detailed problems acc. to Eurocode 3

EC 3-6 (12.10), NA: Deutschland

steel grade

steel grade S 235

cross-section

beam: parameter (I-section):

overall depth h = 2480.0 mm, web thickness t_w = 20.0 mm

flange width top b_{fo} = 650.0 mm, flange thickness top t_{fo} = 30.0 mm

flange width bottom b_{fu} = 500.0 mm, flange thickness bottom t_{fu} = 20.0 mm

longitudinal stiffeners (right): number n_{st} = 2

section parameters (flat steel):

height h = 100.0 mm, thickness t = 20.0 mm

distance of the first stiffener to the top edge of beam $d_{st,0}$ = 100.0 mm

constant distance of stiffeners d_{st} = 100.0 mm

transverse stiffeners: section parameters (flat steel):

height h = 230.0 mm, thickness t = 10.0 mm

distance of transverse stiffeners a = 200.0 cm

crane gantry

A-crane rail 120, floating with fillet welds joined with the girder

crane rail: head width b_k = 120.0 mm, bottom width b_r = 220.0 mm, height of fretted rail h_r = 93.0 mm

moment of inertia, cross-sectional area of fretted rail I_{yr} = 970.00 cm⁴, A_r = 113.50 cm²

loading

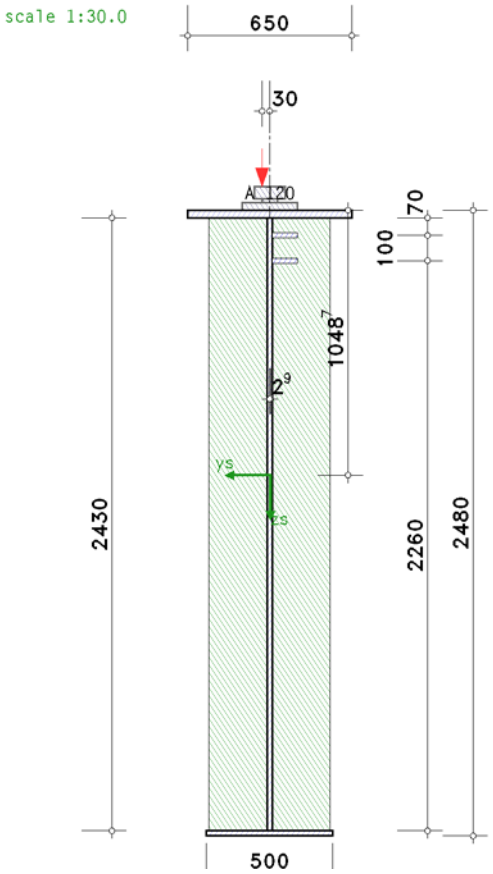
internal forces and moments refering to the unstiffened cross-secion:

transverse loading on upper edge of cross-section:

design value of vertical wheel load $F_{z,Ed}$ = 560.00 kN (eccentricity e_y = 30.00 mm)

partial safety factors for material

serviceability $\gamma_{M,ser}$ = 1.00



Verification of Local Loading due to Crane Gantry

cross-sectional properties
$A = 821.00\ cm^2$, $z_s = 1048.7\ mm$, $I_y = 7006754.11\ cm^4$, $y_s = 2.9\ mm$, $I_z = 91354.76\ cm^4$

effective loading length from crane gantry
effective width $b_{eff} = b_r+h_r+t_{fo} = 343.0\ mm \le b_{fo}$
effective moment of inertia of beam flange $I_{f,eff} = b_{eff}\cdot t_{fo}^3/12 = 77.17\ cm^4$
moment of inertia of crane rail $I_r = 970.00\ cm^4$
effective length $l_{eff} = 3.25\cdot((I_r+I_{f,eff})/t_w)^{1/3} = 261.9\ mm$

local stresses from crane gantry
refering to outer edge of flange $s_s = l_{eff} - 2\cdot t_f = 201.9\ mm$ / auf den web $s_w = l_{eff} = 261.9\ mm$

permissible stresses
$\sigma_{Rd} = f_y/\gamma_{M,ser} = 235.0\ N/mm^2$, $\tau_{Rd} = f_y/(3^{1/2}\cdot\gamma_{M,ser}) = 135.7\ N/mm^2$

bending stress of web
$M_{T,Ed} = F_{z,Ed}\cdot e_y = 16.80\ kNm \Rightarrow \sigma_T = (6\cdot M_{T,Ed})/(a\cdot t_w^2)\cdot\eta\cdot\tanh(\eta) = 98.3\ N/mm^2$
with $\eta = ((0.75\cdot a\cdot t_w^3)/I_t \cdot \sinh^2(\pi\cdot h_w/a)/(\sinh^2(2\cdot\pi\cdot h_w/a)-2\cdot\pi\cdot h_w/a))^{0.5} = 1.016$, $I_t = 585.00\ cm^4$

wheel pressure at top edge of the web
local normal stress $\sigma_{oz,Ed} = -F_{z,Ed}/(t_w\cdot s_w) = -106.9\ N/mm^2$
$|\sigma_{oz,Ed}|+|\sigma_{T,Ed}| = 205.2\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.873 < 1$ ok.
associated local shear stress $\tau_{oxz,Ed} = 0.2\cdot\sigma_{oz,Ed} = -21.4\ N/mm^2$
$|\tau_{oxz,Ed}| = 21.4\ N/mm^2 < \tau_{Rd} = 135.7\ N/mm^2 \Rightarrow U = 0.158 < 1$ ok.

Final Result

maximum utilization: max U = 0.873 < 1 ok.

verification succeeded