POS. 131: SEESSELBERG 12.4.8

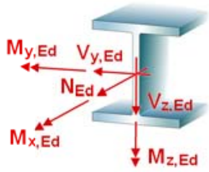
detailed problems acc. to Eurocode 3

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

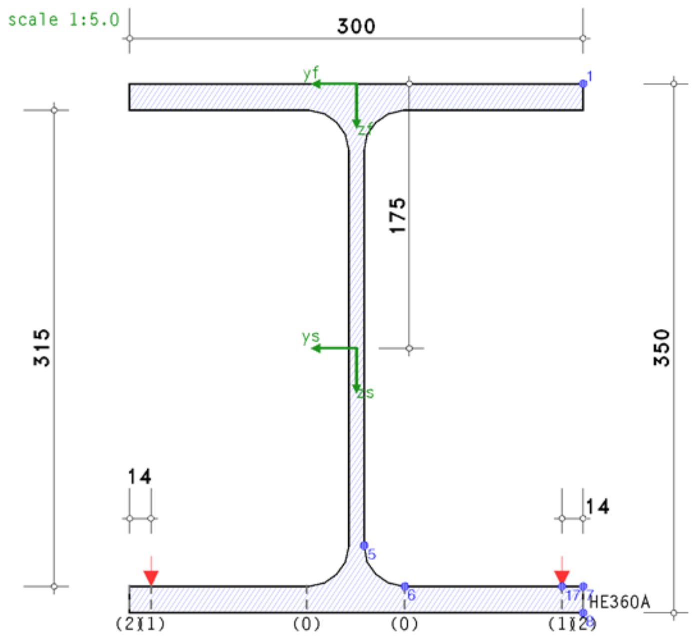
steel grade
steel grade S 235
cross-section
beam: section HE360A
parameters
damage equivalent stress factors for crane class S1: λ_σ = 0.250, λ_τ = 0.436, crane class S2: $\lambda_{\sigma+}$ = 0.315, $\lambda_{\tau+}$ = 0.500
notch class / valid notch stresses:

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.
1	-150.0	0.0	160.0	0.0	0.0	at top flange	8.1(2)
5	-5.0	305.5	160.0	100.0	160.0	at beam web	8.1(2) 8.1(6) 8.10(1)
6	-32.0	332.5	160.0	0.0	0.0	at bottom flange	8.1(2)
7	-150.0	332.5	160.0	0.0	0.0	at bottom flange	8.1(2)
8	-150.0	350.0	160.0	0.0	0.0	at bottom flange	8.1(2)
17	-136.0	332.5	160.0	0.0	0.0	due to crane gantry	8.1(2)

loading
Lk 1: EK 12
$M_{y,Ed}$ = 129.4 kNm, $M_{z,Ed}$ = 4.6 kNm
Lk 2: $M_{y,Ed}$ = 0.0 kNm, $M_{z,Ed}$ = 0.0 kNm



transverse loading on bottom flange:
design value of vertical wheel load $F_{z,Ed}$ = 9.23 kN (per side)
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 (supported lower flange), distance of the wheel from end of girder x_e = 20.0 cm
material safety factor
fatigue strength γ_{Mf} = 1.60



Fatigue Design

cross-sectional properties

$A = 142.76\ cm^2$, $z_s = 175.0$ mm, $I_y = 33090.11\ cm^4$, $y_s = 0.0$ mm, $I_z = 7886.85\ cm^4$

effective loading length from crane gantry

minimum distance of crane gantry wheel to the end of beam neglected $x_e = 200.0$ mm < $b_{fu} = 300.0$ mm !!

wheel at distance $x_e = 200.0$ mm $\leq 2\cdot 2^{1/2}\cdot(m+n) = 349.0$ mm from supported end of flange

effective length $l_{eff} = 2\cdot 2^{1/2}\cdot(m+n)+x_e+2\cdot(m+n)^2/x_e = 701.3$ mm

m = 109.4 mm, n = 14.0 mm (for $x_w = 1000.0$ mm > $2\cdot 2^{1/2}\cdot(m+n)+x_e+2\cdot(m+n)^2/x_e = 701.3$ mm)

local stresses from crane gantry at lower flange

$\sigma_{ux,Ed}(0) = 159.3\ N/mm^2$, $\sigma_{ux,Ed}(1) = 159.3\ N/mm^2$, $\sigma_{ux,Ed}(2) = 159.3\ N/mm^2$

$\sigma_{uy,Ed}(0) = -57.4\ N/mm^2$, $\sigma_{uy,Ed}(1) = 159.3\ N/mm^2$, $\sigma_{uy,Ed}(2) = 0.0\ N/mm^2$

75% of local stresses from crane gantry:

$\sigma_{ux,Ed}(0) = 119.5\ N/mm^2$, $\sigma_{ux,Ed}(1) = 119.5\ N/mm^2$, $\sigma_{ux,Ed}(2) = 119.5\ N/mm^2$

$\sigma_{uy,Ed}(0) = -43.1\ N/mm^2$, $\sigma_{uy,Ed}(1) = 119.5\ N/mm^2$, $\sigma_{uy,Ed}(2) = 0.0\ N/mm^2$

75% of local stresses from crane gantry

$\sigma_{ux,Ed}(0) = 89.6\ N/mm^2$, $\sigma_{ux,Ed}(1) = 89.6\ N/mm^2$, $\sigma_{ux,Ed}(2) = 89.6\ N/mm^2$

$\sigma_{uy,Ed}(0) = -32.3\ N/mm^2$, $\sigma_{uy,Ed}(1) = 89.6\ N/mm^2$, $\sigma_{uy,Ed}(2) = 0.0\ N/mm^2$

elastic stresses / stress ranges

$\Delta\sigma_{x,Ed} = \Delta\sigma_x + \sigma_{ux}$, $\Delta\tau_{Ed} = \Delta\tau$, $\Delta\sigma_{y,Ed} = |\sigma_{uy}|$

pt.				
1:	$y_f = -150.0$ mm, $z_f = 0.0$ mm	Lk 1:	$\sigma_x = -59.7\ N/mm^2$
		2:	$\sigma_x = 0.0\ N/mm^2$
			$\Delta\sigma_{x,Ed} = 59.7\ N/mm^2$
5:	$y_f = -5.0$ mm, $z_f = 305.5$ mm	Lk 1:	$\sigma_x = 51.3\ N/mm^2$
		2:	$\sigma_x = 0.0\ N/mm^2$
			$\Delta\sigma_{x,Ed} = 51.3\ N/mm^2$
6:	$y_f = -32.0$ mm, $z_f = 332.5$ mm	Lk 1:	$\sigma_x = 63.5\ N/mm^2$
		2:	$\sigma_x = 0.0\ N/mm^2$
			$\Delta\sigma_{x,Ed} = 153.1\ N/mm^2$
7:	$y_f = -150.0$ mm, $z_f = 332.5$ mm	Lk 1:	$\sigma_x = 70.3\ N/mm^2$
		2:	$\sigma_x = 0.0\ N/mm^2$
			$\Delta\sigma_{x,Ed} = 160.0\ N/mm^2$
8:	$y_f = -150.0$ mm, $z_f = 350.0$ mm	Lk 1:	$\sigma_x = 77.2\ N/mm^2$
		2:	$\sigma_x = 0.0\ N/mm^2$
			$\Delta\sigma_{x,Ed} = 77.2\ N/mm^2$
17:	$y_f = -136.0$ mm, $z_f = 332.5$ mm	Lk 1:	$\sigma_x = 69.5\ N/mm^2$
		2:	$\sigma_x = 0.0\ N/mm^2$
			$\Delta\sigma_{x,Ed} = 159.1\ N/mm^2$

equivalent constand amplitude stress range

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

pt.		
1:	$y_f = -150.0$ mm, $z_f = 0.0$ mm	$\Delta\sigma_{x,f} = 14.9\ N/mm^2$
5:	$y_f = -5.0$ mm, $z_f = 305.5$ mm	$\Delta\sigma_{x,f} = 12.8\ N/mm^2$
6:	$y_f = -32.0$ mm, $z_f = 332.5$ mm	$\Delta\sigma_{x,f} = 38.3\ N/mm^2$
7:	$y_f = -150.0$ mm, $z_f = 332.5$ mm	$\Delta\sigma_{x,f} = 40.0\ N/mm^2$
8:	$y_f = -150.0$ mm, $z_f = 350.0$ mm	$\Delta\sigma_{x,f} = 19.3\ N/mm^2$
17:	$y_f = -136.0$ mm, $z_f = 332.5$ mm	$\Delta\sigma_{x,f} = 39.8\ N/mm^2$

valid notch stresses

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

pt.		
1:	$y_f = -150.0$ mm, $z_f = 0.0$ mm	$\Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2$
5:	$y_f = -5.0$ mm, $z_f = 305.5$ mm	$\Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2$
6:	$y_f = -32.0$ mm, $z_f = 332.5$ mm	$\Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2$
7:	$y_f = -150.0$ mm, $z_f = 332.5$ mm	$\Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2$
8:	$y_f = -150.0$ mm, $z_f = 350.0$ mm	$\Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2$
17:	$y_f = -136.0$ mm, $z_f = 332.5$ mm	$\Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2$

verification of notch stresses

pt.			
1:	y = -150.0 mm, z = 0.0 mm	$\Delta\sigma_{x,f} = 14.9\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.149$	ok.
5:	y = -5.0 mm, z = 305.5 mm	$\Delta\sigma_{x,f} = 12.8\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.128$	ok.
6:	y = -32.0 mm, z = 332.5 mm	$\Delta\sigma_{x,f} = 38.3\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.383$	ok.
7:	y = -150.0 mm, z = 332.5 mm	$\Delta\sigma_{x,f} = 40.0\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.400$	ok.
8:	y = -150.0 mm, z = 350.0 mm	$\Delta\sigma_{x,f} = 19.3\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.193$	ok.
17:	y = -136.0 mm, z = 332.5 mm	$\Delta\sigma_{x,f} = 39.8\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 100.0\ N/mm^2 \Rightarrow U_{\Delta\sigma x} = 0.398$	ok.

Final Result

fatigue design [pt. 7]: max U = 0.400 < 1 ok.

verification succeeded