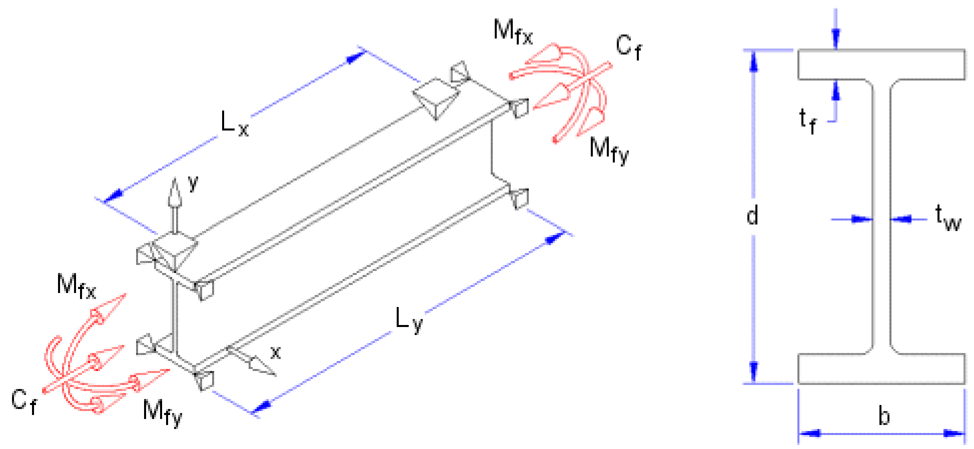
CIVL 231	**PROJECT**	**Design of Beam-Columns to CAN/CSA-S16.1-94**		
	AREA			
	AUTHOR	sfs	**TIME**	9:25:29 AM
	CK'D BY	sfs	**DATE**	04/02/2007

Design of Beam-Columns to CAN/CSA-S16.1-94



INPUT PARAMETERS

Forces

Factored Compressive Load	C_f	=	6000	kN
Factored Moment about X-Axis	M_{fx}	=	400	kN m
Factored Moment about Y-Axis	M_{fy}	=	0	kN m

Geometry

Laterally Unsupported Length - X-Axis Buckling	L_x	=	5000	mm
Effective Length Factor - X-Axis Buckling	K_x	=	1.00	
Laterally Unsupported Length - Y-Axis Buckling	L_y	=	5000	mm
Effective Length Factor - Y-Axis Buckling	K_y	=	1.00	

Section (W530x272)

Depth	d	=	577	mm
Width	b	=	318	mm
Flange Thickness	t_f	=	37.6	mm
Web Thickness	t_w	=	21.1	mm
Area	A	=	34600	mm^2
Radius of Gyration about X-Axis	r_x	=	239	mm
Radius of Gyration about Y-Axis	r_y	=	76.4	mm
Moment of Inertia about X-Axis	I_x	=	1.97E+9	mm^4
Section Modulus about X-Axis	S_x	=	6.84E+6	mm^3
Plastic Modulus about X-Axis	Z_x	=	7.81E+6	mm^3
Moment of Inertia about Y-Axis	I_y	=	2.02E+8	mm^4
Section Modulus about Y-Axis	S_y	=	1.27E+6	mm^3
Plastic Modulus about Y-Axis	Z_y	=	1.96E+6	mm^3

St. Venant Torsional Constant		J	= 1.28E+7	mm^4
Warping Constant		C_w	= 1.47E+13	mm^6
Material				
Specified Yield		F_y	= 350	MPa

DESIGN CHECKS

Section Class

Flange

b/t	=	$b / (2 \cdot t_f) = 318 / (2 \cdot 37.6) = 4.2$	11.3.1
	<=	$145 / (F_y)^{1/2} = 145 / (350)^{1/2}$	11.2
	<=	7.8 -> Flange is class 1	

Web

h/w	=	$(d - 2t_f) / t_w = (577 - 2 \cdot 37.6) / 21.1 = 23.8$	11.3.2
	<=	$1100.0 \cdot [1 - 0.39 \cdot C_f \cdot 1000 / (A \cdot F_y)] / (F_y)^{1/2}$	11.2
	<=	$1100.0 \cdot [1 - 0.39 \cdot 6000 \cdot 1000 / (34600 \cdot 350)] / (350)^{1/2}$	
	<=	47.4 -> Web is class 1	

-> Section is class 1

Axial Compression

C_r	**=**	**$\phi A F_y (1+\lambda^{2n})^{-1/n}$**	**13.3.1**
where			
ϕ	=	0.9	
n	=	1.34 for Group 1, 2 and 3 W-shapes of CSA G40.20 Table 1	
$(KL/r)_{max}$	=	$Max(K_x \cdot L_x/r_x, K_y \cdot L_y/r_y)$	
	=	$Max(1.00 \cdot 5000/239, 1.00 \cdot 5000/76.4)$	
	=	Max(20.9, 65.4)	
	=	65.4	
$(KL/r)_{max}$	<?	200	10.2.1
65.4	<=	200	OK
λ	=	$(KL/r)_{max} [F_y/(\pi^2 E)]^{1/2}$	
	=	$65.4 \cdot [350/(\pi^2\ 200000)]^{1/2}$	
	=	0.871	
C_r	=	$0.9 \cdot 34600 \cdot 350 \cdot (1+ 0.871^{2 \cdot 1.34})^{-1/1.34} / 1000$	
	=	7362 kN	
C_f	<?	C_r	
6000 kN	<	7362 kN	OK

Bending about X-Axis

M_u	**=**	**$\omega_{2x} \cdot \pi \cdot [E \cdot I_y \cdot G \cdot J + (\pi \cdot E / L)^2 \cdot I_y \cdot C_w]^{1/2} / L$**	**13.6.a**
where			
ω_{2x}	=	$Min(1.75 + 1.05 \cdot K_x + 0.3 \cdot K_x^2, 2.50)$	
K_x	=	$M_{fx,min} / M_{fx,max} = 0.00/400 = 0.00$	
ω_{2x}	=	$Min(1.75 + 1.05 \cdot 0.00 + 0.3 \cdot 0.00^2 , 2.50) = 1.75$	
M_u	=	$1.75 \cdot \pi \cdot [(2.0E+5) \cdot (2.02E+8) \cdot (7.7E+4) \cdot (1.28E+7) + (\pi \cdot (2.0E+5)/5000)^2 \cdot (2.02E+8) \cdot (1.47E+13)]^{1/2} / 5000 / (1.0E+6)$	

	=	10239 kN m
M_p	=	$Z_x \cdot F_y$ = (7.81E+6)·350 / (1.0E+6) = 2734 kN m
since M_u	>	$0.67 \cdot M_p$ = 0.67·2734 = 1831,
M_{rx}	=	Min($1.15 \cdot \phi \cdot M_p \cdot (1 - 0.28 \cdot M_p/M_u)$, $\phi \cdot M_p$)
	=	Min(1.15·0.9·2734·(1 - 0.28·2734/10239), 0.9·2734)
	=	Min(2618, 2460) = 2460 kN m
M_{fx}	<?	M_{rx}
400	<	2460 OK

Bending about Y-Axis

M_{ry}	**=**	**$\phi \cdot Z_y \cdot F_y$ = 0.9·(1.96E+6)·350 / (1.0E+6)**	**13.5.a**
	=	617 kN m	
M_{fy}	<?	M_{ry}	
0	<	617	OK

Biaxial Bending

$M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <=? 1.0 **13.6.e**

400/2460 + 0/617 = 0.16 + 0.00 = 0.16 <= 1.0 OK

Cross-Sectional Strength

$C_f/(\phi \cdot A \cdot F_y) + 0.85 \cdot M_{fx}/(\phi \cdot Z_x \cdot F_y) + 0.6 \cdot M_{fy}/(\phi \cdot Z_y \cdot F_y)$ <=? 1.0 **13.8.2a**

6000/(0.9·34600·350/1000) + 0.85·400/[0.9·(7.81E+6)·350/(1.0E+6)] +
0.6·0/[0.9·(1.96E+6)·350/(1.0E+6)] OK
= 0.55 + 0.14 + 0.00 = 0.69 <= 1.0

Overall Member Strength

$C_f/C_{ro} + 0.85 \cdot U_{1x} \cdot M_{fx}/(\phi \cdot Z_x \cdot F_y) + 0.6 \cdot U_{1y} \cdot M_{fy}/(\phi \cdot Z_y \cdot F_y)$ <=? 1.0 **13.8.2b**

where

C_{ro}	=	$\phi A F_y (1+\lambda_x^{2n})^{-1/n}$	13.3.1
λ_x	=	$K_x \cdot L_x / r_x\, [F_y/(\pi^2 E)]^{1/2}$	
	=	$1.00 \cdot 5000/239[350/(\pi^2\, 200000)]^{1/2}$ = 0.28	
C_{ro}	=	$0.9 \cdot 34600 \cdot 350 \cdot (1+ 0.28^{2 \cdot 1.34})^{-1/1.34}$ / 1000	
	=	10642 kN	
U_{1x}	=	$\omega_{1x}/(1 - C_f/C_{ex})$	13.8.3
ω_{1x}	=	Max(0.60 - $0.4 \cdot K_x$, 0.40)	
K_x	=	$M_{fx,min} / M_{fx,max}$ = 0.00/400 = 0.00	
ω_{1x}	=	Max(0.60 - 0.4·0.00, 0.40) = 0.60	
C_{ex}	=	$\pi^2 \cdot E \cdot I_x / L_x^2 = \pi^2 \cdot (2.0E+5) \cdot (1.97E+9)/5000^2$ / 1000 = 155545 kN	
U_{1x}	=	0.60 / (1 - 6000 / 155545) = 0.62	
U_{1y}	=	$\omega_{1y}/(1 - C_f/C_{ey})$	13.8.3
ω_{1y}	=	1.0	
C_{ey}	=	$\pi^2 \cdot E \cdot I_y / L_y^2 = \pi^2 \cdot (2.0E+5) \cdot (2.02E+8)/5000^2$ / 1000 = 15949 kN	
U_{1y}	=	1.00 / (1 - 6000 / 15949) = 1.60	

$6000/10642 + 0.85 \cdot 0.62 \cdot 400/[0.9 \cdot (7.81E+6) \cdot 350/(1.0E+6)] +$
$0.6 \cdot 1.60 \cdot 0/[0.9 \cdot (1.96E+6) \cdot 350/(1.0E+6)]$ OK
$= 0.56 + 0.09 + 0.00 = 0.65 <= 1.0$

Lateral Torsional Buckling Strength

$C_f/C_{ry} + 0.85 \cdot U_{1x} \cdot M_{fx}/M_{rx} + 0.6 \cdot U_{1y} \cdot M_{fy} /(\phi \cdot Z_y \cdot F_y) <=? 1.0$ **13.8.2c**

where

C_{ry}	=	$\phi AF_y(1+\lambda_y^{2n})^{-1/n}$	13.3.1
λ_y	=	$K_y \cdot L_y/r_y [F_y/(\pi^2 E)]^{1/2}$	
	=	$1.00 \cdot 5000/76.4[350/(\pi^2\ 200000)]^{1/2} = 0.87$	
C_{ry}	=	$0.9 \cdot 34600 \cdot 350 \cdot (1+ 0.87^{2 \cdot 1.34})^{-1/1.34} / 1000$	
	=	7362 kN	
U_{1x}	=	$Max[\omega_{1x} /(1 - C_f/C_{ex}), 1.0]$	13.8.3
	=	$Max[0.62, 1.0] = 1.00$	

$6000/7362 + 0.85 \cdot 1.00 \cdot 400/2460 + 0.6 \cdot 1.60 \cdot$
$0/[0.9 \cdot (1.96E+6) \cdot 350/(1.0E+6)]$ OK
$= 0.81 + 0.14 + 0.00 = 0.95 <= 1.0$