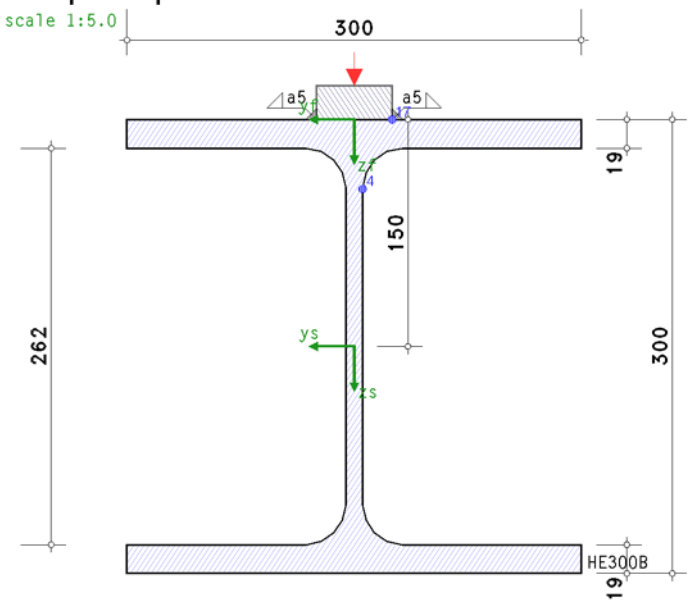
detailed problems acc. to Eurocode 3, EC 3-1-9 (12.10), NA: Deutschland 4H-EC3EM version: 11/2016-1g

1. input report

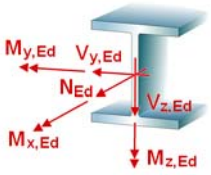


local loading by eine crane gantry
steel grade
steel grade S235
cross-section
beam: section HE300B
crane gantry
crane rail of flat steel, shear-resistant joined with the girder
connection with fillet welds: weld thickness a_w = 5.0 mm (continuous)
crane rail: width b_r = 50.0 mm, height h = 25.7 mm, 12.5% wear
height, cross-sectional area, moments of inertia of fretted rail h_r = 22.5 mm, A_r = 11.25 cm², I_{yr} = 4.75 cm⁴, I_{tr} = 14.18 cm⁴
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 bei N = 2·10⁶ cycles:

Pt.	y_f mm	z_f 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.
4	-5.5	46.0	160.0	100.0	160.0	at beam web	8.1(2) 8.1(6) 8.10(1)
° 17	-25.0	0.0	0.0	80.0	40.0	due to crane gantry	8.5(3)* 8.5(8)

°: verification of the weld, *: notch stress $\Delta\sigma_{z,Rd}$ increased by one category

loading
Lk 1: $M_{y,Ed}$ = 100.3 kNm, $V_{z,Ed}$ = 47.8 kN
Lk 2: $M_{y,Ed}$ = -20.1 kNm, $V_{z,Ed}$ = -34.0 kN
transverse loading on top flange:
vertical wheel pressure $F_{z,Ed}$ = 79.6 kN



material safety factor
design concept: damage tolerance, damage consequence: high ⇒ fatigue strength γ_{Mf} = 1.15

2. fatigue design

check of stress ranges.

cross-sectional properties
A = 149.08 cm², z_s = 150.0 mm, I_y = 25165.90 cm⁴, y_s = 0.0 mm, I_z = 8562.83 cm⁴

effective loading length from crane gantry
effective width $b_{eff} = b_r+h_r+t_{fo}$ = 91.5 mm ≤ b_{fo}
moment of inertia of crane rail with beam flange I_{rf} = 39.38 cm⁴
effective length $l_{eff} = 3.25\cdot(I_{rf}/t_w)^{1/3}$ = 107.1 mm

length of local loading
effective loading length refered ...

... to outer edge of flange $s_s = l_{eff} - 2 \cdot t_f$ = 69.1 mm / ... to periphery of web $s_w = l_{eff} + 2 \cdot r$ = 161.1 mm
local stresses ...
... at crane rail σ_{oz} = -104.7 N/mm², τ_o = 20.9 N/mm² / ... at weld σ_{oz} = -115.2 N/mm², τ_o = 23.0 N/mm²
... at beam web σ_{oz} = -44.9 N/mm², τ_o = 9.0 N/mm²

pt. 4: y_f = -5.5 mm, z_f = 46.0 mm — stress range $\Delta\sigma_{x,Ed} = 49.8 \text{ N/mm}^2 \le 1.5 \cdot f_y = 352.5 \text{ N/mm}^2$ ok
stress range $\Delta\tau_{Ed} = 25.8 \text{ N/mm}^2 \le 1.5 \cdot f_y / 3^{0.5} = 203.5 \text{ N/mm}^2$ ok
pt. 17: y_f = -25.0 mm, z_f = 0.0 mm — stress range $\Delta\sigma_{x,Ed} = 71.8 \text{ N/mm}^2 \le 1.5 \cdot f_y = 352.5 \text{ N/mm}^2$ ok
stress range $\Delta\tau_{Ed} = 5.9 \text{ N/mm}^2 \le 1.5 \cdot f_y / 3^{0.5} = 203.5 \text{ N/mm}^2$ ok

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. 4:	y_f = -5.5 mm, z_f = 46.0 mm	Lk 1:	$\sigma_x = -41.4 \text{ N/mm}^2$	$\tau_{xz} = 15.1 \text{ N/mm}^2$	
		2:	$\sigma_x = 8.3 \text{ N/mm}^2$	$\tau_{xz} = -10.7 \text{ N/mm}^2$	
			$\Delta\sigma_{x,Ed} = 49.8 \text{ N/mm}^2$	$\Delta\tau_{Ed} = 43.7 \text{ N/mm}^2$	$\Delta\sigma_{z,Ed} = 44.9 \text{ N/mm}^2$
	17: y_f = -25.0 mm, z_f = 0.0 mm	Lk 1:		$\tau_{xz} = 3.4 \text{ N/mm}^2$	
		2:		$\tau_{xz} = -2.4 \text{ N/mm}^2$	
				$\Delta\tau_{Ed} = 51.9 \text{ N/mm}^2$	$\Delta\sigma_{z,Ed} = 115.2 \text{ N/mm}^2$

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. 4:	y_f = -5.5 mm, z_f = 46.0 mm	($\lambda_{\tau\sigma z+}$)	$\Delta\sigma_{x,f} = 15.7 \text{ N/mm}^2$	$\Delta\tau_f = 25.1 \text{ N/mm}^2$	$\Delta\sigma_{z,f} = 17.8 \text{ N/mm}^2$
17:	y_f = -25.0 mm, z_f = 0.0 mm	($\lambda_{\tau\sigma z+}$)		$\Delta\tau_f = 29.9 \text{ N/mm}^2$	$\Delta\sigma_{z,f} = 45.7 \text{ N/mm}^2$

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. 4:	y_f = -5.5 mm, z_f = 46.0 mm	$\Delta\sigma_{x,Rd,f} = 139.1 \text{ N/mm}^2$	$\Delta\tau_{Rd,f} = 87.0 \text{ N/mm}^2$	$\Delta\sigma_{z,Rd,f} = 139.1 \text{ N/mm}^2$
17:	y_f = -25.0 mm, z_f = 0.0 mm		$\Delta\tau_{Rd,f} = 69.6 \text{ N/mm}^2$	$\Delta\sigma_{z,Rd,f} = 34.8 \text{ N/mm}^2$

verification of notch stresses

pt. 4: y = -5.5 mm, z = 46.0 mm
$\Delta\sigma_{x,f} = 15.7 \text{ N/mm}^2 < \Delta\sigma_{x,Rd,f} = 139.1 \text{ N/mm}^2 \Rightarrow U_{\Delta\sigma x} = 0.113$ ok
$\Delta\tau_f = 25.1 \text{ N/mm}^2 < \Delta\tau_{Rd,f} = 87.0 \text{ N/mm}^2 \Rightarrow U_{\Delta\tau} = 0.289$ ok
$\Delta\sigma_{z,f} = 17.8 \text{ N/mm}^2 < \Delta\sigma_{z,Rd,f} = 139.1 \text{ N/mm}^2 \Rightarrow U_{\Delta\sigma z} = 0.128$ ok
interaction $U_i = U_{\Delta\sigma x}^3 + U_{\Delta\sigma z}^3 + U_{\Delta\tau}^5 = 0.006 < 1$ ok

17: y = -25.0 mm, z = 0.0 mm
$\Delta\tau_f = 29.9 \text{ N/mm}^2 < \Delta\tau_{Rd,f} = 69.6 \text{ N/mm}^2 \Rightarrow U_{\Delta\tau} = 0.429$ ok
$\Delta\sigma_{z,f} = 45.7 \text{ N/mm}^2 > \Delta\sigma_{z,Rd,f} = 34.8 \text{ N/mm}^2 \Rightarrow U_{\Delta\sigma z} = 1.314$ not ok !!

3. final result

fatigue design [pt. 17]: max U = 1.314 > 1 not ok !!

resistance not ensured !!