STEEL MEMBER DESIGN (EN1993-1-1:2005)

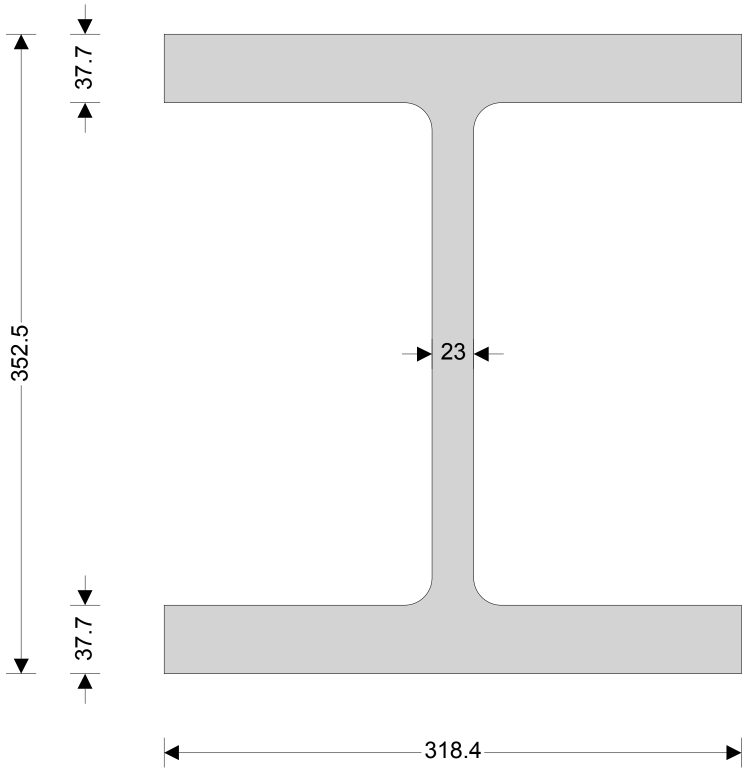
In accordance with EN1993-1-1:2005 incorporating Corrigenda February 2006 and April 2009 and the recommended values

Section details

Section type;	**UKC 305x305x240**
Steel grade;	**S275**

From table 3.1: Nominal values of yield strength f_y and ultimate tensile strength f_u for hot rolled structural steel

Nominal thickness of element;	$t = max(t_f, t_w)$ = **37.7** mm
Nominal yield strength;	f_y = **275** N/mm^2
Nominal ultimate tensile strength;	f_u = **430** N/mm^2
Modulus of elasticity;	E = **210000** N/mm^2



Partial factors - Section 6.1

Resistance of cross-sections; γ_{M0} = **1.00**

Resistance of members to instability; γ_{M1} = **1.00**

Resistance of tensile members to fracture; γ_{M2} = **1.25**

Lateral restraint

Distance between major axis restraints; L_y = **4200** mm

Distance between minor axis restraints; L_z = **4200** mm

Effective length factors

Effective length factor in major axis; K_y = **0.700**

Effective length factor in minor axis; K_z = **1.000**

Effective length factor for torsion; K_{LT} = **1.000**

Classification of cross sections - Section 5.5

$\varepsilon = \sqrt{[235 \text{ N/mm}^2 / f_y]}$ = **0.92**

Internal compression parts subject to bending and compression - Table 5.2 (sheet 1 of 3)

Width of section; c = d = **246.7** mm

$\alpha = \min([h / 2 + N_{Ed} / (2 \times t_w \times f_y) - (t_f + r)] / c, 1)$ = **1.000**

$c / t_w = 11.6 \times \varepsilon <= 396 \times \varepsilon / (13 \times \alpha - 1)$; Class 1

Outstand flanges - Table 5.2 (sheet 2 of 3)

Width of section; $c = (b - t_w - 2 \times r) / 2$ = **132.5** mm

$c / t_f = 3.8 \times \varepsilon <= 9 \times \varepsilon$; Class 1

Section is class 1

Check shear - Section 6.2.6

Height of web; $h_w = h - 2 \times t_f$ = **277.1** mm

Shear area factor; η = **1.000**

$h_w / t_w < 72 \times \varepsilon / \eta$

Shear buckling resistance can be ignored

Design shear force parallel to z axis; $V_{z,Ed}$ = **200** kN

Shear area - cl 6.2.6(3); $A_v = \max(A - 2 \times b \times t_f + (t_w + 2 \times r) \times t_f, \eta \times h_w \times t_w)$ = **8585** mm^2

Design shear resistance - cl 6.2.6(2); $V_{c,z,Rd} = V_{pl,z,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **1363** kN

PASS - Design shear resistance exceeds design shear force

Design shear force parallel to y axis; $V_{y,Ed}$ = **26.2** kN

Shear area - cl 6.2.6(3); $A_v = \max(2 \times b \times t_f - (t_w + 2 \times r) \times t_f, A - (h_w \times t_w))$ = **24206** mm^2

Design shear resistance - cl 6.2.6(2); $V_{c,y,Rd} = V_{pl,y,Rd} = A_v \times (f_y / \sqrt{[3]}) / \gamma_{M0}$ = **3843.2** kN

PASS - Design shear resistance exceeds design shear force

Check bending moment major (y-y) axis - Section 6.2.5

Design bending moment; $M_{y,Ed}$ = **420** kNm

Design bending resistance moment - eq 6.13; $M_{c,y,Rd} = M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0}$ = **1167.9** kNm

Slenderness ratio for lateral torsional buckling

Correction factor - Table 6.6; k_c = **0.603**

$C_1 = 1 / k_c^2$ = **2.75**

Curvature factor; $g = \sqrt{[1 - (I_z / I_y)]}$ = **0.827**

Poissons ratio; ν = **0.3**

Shear modulus; $G = E / [2 \times (1 + \nu)]$ = **80769** N/mm^2

Unrestrained length; $L = 1.00 \times L_z$ = **4200** mm

Elastic critical buckling moment;

$M_{cr} = C_1 \times \pi^2 \times E \times I_z / (L^2 \times g) \times \sqrt{[I_w / I_z + L^2 \times G \times I_t / (\pi^2 \times E \times I_z)]}$ = **20672.7** kNm

Slenderness ratio for lateral torsional buckling; $\bar{\lambda}_{LT} = \sqrt{[W_{pl.y} \times f_y / M_{cr}]}$ = **0.238**

Limiting slenderness ratio; $\bar{\lambda}_{LT,0}$ = **0.4**

$\bar{\lambda}_{LT} < \bar{\lambda}_{LT,0}$ - Lateral torsional buckling can be ignored

Design resistance for buckling - Section 6.3.2.1

Buckling curve - Table 6.5; b

Imperfection factor - Table 6.3; α_{LT} = **0.34**

Correction factor for rolled sections; β = **0.75**

LTB reduction determination factor; $\phi_{LT} = 0.5 \times [1 + \alpha_{LT} \times (\bar{\lambda}_{LT} - \bar{\lambda}_{LT,0}) + \beta \times \bar{\lambda}_{LT}^2]$ = **0.494**

LTB reduction factor - eq 6.57; $\chi_{LT} = \min(1 / [\phi_{LT} + \sqrt{(\phi_{LT}^2 - \beta \times \bar{\lambda}_{LT}^2)}], 1, 1 / \bar{\lambda}_{LT}^2)$ = **1.000**

Modification factor; $f = \min(1 - 0.5 \times (1 - k_c) \times [1 - 2 \times (\bar{\lambda}_{LT} - 0.8)^2], 1)$ = **0.927**

Modified LTB reduction factor - eq 6.58; $\chi_{LT,mod} = \min(\chi_{LT} / f, 1)$ = **1.000**

Design buckling resistance moment - eq 6.55; $M_{b,Rd} = \chi_{LT,mod} \times W_{pl.y} \times f_y / \gamma_{M1}$ = **1167.9** kNm

PASS - Design buckling resistance moment exceeds design bending moment

Check bending moment minor (z-z) axis - Section 6.2.5

Design bending moment; $M_{z,Ed}$ = **110** kNm

Design bending resistance moment - eq 6.13; $M_{c,z,Rd} = M_{pl,z,Rd} = W_{pl.z} \times f_y / \gamma_{M0}$ = **536.4** kNm

PASS - Design bending resistance moment exceeds design bending moment

Biaxial bending - Section 6.2.9

Plastic moment resistance (y-y); $M_{N,y,Rd} = M_{pl,y,Rd} =$ **1167.9** kNm

Plastic moment resistance (z-z); $M_{N,z,Rd} = M_{pl,z,Rd} =$ **536.4** kNm

Normal force to plastic resistance force ratio; $n = N_{Ed} / N_{pl,Rd} =$ **0.41**

Parameter introducing effect of biaxial bending; α_bi = **2.00**

Parameter introducing effect of biaxial bending; β_bi = max(5 × n, 1) = **2.05**

Interaction formula – eq (6.41); $(M_{y,Ed} / M_{N,y,Rd})^{\alpha\_bi} + (M_{z,Ed} / M_{N,z,Rd})^{\beta\_bi} =$ **0.168**

PASS - Biaxial bending check is satisfied

Check compression - Section 6.2.4

Design compression force; $N_{Ed} =$ **3440** kN

Design resistance of section - eq 6.10; $N_{c,Rd} = N_{pl,Rd} = A \times f_y / \gamma_{M0} =$ **8409.2** kN

Slenderness ratio for major (y-y) axis buckling

Critical buckling length; $L_{cr,y} = L_y \times K_y =$ **2940** mm

Critical buckling force; $N_{cr,y} = \pi^2 \times E_{SEC3} \times I_y / L_{cr,y}^2 =$ **153948.9** kN

Slenderness ratio for buckling - eq 6.50; $\bar{\lambda}_y = \sqrt{[A \times f_y / N_{cr,y}]} =$ **0.234**

Design resistance for buckling - Section 6.3.1.1

Buckling curve - Table 6.2; b

Imperfection factor - Table 6.1; $\alpha_y =$ **0.34**

Buckling reduction determination factor; $\phi_y = 0.5 \times [1 + \alpha_y \times (\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2] =$ **0.533**

Buckling reduction factor - eq 6.49; $\chi_y = \min(1 / [\phi_y + \sqrt{(\phi_y^2 - \bar{\lambda}_y^2)}], 1) =$ **0.988**

Design buckling resistance - eq 6.47; $N_{b,y,Rd} = \chi_y \times A \times f_y / \gamma_{M1} =$ **8308.5** kN

PASS - Design buckling resistance exceeds design compression force

Slenderness ratio for minor (z-z) axis buckling

Critical buckling length; $L_{cr,z} = L_z \times K_z =$ **4200** mm

Critical buckling force; $N_{cr,z} = \pi^2 \times E_{SEC3} \times I_z / L_{cr,z}^2 =$ **23868.7** kN

Slenderness ratio for buckling - eq 6.50; $\bar{\lambda}_z = \sqrt{[A \times f_y / N_{cr,z}]} =$ **0.594**

Design resistance for buckling - Section 6.3.1.1

Buckling curve - Table 6.2; c

Imperfection factor - Table 6.1; $\alpha_z =$ **0.49**

Buckling reduction determination factor; $\phi_z = 0.5 \times [1 + \alpha_z \times (\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2] =$ **0.773**

Buckling reduction factor - eq 6.49; $\chi_z = \min(1 / [\phi_z + \sqrt{(\phi_z^2 - \bar{\lambda}_z^2)}], 1) =$ **0.789**

Design buckling resistance - eq 6.47; $N_{b,z,Rd} = \chi_z \times A \times f_y / \gamma_{M1} =$ **6636.5** kN

PASS - Design buckling resistance exceeds design compression force

Check torsional and torsional-flexural buckling - Section 6.3.1.4

Torsional buckling length factor; $K_T =$ **1.00**

Torsional buckling length; $L_{cr,T} = \max(L_y, L_z) \times K_T$ = **4200** mm

Distance from shear centre to centroid in y axis; y_0 = **0.0** mm

Distance from shear centre to centroid in z axis; z_0 = **0.0** mm

Radius of gyration; $i_0 = \sqrt{[i_y^2 + i_z^2]}$ = **166.2** mm

Elastic critical torsional buckling force; $N_{cr,T} = 1 / i_0^2 \times [G \times I_t + \pi^2 \times E_{SEC3} \times I_w / L_{cr,T}^2]$ = **58547.2** kN

Torsion factor; $\beta_T = 1 - (y_0 / i_0)^2$ = **1.000**

Elastic critical torsional-flexural buckling force

$N_{cr,TF} = N_{cr,y} / (2 \times \beta_T) \times [1 + N_{cr,T} / N_{cr,y} - \sqrt{[(1 - N_{cr,T} / N_{cr,y})^2 + 4 \times (y_0 / i_0)^2 \times N_{cr,T} / N_{cr,y}]}]$ = **58547.2** kN

Elastic critical buckling force; $N_{cr} = \min(N_{cr,T}, N_{cr,TF})$ = **58547.2** kN

Slenderness ratio for torsional buckling - eq 6.52; $\bar{\lambda}_T = \sqrt{[A \times f_y / N_{cr}]}$ = **0.379**

Design resistance for buckling - Section 6.3.1.1

Buckling curve - Table 6.2; c

Imperfection factor - Table 6.1; α_T = **0.49**

Buckling reduction determination factor; $\phi_T = 0.5 \times [1 + \alpha_T \times (\bar{\lambda}_T - 0.2) + \bar{\lambda}_T^2]$ = **0.616**

Buckling reduction factor - eq 6.49; $\chi_T = \min(1 / [\phi_T + \sqrt{(\phi_T^2 - \bar{\lambda}_T^2)}], 1)$ = **0.908**

Design buckling resistance - eq 6.47; $N_{b,T,Rd} = \chi_T \times A \times f_y / \gamma_{M1}$ = **7638.7** kN

PASS - Design buckling resistance exceeds design compression force

Combined bending and axial force - Section 6.2.9

Normal force to plastic resistance force ratio; $n = N_{Ed} / N_{pl,Rd}$ = **0.41**

Web area to gross area ratio; $a_w = \min((A - 2 \times b \times t_f) / A, 0.5)$ = **0.21**

Design plastic moment resistance (y-y) - eq 6.13; $M_{pl,y,Rd} = W_{pl.y} \times f_y / \gamma_{M0}$ = **1167.9** kNm

Reduced plastic mnt resistance (y-y)- eq 6.36; $M_{N,y,Rd} = M_{pl,y,Rd} \times \min((1 - n) / (1 - 0.5 \times a_w), 1)$ = **773.3** kNm

Design plastic moment resistance (z-z) - eq 6.13; $M_{pl,z,Rd} = W_{pl.z} \times f_y / \gamma_{M0}$ = **536.4** kNm

Reduced plastic mnt resistance (z-z) - eq 6.38; $M_{N,z,Rd} = M_{pl,z,Rd} \times (1 - ((n-a_w) / (1- a_w))^2)$ = **503.6** kNm

Parameter introducing effect of biaxial bending; α_bi = **2.00**

Parameter introducing effect of biaxial bending; $\beta\_bi = \max(5 \times n, 1)$ = **2.05**

Interaction formula – eq (6.41); $(M_{y,Ed} / M_{N,y,Rd})^{\alpha\_bi} + (M_{z,Ed} / M_{N,z,Rd})^{\beta\_bi}$ = **0.340**

PASS - Reduced bending resistance moment exceeds design bending moment

Check combined bending and compression - Section 6.3.3

Equivalent uniform moment factors - Table B.3; C_{my} = **0.400**

C_{mz} = **0.600**

C_{mLT} = **0.400**

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Interaction factors k_{ij} for members susceptible to torsional deformations - Table B.2

Characteristic moment resistance; $M_{y,Rk} = W_{pl.y} \times f_y = \mathbf{1167.9}$ kNm

Characteristic moment resistance; $M_{z,Rk} = W_{pl.z} \times f_y = \mathbf{536.4}$ kNm

Characteristic resistance to normal force; $N_{Rk} = A \times f_y = \mathbf{8409.2}$ kN

Interaction factors; $k_{yy} = C_{my} \times [1 + \min(\bar{\lambda}_y - 0.2, 0.8) \times N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1})] = \mathbf{0.406}$

$k_{zy} = 1 - 0.1 \times \max(1, \bar{\lambda}_z) \times N_{Ed} / ((C_{mLT} - 0.25) \times \chi_z \times N_{Rk} / \gamma_{M1}) = \mathbf{0.654}$

$k_{zz} = C_{mz} \times [1 + \min(2 \times \bar{\lambda}_z - 0.6, 1.4) \times N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1})] = \mathbf{0.783}$

$k_{yz} = 0.6 \times k_{zz} = \mathbf{0.470}$

Interaction formulae - eq 6.61 & eq 6.62; $N_{Ed} / (\chi_y \times N_{Rk} / \gamma_{M1}) + k_{yy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1}) + k_{yz} \times M_{z,Ed} / (M_{z,Rk} / \gamma_{M1}) = \mathbf{0.656}$

$N_{Ed} / (\chi_z \times N_{Rk} / \gamma_{M1}) + k_{zy} \times M_{y,Ed} / (\chi_{LT} \times M_{y,Rk} / \gamma_{M1}) + k_{zz} \times M_{z,Ed} / (M_{z,Rk} / \gamma_{M1}) = \mathbf{0.914}$

PASS - Combined bending and compression checks are satisfied