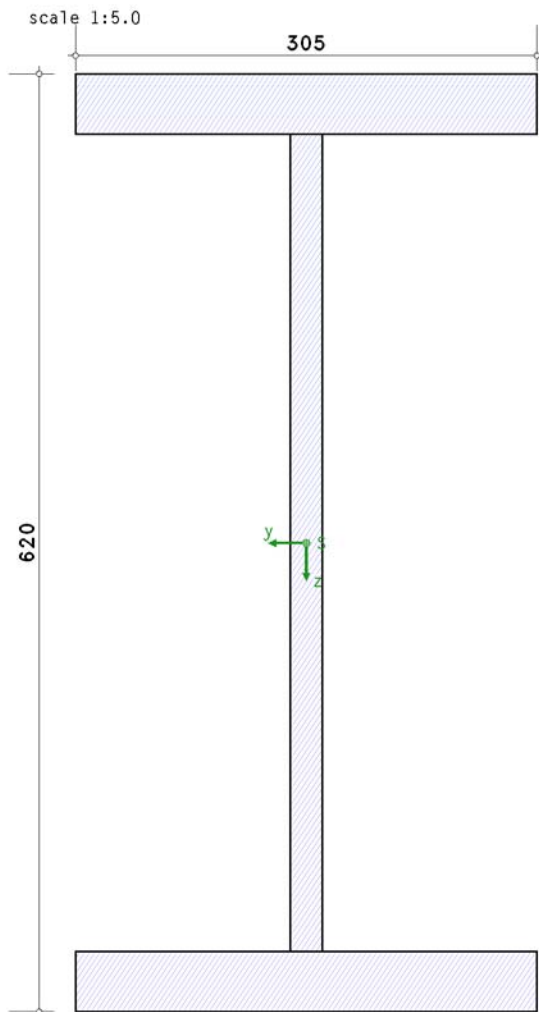


POS. 25: KINDMANN/KRÜGER 2.9.5

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

parameter (I-section):

overall depth $h = 620.0$ mm, web thickness $t_w = 21.0$ mm

flange width $b_f = 305.0$ mm, flange thickness $t_f = 40.0$ mm

resistance

plastic verification with partial internal forces and moments

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: a)

$V_{z,Ed} = 800.00$ kN, $V_{y,Ed} = -500.00$ kN, $T_{t,Ed} = 2000.00$ kNcm, $T_{\omega,Ed} = 18000.00$ kNcm

Lk 2: b)

$N_{Ed} = 300.00$ kN, $M_{y,Ed} = 144000.00$ kNcm, $V_{z,Ed} = 800.00$ kN, $M_{z,Ed} = -10000.00$ kNcm, $V_{y,Ed} = -500.00$ kN

$T_{t,Ed} = 2000.00$ kNcm, $T_{\omega,Ed} = 18000.00$ kNcm, $B_{Ed} = -300000.00$ kNcm²

notes

buckling is not investigated.

2. Lk 1: a)

2.1. verification of cross-section

internal forces and moments: $V_z = 800.00 \text{ kN}$, $V_y = -500.00 \text{ kN}$, $T_t = 2000.00 \text{ kNm}$, $T_\omega = 18000.00 \text{ kNm}$

2.1.1. plastic verification

plastic verification for $V_z = 800.00 \text{ kN}$, $V_y = -500.00 \text{ kN}$, $T_t = 20.00 \text{ kNm}$, $T_\omega = 180.00 \text{ kNm}$

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

top flange: shear force $V_O = 60.34 \text{ kN}$, torsion $T_{pO} = 8.86 \text{ kNm}$, shear stress $\tau_O = 39.50 \text{ N/mm}^2 \Rightarrow U_{\tau,O} = 0.291$
resistance forces $N_{\max,O} = 2742.82 \text{ kN}$, $N_{\min,O} = -2742.82 \text{ kN}$

bottom flange: shear force $V_U = -560.34 \text{ kN}$, torsion $T_{pU} = 8.86 \text{ kNm}$, shear stress $\tau_U = 69.31 \text{ N/mm}^2 \Rightarrow U_{\tau,U} = 0.511$
resistance forces $N_{\max,U} = 2464.63 \text{ kN}$, $N_{\min,U} = -2464.63 \text{ kN}$

web: shear force $V_S = 800.00 \text{ kN}$, torsion $T_{pS} = 2.27 \text{ kNm}$, shear stress $\tau_S = 80.94 \text{ N/mm}^2 \Rightarrow U_{\tau,S} = 0.597$
resistance forces $N_{\max,S} = 2138.76 \text{ kN}$, $N_{\min,S} = -2138.76 \text{ kN}$

total (possibly due to load increase): $\max U = 0.598 < 1$ **ok**

3. Lk 2: b)

3.1. verification of cross-section

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

3.1.1. plastic verification

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

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

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

top flange: shear force $V_O = 60.34 \text{ kN}$, torsion $T_{pO} = 8.86 \text{ kNm}$, shear stress $\tau_O = 39.50 \text{ N/mm}^2 \Rightarrow U_{\tau,O} = 0.291$
flange bending $M_{\sigma,O} = 1.72 \text{ kNm}$, bending stress $\sigma_O = 1.85 \text{ N/mm}^2 \Rightarrow U_{\sigma,O} = 0.008$

resistance forces $N_{\max,O} = 2731.49 \text{ kN}$, $N_{\min,O} = -2731.49 \text{ kN}$

bottom flange: shear force $V_U = -560.34 \text{ kN}$, torsion $T_{pU} = 8.86 \text{ kNm}$, shear stress $\tau_U = 69.31 \text{ N/mm}^2 \Rightarrow U_{\tau,U} = 0.511$
flange bending $M_{\sigma,U} = -101.72 \text{ kNm}$, bending stress $\sigma_U = 109.35 \text{ N/mm}^2 \Rightarrow U_{\sigma,U} = 0.541$

resistance forces $N_{\max,U} = 1669.24 \text{ kN}$, $N_{\min,U} = -1669.24 \text{ kN}$

web: shear force $V_S = 800.00 \text{ kN}$, torsion $T_{pS} = 2.27 \text{ kNm}$, shear stress $\tau_S = 80.94 \text{ N/mm}^2 \Rightarrow U_{\tau,S} = 0.597$
resistance forces $N_{\max,S} = 2138.76 \text{ kN}$, $N_{\min,S} = -2138.76 \text{ kN}$

main bending: axial force $N = 300.00 \text{ kN}$, resistance forces $N_{\max} = 6539.50 \text{ kN}$, $N_{\min} = -6539.50 \text{ kN} \Rightarrow U_N = 0.046$

moment $M_y = 1440.00 \text{ kNm}$, resistance moments $M_{y,\max} = 1447.81 \text{ kNm}$, $M_{y,\min} = -1528.27 \text{ kNm} \Rightarrow U_{M_y} = 0.995$

total (possibly due to load increase): $\max U = 0.999 < 1$ **ok**

4. final result

maximum utilization [Lk 2]: resistance $\max U = 0.999 < 1$ **ok**

verification succeeded