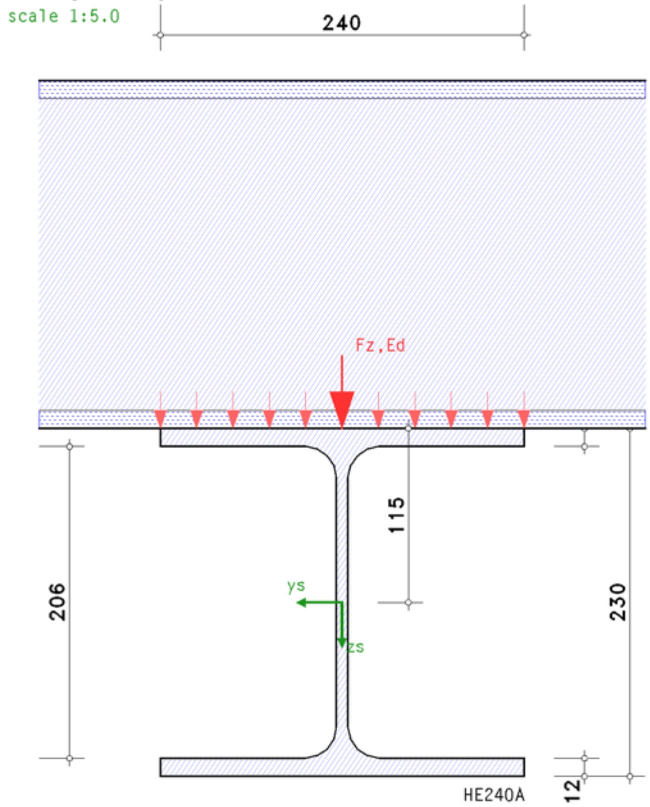
POS. 8: BSP. 6 CROSSING OF GIRDERS

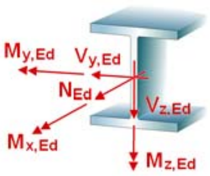
detailed problems acc. to Eurocode 3, EC 3-6 (12.10), NA: Deutschland

4H-EC3LK version: 11/2016-1f

1. input report



steel grade
steel grade S235
cross-section
beam: section HE240A
loading
internal forces and moments at limit state of resistance (ULS):



Lk	N_{Ed} kN	$M_{y,Ed}$ kNm	$V_{z,Ed}$ kN	$M_{z,Ed}$ kNm	$V_{y,Ed}$ kN	$M_{x,Ed}$ kNm
1	-0.9	124.5	-23.3	-0.1	1.4	0.3
2	0.5	124.5	-23.2	0.1	-1.2	-0.3
3	-0.1	22.5	-4.0	0.1	0.3	-0.0
4	0.4	124.5	-23.2	0.2	-0.4	-0.4
5	0.0	22.5	-4.1	0.1	0.0	-0.0
6	-0.4	124.6	-23.2	-0.1	0.2	0.2
7	0.3	124.4	-23.2	0.2	-0.2	-0.4
8	-1.0	124.5	-2.9	-0.4	1.4	0.3
9	0.4	124.5	-2.9	0.4	-1.3	-0.3
10	-0.1	22.5	-2.1	0.1	0.2	-0.0
11	0.3	124.5	-2.9	0.3	-0.6	-0.4
12	0.0	22.5	-2.1	0.1	-0.0	-0.0
13	-0.5	124.6	-2.9	-0.1	0.2	0.2
14	0.4	124.4	-2.9	0.5	-1.1	-0.3

transverse loading on top flange:
vertical single load $F_{z,Ed,ULS}$ = 90.00 kN by a load girder (crossing of girders) section HE240A
verification in beam field
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10

2. verification der local loading

assumption: flange induced web buckling is excluded.
assumption: plated structures-/shear buckling is excluded.

cross-sectional properties: $A = 76.84\ cm^2$, $z_s = 115.0$ mm, $I_y = 7763.27\ cm^4$, $y_s = 0.0$ mm, $I_z = 2768.81\ cm^4$

feed length of load by den Lastträger $s_s = 2 \cdot t_f + t_w + 1.172 \cdot r = 56.1$ mm
effective loading length $l_{eff} = s_s + 2 \cdot t_f = 80.1$ mm
refering to outer edge of flange $s_s = l_{eff} - 2 \cdot t_f = 56.1$ mm / auf den webanschnitt $s_w = l_{eff} + 2 \cdot r = 122.1$ mm

2.1. compression of web (ULS)

permissible stresses: $\sigma_{Rd} = f_y/\gamma_{M0} = 235.0\ N/mm^2$, $\tau_{Rd} = f_y/(3^{1/2} \cdot \gamma_{M0}) = 135.7\ N/mm^2$

compression of single load at first cut of web:
local stresses $\sigma_{oz,Ed} = -98.3\ N/mm^2$, $\tau_{oxz,Ed} = 0.0\ N/mm^2$
$|\sigma_{oz,Ed}| = 98.3\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.418 < 1$ ok

stresses at first cut of web:

Lk	$U_{\sigma x}$	$U_{\tau xz}$	$U_{\sigma v}$	U	Lk	$U_{\sigma x}$	$U_{\tau xz}$	$U_{\sigma v}$	U
1	0.560	0.102	0.515	0.560* < 1 ok	8	0.560	0.013	0.505	0.560* < 1 ok
2	0.559	0.101	0.514	0.559 < 1 ok	9	0.559	0.013	0.504	0.559 < 1 ok
3	0.101	0.018	0.378	0.378 < 1 ok	10	0.101	0.009	0.378	0.378 < 1 ok
4	0.559	0.101	0.514	0.559 < 1 ok	11	0.559	0.013	0.504	0.559 < 1 ok
5	0.101	0.018	0.378	0.378 < 1 ok	12	0.101	0.009	0.378	0.378 < 1 ok
6	0.560	0.101	0.514	0.560* < 1 ok	13	0.560	0.013	0.505	0.560* < 1 ok
7	0.559	0.102	0.514	0.559 < 1 ok	14	0.559	0.013	0.504	0.559 < 1 ok

$U_{\sigma x}$: utilization due to normal stress; $U_{\tau xz}$: utilization due to shear stress; $U_{\sigma v}$: utilization due to equivalent stress
U: utilization
***) maximum utilization**

Lk 8: $N_{Ed} = -1.0$ kN, $M_{y,Ed} = 124.5$ kNm, $V_{z,Ed} = -2.9$ kN, $M_{z,Ed} = -0.4$ kNm... (decisive, detailed edition)
stresses $\sigma_{x,Ed} = -98.3\ N/mm^2$, $\tau_{xz,Ed} = 0.0\ N/mm^2$
$|\sigma_{x,Ed}| = 131.6\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.560 < 1$ ok
$|\tau_{xz,Ed}| = 1.7\ N/mm^2 < \tau_{Rd} = 135.7\ N/mm^2 \Rightarrow U = 0.013 < 1$ ok
$\sigma_v = 118.6\ N/mm^2 < \sigma_{Rd} = 235.0\ N/mm^2 \Rightarrow U = 0.505 < 1$ ok

maximum utilization: max $U_{ULS} = 0.560 < 1$ ok

2.2. buckling of transverse loading (ULS)

slenderness $\lambda_F = (F_y/F_{cr})^{1/2} = 0.404$, $F_y = 380.5$ kN
reduction factor $\chi_F = 1.000$
resistance of buckling $F_{z,Rd} = f_y \cdot L_{eff} \cdot t_w/\gamma_{M1} = 345.88$ kN, $L_{eff} = \chi_F \cdot l_y = 215.9$ mm, $l_y = 215.9$ mm
verification: $F_{z,Ed}/F_{z,Rd} = 0.260 < 1$ ok

interaction (without plated structures-/shear buckling):
transverse loading and equivalent stress $(\eta_2 + 0.8 \cdot \eta_1) / 1.4 = 0.506 < 1$ ok
with $\eta_2 = F_{z,Ed}/F_{z,Rd} = 0.260$, $\eta_1 = \max U_{ULS} = 0.560$

3. final result

maximum utilization: max $U = 0.560 < 1$ ok

verification succeeded