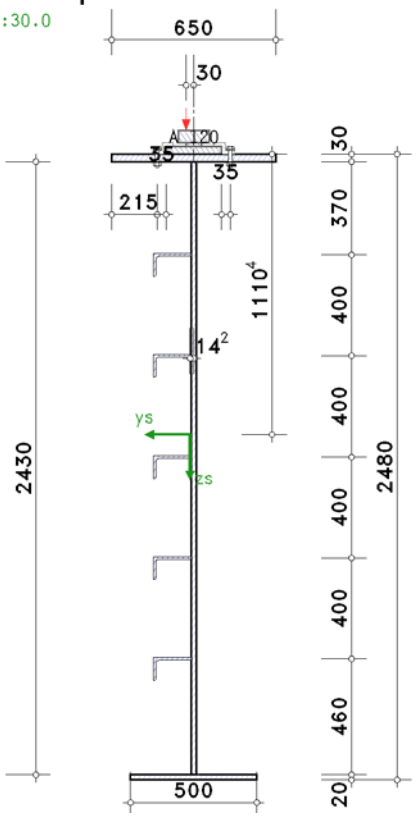
POS. 6: BSP. 4 WHEEL PRESSURE TOP FLANGE

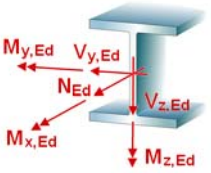
detailed problems acc. to Eurocode 3, EC 3-6 (12.10), NA: Deutschland 4H-EC3LK version: 11/2016-1f

1. input report

scale 1:30.0



steel grade
steel grade S235
cross-section
beam: parameter (I-section):
h = 2480.0 mm, t_w = 20.0 mm, b_{fo} = 650.0 mm, t_{fo} = 30.0 mm, b_{fu} = 500.0 mm, t_{fu} = 20.0 mm, top fillet weld a_o = 8.0 mm, bo
longitudinal stiffeners (left): number n_{st} = 5
section L 150 X 90 X 10
distance of the first stiffener to the upper edge of beam $d_{st,0}$ = 400.0 mm
constant distance of stiffeners d_{st} = 400.0 mm
distance of transverse stiffeners a = 200.0 cm
crane gantry
A-crane rail 120, floating with clamps joined with the girder
clamp connection with bolts: bolt class 8.8, bolt size M16
large wrench size (high strength bolt), preloaded (for info: preloading $F_{p,C}$* = 0.7·f_{yb}·A_s = 70.3 kN)
shear plane passes through the unthreaded portion of the bolt
crane rail: head width b_k = 120.0 mm, bottom width b_r = 220.0 mm, height h = 105.0 mm, 25% wear
height, cross-sectional area, moments of inertia of fretted rail h_r = 93.1 mm, A_r = 113.60 cm², I_{yr} = 973.00 cm⁴, I_{tr} = 954.00 cm⁴
loading
internal forces and moments refering to unstiffened cross-secion:
internal forces and moments at limit state of resistance (ULS):
Lk 1: $M_{y,Ed}$ = 420.0 kNm
internal forces and moments at limit state of serviceability (SLS):
Lk 1: $M_{y,Ed}$ = 360.0 kNm



transverse loading on upper edge of cross-section:
vertical wheel pressure $F_{z,Ed,ULS}$ = 560.00 kN, $F_{z,Ed,SLS}$ = 530.00 kN, eccentricity e_y = 30.0 mm
verification at intermediate support
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10
serviceability $\gamma_{M,ser}$ = 1.00

2. verification der local loading due to crane gantry

assumption: flange induced web buckling is excluded.
assumption: plated structures-/shear buckling is excluded.
assumption: transverse stiffeners serve as rigid support of the plated panel.
assumption: local buckling of stiffeners is excluded.

cross-sectional properties: $A = 897.16\ cm^2$, $z_s = 1110.4\ mm$, $I_y = 7053259.04\ cm^4$, $y_s = -14.2\ mm$, $I_z = 104526.54\ cm^4$

effective loading length from crane gantry:
$l_{eff} = 3.25 \cdot ((I_r + I_{f,eff})/t_w)^{1/3} = 262.2\ mm$
length of local loading:
refering to outer edge of flange $s_s = l_{eff} - 2 \cdot t_f = 202.2\ mm$ / auf den webanschnitt $s_w = l_{eff} = 262.2\ mm$

2.1. compression of web (ULS)

permissible stresses: $\sigma_{Rd} = f_y/\gamma_{M0} = 235.0\ N/mm^2$, $\tau_{Rd} = f_y/(3^{1/2} \cdot \gamma_{M0}) = 135.7\ N/mm^2$
bending stress of web: $M_{T,Ed} = F_{z,Ed} \cdot e_y = 16.80\ kNm \Rightarrow \sigma_T = 98.3\ N/mm^2$

wheel pressure at first cut of web:
local stresses $\sigma_{oz,Ed} = -106.8\ N/mm^2$, $\tau_{oxz,Ed} = -21.4\ N/mm^2$
$|\sigma_{oz,Ed}| + |\sigma_{T,Ed}| = 205.1\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.873 < 1$ ok
$|\tau_{oxz,Ed}| = 21.4\ N/mm^2 < \tau_{Rd} = 135.7\ N/mm^2 \Rightarrow U = 0.157 < 1$ ok

stresses at first cut of web:
Lk 1: $M_{y,Ed} = 420.0\ kNm$
stresses $\sigma_{x,Ed} = -106.8\ N/mm^2$, $\tau_{xz,Ed} = -21.4\ N/mm^2$
$|\sigma_{x,Ed}| = 6.4\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.027 < 1$ ok
$\sigma_v = 110.1\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.469 < 1$ ok

maximum utilization: max $U_{ULS} = 0.469 < 1$ ok

2.2. elastic behaviour (SLS)

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: $M_{T,Ed} = F_{z,Ed} \cdot e_y = 15.90\ kNm \Rightarrow \sigma_T = 93.1\ N/mm^2$

wheel pressure at top edge of the web:
local stresses $\sigma_{oz,Ed} = -101.1\ N/mm^2$, $\tau_{oxz,Ed} = -20.2\ N/mm^2$
$|\sigma_{oz,Ed}| + |\sigma_{T,Ed}| = 194.1\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.826 < 1$ ok
$|\tau_{oxz,Ed}| = 20.2\ N/mm^2 < \tau_{Rd} = 135.7\ N/mm^2 \Rightarrow U = 0.149 < 1$ ok

stresses at top edge of the web:
Lk 1: $M_{y,Ed} = 360.0\ kNm$
stresses $\sigma_{x,Ed} = -101.1\ N/mm^2$, $\tau_{xz,Ed} = -20.2\ N/mm^2$
$|\sigma_{x,Ed}| = 5.5\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.023 < 1$ ok
$\sigma_v = 104.5\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.445 < 1$ ok

maximum utilization: max $U_{SLS} = 0.445 < 1$ ok

2.3. buckling of transverse loading (ULS)

slenderness $\lambda_F = (F_y/F_{cr})^{1/2} = 0.839$, $F_y = 2840.0\ kN$
reduction factor $\chi_F = 0.596$
resistance of buckling $F_{z,Rd} = f_y \cdot L_{eff} \cdot t_w/\gamma_{M1} = 1538.11\ kN$, $L_{eff} = \chi_F \cdot l_y = 360.0\ mm$, $l_y = 604.3\ mm$
verification: $F_{z,Ed}/F_{z,Rd} = 0.364 < 1$ ok

interaction (without plated structures-/shear buckling):
transverse loading and equivalent stress $(\eta_2 + 0.8 \cdot \eta_1) / 1.4 = 0.528 < 1$ ok
with $\eta_2 = F_{z,Ed}/F_{z,Rd} = 0.364$, $\eta_1 = \max U_{ULS} = 0.469$

3. final result

maximum utilization: max $U = 0.873 < 1$ ok

verification succeeded