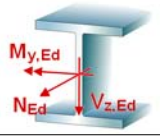
detailed problems acc. to Eurocode 3

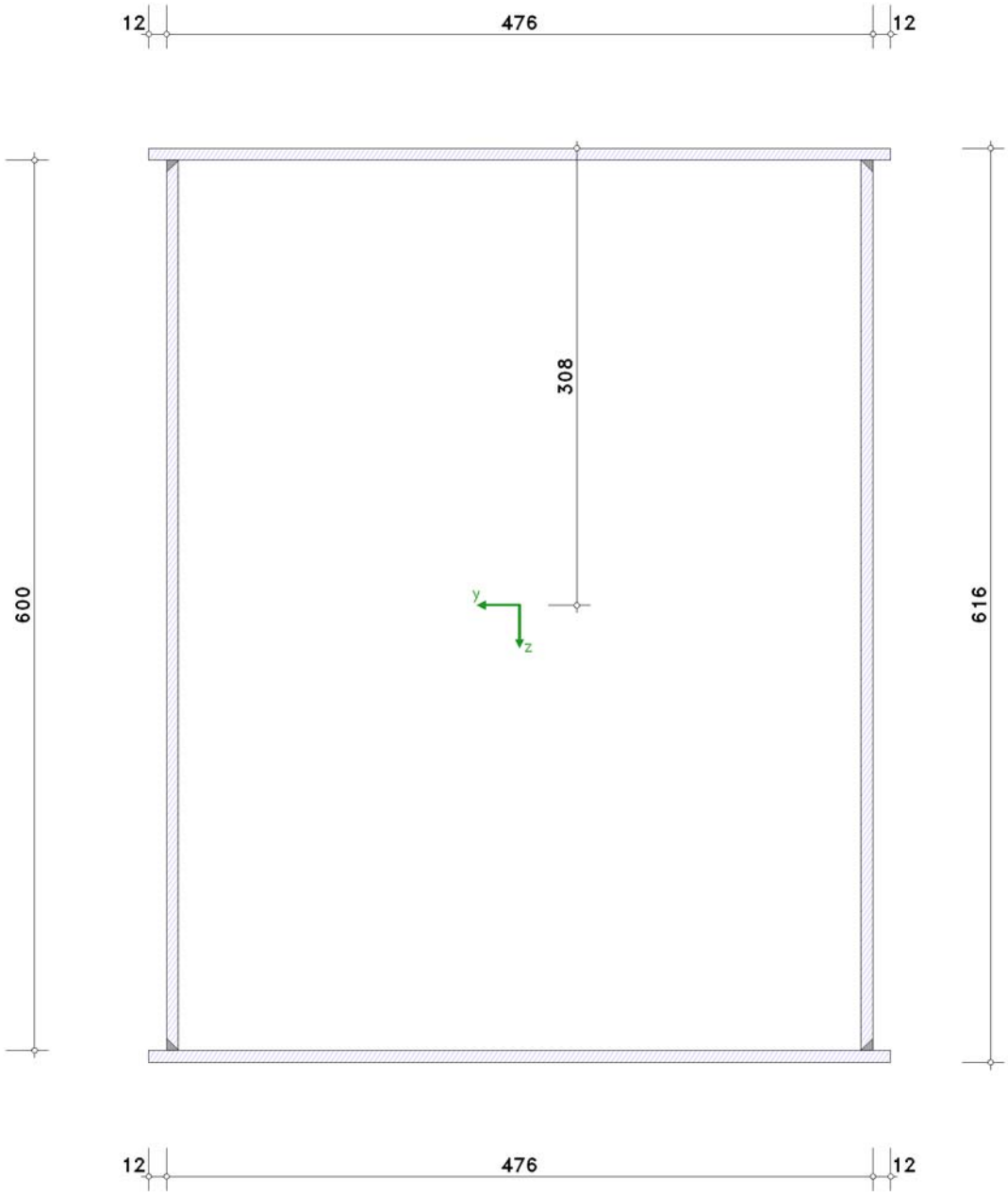
EC 3-1-5 (12.10), NA: Deutschland

steel grade
steel grade S 235
cross-section
beam: section parameters (box section):
h = 616.0 mm, t_w = 8.0 mm (2x), b_f = 476.0 mm, $b_ü$ = 12.0 mm, t_f = 8.0 mm
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: M_{Ed} = 585.0 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.

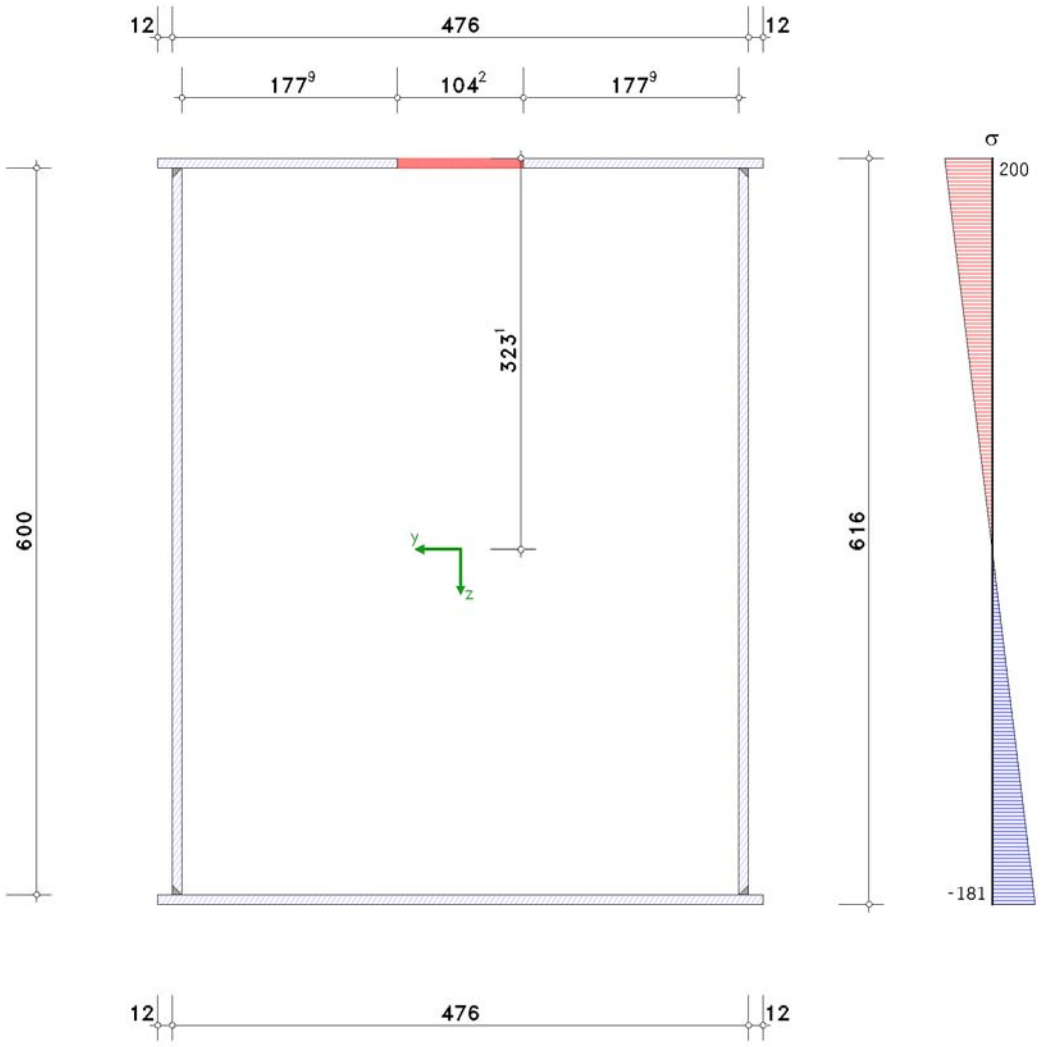


Lk 1:

method of effective cross-sectional area
EC 3-convention, compressive stresses positive
shear distortions are ignored.
cross-sectional properties: A = 176.00 cm², z_s = 308.0 mm, I_y = 102737.07 cm⁴, y_s = 0.0 mm, I_z = 69237.55 cm⁴
maximum/minimum stresses: σ_o = 175.4 N/mm², σ_u = -175.4 N/mm²
section class: 4 ⇒ verification of plate buckling required !!

plate buckling
effective section modulus for M_{Ed} = -585.0 kNm, N_{Ed} = 0
web:
section class 2 for α = 0.500 and 72.00 < c/t = 75.00 < 83.00
effective width $b_{c,eff} = (\rho \cdot b) / (1-\psi)$ = 300.0 mm (b_{e1} = 120.0 mm, b_{e2} = 180.0 mm), $b_{t,eff}$ = 300.0 mm, ψ = -1.000
flange induced web buckling:
h_w/t_w = 75.00 < $(k \cdot E)/(f_y \cdot (A_w/A_{fc})^{1/2})$ = 567.54 **ok.** with k = 0.40, A_w = 48.00 cm², A_{fc} = 19.04 cm²
flange top:
section class 4 for 42.00 < c/t = 57.50
critical buckling stress $\sigma_{cr,p} = k_\sigma \cdot \sigma_E$ = 229.6 N/mm², σ_E = 57.4 N/mm², k_σ = 4.00
buckling slenderness ratio $\lambda_p = (f_y/\sigma_{cr,p})^{1/2}$ = 1.012
reduction factor $\rho = (\lambda_p - 0.055 \cdot (3+\psi))/\lambda_p^2$ = 0.774 ≤ 1 for $\lambda_p > 0.5 + (0.085 - 0.055 \cdot \psi)^{1/2}$ = 0.673, ψ = 1.000
effective width $b_{c,eff} = \rho \cdot b$ = 355.8 mm (b_{e1} = 177.9 mm, b_{e2} = 177.9 mm)

flange bottom:
stresses at edge of plate σ_o = -173.1 N/mm² ≤ 0, σ_u = -173.1 N/mm² ≤ 0 ⇒ no buckling !!
limit loads refering to the reduced cross-section:
distance of centroid from top $z_{s,eff}$ = 323.1 mm
second moment of area $I_{y,eff}$ = 94651.76 cm⁴
section modulus $W_{y,eff}$ = 2966.11 cm³
load capacities $M_{Rd} = (f_y \cdot W_{eff}) / \gamma_{M1}$ = 633.67 kNm



verification
$|M_{Ed}|/M_{Rd,u}$ = 0.923 < 1 ok.

total utilization: U = 0.923 < 1 ok.

Final Result

maximum utilization: max U = 0.923 < 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