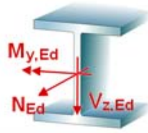
POS. 8: SK'15, LENER, BSP.2B, S.254

detailed problems acc. to Eurocode 3

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

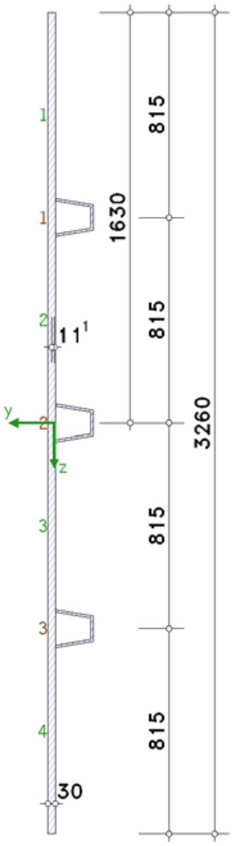
steel grade
steel grade S 355
cross-section
buckling field: thickness t = 30.0 mm, width b = 3260.0 mm
longitudinal stiffeners: number n_{st} = 3
section parameters (trapezoidal section):
h = 150.0 mm, b_f = 100.0 mm, t = 10.0 mm, b = 150.0 mm
distance of the first stiffener to the top edge of plate $d_{st,0}$ = 815.0 mm
constant distance of stiffeners d_{st} = 815.0 mm
parameters
length of buckling field a = 300.0 cm
method of reduced stresses
verification in beam field
calculation of buckling factors with 4H-tool
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: plate area is supported rigidly.
the assumptions are not checked !!

scale 1:30.0



Lk 1:

method of reduced stresses
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: $\sigma_o = 246.8\ N/mm^2$, $\sigma_u = 246.8\ N/mm^2$
buckling factors (4H-tool)
web: $\alpha_{cr} = 1.891$, $\alpha_{cr,1} = 5.021$, $\alpha_{cr,2} = 6.240$, $\alpha_{cr,3} = 6.240$, $\alpha_{cr,4} = 5.021$
reduced stresses
single buckling field 1:
$\sigma_{Ed} = 246.8\ N/mm^2$
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2} = 0.535$, $\alpha_{ult} = 1.438$, $\alpha_{cr} = 5.021$ (4H-tool)
reduction factor $\rho = 1$ for $\lambda_p < 0.5 + (0.085\text{-}0.055\cdot\psi)^{1/2} = 0.673$, $\psi = 1.000$
ultimate buckling stress $\sigma_{Rd} = \rho\cdot f_y/\gamma_{M1} = 322.7\ N/mm^2$
verification: $\sigma_{Ed}/\sigma_{Rd} = 0.765 < 1$ ok.
single buckling field 2:
$\sigma_{Ed} = 246.8\ N/mm^2$
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2} = 0.480$, $\alpha_{ult} = 1.438$, $\alpha_{cr} = 6.240$ (4H-tool)
reduction factor $\rho = 1$ for $\lambda_p < 0.5 + (0.085\text{-}0.055\cdot\psi)^{1/2} = 0.673$, $\psi = 1.000$
ultimate buckling stress $\sigma_{Rd} = \rho\cdot f_y/\gamma_{M1} = 322.7\ N/mm^2$
verification: $\sigma_{Ed}/\sigma_{Rd} = 0.765 < 1$ ok.
single buckling field 3:
$\sigma_{Ed} = 246.8\ N/mm^2$
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2} = 0.480$, $\alpha_{ult} = 1.438$, $\alpha_{cr} = 6.240$ (4H-tool)
reduction factor $\rho = 1$ for $\lambda_p < 0.5 + (0.085\text{-}0.055\cdot\psi)^{1/2} = 0.673$, $\psi = 1.000$
ultimate buckling stress $\sigma_{Rd} = \rho\cdot f_y/\gamma_{M1} = 322.7\ N/mm^2$
verification: $\sigma_{Ed}/\sigma_{Rd} = 0.765 < 1$ ok.
single buckling field 4:
$\sigma_{Ed} = 246.8\ N/mm^2$
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2} = 0.535$, $\alpha_{ult} = 1.438$, $\alpha_{cr} = 5.021$ (4H-tool)
reduction factor $\rho = 1$ for $\lambda_p < 0.5 + (0.085\text{-}0.055\cdot\psi)^{1/2} = 0.673$, $\psi = 1.000$
ultimate buckling stress $\sigma_{Rd} = \rho\cdot f_y/\gamma_{M1} = 322.7\ N/mm^2$
verification: $\sigma_{Ed}/\sigma_{Rd} = 0.765 < 1$ ok.
overall buckling field:
$\sigma_{Ed} = 246.8\ N/mm^2$
non-dimensional slenderness ratio $\lambda_p = \lambda_c = \lambda_w = (\alpha_{ult}/\alpha_{cr})^{1/2} = 0.872$, $\alpha_{ult} = 1.438$, $\alpha_{cr} = 1.891$ (4H-tool)
reduction factor $\rho = (\lambda_p\text{-}0.055\cdot(3+\psi))/\lambda_p^2 = 0.857 \le 1$ for $\lambda_p > 0.5 + (0.085\text{-}0.055\cdot\psi)^{1/2} = 0.673$, $\psi = 1.000$
critical buckling stress $\sigma_{cr,p} = \alpha_{cr}\cdot\sigma_{Ed}' = 466.7\ N/mm^2$, $\sigma_{Ed}' = 246.8\ N/mm^2$
critical buckling stress $\sigma_{cr,c} = \sigma_{cr,c,sl}\cdot\sigma_1/\sigma_{sl} = 384.4\ N/mm^2$, $\sigma_1/\sigma_{sl} = 1.000$, $\sigma_{cr,c,sl} = 384.4\ N/mm^2$
reduction factor $\chi_c = 0.600 \le 1$ for $\lambda_c > 0.2$
final reduction factor $\rho = (\rho\text{-}\chi_c)\cdot\xi\cdot(2\text{-}\xi) + \chi_c = 0.698$ with $\xi = 0.214$
ultimate buckling stress $\sigma_{Rd} = \rho\cdot f_y/\gamma_{M1} = 225.4\ N/mm^2$
verification: $\sigma_{Ed}/\sigma_{Rd} = 1.095 > 1$ not ok. !!

total utilization: U = 1.095 > 1 not ok. !!

Final Result

maximum utilization: max U = 1.095 > 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