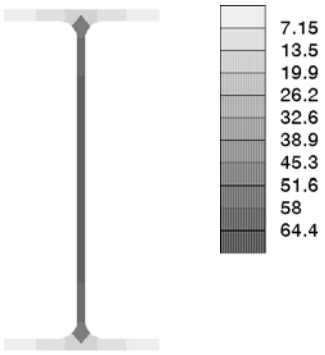
max σ_x	bei y = 90.0 mm, z = -200.0 mm:	$\sigma_x = 225.68$ N/mm², $\tau = 0.00$ N/mm², $\sigma_v = 225.68$ N/mm²
min σ_x	bei y = 90.0 mm, z = 200.0 mm:	$\sigma_x = -225.68$ N/mm², $\tau = 0.00$ N/mm², $\sigma_v = 225.68$ N/mm²
max τ	bei y = 0.0 mm, z = 0.0 mm:	$\sigma_x = -0.00$ N/mm², $\tau = 71.51$ N/mm², $\sigma_v = 123.86$ N/mm²
max σ_v	bei y = 0.0 mm, z = -193.2 mm:	$\sigma_x = 218.06$ N/mm², $\tau = 53.29$ N/mm², $\sigma_v = 236.79$ N/mm²

valid equivalent stress: $\sigma_{v,Rd} = 235.0$ N/mm²
verification: $\sigma_v = 236.79$ N/mm² > $\sigma_{v,Rd} = 235.00$ N/mm² ⇒ $U_\sigma = 1.008 > 1$ fault !!

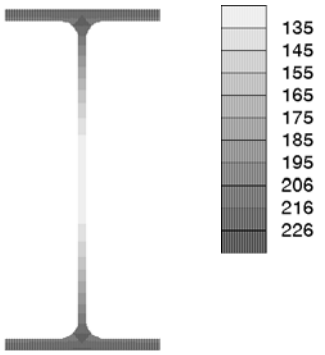
normal stresses σ_x [N/mm²]
min σ_x = -225.8, max σ_x = 225.8



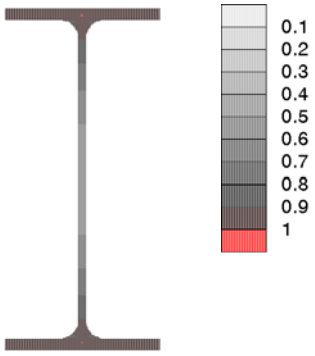
shear stresses τ [N/mm²]
max τ = 71.5



equivalent stresses σ_v [N/mm²]
max σ_v = 236.9



utilization U_σ
max U_σ = 1.008



stresses, utilizations

y	z	σ_x	τ	σ_v	U_σ
mm	mm	N/mm²	N/mm²	N/mm²	
0.0	0.0	225.76	0.00	225.76	0.961
-90.0	6.8	218.20	53.29	236.91	1.008 > 1
-85.7	200.0	0.00	71.51	123.86	0.527
0.0	400.0	-225.76	0.00	225.76	0.961

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

2.1.2. plastic verification

plastic verification for M_y = -261.00 kNm, V_z = 217.50 kN
plate buckling: section class of the section 1 ≤ 2 ok
shear buckling: $h_p/t_p = 43.37 \le 72\cdot\varepsilon/\eta = 60.00$ ok
plastic values: $M_{pl,y,Rd} = W_{pl,y}\cdot f_y/\gamma_{M0}$ = 307.15 kNm, $V_{pl,z,Rd} = A_{vz}\cdot f_y/(3^{1/2}\cdot\gamma_{M0})$ = 579.27 kN

shear force
reduction factors:
web: $0.5\cdot V_{pl,z,Rd}$ = 289.63 kN > $|V_{z,Ed}|$ = 217.50 kN: ρ_z = 0 (no deduction)
$|V_{y,Ed}|$ = 0: ρ_y = 0 (no deduction)

bending
verification: $|M_{y,Ed}|/M_{pl,y,Rd}$ = 0.850 < 1 ok

3. final result

maximum utilization: resistance max U = 1.008 > 1 fault !!

resistance not ensured !!