detailed problems acc. to Eurocode 3

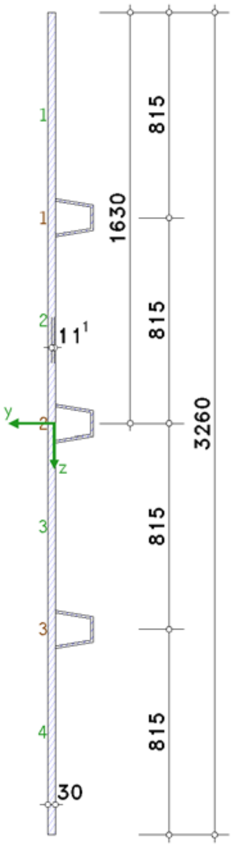
EC 3-1-5 (12.10), NA: Deutschland

steel grade
steel grade S 355
cross-section
buckling field: thickness t = 30.0 mm, width b = 3260.0 mm
longitudinal stiffeners: number n_{st} = 3
section parameters (trapezoidal section):
h = 150.0 mm, b_f = 100.0 mm, t = 10.0 mm, b = 150.0 mm
distance of the first stiffener to the top edge of plate $d_{st,0}$ = 815.0 mm
constant distance of stiffeners d_{st} = 815.0 mm
parameters
length of buckling field a = 300.0 cm
method of effective cross-sectional area
verification in beam field
calculation of buckling factors with 4H-tool
effective cross-sectional properties: A_{eff} solely from compression, W_{eff} solely from bending
loading
internal forces and moments refering to the stiffened cross-section:
Lk 1: N_{Ed} = -26996.0 kN
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: rotational ability of stiffeners for stress redistribution is sufficient.
assumption: plate area is supported rigidly.
the assumptions are not checked !!

scale 1:30.0



method of effective cross-sectional area

EC 3-convention, compressive stresses positive

shear distortions are ignored.

cross-sectional properties: $A = 1093.66\ cm^2$, $z_s = 1630.0$ mm, $I_y = 9176849.51\ cm^4$, $y_s = 11.1$ mm, $I_z = 14742.39\ cm^4$

maximum/minimum stresses: $\sigma_o = 246.8\ N/mm^2$, $\sigma_u = 246.8\ N/mm^2$

plate buckling

effective cross-sectional area for $N_{Ed} = 26996.0$ kN, $M_{Ed} = 0$

single buckling field 1:
- section class 1 for $c/t = 24.75 < 26.85$
- effective width $b_{c,eff} = b = 742.6$ mm ($b_{e1} = 371.3$ mm, $b_{e2} = 371.3$ mm)

single buckling field 2:
- section class 1 for $c/t = 22.34 < 26.85$
- effective width $b_{c,eff} = b = 670.1$ mm ($b_{e1} = 335.1$ mm, $b_{e2} = 335.1$ mm)

single buckling field 3:
- section class 1 for $c/t = 22.34 < 26.85$
- effective width $b_{c,eff} = b = 670.1$ mm ($b_{e1} = 335.1$ mm, $b_{e2} = 335.1$ mm)

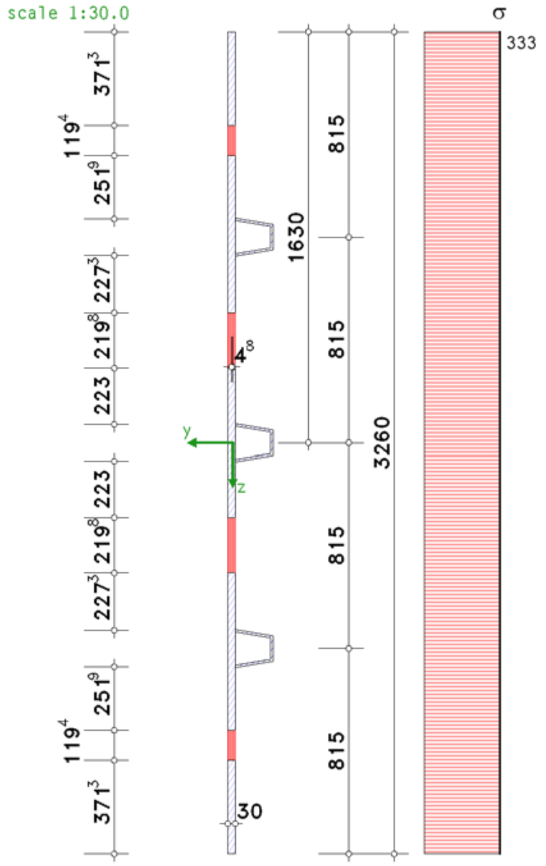
single buckling field 4:
- section class 1 for $c/t = 24.75 < 26.85$
- effective width $b_{c,eff} = b = 742.6$ mm ($b_{e1} = 371.3$ mm, $b_{e2} = 371.3$ mm)

overall buckling field, stiffener 1:
- critical buckling stress $\sigma_{cr,p} = \alpha_{cr} \cdot \sigma_{Ed} = 466.7\ N/mm^2$, $\alpha_{cr} = 1.891$ (4H-tool)
- buckling slenderness ratio $\lambda_p = (\beta_A \cdot f_y/\sigma_{cr,p})^{1/2} = 0.872$, $\beta_A = A_{sl,eff}/A_{sl} = 1.000$
- reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2 = 0.857 \le 1$ for $\lambda_p > 0.5 + (0.085-0.055 \cdot \psi)^{1/2} = 0.673$, $\psi = 1.000$
- critical buckling stress $\sigma_{cr,c} = \sigma_{cr,c,sl} \cdot \sigma_1/\sigma_{sl} = 372.5\ N/mm^2$, $\sigma_1/\sigma_{sl} = 1.000$, $\sigma_{cr,c,sl} = 372.5\ N/mm^2$
- buckling slenderness ratio $\lambda_c = (\beta_A \cdot f_y/\sigma_{cr,c})^{1/2} = 0.976$, $\beta_A = A_{sl,eff}/A_{sl} = 1.000$
- reduction factor $\chi_c = 0.537 \le 1$ for $\lambda_c > 0.2$
- final reduction factor $\rho = (\rho - \chi_c) \cdot \xi \cdot (2-\xi) + \chi_c = 0.678$ with $\xi = 0.253$
- effective widths of adjacent buckling fields $b_{1,e2,eff} = \rho \cdot b_{1,c,eff} = 251.9$ mm, $b_{2,e1,eff} = \rho \cdot b_{2,c,eff} = 227.3$ mm
- effective area of stiffener $A_{sl,eff} = \rho \cdot A_{st} = 26.15\ cm^2$

overall buckling field, stiffener 2:
- critical buckling stress $\sigma_{cr,p} = \alpha_{cr} \cdot \sigma_{Ed} = 466.7\ N/mm^2$, $\alpha_{cr} = 1.891$ (4H-tool)
- buckling slenderness ratio $\lambda_p = (\beta_A \cdot f_y/\sigma_{cr,p})^{1/2} = 0.872$, $\beta_A = A_{sl,eff}/A_{sl} = 1.000$
- reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2 = 0.857 \le 1$ for $\lambda_p > 0.5 + (0.085-0.055 \cdot \psi)^{1/2} = 0.673$, $\psi = 1.000$
- critical buckling stress $\sigma_{cr,c} = \sigma_{cr,c,sl} \cdot \sigma_1/\sigma_{sl} = 384.4\ N/mm^2$, $\sigma_1/\sigma_{sl} = 1.000$, $\sigma_{cr,c,sl} = 384.4\ N/mm^2$
- buckling slenderness ratio $\lambda_c = (\beta_A \cdot f_y/\sigma_{cr,c})^{1/2} = 0.961$, $\beta_A = A_{sl,eff}/A_{sl} = 1.000$
- reduction factor $\chi_c = 0.547 \le 1$ for $\lambda_c > 0.2$
- final reduction factor $\rho = (\rho - \chi_c) \cdot \xi \cdot (2-\xi) + \chi_c = 0.666$ with $\xi = 0.214$
- effective widths of adjacent buckling fields $b_{2,e2,eff} = \rho \cdot b_{2,c,eff} = 223.0$ mm, $b_{3,e1,eff} = \rho \cdot b_{3,c,eff} = 223.0$ mm
- effective area of stiffener $A_{sl,eff} = \rho \cdot A_{st} = 25.66\ cm^2$

overall buckling field, stiffener 3:
- critical buckling stress $\sigma_{cr,p} = \alpha_{cr} \cdot \sigma_{Ed} = 466.7\ N/mm^2$, $\alpha_{cr} = 1.891$ (4H-tool)
- buckling slenderness ratio $\lambda_p = (\beta_A \cdot f_y/\sigma_{cr,p})^{1/2} = 0.872$, $\beta_A = A_{sl,eff}/A_{sl} = 1.000$
- reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2 = 0.857 \le 1$ for $\lambda_p > 0.5 + (0.085-0.055 \cdot \psi)^{1/2} = 0.673$, $\psi = 1.000$
- critical buckling stress $\sigma_{cr,c} = \sigma_{cr,c,sl} \cdot \sigma_1/\sigma_{sl} = 372.5\ N/mm^2$, $\sigma_1/\sigma_{sl} = 1.000$, $\sigma_{cr,c,sl} = 372.5\ N/mm^2$
- buckling slenderness ratio $\lambda_c = (\beta_A \cdot f_y/\sigma_{cr,c})^{1/2} = 0.976$, $\beta_A = A_{sl,eff}/A_{sl} = 1.000$
- reduction factor $\chi_c = 0.537 \le 1$ for $\lambda_c > 0.2$
- final reduction factor $\rho = (\rho - \chi_c) \cdot \xi \cdot (2-\xi) + \chi_c = 0.678$ with $\xi = 0.253$
- effective widths of adjacent buckling fields $b_{3,e2,eff} = \rho \cdot b_{3,c,eff} = 227.3$ mm, $b_{4,e1,eff} = \rho \cdot b_{4,c,eff} = 251.9$ mm
- effective area of stiffener $A_{sl,eff} = \rho \cdot A_{st} = 26.15\ cm^2$

limit loads refering to the reduced cross-section:
- distance of centroid from top $z_{s,eff} = 1630.0$ mm
- cross-sectional area $A_{eff} = 811.04\ cm^2$
- load capacities $N_{Rd} = (f_y \cdot A_{eff}) / \gamma_{M0} = 28792.06$ kN



verification
$|N_{Ed}|/N_{Rd}$ = 0.938 < 1 ok.

total utilization: U = 0.938 < 1 ok.

Final Result

maximum utilization: max U = 0.938 < 1 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