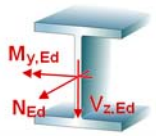
detailed problems acc. to Eurocode 3

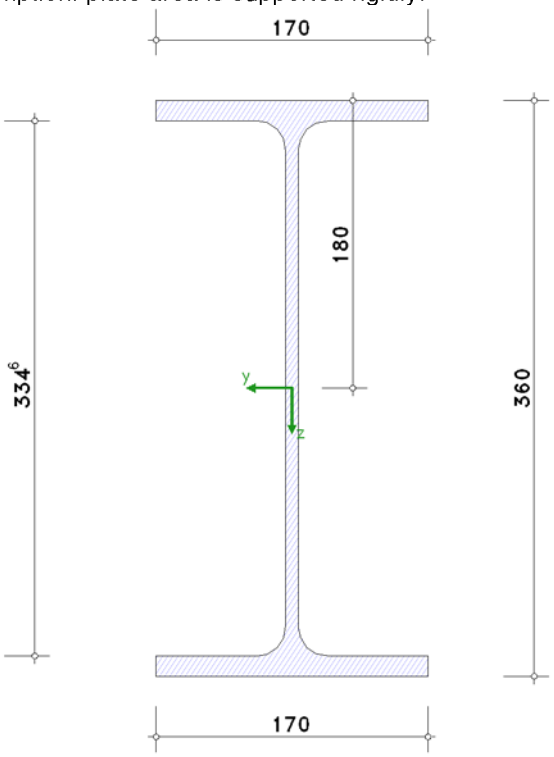
EC 3-1-5 (12.10), NA: Deutschland

steel grade
steel grade S 355
cross-section
beam: section IPE360
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: N_{Ed} = -541.0 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

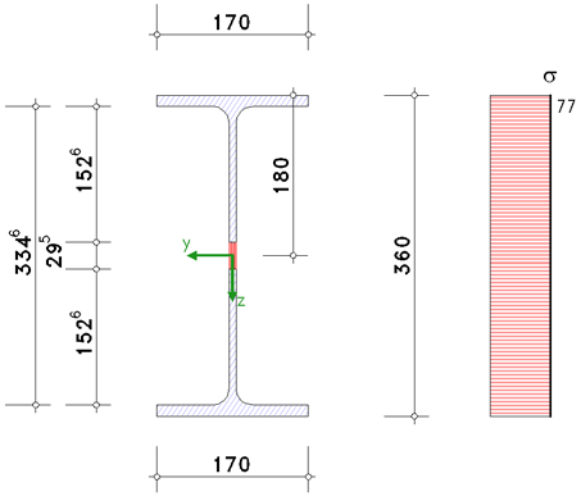
assumption: flange induced web buckling is excluded.
assumption: plate area is supported rigidly.



Lk 1:

method of effective cross-sectional area
EC 3-convention, compressive stresses positive
shear distortions are ignored.
cross-sectional properties: $A = 72.73\ cm^2$, $z_s = 180.0\ mm$, $I_y = 16265.80\ cm^4$, $y_s = 0.0\ mm$, $I_z = 1043.45\ cm^4$
maximum/minimum stresses: $\sigma_o = 74.4\ N/mm^2$, $\sigma_u = 74.4\ N/mm^2$
section class: 4 $\Rightarrow$ verification of plate buckling required !!

plate buckling
effective cross-sectional area for $N_{Ed} = 541.0\ kN$, $M_{Ed} = 0$
flange top:
section class 1 for $c/t = 4.96 < 7.32$
effective width $b_{c,eff} = b = 63.0\ mm$
flange bottom:
section class 1 for $c/t = 4.96 < 7.32$
effective width $b_{c,eff} = b = 63.0\ mm$
web:
section class 4 for $34.17 < c/t = 37.32$
critical buckling stress $\sigma_{cr,p} = k_\sigma \cdot \sigma_E = 545.0\ N/mm^2$, $\sigma_E = 136.2\ N/mm^2$, $k_\sigma = 4.00$
buckling slenderness ratio $\lambda_p = (f_y/\sigma_{cr,p})^{1/2} = 0.807$
reduction factor $\rho = (\lambda_p - 0.055\cdot(3+\psi))/\lambda_p^2 = 0.901 \le 1$ for $\lambda_p > 0.5 + (0.085-0.055\cdot\psi)^{1/2} = 0.673$, $\psi = 1.000$
effective width $b_{c,eff} = \rho \cdot b = 269.1\ mm$ ($b_{e1} = 134.6\ mm$, $b_{e2} = 134.6\ mm$)
flange induced web buckling:
$h_w/t_w = 41.82 < (k\cdot E)/(f_y\cdot(A_w/A_{fc})^{1/2}) = 362.36$ ok. with $k = 0.55$, $A_w = 26.77\ cm^2$, $A_{fc} = 21.58\ cm^2$
limit loads refering to the reduced cross-section:
distance of centroid from top $z_{s,eff} = 180.0\ mm$
cross-sectional area $A_{eff} = 70.37\ cm^2$
load capacities $N_{Rd} = (f_y \cdot A_{eff}) / \gamma_{M1} = 2271.07\ kN$



verification
$|N_{Ed}|/N_{Rd} = 0.238 < 1$ ok.

total utilization: $U = 0.238 < 1$ ok.

Final Result

maximum utilization: max $U = 0.238 < 1$ 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;