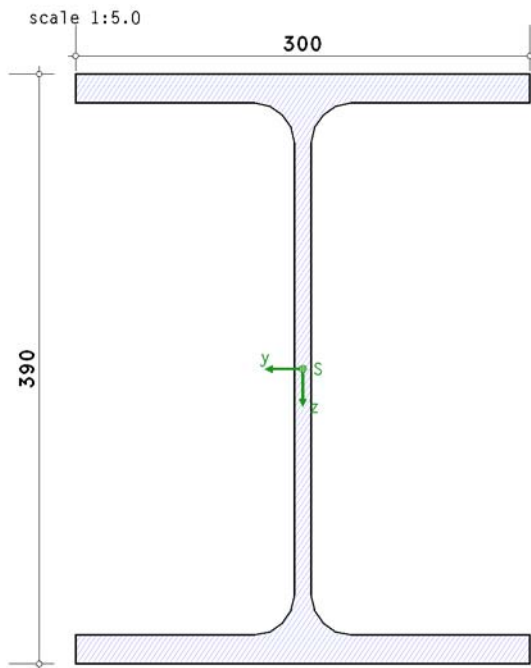


POS. 8: WAGENKNECHT 8.4.3

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 HE400A

resistance

elastic verification, calculation as thin-walled cross-section

plastic verification with partial internal forces and moments

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 main axes

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: $N_{Ed} = -480.00 \text{ kN}$, $M_{y,Ed} = 240.00 \text{ kNm}$, $V_{z,Ed} = 167.00 \text{ kN}$, $M_{z,Ed} = 20.00 \text{ kNm}$, $V_{y,Ed} = -13.30 \text{ kN}$

$T_{t,Ed} = -4.00 \text{ kNm}$, $T_{\omega,Ed} = -16.00 \text{ kNm}$, $B_{Ed} = -9.10 \text{ kNm}^2$

notes

buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: $N = -480.00 \text{ kN}$, $M_y = 240.00 \text{ kNm}$, $V_z = 167.00 \text{ kN}$, $M_z = 20.00 \text{ kNm}$, $V_y = -13.30 \text{ kN}$, $T_t = -4.00 \text{ kNm}$

$T_\omega = -16.00 \text{ kNm}$, $B = -9.10 \text{ kNm}^2$

2.1.1. elastic verification

elastic verification for $N = -480.00 \text{ kN}$, $M_y = 240.00 \text{ kNm}$, $V_z = 167.00 \text{ kN}$, $M_z = 20.00 \text{ kNm}$

$V_y = -13.30 \text{ kN}$, $T_t = -4.00 \text{ kNm}$, $T_\omega = -16.00 \text{ kNm}$, $B = -9.10 \text{ kNm}^2$

elastic stresses: $\max |\sigma_x| = 255.14 \text{ N/mm}^2$, $\max \tau = 66.26 \text{ N/mm}^2$, $\max \sigma_v = 264.38 \text{ N/mm}^2$

$\max \sigma_x$ bei $y = 150.0 \text{ mm}$, $z = 195.0 \text{ mm}$: $\sigma_x = 124.67 \text{ N/mm}^2$, $\tau = -40.00 \text{ N/mm}^2$, $\sigma_v = 142.63 \text{ N/mm}^2$

$\min \sigma_x$ bei $y = 150.0 \text{ mm}$, $z = -195.0 \text{ mm}$: $\sigma_x = -255.14 \text{ N/mm}^2$, $\tau = 40.00 \text{ N/mm}^2$, $\sigma_v = 264.38 \text{ N/mm}^2$

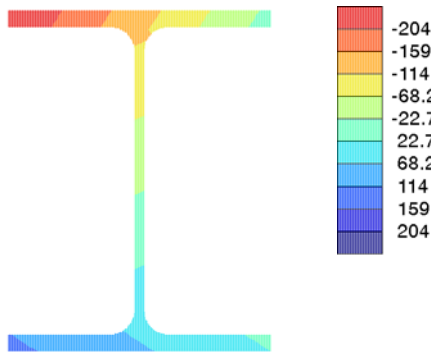
$\max \tau$ bei $y = -5.5 \text{ mm}$, $z = 0.0 \text{ mm}$: $\sigma_x = -28.90 \text{ N/mm}^2$, $\tau = 66.26 \text{ N/mm}^2$, $\sigma_v = 118.35 \text{ N/mm}^2$

$\max \sigma_v$ bei $y = 150.0 \text{ mm}$, $z = -195.0 \text{ mm}$: $\sigma_x = -255.14 \text{ N/mm}^2$, $\tau = 40.00 \text{ N/mm}^2$, $\sigma_v = 264.38 \text{ N/mm}^2$

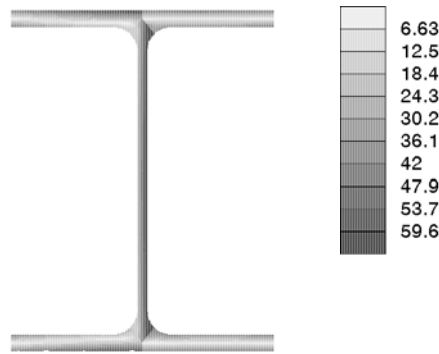
valid equivalent stress: $\sigma_{v,Rd} = 235.0 \text{ N/mm}^2$

verification: $\sigma_v = 264.38 \text{ N/mm}^2 > \sigma_{v,Rd} = 235.00 \text{ N/mm}^2 \Rightarrow U_\sigma = 1.125 > 1$ **fault !!**

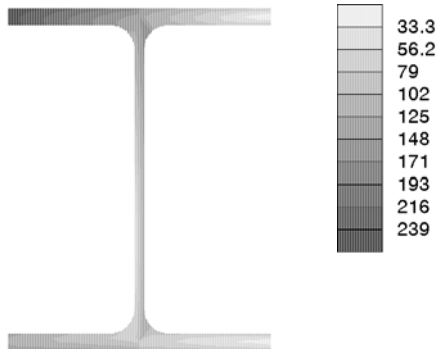
normal stresses σ_x [N/mm²]
min σ_x = -255.6, max σ_x = 125.1



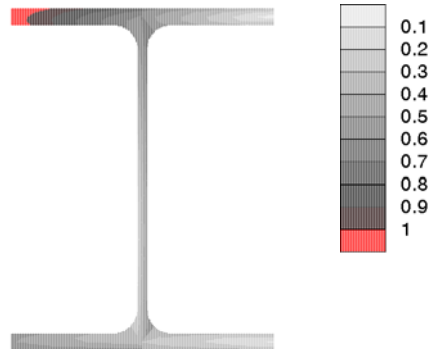
shear stresses τ [N/mm²]
max τ = 66.3



equivalent stresses σ_v [N/mm²]
max σ_v = 264.8



utilization U_σ
max U_σ = 1.127



stresses, utilizations

y mm	z mm	σ_x N/mm ²	τ N/mm ²	σ_v N/mm ²	U_σ
0.0	0.0	-255.60	40.00	264.83	1.127 > 1
-155.5	195.0	-28.91	66.26	118.35	0.504
0.0	390.0	125.14	40.00	143.04	0.609

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

2.1.2. plastic verification

plastic verification for $N = -480.00$ kN, $M_y = 240.00$ kNm, $V_z = 167.00$ kN, $M_z = 20.00$ kNm

$V_y = -13.30$ kN, $T_t = -4.00$ kNm, $T_\omega = -16.00$ kNm, $B = -9.10$ kNm²

valid normal/shear stress: $\sigma_{x,Rd} = 235.0$ N/mm², $\tau_{Rd} = 135.7$ N/mm²

top flange: shear force $V_O = -49.78$ kN, torsion $T_{pO} = -1.79$ kNm, shear stress $\tau_O = 36.16$ N/mm² $\Rightarrow U_{\tau,O} = 0.267$
flange bending $M_{\sigma,O} = 34.53$ kNm, bending stress $\sigma_O = 80.77$ N/mm² $\Rightarrow U_{\sigma,O} = 0.357$
resistance forces $N_{max,O} = 1035.58$ kN, $N_{min,O} = -1035.58$ kN

bottom flange: shear force $V_U = 36.48$ kN, torsion $T_{pU} = -1.79$ kNm, shear stress $\tau_U = 35.22$ N/mm² $\Rightarrow U_{\tau,U} = 0.260$
flange bending $M_{\sigma,U} = -14.53$ kNm, bending stress $\sigma_U = 33.98$ N/mm² $\Rightarrow U_{\sigma,U} = 0.150$
resistance forces $N_{max,U} = 1192.80$ kN, $N_{min,U} = -1192.80$ kN

web: shear force $V_S = 167.00$ kN, torsion $T_{pS} = -0.43$ kNm, shear stress $\tau_S = 51.74$ N/mm² $\Rightarrow U_{\tau,S} = 0.381$
resistance forces $N_{max,S} = 886.56$ kN, $N_{min,S} = -886.56$ kN

main bending: axial force $N = -480.00$ kN, resistance forces $N_{max} = 3114.93$ kN, $N_{min} = -3114.93$ kN $\Rightarrow U_N = 0.154$
moment $M_y = 240.00$ kNm, resistance moments $M_{y,max} = 453.11$ kNm, $M_{y,min} = -484.69$ kNm $\Rightarrow U_{M_y} = 0.546$

total (possibly due to load increase): max $U = 0.706 < 1$ **ok**

3. final result

maximum utilization: resistance max $U = 1.125 > 1$ **fault !!**

resistance not ensured !!