POS. 1: SEESSELBERG 4.AUFL., BSP.11.7.4

detailed problems acc. to Eurocode 3

EC 3-1-5 (12.10), NA: EC-standard parameters

steel grade

steel grade S 235

cross-section

beam: parameter (I-section):

$h = 300.0$ mm, $t_w = 11.0$ mm, $b_f = 300.0$ mm, $t_f = 19.0$ mm, $r = 27.0$ mm

parameters

length of buckling field a = 600.0 cm

method of effective cross-sectional area

verification in beam field

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

effective cross-section values from resulting distribution of longitudinal stresses

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

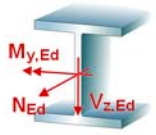
loading

Lk 1: $M_{Ed} = 147.9$ kNm

transverse loading on upper edge of cross-section:

design value of the vertical single load $F_{z,Ed} = 113.7$ kN, loading length $s_s = 69.0$ mm

distance of two single loads $a_R = 360.0$ cm



partial safety factors for material

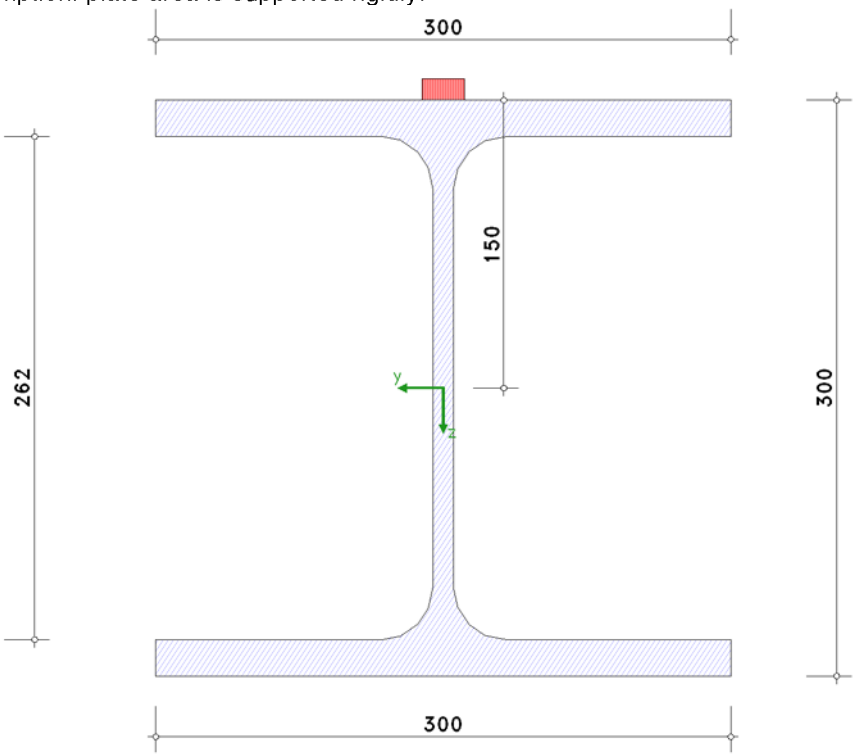
resistance of cross-sections $\gamma_{M0} = 1.00$

resistance of members in stability failure $\gamma_{M1} = 1.00$

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
buckling of transverse loading: distance of two single loads > height of buckling field, double load is not investigated !!
shear distortions are ignored.
cross-sectional properties: A = 149.08 cm², z_s = 150.0 mm, I_y = 25165.90 cm⁴, y_s = 0.0 mm, I_z = 8562.83 cm⁴
maximum/minimum stresses: σ_o = 88.2 N/mm², σ_u = -88.2 N/mm², σ_z = 149.8 N/mm²
section class: 1

plate buckling
effective cross-sectional area
flange top:
section class 1 for c/t = 6.18 < 9.00
effective width $b_{c,eff}$ = b = 117.5 mm
flange bottom:
effective width $b_{t,eff}$ = b = 117.5 mm
web:
section class 1 for α = 0.500 and c/t = 18.91 < 72.00
effective width $b_{c,eff} = (\rho \cdot b) / (1-\psi)$ = 104.0 mm (b_{e1} = 41.6 mm, b_{e2} = 62.4 mm), $b_{t,eff}$ = 104.0 mm, ψ = -1.000
flange induced web buckling:
h_w/t_w = 23.82 < $(k \cdot E)/(f_y \cdot (A_w/A_{fc})^{1/2})$ = 190.63 **ok.** with k = 0.30, A_w = 28.82 cm², A_{fc} = 57.00 cm²
load capacities:
res. stresses σ_o = 88.2 N/mm², σ_u = -88.2 N/mm²
distance of centroid from top $z_{s,eff}$ = 150.0 mm
cross-sectional area A_{eff} = 149.08 cm²
second moment of area $I_{y,eff}$ = 25165.90 cm⁴
section moduli of the pin $W_{y,eff,o}$ = 1791.17 cm³, $W_{y,eff,u}$ = 1791.17 cm³
load capacities $N_{Rd} = (f_y \cdot A_{eff}) / \gamma_{M1}$ = 3503.36 kN
$M_{Rd,o} = (f_y \cdot W_{eff,o}) / \gamma_{M1}$ = 420.92 kNm, $M_{Rd,u} = (f_y \cdot W_{eff,u}) / \gamma_{M1}$ = 420.92 kNm
verification
$|M_{Ed}|/M_{Rd,u}$ = 0.351 < 1 **ok.**

buckling of transverse loading
slenderness $\lambda_F = (F_y/F_{cr})^{1/2}$ = 0.369, F_y = 789.6 kN
reduction factor χ_F = 1.000
resistance of buckling $F_{z,Rd} = f_y \cdot L_{eff} \cdot t_w / \gamma_{M1}$ = 789.58 kN, $L_{eff} = \chi_F \cdot l_y$ = 305.4 mm, l_y = 305.4 mm
verification: $F_{z,Ed}/F_{z,Rd}$ = 0.144 < 1 **ok.**

interaction between transverse loading, bending and/or shear
utilization due to buckling of transverse loading η_2 = 0.144
utilization due to plate buckling η_1 = 0.351 (s.o.)
interaction between transverse loading and bending: $\eta_2 + 0.8 \cdot \eta_1$ = 0.425 < 1.4 ⇒ 0.425/1.4 = 0.304 < 1 **ok.**

total utilization: U = 0.351 < 1 **ok.**

Final Result

maximum utilization: max U = 0.351 < 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 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 1993-1-5, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-5: Plattenförmige Bauteile;
Deutsche Fassung EN 1993-1-5:2006 + AC:2009, Ausgabe Dezember 2010