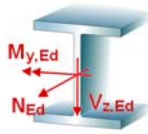
detailed problems acc. to Eurocode 3

EC 3-1-5 (12.10), NA: Deutschland

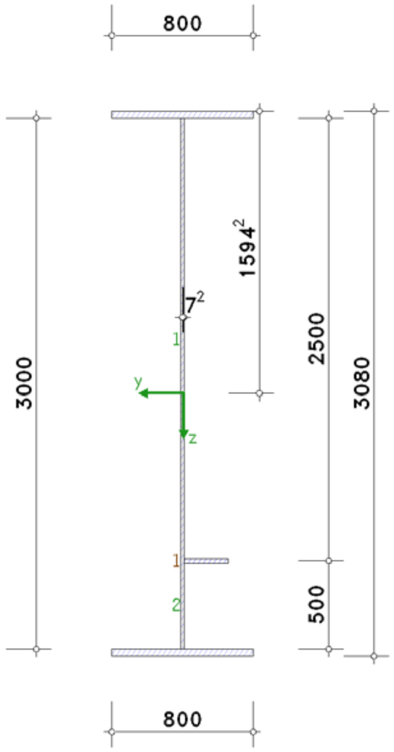
steel grade
steel grade S 355
cross-section
beam: parameter (I-section):
$h = 3080.0$ mm, $t_w = 15.0$ mm, $b_f = 800.0$ mm, $t_f = 40.0$ mm
longitudinal stiffeners: number $n_{st} = 1$
section parameters (flat steel):
$h = 250.0$ mm, $t = 25.0$ mm
distance of stiffener to the top edge of beam $d_{st,0} = 2540.0$ mm
parameters
length of buckling field a = 300.0 cm
method of reduced stresses
rigid support stiffener
verification at intermediate support
calculation of buckling factors with 4H-tool
loading
internal forces and moments refering to the stiffened cross-section:
Lk 1: method of reduced stresses (chap. 10)
$N_{Ed} = -4000.0$ kN $M_{Ed} = -32750.0$ kNm $V_{Ed} = 3288.0$ kN



partial safety factors for material
resistance of cross-sections $\gamma_{M0} = 1.00$
resistance of members in stability failure $\gamma_{M1} = 1.10$

verifications of buckling resistance

assumption: flange induced web buckling is excluded.
assumption: local buckling of stiffeners is excluded.
assumption: plate area is supported rigidly.
the assumptions are not checked !!



method of reduced stresses
EC 3-convention, compressive stresses positive
shear distortions are ignored.
cross-sectional properties: A = 1152.50 cm², z_s = 1594.2 mm, I_y = 18753552.18 cm⁴, y_s = 7.2 mm, I_z = 355050.53 cm⁴
maximum/minimum stresses: σ_o = -243.7 N/mm², σ_u = 294.2 N/mm², τ = 73.1 N/mm²
section class: 4 ⇒ verification of buckling resistance required !!
buckling factors (4H-tool)
web: α_{cr} = 0.838, $\alpha_{cr,1}$ = 0.621, $\alpha_{cr,2}$ = 2.688
reduced stresses
flange top:
buckling stresses σ_{Ed} = -240.2 N/mm² ≤ 0 ⇒ verification not required
flange bottom:
σ_{Ed} = 290.7 N/mm²
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2}$ = 0.646, α_{ult} = 1.221, α_{cr} = 2.925
reduction factor ρ = 1 for λ_p < 0.748, ψ = 1.000
ultimate buckling stress $\sigma_{Rd} = \rho \cdot f_y/\gamma_{M1}$ = 322.7 N/mm²
verification: σ_{Ed}/σ_{Rd} = 0.901 < 1 ok.
web:
single buckling field 1:
σ_{Ed} = 236.7 N/mm², τ_{Ed} = 73.1 N/mm²
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2}$ = 1.459, α_{ult} = 1.323, α_{cr} = 0.621 (4H-tool)
reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2$ = 0.638 ≤ 1 for $\lambda_p > 0.5 + (0.085-0.055 \cdot \psi)^{1/2}$ = 0.887, ψ = -1.184
reduction factor $\chi_w = 1.37/(0.7+\lambda_w)$ = 0.635 for λ_w ≥ 1.08
ultimate buckling stresses $\sigma_{Rd} = \rho \cdot f_y/\gamma_{M1}$ = 206.1 N/mm², $\tau_{Rd} = \chi_w \cdot f_y/(3^{1/2} \cdot \gamma_{M1})$ = 118.2 N/mm²
verification: $((\sigma_{Ed}/\sigma_{Rd})^2 + (\tau_{Ed}/\tau_{Rd})^2)^{1/2}$ = 1.304 > 1 not ok. !!
single buckling field 2:
σ_{Ed} = 287.2 N/mm², τ_{Ed} = 73.1 N/mm²
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2}$ = 0.649, α_{ult} = 1.131, α_{cr} = 2.688 (4H-tool)
reduction factor ρ = 1 for $\lambda_p < 0.5 + (0.085-0.055 \cdot \psi)^{1/2}$ = 0.716, ψ = 0.696
reduction factor $\chi_w = 1.200 = \eta$ for $\lambda_w < 0.83/\eta$ = 0.692
ultimate buckling stresses $\sigma_{Rd} = \rho \cdot f_y/\gamma_{M1}$ = 322.7 N/mm², $\tau_{Rd} = \chi_w \cdot f_y/(3^{1/2} \cdot \gamma_{M1})$ = 223.6 N/mm²
verification: $((\sigma_{Ed}/\sigma_{Rd})^2 + (\tau_{Ed}/\tau_{Rd})^2)^{1/2}$ = 0.948 < 1 ok.
overall buckling field:
σ_{Ed} = 287.2 N/mm², τ_{Ed} = 73.1 N/mm²
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2}$ = 1.162, α_{ult} = 1.131, α_{cr} = 0.838 (4H-tool)
reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2$ = 0.772 ≤ 1 for $\lambda_p > 0.5 + (0.085-0.055 \cdot \psi)^{1/2}$ = 0.861, ψ = -0.824
critical buckling stress $\sigma_{cr,p} = \alpha_{cr} \cdot \sigma_{Ed}'$ = 240.8 N/mm², σ_{Ed}' = 287.2 N/mm²
critical buckling stress $\sigma_{cr,c} = \sigma_{cr,c,sl} \cdot \sigma_1/\sigma_{sl}$ = 1978.8 N/mm², σ_1/σ_{sl} = 1.437, $\sigma_{cr,c,sl}$ = 1377.2 N/mm²
reduction factor χ_c = 0.428 ≤ 1 for λ_c > 0.2
final reduction factor $\rho = (\rho - \chi_c) \cdot \xi \cdot (2-\xi) + \chi_c$ = 0.428 with ξ = 0.000
reduction factor $\chi_w = 1.37/(0.7+\lambda_w)$ = 0.736 for λ_w ≥ 1.08
ultimate buckling stresses $\sigma_{Rd} = \rho \cdot f_y/\gamma_{M1}$ = 138.1 N/mm², $\tau_{Rd} = \chi_w \cdot f_y/(3^{1/2} \cdot \gamma_{M1})$ = 137.1 N/mm²
verification: $((\sigma_{Ed}/\sigma_{Rd})^2 + (\tau_{Ed}/\tau_{Rd})^2)^{1/2}$ = 2.147 > 1 not ok. !!

total utilization: U = 2.147 > 1 not ok. !!

Final Result

maximum utilization: max U = 2.147 > 1 not ok. !!

design resistance not ensured !!

Regulations

DIN EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
DIN EN 1990/NA, Nationaler Anhang zur DIN EN 1990, Ausgabe Dezember 2010

DIN EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-1/NA, Nationaler Anhang zur DIN EN 1993-1-1, Ausgabe Dezember 2010

DIN EN 1993-1-5, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-5: Plattenförmige Bauteile;

Deutsche Fassung EN 1993-1-5:2006 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-5/NA, Nationaler Anhang zur DIN EN 1993-1-5, Ausgabe Dezember 2010