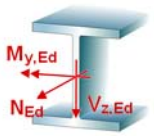
detailed problems acc. to Eurocode 3

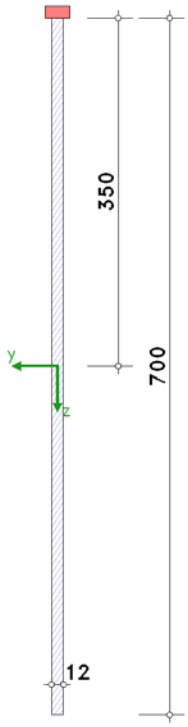
EC 3-1-5 (12.10), NA: Deutschland

steel grade
steel grade S 235
cross-section
buckling field: thickness t = 12.0 mm, width b = 700.0 mm
transverse stiffeners to limit the buckling field:
section L100X65X9
parameters
length of buckling field a = 200.0 cm
method of reduced stresses
verification in beam field
calculation of buckling factors acc. to EC 3-1-5
loading
Lk 1: M_{Ed} = 69.6 kNm V_{Ed} = 244.0 kN
transverse loading on upper edge of cross-section:
design value of the vertical single load $F_{z,Ed}$ = 400.0 kN, loading length s_s = 300.0 mm
partial safety factors for material
resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10



verifications of buckling resistance

assumption: flange induced web buckling is excluded.
assumption: local buckling of stiffeners is excluded.
assumption: transverse stiffeners serve as rigid support of the plated panel.



Lk 1:

method of reduced stresses
EC 3-convention, compressive stresses positive
buckling of transverse loading: loading length > distance of two single loads, double load is not investigated !!
shear distortions are ignored.
cross-sectional properties: A = 84.00 cm², z_s = 350.0 mm, I_y = 34300.00 cm⁴, y_s = 0.0 mm, I_z = 10.08 cm⁴
maximum/minimum stresses: σ_o = 71.0 N/mm², σ_u = -71.0 N/mm², τ = 29.0 N/mm², σ_z = 111.1 N/mm²
reduced stresses
σ_{Ed} = 71.0 N/mm², $\sigma_{z,Ed}$ = 111.1 N/mm², τ_{Ed} = 29.0 N/mm²
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2}$ = 0.983, α_{ult} = 2.143, α_{cr} = 2.218
reduction factor $\rho = (\lambda_p - 0.055\cdot(3+\psi))/\lambda_p^2$ = 0.904 ≤ 1 for $\lambda_p > 0.5 + (0.085-0.055\cdot\psi)^{1/2}$ = 0.874, ψ = -1.000
reduction factor $\rho_z = 1/(\varphi_p + (\varphi_p^2-\lambda_p)^{1/2})$ = 0.786 with $\varphi_p = (1+\alpha_p\cdot(\lambda_p-\lambda_{p0})+\lambda_p)/2$ = 1.023, α_p = 0.34, λ_{p0} = 0.8
critical buckling stress $\sigma_{cr,p} = \alpha_{cr}\cdot\sigma_{z,Ed}$ = 246.5 N/mm²
critical buckling stress $\sigma_{cr,c} = \pi^2\cdot E/(12\cdot(1-\mu^2))\cdot(t/b')^2$ = 55.8 N/mm², b' = 700.0 mm
reduction factor χ_c = 0.678 ≤ 1 for λ_c > 0.2
final reduction factor $\rho_z = (\rho_z-\chi_c)\cdot\xi\cdot(2-\xi) + \chi_c$ = 0.786 with ξ = 1.000
reduction factor χ_w = 0.83/λ_w = 0.844 for 0.83/η = 0.692 ≤ λ_w < 1.08
ultimate buckling stresses $\sigma_{Rd} = \rho\cdot f_y/\gamma_{M1}$ = 193.0 N/mm², $\sigma_{z,Rd} = \rho_z\cdot f_y/\gamma_{M1}$ = 167.8 N/mm²,
$\tau_{Rd} = \chi_w\cdot f_y/(3^{1/2}\cdot\gamma_{M1})$ = 104.2 N/mm²
verification: $((\sigma_{Ed}/\sigma_{Rd})^2 + (\sigma_{z,Ed}/\sigma_{z,Rd})^2 - \rho\cdot\rho_z\cdot(\sigma_{Ed}/\sigma_{Rd})\cdot(\sigma_{z,Ed}/\sigma_{z,Rd}) + (\tau_{Ed}/\tau_{Rd})^2)^{1/2}$ = 0.692 < 1 ok.
transverse stiffeners:
rigid support of buckling field:
assumption: transverse stiffeners without axial force.
I_{st} = 140.66 cm⁴ > $\sigma_m/E\cdot(b/\pi)^4\cdot(1+w_0\cdot 300\cdot u/b)$ = 0.17 cm⁴ ok.
torsional buckling:
$I_{T,st}/I_{p,st}$ = 0.47% < $5.3\cdot f_y/E$ = 0.59% ok.
minimum moment of inertia to ensure a rigid support:
I_{sl} = 707.95 cm⁴ > $0.75\cdot h_w\cdot t^3$ = 90.72 cm⁴ ok. for a/h_w = 2.86 ≥ $2^{1/2}$

total utilization: U = 0.692 < 1 ok.

Final Result

maximum utilization: max U = 0.692 < 1 ok.
assumptions: succeeded ok.

verifications succeeded

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