Examples

Problem: 1

A non – sway intermediate column in a building frame with flexible joints is 4.0 m high and it is ISHB 300 @ 588 N/m steel section. Check the adequacy of the section when the column is subjected to following load:

Factored axial load = 500 kN

Factored moments:

	M_x	M_y
Bottom	+ 7.0 kN –m	- 1.0 kN - m
Top	+ 15.0 kN – m	+ 0.75 kN – m

[f_y = 250 N/mm^2 ; E = 2* 10^5 N/mm^2]

Assume effective length of the column as 3.4 m along both the axes.

Cross-section properties:

Flange thickness	=	T	=	10.6 mm
Clear depth between flanges	=	d	=	300 – (10.6 * 2)
			=	278.8 mm
Thickness of web	=	t	=	7.6 mm
Flange width	=	2b	=	250 mm
		b	=	125 mm
Area of cross-section	=	A_g	=	7485 mm^2

τ_x = 129.5 mm

τ_y = 54.1 mm

I_x = $12545.2*10^4$ mm^4

I_y = $2193.6*10^4$ mm^4

Z_x = $836.3*10^3$ mm^3

Z_y = $175.5*10^3$ mm^3

Z_{px} = $953.4*10^3$ mm^3

Z_{py} = $200.1*10^3$ mm^3

(i) Type of section:

$$\frac{b}{T} = \frac{125}{10.6} = 11.8 < 13.65\epsilon$$

$$\frac{d}{t} = \frac{278.8}{7.6} = 36.7 < 40.95\epsilon$$

$$\text{where, } \epsilon = \sqrt{\frac{250}{f_y}} = \sqrt{\frac{250}{250}} = 1.0$$

Hence, cross- section is " SEMI-COMPACT" (Class 3)

(ii) Check for resistance of cross-section to the combined effects for yielding:

f_{yd} = f_y/γ_a = 250/1.15

= 217.4 N/mm^2

A_g = 7485 mm^2

Z_x = $836.3*10^3$ mm^3

Z_y = $175.5*10^3$ mm^3

F_c = 500 kN

M_x = 15 kN-m

M_y = 1.0 kN-m

The interaction equation is:

$$\frac{F_c}{A_g f_y d} + \frac{M_x}{Z_x f_y d} + \frac{M_y}{Z_y f_y d} \leq 1$$

$$\frac{500 \times 10^3}{7845 \times 217.4} + \frac{15 \times 10^6}{836.3 \times 217.4} + \frac{1 \times 10^3}{175.5 \times 10^3 \times 217.4}$$

$= 0.307 + 0.083 + 0.026 = 0.416 < 1.0$

Hence, section is O.K. against combined effects

(iii) Check for resistance of cross-section to the combined effects for buckling:

Slenderness ratios:

Effective length of the column = 3.4 m

λ_x = 3400/129.5 = 26.3

λ_y = 3400/54.1 = 62.8

$\lambda_1 = \pi(E/f_y)^{1/2} = \pi(200000/250)^{1/2}$

= 88.9

Non-dimensional slenderness ratios:

$$\bar{\lambda} = \frac{\lambda}{\lambda_1}$$

$$\bar{\lambda}_x = \frac{26.3}{88.9} = 0.296$$

$$\bar{\lambda}_y = \frac{62.8}{88.9} = 0.706$$

Calculation of χ :

Imperfection factors:

$\alpha_x = 0.21$; $\alpha_y = 0.34$

ϕ - values:

$$\phi = 0.5\left[1 + \alpha\left(\bar{\lambda} - 0.2\right) + \bar{\lambda}^2\right]$$

$\phi_x = 0.5[1 + 0.21(0.296 - 0.2) + (0.296)^2] = 0.554$

$\phi_y = 0.5[1 + 0.34(0.706 - 0.2) + (0.706)^2] = 1.006$

χ - values:

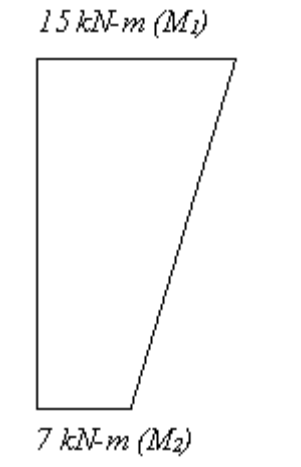
$$\chi = \frac{\chi_1}{\phi + \left(\phi^2 - \bar{\lambda}^2\right)^{\frac{1}{2}}} \leq 1.0$$

$\chi_x = 1/[0.554 + (0.554^2 - 0.296^2)^{1/2}] = 0.978$

$\chi_y = 1/[1.006 + (1.006^2 - 0.706^2)^{1/2}] = 0.580$

The interaction equation is

$$\frac{F_c}{f_d} + \frac{k_x M_x}{M_{ux}} + \frac{k_y M_y}{M_{uy}} \leq 1$$



$\psi_x = M_2/M_1 = 7/15 = 0.467$

$\beta_{Mx} = 1.8 - 0.7\psi = 1.8 - 0.7 \times 0.467$

$= 1.473$

$\mu_x = \bar{\lambda}_x (2\beta_{Mx} - 4) = 0.296\ (2 \times 1.473 - 4)$

$= -0.312$

$$k_x = 1 - \frac{\mu_x F_c}{P_{cx}} = 1 - \frac{\mu_x F_c}{\chi_x A f_y} = 1 - \frac{(-0.312) \times 500 \times 10^3}{0.978 \times 7485 \times 250} = 1.085$$

$\psi_y = 0.75/(-1.0) = -0.75$

$\beta_{My} = 1.8 - 0.7\psi$

$= 1.8 + 0.7 \times 0.75 = 2.325$

$\mu_y = \bar{\lambda}_y (2\beta_{My} - 4)$

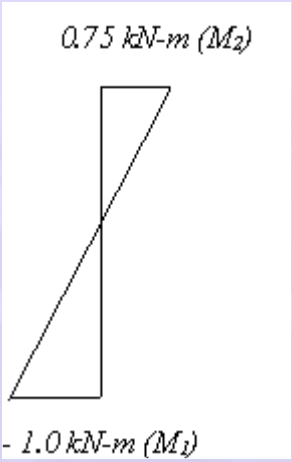
$= 0.706\ (2 \times 2.325 - 4) = 0.459$

$$k_y = 1 - \frac{\mu_y F_c}{P_{cy}} = 1 - \frac{\mu_y F_c}{\chi_y A f_y} = 1 - \frac{0.459 \times 500 \times 10^3}{0.58 \times 7485 \times 250} = 0.788$$

Note: $F_{cl} = \chi_{min} A_g f_{yd}$

$M_{ux} = Z_x f_{yd}$

$M_{uy} = Z_y f_{yd}$



Substituting the interaction equation,

$$\frac{500 \times 10^3}{7845 \times 217.4 \times 0.58} + \frac{15 \times 10^6 \times 1.085}{836.3 \times 10^3 \times 217.4} + \frac{1 \times 10^6 \times 0.788}{175.5 \times 10^3 \times 217.4}$$

$$= 0.530 + 0.089 + 0.021 = 0.640 < 1.0$$

Hence, section is O.K. against combined effects for buckling.