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 = 1720.0 mm, t_w = 12.0 mm, b_{fo} = 750.0 mm, t_{fo} = 100.0 mm, b_{fu} = 850.0 mm, t_{fu} = 120.0 mm

parameters

length of buckling field a = 1000.0 cm

method of effective cross-sectional area

verification in beam field

calculation of buckling factors acc. to EC 3-1-5

effective cross-sectional properties: A_{eff} solely from compression, W_{eff} solely from bending

verification of stability acc. to EC 3-1-1, 6.3

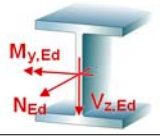
loading

Lk 1: M_{Ed} = 10000.0 kNm

partial safety factors for material

resistance of cross-sections γ_{M0} = 1.00

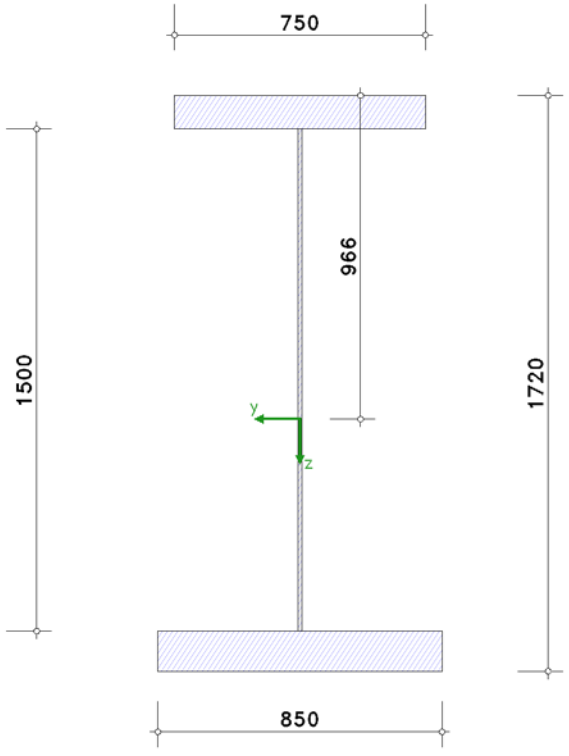
resistance of members in stability failure γ_{M1} = 1.10



verifications of buckling resistance

assumption: flange induced web buckling is excluded.

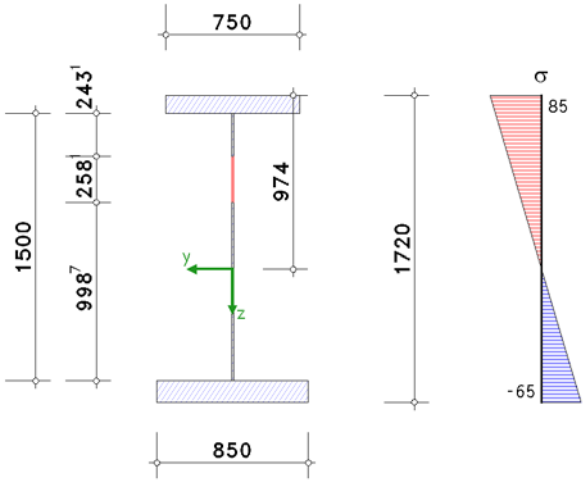
assumption: plate area is supported rigidly.



Lk 1:

method of effective cross-sectional area
EC 3-convention, compressive stresses positive
shear distortions are ignored.
cross-sectional properties: A = 1950.00 cm², z_s = 966.0 mm, I_y = 11585818.00 cm⁴, y_s = 0.0 mm, I_z = 965709.10 cm⁴
maximum/minimum stresses: σ_o = 83.4 N/mm², σ_u = -65.1 N/mm²
section class: 4 ⇒ verification of plate buckling required !!

plate buckling
effective section modulus for M_{Ed} = -10000.0 kNm, N_{Ed} = 0
flange top:
  section class 1 for c/t = 3.69 < 7.32
  effective width $b_{c,eff}$ = b = 369.0 mm
flange bottom:
  effective width $b_{t,eff}$ = b = 419.0 mm
web:
  section class 4 for α = 0.577 and 80.85 < c/t = 125.00
  critical buckling stress $\sigma_{cr,p} = k_\sigma \cdot \sigma_E$ = 214.5 N/mm², σ_E = 12.1 N/mm², k_σ = 17.66
  buckling slenderness ratio $\lambda_p = (f_y/\sigma_{cr,p})^{1/2}$ = 1.287
  reduction factor $\rho = (\lambda_p - 0.055\cdot(3+\psi))/\lambda_p^2$ = 0.702 ≤ 1 for $\lambda_p > 0.5 + (0.085-0.055\cdot\psi)^{1/2}$ = 0.854, ψ = -0.732
  effective width $b_{c,eff} = (\rho \cdot b) / (1-\psi)$ = 607.9 mm (b_{e1} = 243.1 mm, b_{e2} = 364.7 mm), $b_{t,eff}$ = 634.0 mm, ψ = -0.732
flange induced web buckling:
  h_w/t_w = 125.00 < $(k\cdot E)/(f_y\cdot(A_w/A_{fc})^{1/2})$ = 159.39 ok. with k = 0.55, A_w = 180.00 cm², A_{fc} = 750.00 cm²
limit loads refering to the reduced cross-section:
  distance of centroid from top $z_{s,eff}$ = 974.0 mm
  second moment of area $I_{y,eff}$ = 11507350.99 cm⁴
  section modulus $W_{y,eff}$ = 124542.40 cm³
  load capacities $M_{Rd} = (f_y \cdot W_{eff}) / \gamma_{M1}$ = 40193.23 kNm



verification
$|M_{Ed}|/M_{Rd,u}$ = 0.249 < 1 ok.

total utilization: U = 0.249 < 1 ok.

Final Result

maximum utilization: max U = 0.249 < 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