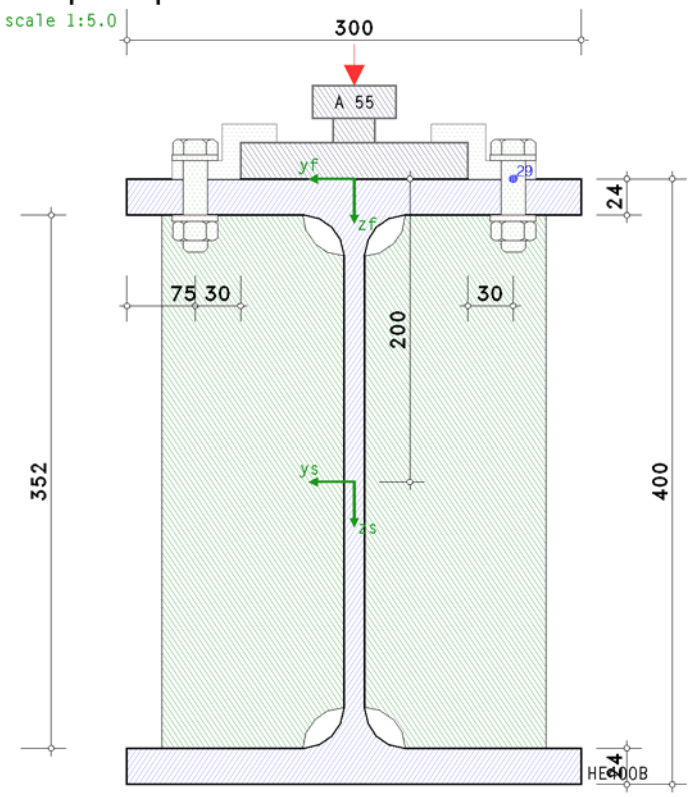
detailed problems acc. to Eurocode 3, EC 3-1-9 (12.10), NA: Deutschland 4H-EC3EM version: 11/2016-1g

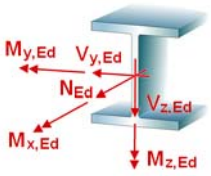
1. input report



local loading by eine crane gantry
steel grade
steel grade S355
cross-section
beam: section HE400B
transverse stiffeners: section parameters (flat steel):
height h = 120.0 mm, thickness t = 20.0 mm
recess at transverse stiffener $c_{st,q}$ = 27.0 mm
crane gantry
A-crane rail 55, 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 $F_{p,C}^* = 0.7 \cdot f_{yb} \cdot A_s$ = 70.3 kN)
shear plane passes through the unthreaded portion of the bolt
crane rail: head width b_k = 55.0 mm, bottom width b_r = 150.0 mm, height h = 65.0 mm, 12.5% wear
height, cross-sectional area, moments of inertia of fretted rail h_r = 61.8 mm, A_r = 38.80 cm², I_{yr} = 155.00 cm⁴, I_{tr} = 77.90 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 = $2 \cdot 10^6$ 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.
29	-105.0	0.0	90.0	100.0	0.0	due to crane gantry	8.1(11) 8.1(15)

loading
Lk 1: $M_{y,Ed}$ = 301.0 kNm, $V_{z,Ed}$ = 290.0 kN
Lk 2: $M_{y,Ed}$ = -30.0 kNm, $V_{z,Ed}$ = 0.0 kN
transverse loading on top flange:
vertical wheel pressure $F_{z,Ed}$ = 290.0 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
$A = 197.78\ cm^2$, $z_s = 200.0\ mm$, $I_y = 57680.93\ cm^4$, $y_s = 0.0\ mm$, $I_z = 10819.05\ cm^4$

effective loading length from crane gantry
effective width $b_{eff} = b_r+h_r+t_{fo} = 235.8\ mm \le b_{fo}$
effective moment of inertia of beam flange $I_{f,eff} = b_{eff}\cdot t_{fo}^3/12 = 27.16\ cm^4$
moment of inertia of crane rail $I_r = 155.00\ cm^4$
effective length $l_{eff} = 3.25\cdot((I_r+I_{f,eff})/t_w)^{1/3} = 166.7\ mm$

length of local loading
effective loading length refered ...
... to outer edge of flange $s_s = l_{eff} - 2\cdot t_f = 118.7\ mm$ / ... to periphery of web $s_w = l_{eff} + 2\cdot r = 220.7\ mm$
local stresses ...
... at crane rail $\sigma_{oz} = -181.0\ N/mm^2$, $\tau_o = 36.2\ N/mm^2$
... at beam web $\sigma_{oz} = -97.3\ N/mm^2$, $\tau_o = 19.5\ N/mm^2$

pt. 29: $y_f = -105.0\ mm$, $z_f = 0.0\ mm$
stress range $\Delta\sigma_{x,Ed} = 130.4\ N/mm^2 \le 1.5\cdot f_y = 532.5\ N/mm^2$ ok
stress range $\Delta\tau_{Ed} = 4.3\ N/mm^2 \le 1.5\cdot f_y/3^{0.5} = 307.4\ N/mm^2$ 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. 29: $y_f = -105.0\ mm$, $z_f = 0.0\ mm$	Lk 1:	$\sigma_x = -118.6\ N/mm^2$	$\tau_{xz} = 4.3\ N/mm^2$
	2:	$\sigma_x = 11.8\ N/mm^2$	$\tau_{xz} = 0.0\ N/mm^2$
		$\Delta\sigma_{x,Ed} = 130.4\ N/mm^2$	$\Delta\tau_{Ed} = 43.2\ N/mm^2$

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. 29: $y_f = -105.0\ mm$, $z_f = 0.0\ mm$	($\lambda_{\tau+}$)	$\Delta\sigma_{x,f} = 41.1\ N/mm^2$	$\Delta\tau_f = 24.9\ N/mm^2$

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. 29: $y_f = -105.0\ mm$, $z_f = 0.0\ mm$	$\Delta\sigma_{x,Rd,f} = 78.3\ N/mm^2$	$\Delta\tau_{Rd,f} = 87.0\ N/mm^2$

verification of notch stresses

pt. 29: $y = -105.0\ mm$, $z = 0.0\ mm$	$\Delta\sigma_{x,f} = 41.1\ N/mm^2 < \Delta\sigma_{x,Rd,f} = 78.3\ N/mm^2$	$\Rightarrow U_{\Delta\sigma x} = 0.525$	ok
	$\Delta\tau_f = 24.9\ N/mm^2 < \Delta\tau_{Rd,f} = 87.0\ N/mm^2$	$\Rightarrow U_{\Delta\tau} = 0.286$	ok

3. final result

fatigue design [pt. 29]: max U = 0.525 < 1 ok

verification succeeded