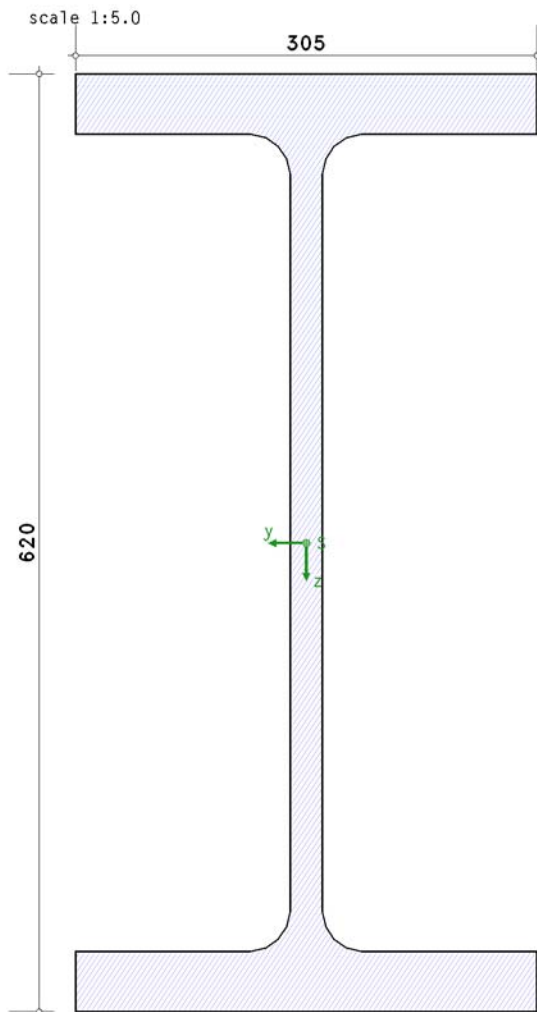


POS. 15: KINDMANN/KRÜGER 2.8.3

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 HE600M

resistance

elastic verification, calculation as thin-walled cross-section

valid normal, shear-, equivalent stress: $\sigma_{x,Rd} = 235.0 \text{ N/mm}^2$, $\tau_{Rd} = 135.7 \text{ N/mm}^2$, $\sigma_{v,Rd} = 235.0 \text{ N/mm}^2$

internal forces and moments referring to local axes of cross-section

σ -generating forces (N, M) work at centroid, τ -generating forces (V, T_t) work at shear center

warping forces (T_ω , B) work at shear center

Lk 1: $N_{Ed} = 300.00 \text{ kN}$, $M_{y,Ed} = 144000.00 \text{ kNcm}$, $V_{z,Ed} = 800.00 \text{ kN}$, $M_{z,Ed} = -10000.00 \text{ kNcm}$, $V_{y,Ed} = -500.00 \text{ kN}$, $T_{t,Ed} = 2000.00 \text{ kNcm}$, $T_{\omega,Ed} = 18000.00 \text{ kNcm}$, $B_{Ed} = -300000.00 \text{ kNcm}^2$

Lk 2: N, M_y, M_z, M_w

$N_{Ed} = 300.00 \text{ kN}$, $M_{y,Ed} = 144000.00 \text{ kNcm}$, $M_{z,Ed} = -10000.00 \text{ kNcm}$, $B_{Ed} = -300000.00 \text{ kNcm}^2$

Lk 3: V_z, V_y, T_w

$V_{z,Ed} = 800.00 \text{ kN}$, $V_{y,Ed} = -500.00 \text{ kN}$, $T_{\omega,Ed} = 18000.00 \text{ kNcm}$

Lk 4: T_t

$T_{t,Ed} = 2000.00 \text{ kNcm}$

notes

buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: $N = 300.00 \text{ kN}$, $M_y = 144000.00 \text{ kNcm}$, $V_z = 800.00 \text{ kN}$, $M_z = -10000.00 \text{ kNcm}$, $V_y = -500.00 \text{ kN}$,
 $T_\omega = 18000.00 \text{ kNcm}$, $B = -300000.00 \text{ kNcm}^2$

2.1.1. elastic verification

elastic verification for $N = 300.00 \text{ kN}$, $M_y = 1440.00 \text{ kNm}$, $V_z = 800.00 \text{ kN}$, $M_z = -100.00 \text{ kNm}$

$V_y = -500.00 \text{ kN}$, $T_t = 20.00 \text{ kNm}$, $T_\omega = 180.00 \text{ kNm}$, $B = -30.00 \text{ kNm}^2$

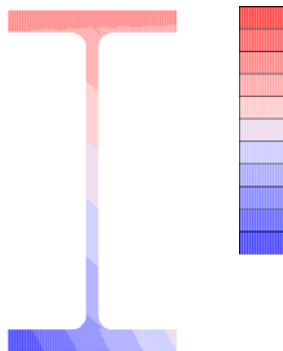
elastic stresses: $\max |\sigma_x| = 360.03 \text{ N/mm}^2$, $\max \tau = 134.63 \text{ N/mm}^2$, $\max \sigma_v = 370.69 \text{ N/mm}^2$

$\max \sigma_x$ bei $y = 152.5 \text{ mm}$, $z = 310.0 \text{ mm}$: $\sigma_x = 360.03 \text{ N/mm}^2$, $\tau = 50.96 \text{ N/mm}^2$, $\sigma_v = 370.69 \text{ N/mm}^2$
 $\min \sigma_x$ bei $y = 152.5 \text{ mm}$, $z = -310.0 \text{ mm}$: $\sigma_x = -182.85 \text{ N/mm}^2$, $\tau = -50.96 \text{ N/mm}^2$, $\sigma_v = 203.03 \text{ N/mm}^2$
 $\max \tau$ bei $y = 0.0 \text{ mm}$, $z = 310.0 \text{ mm}$: $\sigma_x = 196.28 \text{ N/mm}^2$, $\tau = 134.63 \text{ N/mm}^2$, $\sigma_v = 304.80 \text{ N/mm}^2$
 $\max \sigma_v$ bei $y = 152.5 \text{ mm}$, $z = 310.0 \text{ mm}$: $\sigma_x = 360.03 \text{ N/mm}^2$, $\tau = 50.96 \text{ N/mm}^2$, $\sigma_v = 370.69 \text{ N/mm}^2$

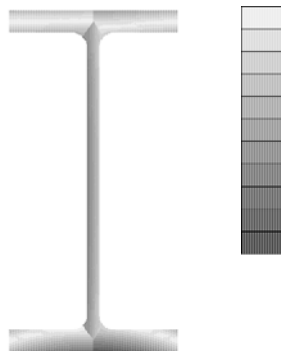
valid equivalent stress: $\sigma_{v,Rd} = 235.0 \text{ N/mm}^2$

verification: $\sigma_v = 370.69 \text{ N/mm}^2 > \sigma_{v,Rd} = 235.00 \text{ N/mm}^2 \Rightarrow U_\sigma = 1.577 > 1$ **fault !!**

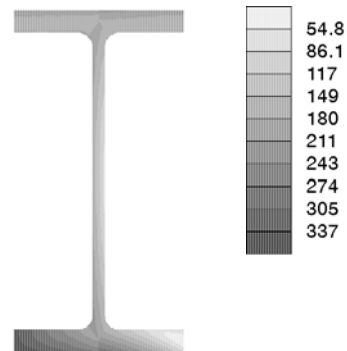
normal stresses σ_x [N/mm²]
 $\min \sigma_x = -184.1$, $\max \sigma_x = 361.3$



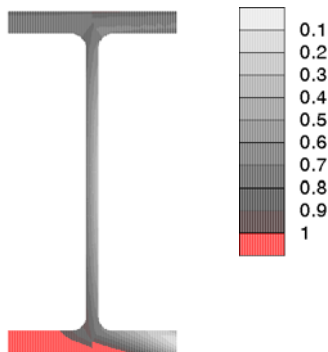
shear stresses τ [N/mm²]
 $\max \tau = 134.6$



equivalent stresses σ_v [N/mm²]
 $\max \sigma_v = 371.9$



utilization U_σ
 $\max U_\sigma = 1.583$



stresses, utilizations

y mm	z mm	σ_x N/mm ²	τ N/mm ²	σ_v N/mm ²	U_σ
-22.9	0.0	-184.09	50.83	204.06	0.868
0.0	620.0	361.29	50.96	371.92	1.583 > 1
-152.5	620.0	196.89	134.64	305.21	1.299 > 1

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

3. Lk 2: N, My, Mz, Mw

3.1. verification of cross-section

internal forces and moments: $N = 300.00 \text{ kN}$, $M_y = 144000.00 \text{ kNcm}$, $M_z = -10000.00 \text{ kNcm}$, $B = -300000.00 \text{ kNcm}^2$

3.1.1. elastic verification

elastic verification for $N = 300.00 \text{ kN}$, $M_y = 1440.00 \text{ kNm}$, $M_z = -100.00 \text{ kNm}$, $B = -30.00 \text{ kNm}^2$

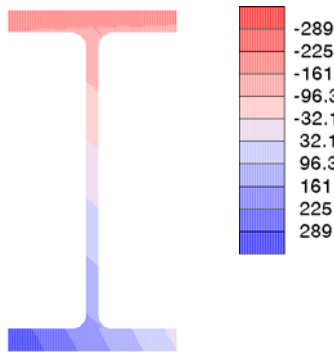
elastic stresses: $\max |\sigma_x| = 360.03 \text{ N/mm}^2$, $\max \tau = 0.00 \text{ N/mm}^2$, $\max \sigma_v = 360.03 \text{ N/mm}^2$

$\max \sigma_x$ bei $y = 152.5 \text{ mm}$, $z = 310.0 \text{ mm}$: $\sigma_x = 360.03 \text{ N/mm}^2$, $\tau = 0.00 \text{ N/mm}^2$, $\sigma_v = 360.03 \text{ N/mm}^2$
 $\min \sigma_x$ bei $y = 152.5 \text{ mm}$, $z = -310.0 \text{ mm}$: $\sigma_x = -182.85 \text{ N/mm}^2$, $\tau = 0.00 \text{ N/mm}^2$, $\sigma_v = 182.85 \text{ N/mm}^2$
 $\max \sigma_v$ bei $y = 152.5 \text{ mm}$, $z = 310.0 \text{ mm}$: $\sigma_x = 360.03 \text{ N/mm}^2$, $\tau = 0.00 \text{ N/mm}^2$, $\sigma_v = 360.03 \text{ N/mm}^2$

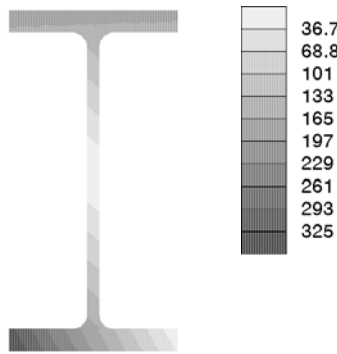
valid equivalent stress: $\sigma_{v,Rd} = 235.0 \text{ N/mm}^2$

verification: $\sigma_v = 360.03 \text{ N/mm}^2 > \sigma_{v,Rd} = 235.00 \text{ N/mm}^2 \Rightarrow U_\sigma = 1.532 > 1$ **fault !!**

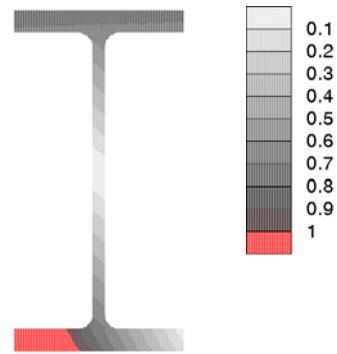
normal stresses σ_x [N/mm²]
min $\sigma_x = -184.1$, max $\sigma_x = 361.3$



equivalent stresses σ_v [N/mm²]
max $\sigma_v = 361.3$



utilization U_σ
max $U_\sigma = 1.537$



stresses, utilizations

y mm	z mm	σ_x N/mm ²	σ_v N/mm ²	U_σ
-22.9	0.0	-184.09	184.09	0.783
0.0	620.0	361.29	361.29	1.537 > 1

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

4. Lk 3: V_z, V_y, T_ω

4.1. verification of cross-section

internal forces and moments: $V_z = 800.00$ kN, $V_y = -500.00$ kN, $T_\omega = 18000.00$ kNcm

4.1.1. elastic verification

elastic verification for $V_z = 800.00$ kN, $V_y = -500.00$ kN, $T_\omega = 180.00$ kNm

elastic stresses: max $|\sigma_x| = 0.00$ N/mm², max $\tau = 83.68$ N/mm², max $\sigma_v = 144.93$ N/mm²

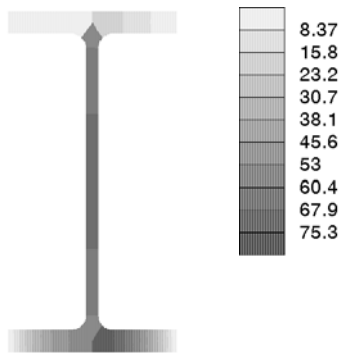
max τ bei $y = 0.0$ mm, $z = 290.0$ mm: $\sigma_x = 0.00$ N/mm², $\tau = 83.68$ N/mm², $\sigma_v = 144.93$ N/mm²

max σ_v bei $y = 0.0$ mm, $z = 290.0$ mm: $\sigma_x = 0.00$ N/mm², $\tau = -83.68$ N/mm², $\sigma_v = 144.93$ N/mm²

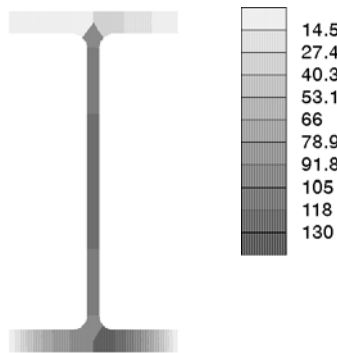
valid equivalent stress: $\sigma_{v,Rd} = 235.0$ N/mm²

verification: $\sigma_v = 144.93$ N/mm² < $\sigma_{v,Rd} = 235.00$ N/mm² $\Rightarrow U_\sigma = 0.617 < 1$ **ok**

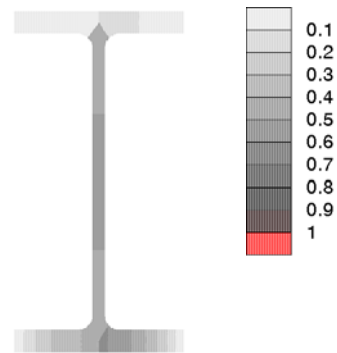
shear stresses τ [N/mm²]
max $\tau = 83.7$



equivalent stresses σ_v [N/mm²]
max $\sigma_v = 144.9$



utilization U_σ
max $U_\sigma = 0.617$



stresses, utilizations

y mm	z mm	τ N/mm ²	σ_v N/mm ²	U_σ
-152.5	600.0	83.68	144.94	0.617
-152.5	620.0	83.68	144.94	0.617

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

5. Lk 4: T_t

5.1. verification of cross-section

internal forces and moments: $T_t = 2000.00$ kNcm

5.1.1. elastic verification

elastic verification for $T_t = 20.00 \text{ kNm}$

elastic stresses: $\max |\sigma_x| = 0.00 \text{ N/mm}^2$, $\max \tau = 50.96 \text{ N/mm}^2$, $\max \sigma_v = 88.26 \text{ N/mm}^2$

$\max \sigma_v$ bei $y = 152.5 \text{ mm}$, $z = -310.0 \text{ mm}$: $\sigma_x = 0.00 \text{ N/mm}^2$, $\tau = -50.96 \text{ N/mm}^2$, $\sigma_v = 88.26 \text{ N/mm}^2$

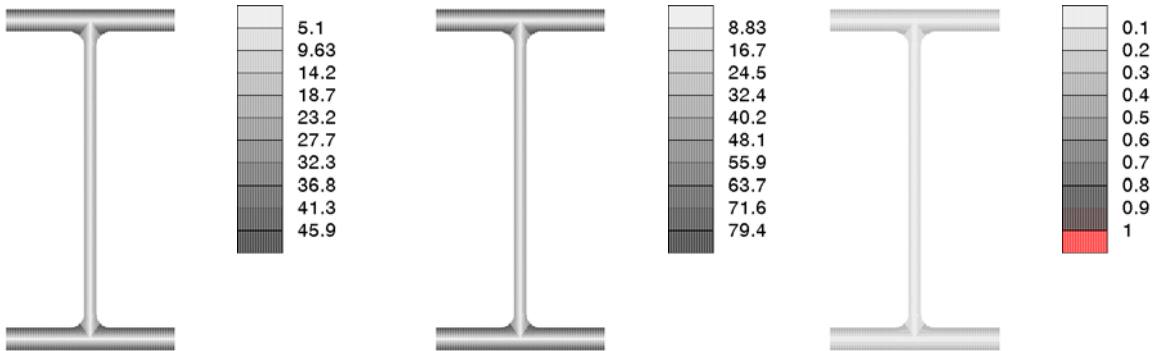
valid equivalent stress: $\sigma_{v,Rd} = 235.0 \text{ N/mm}^2$

verification: $\sigma_v = 88.26 \text{ N/mm}^2 < \sigma_{v,Rd} = 235.00 \text{ N/mm}^2 \Rightarrow U_\sigma = 0.376 < 1$ **ok**

shear stresses τ [N/mm²]
 $\max \tau = 51.0$

equivalent stresses σ_v [N/mm²]
 $\max \sigma_v = 88.3$

utilization U_σ
 $\max U_\sigma = 0.376$



stresses, utilizations

y mm	z mm	τ N/mm ²	σ_v N/mm ²	U_σ
0.0	40.0	50.96	88.27	0.376
0.0	0.0	50.96	88.27	0.376
-134.1	47.9	50.96	88.27	0.376

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

6. final result

maximum utilization [Lk 1]: resistance $\max U = 1.577 > 1$ **fault !!**

resistance not ensured !!