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
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: $\lambda_{e} = 0.315$, $\lambda_{r} = 0.500$, crane class S3: $\lambda_{e+} = 0.397$, $\lambda_{r+} = 0.575$
- notch class / valid notch stresses:

<table>
<thead>
<tr>
<th>Pt.</th>
<th>$y_f$ (mm)</th>
<th>$z_f$ (mm)</th>
<th>$\Delta \sigma_{x, Ed}$ (N/mm$^2$)</th>
<th>$\Delta \tau_{Ed}$ (N/mm$^2$)</th>
<th>$\Delta \sigma_{z, Ed}$ (N/mm$^2$)</th>
<th>notch point</th>
<th>EC 3-1-9, tab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>-5.5</td>
<td>46.0</td>
<td>160.0</td>
<td>100.0</td>
<td>160.0</td>
<td>at beam web</td>
<td>8.1(2) 8.1(6) 8.10(1)</td>
</tr>
</tbody>
</table>

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:
design value of vertical wheel load $F_{z, Ed} = 79.60$ kN

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

scale 1:5.0

Fatigue Design

cross-sectional properties
- $A = 149.08$ cm$^2$, $z_x = 150.0$ 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 $b_{eff} = b_r + h_r + t_0 = 91.5$ mm ≤ $b_0$
-moment of inertia of crane rail with beam flange $I_{rt} = 39.38$ cm$^4$
effective length $l_{eff} = 3.25\cdot(l_{rt}/w)^{1/3} = 107.1$ mm

local stresses from crane gantry
effective loading length referred ...
- to outer edge of flange $s_o = l_{eff} - 2 \cdot t_r = 69.1$ mm / ...
- to web $s_w = l_{eff} + 2 \cdot t_r = 161.1$ mm

local stresses ...

#4 EC3EM / pceo GmbH / Kopernikusstrasse 4A / 30167 Hannover / Tel (0511) 70030 / Fax (0511) 700389 / pco0000001
... at crane rail $\sigma_{oz} = -104.7\ \text{N/mm}^2$, $\tau_o = 20.9\ \text{N/mm}^2$ / ... at weld $\sigma_{oz} = -115.2\ \text{N/mm}^2$, $\tau_o = 23.0\ \text{N/mm}^2$

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

elastic stresses / stress ranges

$L_k$: $\sigma_x = 41.4\ \text{N/mm}^2$  
$\tau_{xz} = 15.1\ \text{N/mm}^2$  
$\Delta\sigma_{x,Ed} = 49.8\ \text{N/mm}^2$  
$\Delta\tau_{Ed} = 43.7\ \text{N/mm}^2$  
$\Delta\sigma_{x,Ed} = 44.9\ \text{N/mm}^2$

equivalent constant amplitude stress range

$L_k$: $\sigma_x = 41.4\ \text{N/mm}^2$  
$\tau_{xz} = 15.1\ \text{N/mm}^2$  
$\Delta\sigma_{x,f} = 49.8\ \text{N/mm}^2$  
$\Delta\tau_{f} = 43.7\ \text{N/mm}^2$  
$\Delta\sigma_{x,f} = 44.9\ \text{N/mm}^2$

valid notch stresses

$L_k$: $\sigma_x = 41.4\ \text{N/mm}^2$  
$\tau_{xz} = 15.1\ \text{N/mm}^2$  
$\Delta\sigma_{x,Ed} = 49.8\ \text{N/mm}^2$  
$\Delta\tau_{Ed} = 43.7\ \text{N/mm}^2$  
$\Delta\sigma_{x,Ed} = 44.9\ \text{N/mm}^2$

verification of notch stresses

$L_k$: $\sigma_x = 41.4\ \text{N/mm}^2$  
$\tau_{xz} = 15.1\ \text{N/mm}^2$  
$\Delta\sigma_{x,f} = 49.8\ \text{N/mm}^2$  
$\Delta\tau_{f} = 43.7\ \text{N/mm}^2$  
$\Delta\sigma_{x,f} = 44.9\ \text{N/mm}^2$

Final Result

fatigue design [pt. 4]: $\max U = 0.289 < 1 \ \text{ok.}$

verification succeeded