IS 800-2007 Example 001

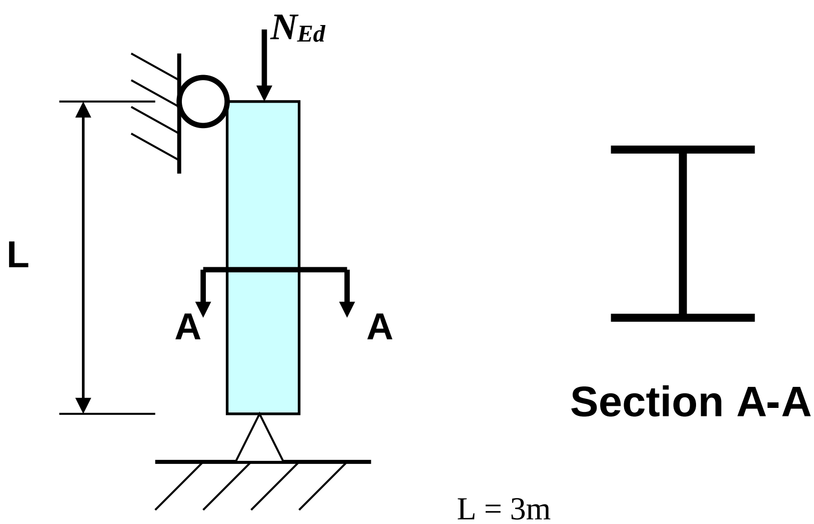
WIDE FLANGE MEMBER UNDER COMPRESSION

EXAMPLE DESCRIPTION

The frame object axial strengths are tested in this example.

A continuous column is subjected to factored load N = 1 kN. This example was tested using the Indian IS 800:2007 steel frame design code. The design capacities are compared with independent hand calculated results.

GEOMETRY, PROPERTIES AND LOADING



L = 3m

Material Properties	Loading	Design Properties
E = 200x10^3 MPa	N = 1 kN	f_y = 250 *MPa*
v = 0.3		f_u = 410 *MPa*
G = 76923 MPa		*Section: ISMB 350*

TECHNICAL FEATURES TESTED

- Section compactness check (column)
- Member compression capacity

RESULTS COMPARISON

Independent results are taken from hand calculations based on the CSI steel design documentation contained in the file "SFD-IS-800-2007.pdf," which is available through the program "Help" menu. The example was taken from Example 9.2 on pp. 765-766 in "Design of Steel Structures" by N. Subramanian.

Output Parameter	ETABS	Independent	Percent Difference
Compactness	Plastic	Plastic	0.00%
Design Axial Strength, N_{crd}	733.85	734.07	-0.03%

COMPUTER FILE: IS 800-2007 EX001

CONCLUSION

The results show an acceptable comparison with the independent results.

HAND CALCULATION

Properties:

Material: Fe 250

E = 200,000 MPa

f_y = 250 MPa

Section: ISMB 350

A = 6670 mm^2

b = 140 mm, t_f = 14.2 mm, d = 350 mm, t_w = 8.1 mm, r = 1.8 mm

$$h = d - 2\left(t_f + r\right) = 350 - 2\left(14.2 + 1.8\right) = 318\,\text{mm}$$

r_y = *28.4* mm, r_z = *143* mm

Member:

$KL_y = KL_z$ = 3,000 mm (unbraced length)

$$\gamma_{M0} = 1.1$$

Loadings:

$$N_{Ed} = 1\,\text{kN}$$

Section Compactness:

$$\varepsilon = \sqrt{\frac{250}{f_y}} = \sqrt{\frac{250}{250}} = 1$$

Localized Buckling for Flange:

$$\lambda_p = 8.4\varepsilon = 8.4 \bullet 1 = 8.4$$

$$\lambda_e = \frac{b}{t_f} = \frac{70}{14.2} = 4.93$$

$$\lambda_e = 4.93 < \lambda_p = 8.40$$

So Flange is Plastic in compression

Localized Buckling for Web:

$\lambda_p = N/A$ & $\lambda_s = 42\varepsilon = 42$ for compression

$$\lambda_e = \frac{d}{t_w} = \frac{318}{8.1} = 39.26$$

$\lambda_e = 39.26 < \lambda_s = 42$

So Web is Plastic in compression

Since Flange & Web are Plastic, Section is Plastic.

Member Compression Capacity:

Non-Dimensional Slenderness Ratio:

$$\frac{h}{b_f} = \frac{350}{140} = 2.5 > 1.2$$

and

$t_f = 14.2\,\text{mm} < 40\,\text{mm}$

So we should use the Buckling Curve 'a' for the z-z axis and Buckling Curve 'b' for the y-y axis (IS 7.1.1, 7.1.2.1, Table 7).

Z-Z Axis Parameters:

For buckling curve a, $\alpha = 0.21$ (IS 7.1.1, 7.1.2.1, Table 7)

Euler Buckling Stress: $f_{cc} = \dfrac{\pi^2 E}{\left(\dfrac{K_z L_z}{r_z}\right)^2} = \dfrac{\pi^2 200{,}000}{\left(\dfrac{3{,}000}{143}\right)^2} = 4485\,\text{MPa}$

$$\lambda_z = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{250}{4485}} = 0.2361$$

$$\phi = 0.5\left[1+\alpha\left(\lambda-0.2\right)+\lambda^2\right] = 0.5\left[1+0.21\left(0.2361-0.2\right)+0.2361^2\right]$$

$$\phi = 0.532$$

Stress Reduction Factor: $\chi = \dfrac{1}{\phi+\sqrt{\phi^2-\lambda^2}} = \dfrac{1}{0.532+\sqrt{0.532^2-0.2361^2}} = 0.9920$

$$f_{cd,z} = \chi\frac{f_y}{\gamma_{M0}} = 0.992 \bullet \frac{250}{1.1} = 255.5\,\text{MPa}$$

Y-Y Axis Parameters:

For buckling curve b, $\alpha = 0.34$ (IS 7.1.1, 7.1.2.1, Table 7)

Euler Buckling Stress: $f_{cc} = \dfrac{\pi^2 E}{\left(\dfrac{K_z L_z}{r_z}\right)^2} = \dfrac{\pi^2 200,000}{\left(\dfrac{3,000}{28.4}\right)^2} = 177\,\text{MPa}$

$$\lambda_y = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{250}{177}} = 1.189$$

$$\phi = 0.5\left[1+\alpha\left(\lambda-0.2\right)+\lambda^2\right] = 0.5\left[1+0.34\left(1.189-0.2\right)+1.189^2\right]$$

$$\phi = 1.375$$

Stress Reduction Factor: $\chi = \dfrac{1}{\phi+\sqrt{\phi^2-\lambda^2}} = \dfrac{1}{1.375+\sqrt{1.375^2-1.189^2}} = 0.4842$

$$f_{cd,y} = \chi\frac{f_y}{\gamma_{M0}} = 0.4842 \bullet \frac{250}{1.1} = 110.1\,\text{MPa} \quad \text{Governs}$$

$$P_d = Af_{cd,y} = 6670 \bullet 110.1$$

$$\boxed{P_d = 734.07\,\text{kN}}$$