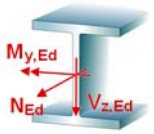
detailed problems acc. to Eurocode 3

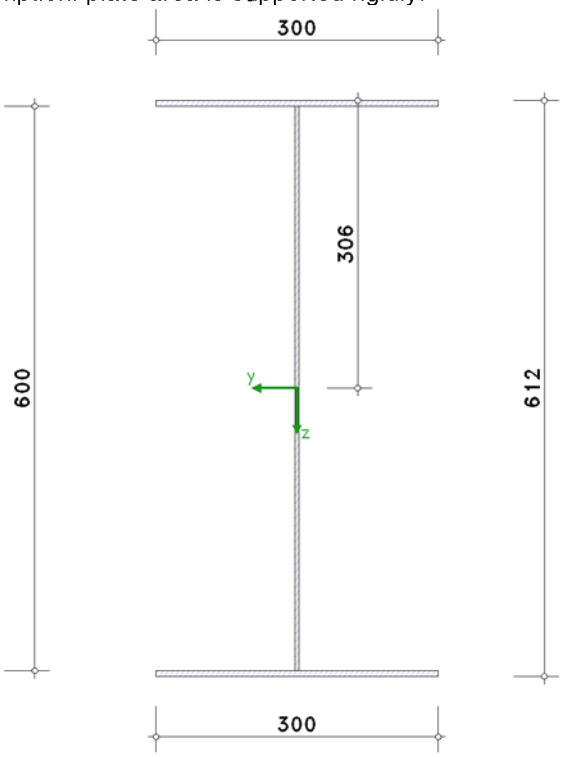
EC 3-1-5 (12.10), NA: Deutschland

steel grade
steel grade S 235
cross-section
beam: parameter (I-section):
h = 612.0 mm, t_w = 4.0 mm, b_f = 300.0 mm, t_f = 6.0 mm
parameters
length of buckling field a = 1000.0 cm
method of effective cross-sectional area
verification in beam field
effective girder length (shear distortion) L_e = 1000.0 cm
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} = 60.0 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

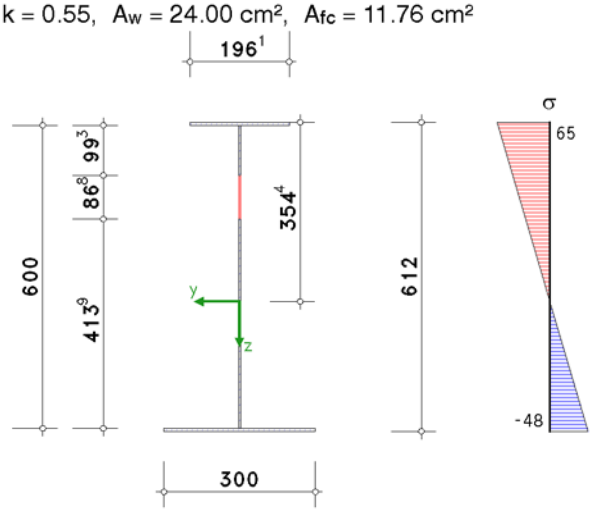
assumption: flange induced web buckling is excluded.
assumption: plate area is supported rigidly.



Lk 1:

method of effective cross-sectional area
EC 3-convention, compressive stresses positive
shear distortion
flange top: $b_0 = b_{fo}/2 = 150.0$ mm $<$ $L_e/50 = 200.0$ mm $\Rightarrow$ without shear distortion !!
flange bottom: $b_0 = b_{fu}/2 = 150.0$ mm $<$ $L_e/50 = 200.0$ mm $\Rightarrow$ without shear distortion !!
cross-sectional properties: $A = 60.00$ cm², $z_s = 306.0$ mm, $I_y = 40252.32$ cm⁴, $y_s = 0.0$ mm, $I_z = 2700.32$ cm⁴
maximum/minimum stresses: $\sigma_o = 45.6$ N/mm², $\sigma_u = -45.6$ N/mm²
section class: 4 $\Rightarrow$ verification of plate buckling required !!

plate buckling
effective section modulus for $M_{Ed} = -60.0$ kNm, $N_{Ed} = 0$
flange top:
section class 4 for $13.77 < c/t = 24.67$
critical buckling stress $\sigma_{cr,p} = k_\sigma \cdot \sigma_E = 134.6$ N/mm², $\sigma_E = 311.9$ N/mm², $k_\sigma = 0.43$
buckling slenderness ratio $\lambda_p = (f_y/\sigma_{cr,p})^{1/2} = 1.322$
reduction factor $\rho = (\lambda_p - 0.188)/\lambda_p^2 = 0.649 \le 1$ for $\lambda_p > 0.748$, $\psi = 1.000$
effective width $b_{c,eff} = \rho \cdot b = 96.1$ mm
flange bottom:
effective width $b_{t,eff} = b = 148.0$ mm
web:
section class 4 for $\alpha = 0.559$ and $104.16 < c/t = 150.00$
critical buckling stress $\sigma_{cr,p} = k_\sigma \cdot \sigma_E = 159.4$ N/mm², $\sigma_E = 8.4$ N/mm², $k_\sigma = 18.89$
buckling slenderness ratio $\lambda_p = (f_y/\sigma_{cr,p})^{1/2} = 1.214$
reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2 = 0.741 \le 1$ for $\lambda_p > 0.5 + (0.085 - 0.055 \cdot \psi)^{1/2} = 0.858$, $\psi = -0.790$
effective width $b_{c,eff} = (\rho \cdot b) / (1-\psi) = 248.3$ mm ($b_{e1} = 99.3$ mm, $b_{e2} = 149.0$ mm), $b_{t,eff} = 264.9$ mm, $\psi = -0.790$
flange induced web buckling:
$h_w/t_w = 150.00 < (k \cdot E)/(f_y \cdot (A_w/A_{fc})^{1/2}) = 702.13$ ok. with $k = 0.55$, $A_w = 24.00$ cm², $A_{fc} = 11.76$ cm²
limit loads refering to the reduced cross-section:
distance of centroid from top $z_{s,eff} = 354.4$ mm
second moment of area $I_{y,eff} = 32470.94$ cm⁴
section modulus $W_{y,eff} = 924.04$ cm³
load capacities $M_{Rd} = (f_y \cdot W_{eff}) / \gamma_{M1} = 197.41$ kNm



verification
$|M_{Ed}|/M_{Rd,u} = 0.304 < 1$ ok.

total utilization: $U = 0.304 < 1$ ok.

Final Result

maximum utilization: max $U = 0.304 < 1$ 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