POS. 130: SEESSELBERG 11.9.6

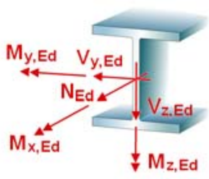
detailed problems acc. to Eurocode 3

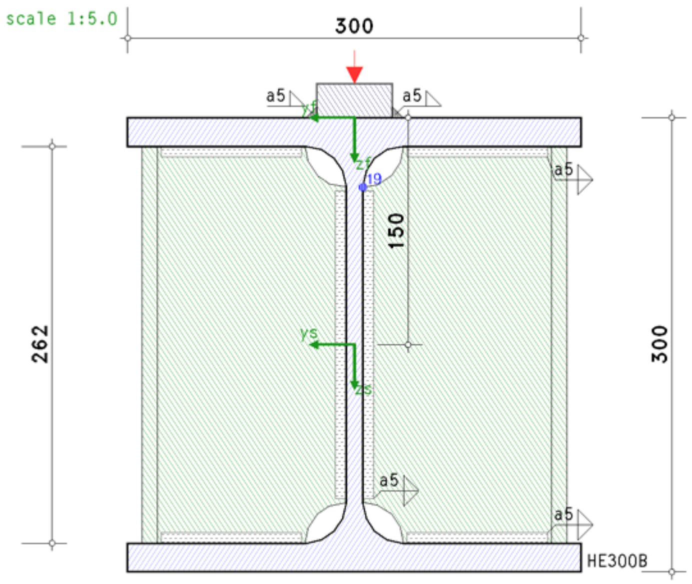
EC 3-1-9 (12.10), NA: Deutschland

steel grade
steel grade S 235
cross-section
beam: section HE300B
transverse stiffeners: section ½ IPE270
  recess at transverse stiffener $c_{st,q}$ = 27.0 mm
  weld thickness $a_{st,q}$ = 5.0 mm
crane gantry
crane rail of flat steel, shear-resistant joined with the girder
connection with fillet welds: weld thickness a_w = 5.0 mm (continuous)
crane rail: width b_r = 50.0 mm, height of fretted rail h_r = 22.5 mm
  moment of inertia, cross-sectional area of fretted rail I_{yr} = 4.75 cm^4, A_r = 11.25 cm^2
parameters
damage equivalent stress factors for crane class S2: λ_σ = 0.315, λ_τ = 0.500, crane class S3: $\lambda_{\sigma+}$ = 0.397, $\lambda_{\tau+}$ = 0.575
notch class / valid notch stresses:

Pt.	yf mm	zf mm	$\Delta\sigma_{x,Rd}$ N/mm²	$\Delta\tau_{Rd}$ N/mm²	$\Delta\sigma_{z,Rd}$ N/mm²	notch point	EC 3-1-9, tab.
19	-5.5	46.0	80.0	100.0	100.0	due to transv.stiff.	8.4(7) 8.1(6) 8.2(7)

loading
Lk 1: $M_{y,Ed}$ = -85.2 kNm, $V_{z,Ed}$ = 118.0 kN
Lk 2: $M_{y,Ed}$ = 0.0 kNm, $V_{z,Ed}$ = 0.0 kN
transverse loading on top flange:
design value of vertical wheel load $F_{z,Ed}$ = 79.60 kN
material safety factor
design concept: damage tolerance, damage consequence: high ⇒ fatigue strength γ_{Mf} = 1.15





Fatigue Design

cross-sectional properties

$A = 149.08\ cm^2$, $z_s = 150.0$ mm, $I_y = 25165.90\ cm^4$, $y_s = 0.0$ mm, $I_z = 8562.83\ cm^4$

effective loading length from crane gantry

effective width $b_{eff} = b_r + h_r + t_{fo} = 91.5$ mm $\leq b_{fo}$

moment of inertia of crane rail with beam flange $I_{rf} = 39.38\ cm^4$

effective length $l_{eff} = 3.25 \cdot (I_{rf}/t_w)^{1/3} = 107.1$ mm

local stresses from crane gantry

effective loading length refered ...

... to outer edge of flange $s_s = l_{eff} - 2 \cdot t_f = 69.1$ mm / ... to web $s_w = l_{eff} + 2 \cdot r = 161.1$ mm

local stresses ...

... at crane rail $\sigma_{oz} = -104.7\ N/mm^2$, $\tau_o = 20.9\ N/mm^2$ / ... at weld $\sigma_{oz} = -115.2\ N/mm^2$, $\tau_o = 23.0\ N/mm^2$

... at beam web $\sigma_{oz} = -44.9\ N/mm^2$, $\tau_o = 9.0\ N/mm^2$

elastic stresses / stress ranges

$\Delta\sigma_{x,Ed} = \sigma_{x,max} - \sigma_{x,min}$, $\tau_{Ed} = \tau_{xz,max} - \tau_{xz,min} + 2 \cdot \tau_o$, $\Delta\sigma_{z,Ed} = -\sigma_{oz}$

pt. 19: $y_f = -5.5$ mm, $z_f = 46.0$ mm	Lk 1:	$\sigma_x = 35.2\ N/mm^2$	$\tau_{xz} = 37.2\ N/mm^2$	
	2:	$\sigma_x = 0.0\ N/mm^2$	$\tau_{xz} = 0.0\ N/mm^2$	
		$\Delta\sigma_{x,Ed} = 35.2\ N/mm^2$	$\Delta\tau_{Ed} = 55.1\ N/mm^2$	$\Delta\sigma_{z,Ed} = 44.9\ N/mm^2$

equivalent constand amplitude stress range

$\Delta\sigma_{x,f} = \Delta\sigma_{x,Ed} \cdot \lambda_\sigma$, $\Delta\tau_f = \Delta\tau_{Ed} \cdot \lambda_\tau$, $\Delta\sigma_{z,f} = \Delta\sigma_{z,Ed} \cdot \lambda_\sigma$

pt. 19: $y_f = -5.5$ mm, $z_f = 46.0$ mm ($\lambda_{\tau\sigma z+}$) $\Delta\sigma_{x,f} = 11.1\ N/mm^2$ $\Delta\tau_f = 31.7\ N/mm^2$ $\Delta\sigma_{z,f} = 17.8\ N/mm^2$

valid notch stresses

$\Delta\sigma_{x,Rd,f} = \Delta\sigma_{x,Rd}/\gamma_{Mf}$, $\Delta\tau_{Rd,f} = \Delta\tau_{Rd}/\gamma_{Mf}$, $\Delta\sigma_{z,Rd,f} = \Delta\sigma_{z,Rd}/\gamma_{Mf}$

pt. 19: $y_f = -5.5$ mm, $z_f = 46.0$ mm $\Delta\sigma_{x,Rd,f} = 69.6\ N/mm^2$ $\Delta\tau_{Rd,f} = 87.0\ N/mm^2$ $\Delta\sigma_{z,Rd,f} = 87.0\ N/mm^2$

verification of notch stresses

pt. 19: y = -5.5 mm, z = 46.0 mm

$\Delta\sigma_{x,f} = 11.1\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 69.6\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.159$ ok.

$\Delta\tau_f = 31.7\ N/mm^2 < \Delta\tau_{Rd,f} = 87.0\ N/mm^2 \Rightarrow U_{\Delta\tau} = 0.364$ ok.

$\Delta\sigma_{z,f} = 17.8\ N/mm^2 < \Delta\sigma_{z,Rd,f} = 87.0\ N/mm^2 \Rightarrow U_{\Delta\sigma z} = 0.205$ ok.

interaction $U_i = U_{\Delta\sigma x}^3 + U_{\Delta\sigma z}^3 + U_{\Delta\tau}^5 = 0.019 < 1$ ok.

Final Result

fatigue design [pt. 19]: max $U = 0.364 < 1$ ok.

verification succeeded