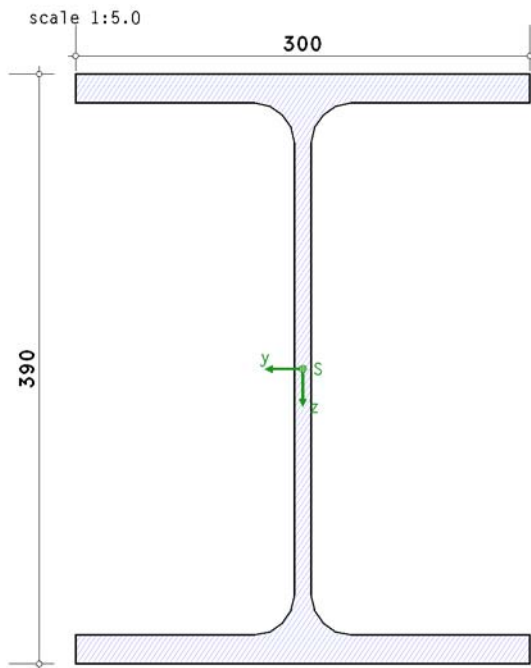


POS. 9: WAGENKNECHT 8.4.4

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

plastic verification with partial internal forces and moments

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: $N_{Ed} = -480.00$ kN, $M_{y,Ed} = 240.00$ kNm, $V_{z,Ed} = 167.00$ kN, $M_{z,Ed} = 20.00$ kNm, $V_{y,Ed} = -13.30$ kN
 $T_{t,Ed} = -4.00$ kNm, $T_{\omega,Ed} = -16.00$ kNm, $B_{Ed} = -9.10$ kNm²

Lk 2: $N_{Ed} = -480.00$ kN, $M_{y,Ed} = 446.00$ kNm, $V_{z,Ed} = 167.00$ kN, $M_{z,Ed} = 20.00$ kNm, $V_{y,Ed} = -13.30$ kN
 $T_{t,Ed} = -4.00$ kNm, $T_{\omega,Ed} = -16.00$ kNm, $B_{Ed} = -9.10$ kNm²

notes

buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: $N = -480.00$ 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

2.1.1. 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 $\Rightarrow U_{My} = 0.546$
total (possibly due to load increase): max $U = 0.706 < 1$ **ok**

3. Lk 2

3.1. verification of cross-section

internal forces and moments: $N = -480.00$ kN, $M_y = 446.00$ 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

3.1.1. plastic verification

plastic verification for $N = -480.00$ kN, $M_y = 446.00$ 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 $M_y = 446.00$ kNm, resistance moments $M_{y,max} = 453.11$ kNm, $M_{y,min} = -484.69$ kNm $\Rightarrow U_{My} = 0.985$

total (possibly due to load increase): max $U = 0.992 < 1$ **ok**

4. final result

maximum utilization [Lk 2]: resistance max $U = 0.992 < 1$ **ok**

verification succeeded