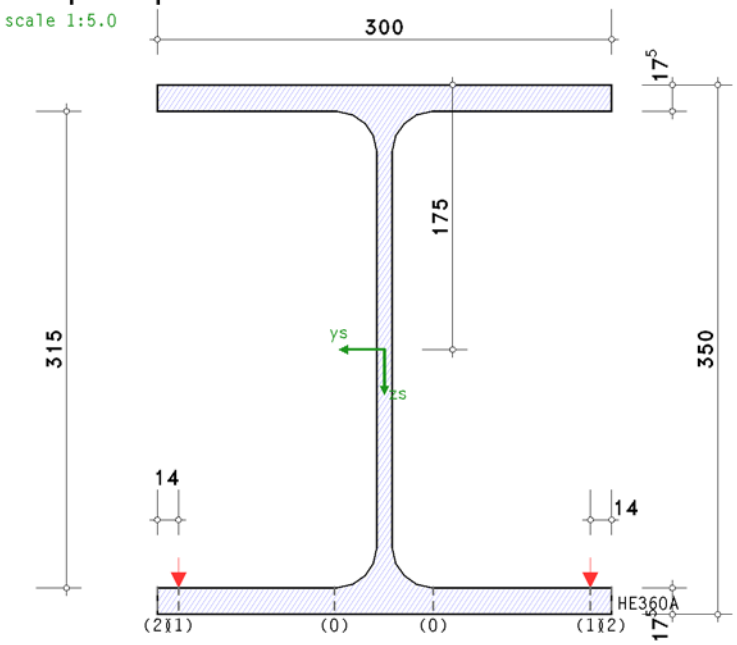
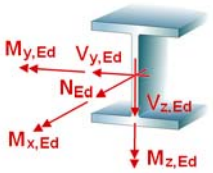
detailed problems acc. to Eurocode 3, EC 3-6 (12.10), NA: Deutschland

4H-EC3LK version: 11/2016-1f

1. input report



steel grade
steel grade S235
cross-section
beam: section HE360A
loading
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 $F_{z,Ed,SLS}$ = 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
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
wheel at unsupported end of flange
effective length l_{eff} = 2·(m+n) = 246.8 mm, m = 109.4 mm, n = 14.0 mm

local stresses from crane gantry at lower flange
Vertikallast $F_{z,Ed}$ = 9.2 kN
$\sigma_{ux,Ed}'(0)$ = 5.8 N/mm² with c_{x0} = 0.192, $\sigma_{uy,Ed}'(0)$ = -57.4 N/mm² with c_{y0} = -1.905
$\sigma_{ux,Ed}'(1)$ = 70.0 N/mm² with c_{x1} = 2.323, $\sigma_{uy,Ed}'(1)$ = 16.0 N/mm² with c_{y1} = 0.532
$\sigma_{ux,Ed}'(2)$ = 66.5 N/mm² with c_{x2} = 2.208, $\sigma_{uy,Ed}'(2)$ = 0.0 N/mm² with c_{y2} = 0.000
local stresses:
$\sigma_{ux,Ed}(0)$ = 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. 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) stresses $\sigma_{x,Ed}(0) = 68.7$ N/mm², $\tau_{Ed}(0) = 0.0$ N/mm²
superposition $\sigma_x = \sigma_{x,Ed}(0)+\sigma_{ux,Ed}(0) = 73.1$ N/mm², $\sigma_y = \sigma_{uy,Ed}(0) = 43.1$ N/mm², $\tau = \tau_{Ed}(0) = 0.0$ 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 stressen $\sigma_{v1} = (\sigma_x^2+3\cdot\tau^2)^{1/2} = 73.1$ N/mm², $\sigma_{v2} = (\sigma_x^2+\sigma_y^2-\sigma_x\cdot\sigma_y+3\cdot\tau^2)^{1/2} = 101.7$ N/mm²
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) stresses $\sigma_{x,Ed}(1) = 76.4$ N/mm², $\tau_{Ed}(1) = 0.0$ N/mm²
superposition $\sigma_x = \sigma_{x,Ed}(1)+\sigma_{ux,Ed}(1) = 128.9$ N/mm², $\sigma_y = \sigma_{uy,Ed}(1) = 12.0$ N/mm², $\tau = \tau_{Ed}(1) = 0.0$ 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 stressen $\sigma_{v1} = (\sigma_x^2+3\cdot\tau^2)^{1/2} = 128.9$ N/mm², $\sigma_{v2} = (\sigma_x^2+\sigma_y^2-\sigma_x\cdot\sigma_y+3\cdot\tau^2)^{1/2} = 123.3$ N/mm²
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) stresses $\sigma_{x,Ed}(2) = 77.2$ N/mm², $\tau_{Ed}(2) = 0.0$ N/mm²
superposition $\sigma_x = \sigma_{x,Ed}(2)+\sigma_{ux,Ed}(2) = 127.1$ N/mm², $\sigma_y = \sigma_{uy,Ed}(2) = 0.0$ N/mm², $\tau = \tau_{Ed}(2) = 0.0$ N/mm²
normal stress $\sigma_x = 127.1$ N/mm² $<$ $\sigma_{Rd} = 235.0$ N/mm² $\Rightarrow$ $U = 0.541 < 1$ ok
equivalent stressen $\sigma_{v1} = (\sigma_x^2+3\cdot\tau^2)^{1/2} = 127.1$ N/mm², $\sigma_{v2} = (\sigma_x^2+\sigma_y^2-\sigma_x\cdot\sigma_y+3\cdot\tau^2)^{1/2} = 127.1$ N/mm²
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