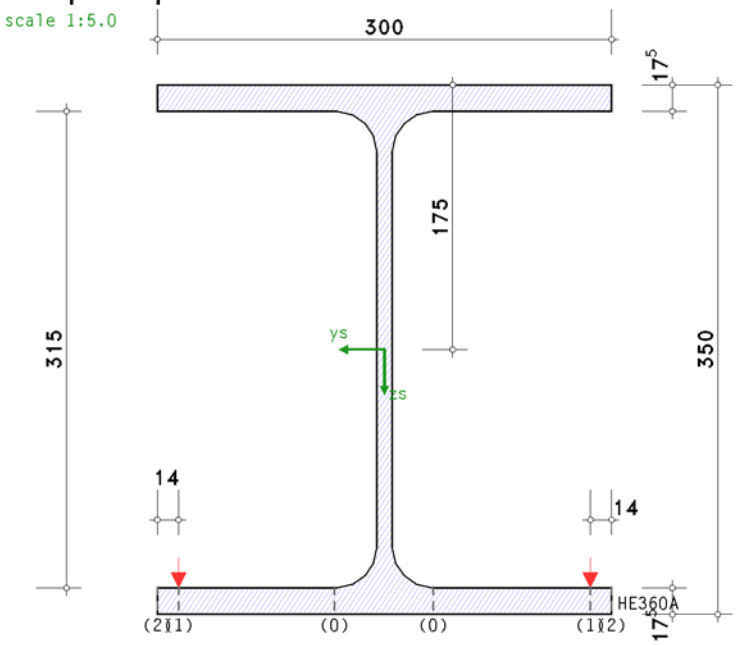
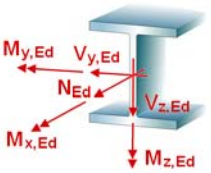
detailed problems acc. to Eurocode 3, EC 3-6 (12.10), NA: Deutschland

1. input report



steel grade
steel grade S235
cross-section
beam: section HE360A
loading
internal forces and moments at limit state of resistance (ULS):
Lk 1: EK 1
$M_{y,Ed}$ = 174.7 kNm, $M_{z,Ed}$ = 6.2 kNm
internal forces and moments at limit state of serviceability (SLS):
Lk 1: EK 12
$M_{y,Ed}$ = 129.4 kNm, $M_{z,Ed}$ = 4.6 kNm
transverse loading on lower edge of cross-section:
vertical wheel pressure $F_{z,Ed,ULS}$ = 9.23 kN, $F_{z,Ed,SLS}$ = 9.23 kN
distance of wheel axles a_R = 100.0 cm
distance of wheel from lateral edge of flange n_y = 14.0 mm
wheel at end of beam (unsupported lower flange, reinforced)
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
serviceability $\gamma_{M,ser}$ = 1.00



2. verification der local loading due to crane gantry

reinforcement of lower flange at end of beam: minimum dimensions t_p = 17.5 mm x b_p = 300.0 mm

cross-sectional properties: A = 142.76 cm², z_s = 175.0 mm, I_y = 33090.11 cm⁴, y_s = 0.0 mm, I_z = 7886.85 cm⁴

effective loading length from crane gantry:
l_{eff} = 2·(m+n) = 246.8 mm
local stresses from crane gantry:
$\sigma_{ux,Ed}(0)$ = 5.8 N/mm², $\sigma_{ux,Ed}(1)$ = 70.0 N/mm², $\sigma_{ux,Ed}(2)$ = 66.5 N/mm²
$\sigma_{uy,Ed}(0)$ = -57.4 N/mm², $\sigma_{uy,Ed}(1)$ = 16.0 N/mm², $\sigma_{uy,Ed}(2)$ = 0.0 N/mm²
75% of local stresses from crane gantry:
$\sigma_{ux,Ed}(0)$ = 4.3 N/mm², $\sigma_{ux,Ed}(1)$ = 52.5 N/mm², $\sigma_{ux,Ed}(2)$ = 49.9 N/mm²
$\sigma_{uy,Ed}(0)$ = -43.1 N/mm², $\sigma_{uy,Ed}(1)$ = 12.0 N/mm², $\sigma_{uy,Ed}(2)$ = 0.0 N/mm²

2.1. resistance of lower flange (ULS)

permissible stress: $\sigma_{Rd} = f_y/\gamma_{M0} = 235.0$ N/mm²
Lk 1: $M_{y,Ed} = 174.7$ kNm, $M_{z,Ed} = 6.2$ kNm
  normal stress $\sigma_{x,Ed} = 87.8$ N/mm²
  $F_{z,Rd} = (l_{eff} \cdot t_{fu}^2 \cdot \sigma_{Rd})/(4 \cdot m) \cdot [1-(\sigma_{x,Ed}/\sigma_{Rd})^2] = 34.9$ kN
  $F_{z,Ed} = 9.2$ kN $<$ $F_{z,Rd} = 34.9$ kN $\Rightarrow$ $U = 0.264 < 1$ ok
maximum utilization: max $U_{ULS} = 0.264 < 1$ ok

2.2. bending of lower flange (SLS)

permissible stress: $\sigma_{Rd} = f_y/\gamma_{M,ser} = 235.0$ N/mm², $\tau_{Rd} = f_y/(3^{1/2} \cdot \gamma_{M,ser}) = 135.7$ N/mm²
Lk 1: $M_{y,Ed} = 129.4$ kNm, $M_{z,Ed} = 4.6$ kNm
  (0) $\sigma_x = 73.1$ N/mm², $\sigma_y = 43.1$ N/mm², $\tau = 0.0$ N/mm²
  normal stress $\sigma_x = 73.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.311 < 1$ ok
  normal stress $\sigma_y = 43.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.183 < 1$ ok
  equivalent stress $\sigma_{v1} = 73.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.311 < 1$ ok
  equivalent stress $\sigma_{v2} = 101.7$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.433 < 1$ ok
  utilization $U_{(0)} = 0.433 < 1$ ok
  (1) $\sigma_x = 128.9$ N/mm², $\sigma_y = 12.0$ N/mm², $\tau = 0.0$ N/mm²
  normal stress $\sigma_x = 128.9$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.548 < 1$ ok
  normal stress $\sigma_y = 12.0$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.051 < 1$ ok
  equivalent stress $\sigma_{v1} = 128.9$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.548 < 1$ ok
  equivalent stress $\sigma_{v2} = 123.3$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.525 < 1$ ok
  utilization $U_{(1)} = 0.548 < 1$ ok
  (2) $\sigma_x = 127.1$ N/mm², $\sigma_y = 0.0$ N/mm², $\tau = 0.0$ N/mm²
  normal stress $\sigma_x = 127.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.541 < 1$ ok
  equivalent stress $\sigma_{v1} = 127.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.541 < 1$ ok
  equivalent stress $\sigma_{v2} = 127.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.541 < 1$ ok
  utilization $U_{(2)} = 0.541 < 1$ ok
  total: $U = 0.548 < 1$ ok
maximum utilization: max $U_{SLS} = 0.548 < 1$ ok

3. final result

maximum utilization: max $U = 0.548 < 1$ ok

verification succeeded