Structural Steel Design Project	Job No:	Sheet *1 of 6*	Rev
	Job Title: *BEAM COLUMN*		
	Worked Example - 1		
		Made by *SSSR*	Date *3-1-00*
Calculation Sheet		Checked by *VK*	Date *10-1-00*

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

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r_x = $129.5\ mm$

r_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:

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

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

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

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

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

$f_{yd} = f_y/\gamma_a = 250/1.15$

$= 217.4 \text{ N/mm}^2$

$A_g = 7485 \text{ mm}^2$

$Z_x = 836.3*10^3 \text{ mm}^3$

$Z_y = 175.5*10^3 \text{ mm}^3$

$F_c = 500 \text{ kN}$

$M_x = 15 \text{ kN-m}$

$M_y = 1.0 \text{ kN-m}$

The interaction equation is:

$$\frac{F_c}{A_g f_{yd}} + \frac{M_x}{Z_x f_{yd}} + \frac{M_y}{Z_y f_{yd}} \le 1$$

$$= \frac{500 \times 10^3}{7485 \times 217.4} + \frac{15 \times 10^6}{836.3 \times 10^3 \times 217.4} + \frac{1 \times 10^6}{175.5 \times 10^3 \times 217.4}$$

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

Hence, section is O.K. against combined effects

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

Slenderness ratios:

Effective length of the column = 3.4 m

$\lambda_x = 3400/129.5 = 26.3$

$\lambda_y = 3400/54.1 = 62.8$

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

$= 88.9$

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:

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

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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:

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

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

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

The interaction equation is

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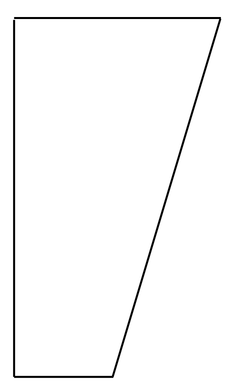
$$\frac{F_c}{F_{cl}} + \frac{k_x M_x}{M_{ux}} + \frac{k_y M_y}{M_{uy}} \le 1$$



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

$$\beta_{Mx} = 1.8 - 0.7\psi = 1.8 - 0.7 \times 0.467 = 1.473$$

$$\mu_x = \bar{\lambda}_x\left(2\beta_{Mx} - 4\right) = 0.296\ (2 \times 1.473 - 4) = -0.312$$

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

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

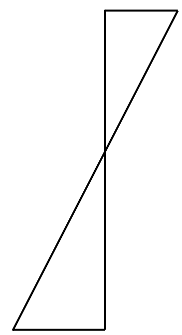
$\beta_{My} = 1.8 - 0.7\psi$

$= 1.8 + 0.7 \times 0.75 = 2.325$

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

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

0.75 kN-m (M_2)



- 1.0 kN-m (M_1)

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

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,

$$\frac{500 \times 10^3}{7485 \times 217.4 \times 0.58} + \frac{15 \times 10^6 \times 1.085}{836.3 \times 10^3 \times 217.4} + \frac{1 \times 10^6 \times 0.788}{175.5 \times 10^3 \times 217.4}$$

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

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