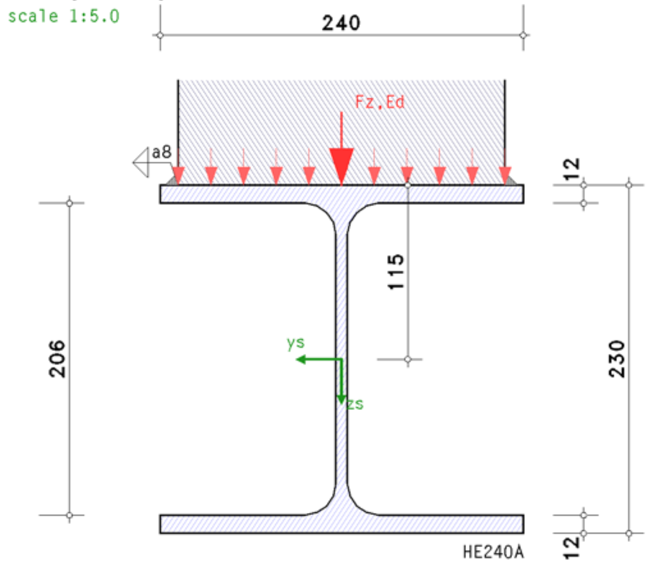
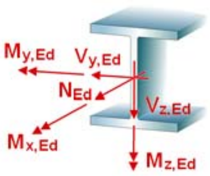
POS. 9: BSP. 7 AUFGESCHW. PLATE

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 1: N_{Ed} = -345.0 kN, $M_{y,Ed}$ = 125.0 kNm, $V_{z,Ed}$ = 86.0 kN
$M_{z,Ed}$ = 85.0 kNm, $V_{y,Ed}$ = 167.0 kN
transverse loading on top flange:
vertical single load $F_{z,Ed,ULS}$ = 90.00 kN by a welded plate
plate thickness t_p = 20.0 mm, weld thickness a_w = 6.0 mm
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 cm², z_s = 115.0 mm, I_y = 7763.27 cm⁴, y_s = 0.0 mm, I_z = 2768.81 cm⁴

feed length of load due to the welded plate $s_s = t_p + 2.828 \cdot a_w$ = 37.0 mm
effective loading length $l_{eff} = s_s + 2 \cdot t_f$ = 61.0 mm, t_f = 12.0 mm
refering to outer edge of flange $s_s = l_{eff} - 2 \cdot t_f$ = 37.0 mm / auf den webanschnitt $s_w = l_{eff} + 2 \cdot r$ = 103.0 mm

2.1. compression of web (ULS)

permissible stresses
$\sigma_{Rd} = f_y/\gamma_{M0}$ = 235.0 N/mm², $\tau_{Rd} = f_y/(3^{1/2} \cdot \gamma_{M0})$ = 135.7 N/mm²

compression of single load at first cut of web
local normal stress $\sigma_{oz,Ed} = -F_{z,Ed}/(t_w \cdot s_w)$ = -116.5 N/mm², $F_{z,Ed}$ = 90.0 kN, s_w = 103.0 mm
$|\sigma_{oz,Ed}|$ = 116.5 N/mm² < σ_{Rd} = 235.0 N/mm² ⇒ U = 0.496 < 1 ok

stresses at first cut of web
Lk 1: N_{Ed} = -345.0 kN, $M_{y,Ed}$ = 125.0 kNm, $V_{z,Ed}$ = 86.0 kN, $M_{z,Ed}$ = 85.0 kNm
normal stress $\sigma_{x,Ed}$ = -176.9 N/mm²
$|\sigma_{x,Ed}|$ = 176.9 N/mm² < σ_{Rd} = 235.0 N/mm² ⇒ U = 0.753 < 1 ok
shear stress $\tau_{xz,Ed}$ = 51.0 N/mm²
$|\tau_{xz,Ed}|$ = 51.0 N/mm² < τ_{Rd} = 135.7 N/mm² ⇒ U = 0.376 < 1 ok
equivalent stress $\sigma_v = (\sigma_{x,Ed}^2 + \sigma_{oz,Ed}^2 - \sigma_{x,Ed} \cdot \sigma_{oz,Ed} + 3 \cdot \tau_{xz,Ed}^2)^{1/2}$ = 179.1 N/mm²

σ_v = 179.1 N/mm² < σ_{Rd} = 235.0 N/mm² ⇒ U = 0.762 < 1 ok

maximum utilization: max U_{ULS} = 0.762 < 1 ok

2.2. buckling of transverse loading (ULS)

buckling field a = 20600.0 mm, h_w = 206.0 mm, t_w = 7.5 mm
buckling factor $k_F = 6.0 + 2 \cdot (h_w/a)^2 = 6.00$ (type (a))
critical buckling load $F_{cr} = k_F \cdot \sigma_E \cdot t_w \cdot h_w$ = 2332.3 kN, $\sigma_E = \pi^2 \cdot E/(12 \cdot (1-\mu^2)) \cdot (t/b')^2$ = 251.6 N/mm², b' = 206.0 mm
effective load expansion length $l_y = s_s + 2 \cdot t_f \cdot (1+m_1^{1/2})$ = 196.7 mm, $m_1 = b_f/t_w$ = 32.00
yield load $F_y = f_y \cdot t_w \cdot l_y$ = 346.7 kN
slenderness $\lambda_F = (F_y/F_{cr})^{1/2}$ = 0.386
reduction factor $\chi_F = 0.5/\lambda_F$ = 1.297 > 1 ⇒ χ_F = 1.000
effective buckling length $L_{eff} = \chi_F \cdot l_y$ = 196.7 mm
resistance of buckling $F_{z,Rd} = f_y \cdot L_{eff} \cdot t_w / \gamma_{M1}$ = 315.22 kN
verification
$F_{z,Ed}/F_{z,Rd}$ = 0.286 < 1 ok

interaction (without plated structures-/shear buckling)
transverse loading and equivalent stress $(\eta_2 + 0.8 \cdot \eta_1) / 1.4$ = 0.639 < 1 ok
with $\eta_2 = F_{z,Ed}/F_{z,Rd}$ = 0.286, η_1 = max U_{ULS} = 0.762

3. final result

maximum utilization: max U = 0.762 < 1 ok

verification succeeded