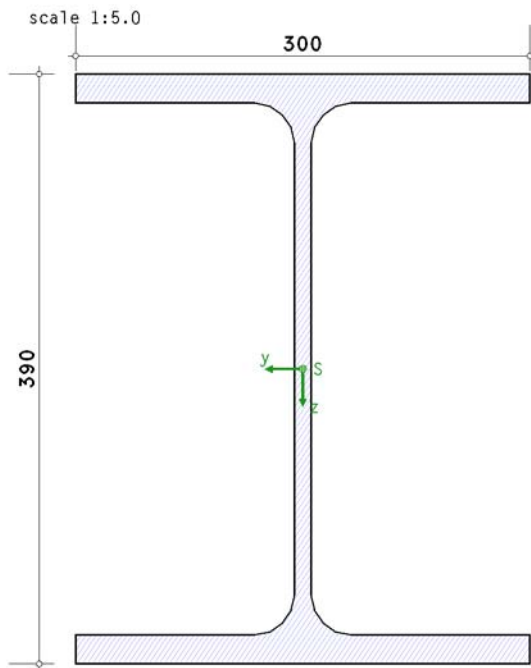


POS. 5: WAGENKNECHT 2.6.5

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

section HE400A

resistance

plastic verification acc. to EC 3-1-1, 6.2

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

Lk 1: $N_{Ed} = -1190.00$ kN, $M_{y,Ed} = 375.00$ kNm, $V_{z,Ed} = 470.00$ kN, $M_{z,Ed} = -96.00$ kNm, $V_{y,Ed} = -180.00$ kN

notes

buckling is not investigated.

2. Lk 1

2.1. verification of cross-section

internal forces and moments: $N = -1190.00$ kN, $M_y = 375.00$ kNm, $V_z = 470.00$ kN, $M_z = -96.00$ kNm, $V_y = -180.00$ kN

2.1.1. plastic verification

plastic verification for $N = -1190.00$ kN, $M_y = 375.00$ kNm, $V_z = 470.00$ kN, $M_z = -96.00$ kNm

$V_y = -180.00$ kN

plate buckling: section class of the section $1 \leq 2$ **ok**

shear buckling: $h_p/t_p = 32.00 \leq 72 \cdot \epsilon / \eta = 60.00$ **ok**

plastic values: $N_{pl,Rd} = A \cdot f_y / \gamma_{M0} = 3735.98$ kN, $M_{pl,y,Rd} = W_{pl,y} \cdot f_y / \gamma_{M0} = 601.97$ kNm

$V_{pl,z,Rd} = A_{vz} \cdot f_y / (3^{1/2} \cdot \gamma_{M0}) = 777.81$ kN, $M_{pl,z,Rd} = W_{pl,z} \cdot f_y / \gamma_{M0} = 205.02$ kNm, $V_{pl,y,Rd} = A_{vy} \cdot f_y / (3^{1/2} \cdot \gamma_{M0}) = 1379.16$ kN

shear force

reduction factors:

web: $0.5 \cdot V_{pl,z,Rd} = 388.90$ kN $< |V_{z,Ed}| = 470.00$ kN: $\rho_z = (2 \cdot |V_{z,Ed}| / V_{pl,z,Rd} - 1)^2 = 0.043$

flanges: $0.5 \cdot V_{pl,y,Rd} = 689.58$ kN $> |V_{y,Ed}| = 180.00$ kN: $\rho_y = 0$ (no deduction)

axial force and shear force/torsion

web: $\Delta A_w = \rho_z \cdot A_w = 1.96$ cm², $A_w = 44.98$ cm²

$\Rightarrow N_{pl,v,Rd} = A_{red} \cdot f_y / \gamma_{M0} = 3690.02$ kN, $A_{red} = A - \Delta A_w = 157.02$ cm²

bending and shear force/torsion

web: $W_{V,y} = W_{pl,y} - \rho_z \cdot W_{pl,w} = 2542.14 \text{ cm}^3$, $W_{pl,w} = W_{pl,y} - W_{pl,y,f} = 446.87 \text{ cm}^3$, $W_{pl,y,f} = 2 \cdot b_f \cdot t_f \cdot z_f = 2114.70 \text{ cm}^3$
 $\Rightarrow M_{pl,V,y,Rd} = W_{V,y} \cdot f_y / \gamma_{M0} = 597.40 \text{ kNm}$

bending and axial force

deduction M_y : $N_{c,lim} = \min(0.25 \cdot N_{pl,V,Rd}, 0.5 \cdot A_w \cdot f_y / \gamma_{M0}) = 435.18 \text{ kN}$, $A_w = h_w \cdot t_w \cdot (1 - \rho_z) = 3703.64 \text{ cm}^2$

$N_{Ed} > N_{c,lim}$: $f_{N,y} = (1 - n) / (1 - 0.5 \cdot a) = 0.785 < 1$, $n = |N_{Ed}| / N_{pl,V,,Rd} = 0.322$, $a = (A_{red} - A_f) / A_{red} = 0.274 \leq 0.5$

$A_f = 2 \cdot b_f \cdot t_f = 114.00 \text{ cm}^2$, $A_{red} = 157.02 \text{ cm}^2 \Rightarrow M_{pl,V,N,y,Rd} = M_{pl,y,Rd} \cdot f_{N,y} = 468.99 \text{ kNm}$

deduction M_z : $N_{c,lim} = A_w \cdot f_y / \gamma_{M0} = 909.92 \text{ kN}$, $A_w = h_w \cdot t_w = 3872.00 \text{ cm}^2$

$N_{Ed} > N_{c,lim}$ and $n > a$: $f_{N,z} = 1 - ((n - a) / (1 - a))^2 = 0.996 < 1$, $n = |N_{Ed}| / N_{pl,V,,Rd} = 0.322$, $a = (A_{red} - A_f) / A_{red} = 0.274 \leq 0.5$

$A_f = 2 \cdot b_f \cdot t_f = 114.00 \text{ cm}^2$, $A_{red} = 157.02 \text{ cm}^2 \Rightarrow M_{pl,N,z,Rd} = M_{pl,z,Rd} \cdot f_{N,z} = 204.10 \text{ kNm}$

bending

verification: $(|M_{y,Ed}| / M_{pl,V,N,y,Rd})^\alpha + (|M_{z,Ed}| / M_{pl,N,z,Rd})^\beta = 0.639 + 0.296 = 0.936 < 1$ **ok**

with $\alpha = 2.00$, $\beta = 1.61 = 5 \cdot n \geq 1$

utilization: $U = 0.936^{1/2} = 0.967$

3. final result

maximum utilization: resistance max $U = 0.967 < 1$ **ok**

verification succeeded