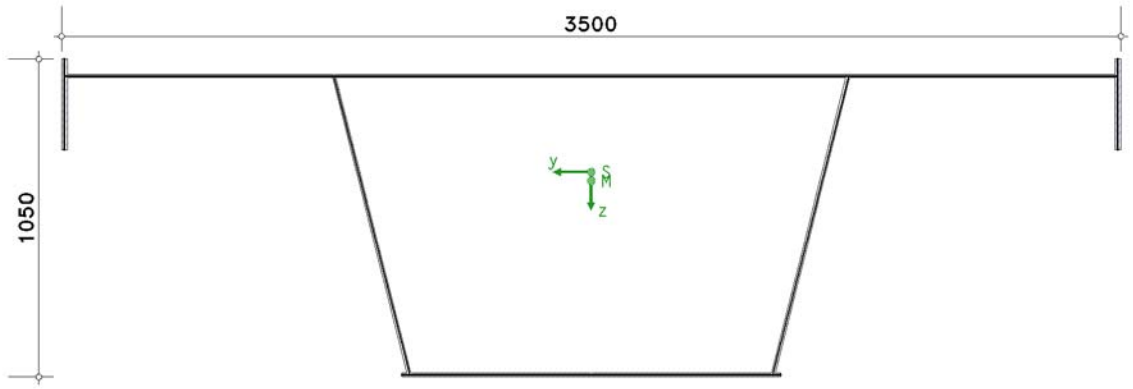
POS. 20: KINDMANN/KRÜGER 2.8.8

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
dimensions of cross-section: y_{min} = -1750.0 mm, y_{max} = 1750.0 mm, z_{min} = -56.0 mm, z_{max} = 994.0 mm
width,height of cross-section: b = 3500.0 mm, h = 1050.0 mm
centroid, rotation angle of main axis: e_y = 0.0 mm, e_z = 318.4 mm, α = 0.00 °

cross-sectional area	A	=	951.34 cm²
bending moment of inertia	I_η	=	1536874.74 cm⁴
bending moment of inertia	I_ζ	=	9283406.01 cm⁴
section modulus	$W_{\eta+}$	=	22747.61 cm³
section modulus	$W_{\eta-}$	=	41051.23 cm³
section modulus	$W_{\zeta+}$	=	53048.03 cm³
section modulus	$W_{\zeta-}$	=	53048.03 cm³
torsional moment of inertia	I_T	=	2063865.66 cm⁴

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} = 50.00 kN, $M_{y,Ed}$ = 4200.00 kNm, $V_{z,Ed}$ = 230.00 kN, $M_{z,Ed}$ = 205.00 kNm, $V_{y,Ed}$ = 60.00 kN
$T_{t,Ed}$ = 160.00 kNm
Lk 2: N,My,Mz
N_{Ed} = 50.00 kN, $M_{y,Ed}$ = 4200.00 kNm, $M_{z,Ed}$ = 205.00 kNm
Lk 3: Vz,Vy
$V_{z,Ed}$ = 230.00 kN, $V_{y,Ed}$ = 60.00 kN
Lk 4: Tt
$T_{t,Ed}$ = 160.00 kNm

notes
buckling is not investigated.

2. Lk 1

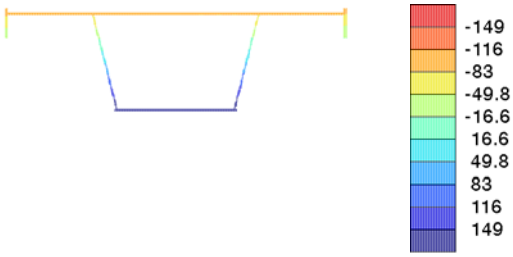
2.1. verification of cross-section

internal forces and moments: N = 50.00 kN, M_y = 4200.00 kNm, V_z = 230.00 kN, M_z = 205.00 kNm, V_y = 60.00 kN, T_t = 160.00

2.1.1. elastic verification

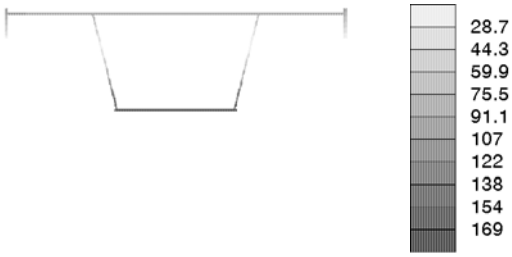
elastic verification for N = 50.00 kN, M_y = 4200.00 kNm, V_z = 230.00 kN, M_z = 205.00 kNm
V_y = 60.00 kN, T_t = 160.00 kNm
elastic stresses: max $|\sigma_x|$ = 186.54 N/mm², max τ = 14.97 N/mm², max σ_v = 186.54 N/mm²
max σ_x bei y = -625.0 mm, z = 675.6 mm: σ_x = 186.54 N/mm², τ = 0.11 N/mm², σ_v = 186.54 N/mm²
min σ_x bei y = 1750.0 mm, z = -374.4 mm: σ_x = -105.65 N/mm², τ = -0.16 N/mm², σ_v = 105.65 N/mm²
max τ bei y = 780.7 mm, z = -20.2 mm: σ_x = -6.71 N/mm², τ = 14.97 N/mm², σ_v = 26.79 N/mm²
max σ_v bei y = -625.0 mm, z = 675.6 mm: σ_x = 186.54 N/mm², τ = 0.11 N/mm², σ_v = 186.54 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 186.54 N/mm² < $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 0.794 < 1 ok

normal stresses σ_x [N/mm²]
min σ_x = -104.2, max σ_x = 186.8

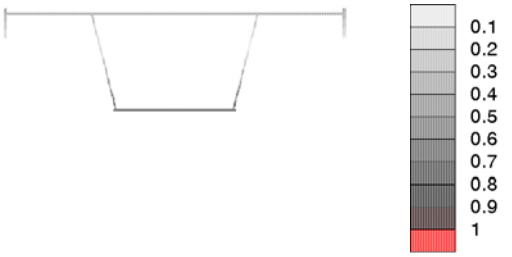


shear stresses τ [N/mm²]
max τ = 15.0

equivalent stresses σ_v [N/mm²]
max σ_v = 186.8



utilization U_σ
max U_σ = 0.795



stresses, utilizations

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
-20.0	0.0	-104.17	0.16	104.17	0.443
-969.3	354.2	-5.31	15.02	26.55	0.113
-2375.0	1050.0	186.76	0.16	186.76	0.795

y mm	z mm	σ_x N/mm²	τ N/mm²	σ_v N/mm²	U_σ
-2375.0	1043.0	186.76	0.00	186.76	0.795
-2355.0	1050.0	186.76	0.35	186.76	0.795

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

3. Lk 2: N,My,Mz

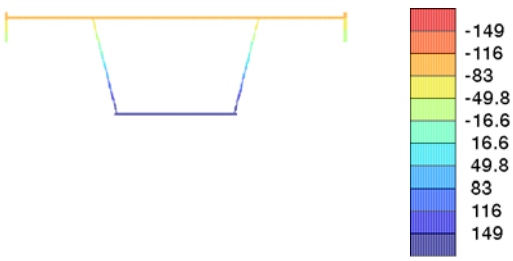
3.1. verification of cross-section

internal forces and moments: N = 50.00 kN, M_y = 4200.00 kNm, M_z = 205.00 kNm

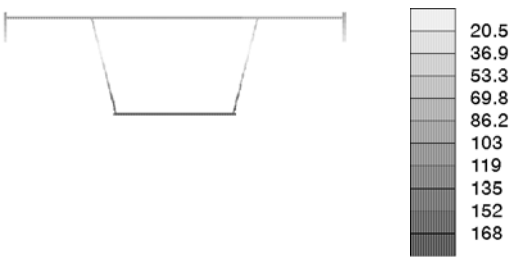
3.1.1. elastic verification

elastic verification for N = 50.00 kN, M_y = 4200.00 kNm, M_z = 205.00 kNm
elastic stresses: max $|\sigma_x|$ = 186.54 N/mm², max τ = 0.00 N/mm², max σ_v = 186.54 N/mm²
max σ_x bei y = -625.0 mm, z = 675.6 mm: σ_x = 186.54 N/mm², τ = 0.00 N/mm², σ_v = 186.54 N/mm²
min σ_x bei y = 1750.0 mm, z = -374.4 mm: σ_x = -105.65 N/mm², τ = 0.00 N/mm², σ_v = 105.65 N/mm²
max σ_v bei y = -625.0 mm, z = 675.6 mm: σ_x = 186.54 N/mm², τ = 0.00 N/mm², σ_v = 186.54 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 186.54 N/mm² < $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 0.794 < 1 ok

normal stresses σ_x [N/mm²]
min σ_x = -104.2, max σ_x = 186.8



equivalent stresses σ_v [N/mm²]
max σ_v = 186.8



utilization U_σ
max U_σ = 0.795

stresses, utilizations

y mm	z mm	σ_x N/mm²	σ_v N/mm²	U_σ
-20.0	0.0	-104.17	104.17	0.443
-2375.0	1050.0	186.76	186.76	0.795
-2375.0	1043.0	186.76	186.76	0.795
-2355.0	1050.0	186.76	186.76	0.795

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

4. Lk 3: Vz,Vy

4.1. verification of cross-section

internal forces and moments: V_z = 230.00 kN, V_y = 60.00 kN

4.1.1. elastic verification

elastic verification for V_z = 230.00 kN, V_y = 60.00 kN
elastic stresses: max $|\sigma_x|$ = 0.00 N/mm², max τ = 11.12 N/mm², max σ_v = 19.26 N/mm²
max τ bei y = -750.0 mm, z = 76.4 mm: σ_x = 0.00 N/mm², τ = 11.12 N/mm², σ_v = 19.26 N/mm²
max σ_v bei y = -750.0 mm, z = 76.4 mm: σ_x = 0.00 N/mm², τ = 11.12 N/mm², σ_v = 19.26 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 19.26 N/mm² < $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 0.082 < 1 **ok**

shear stresses τ [N/mm²]
max τ = 11.1

equivalent stresses σ_v [N/mm²]
max σ_v = 19.3

utilization U_σ
max U_σ = 0.082

stresses, utilizations

y mm	z mm	τ N/mm²	σ_v N/mm²	U_σ
-2509.1	402.5	11.13	19.28	0.082
-2512.5	401.4	11.13	19.28	0.082
-2505.9	402.9	11.13	19.29	0.082

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

5. Lk 4: Tt

5.1. verification of cross-section

internal forces and moments: T_t = 160.00 kNm

5.1.1. elastic verification

elastic verification for T_t = 160.00 kNm
elastic stresses: max $|\sigma_x|$ = 0.00 N/mm², max τ = 4.75 N/mm², max σ_v = 8.23 N/mm²
max σ_v bei y = 0.0 mm, z = -324.4 mm: σ_x = 0.00 N/mm², τ = 4.75 N/mm², σ_v = 8.23 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 8.23 N/mm² < $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 0.035 < 1 ok

shear stresses τ [N/mm²]
max τ = 4.8

equivalent stresses σ_v [N/mm²]
max σ_v = 8.3

utilization U_σ
max U_σ = 0.035

stresses, utilizations

y mm	z mm	τ N/mm²	σ_v N/mm²	U_σ
-1750.0	50.0	4.80	8.31	0.035
-900.0	50.0	4.80	8.31	0.035
-1665.0	50.0	4.80	8.31	0.035

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

6. final result

maximum utilization [Lk 1]: resistance max U = 0.794 < 1 ok

verification succeeded