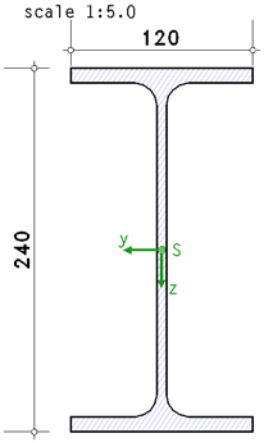
POS. 14: KINDMANN/KRÜGER 2.8.2

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 γ_{M0} = 1.00
geometry
section IPE240
resistance
elastic verification, calculation as thin-walled cross-section
valid normal, shear-, equivalent stress: $\sigma_{x,Rd}$ = 235.0 N/mm², τ_{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: N_{Ed} = 100.00 kN, $M_{y,Ed}$ = 70.00 kNm, $V_{z,Ed}$ = 80.00 kN
Lk 2: $V_{z,Ed} < 0.5 * V_{pl,z,Rd}$
N_{Ed} = 100.00 kN, $M_{y,Ed}$ = 70.00 kNm
Lk 3: N_{Ed} = 100.00 kN, $M_{z,Ed}$ = 9.80 kNm, $V_{y,Ed}$ = 80.00 kN

notes
buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: N = 100.00 kN, M_y = 70.00 kNm, V_z = 80.00 kN

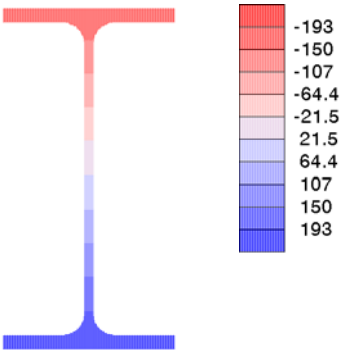
2.1.1. elastic verification

elastic verification for N = 100.00 kN, M_y = 70.00 kNm, V_z = 80.00 kN
elastic stresses: max $|\sigma_x|$ = 241.51 N/mm², max τ = 60.77 N/mm², max σ_v = 246.31 N/mm²

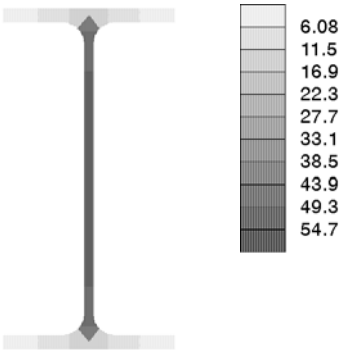
max σ_x	bei y = 60.0 mm, z = 120.0 mm:	σ_x = 241.51 N/mm², τ = 0.00 N/mm², σ_v = 241.51 N/mm²
min σ_x	bei y = 60.0 mm, z = -120.0 mm:	σ_x = -190.36 N/mm², τ = 0.00 N/mm², σ_v = 190.36 N/mm²
max τ	bei y = 0.0 mm, z = 0.0 mm:	σ_x = 25.58 N/mm², τ = 60.77 N/mm², σ_v = 108.32 N/mm²
max σ_v	bei y = 0.0 mm, z = 115.1 mm:	σ_x = 232.70 N/mm², τ = 46.62 N/mm², σ_v = 246.31 N/mm²

valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 246.31 N/mm² > $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 1.048 > 1 fault !!

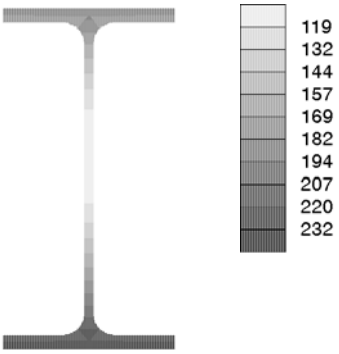
normal stresses σ_x [N/mm²]
min σ_x = -190.3, max σ_x = 241.4



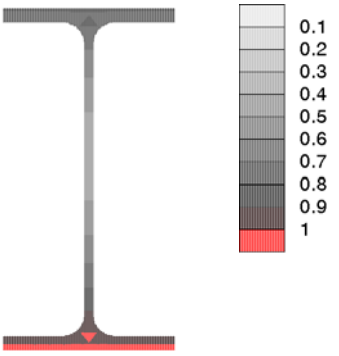
shear stresses τ [N/mm²]
max τ = 60.8



equivalent stresses σ_v [N/mm²]
max σ_v = 246.2



utilization U_σ
max U_σ = 1.048



stresses, utilizations

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
0.0	0.0	-190.32	0.00	190.32	0.810
-60.0	235.1	232.63	46.62	246.24	1.048 > 1
-56.9	120.0	25.57	60.77	108.31	0.461
0.0	240.0	241.44	0.00	241.44	1.027 > 1

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

3. Lk 2: Vz,Ed < 0.5*Vpl,z,Rd

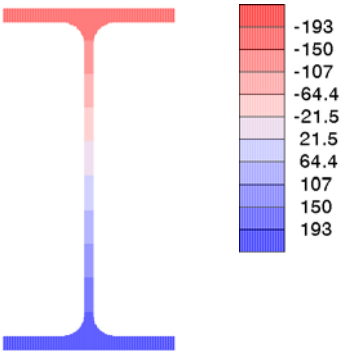
3.1. verification of cross-section

internal forces and moments: N = 100.00 kN, M_y = 70.00 kNm

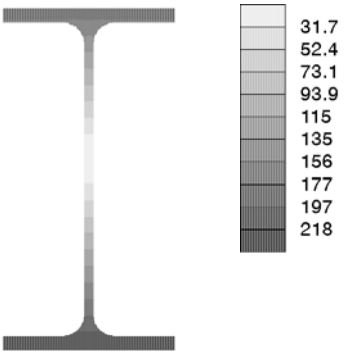
3.1.1. elastic verification

elastic verification for N = 100.00 kN, M_y = 70.00 kNm
elastic stresses: max $|\sigma_x|$ = 241.51 N/mm², max τ = 0.00 N/mm², max σ_v = 241.51 N/mm²
max σ_x bei y = 60.0 mm, z = 120.0 mm: σ_x = 241.51 N/mm², τ = 0.00 N/mm², σ_v = 241.51 N/mm²
min σ_x bei y = 60.0 mm, z = -120.0 mm: σ_x = -190.36 N/mm², τ = 0.00 N/mm², σ_v = 190.36 N/mm²
max σ_v bei y = 60.0 mm, z = 120.0 mm: σ_x = 241.51 N/mm², τ = 0.00 N/mm², σ_v = 241.51 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 241.51 N/mm² > $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 1.028 > 1 **fault !!**

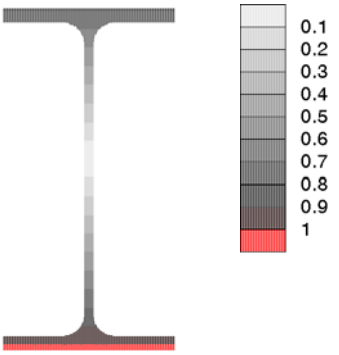
normal stresses σ_x [N/mm²]
min σ_x = -190.3, max σ_x = 241.4



equivalent stresses σ_v [N/mm²]
max σ_v = 241.4



utilization U_σ
max U_σ = 1.027



stresses, utilizations

y mm	z mm	σ_x N/mm²	σ_v N/mm²	U_σ
0.0	0.0	-190.32	190.32	0.810
0.0	240.0	241.44	241.44	1.027 > 1
-60.0	240.0	241.44	241.44	1.027 > 1

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

4. Lk 3

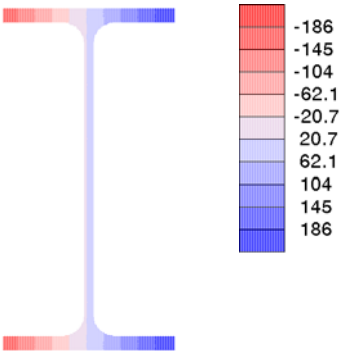
4.1. verification of cross-section

internal forces and moments: N = 100.00 kN, M_z = 9.80 kNm, V_y = 80.00 kN

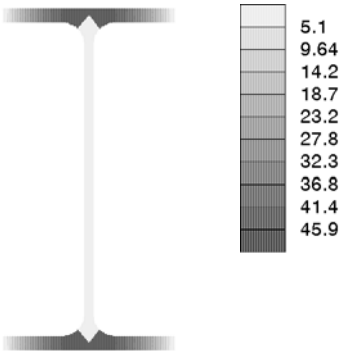
4.1.1. elastic verification

elastic verification for N = 100.00 kN, M_z = 9.80 kNm, V_y = 80.00 kN
elastic stresses: max $|\sigma_x|$ = 232.62 N/mm², max τ = 51.02 N/mm², max σ_v = 232.62 N/mm²
max σ_x bei y = -60.0 mm, z = -115.1 mm: σ_x = 232.62 N/mm², τ = 0.00 N/mm², σ_v = 232.62 N/mm²
min σ_x bei y = 60.0 mm, z = -115.1 mm: σ_x = -181.47 N/mm², τ = 0.00 N/mm², σ_v = 181.47 N/mm²
max σ_v bei y = -60.0 mm, z = -115.1 mm: σ_x = 232.62 N/mm², τ = 0.00 N/mm², σ_v = 232.62 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 232.62 N/mm² < $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 0.990 < 1 ok

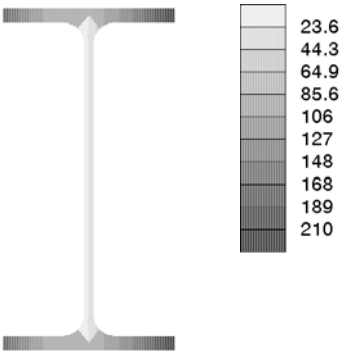
normal stresses σ_x [N/mm²]
min σ_x = -181.7, max σ_x = 232.9



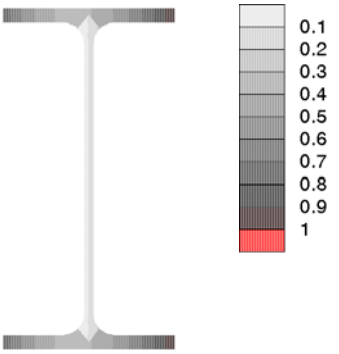
shear stresses τ [N/mm²]
max τ = 51.0



equivalent stresses σ_v [N/mm²]
max σ_v = 232.9



utilization U_σ
max U_σ = 0.991



stresses, utilizations

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
0.0	9.8	-181.74	0.00	181.74	0.773
-60.0	4.9	25.57	51.02	91.99	0.391
-120.0	0.0	232.87	0.00	232.87	0.991

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
-120.0	4.9	232.87	0.00	232.87	0.991
-120.0	9.8	232.87	0.00	232.87	0.991

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

5. final result

maximum utilization [Lk 1]: resistance max U = 1.048 > 1 fault !!

resistance not ensured !!