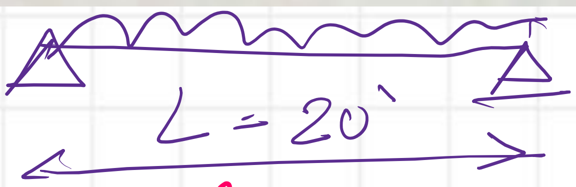
Design

SALmon 7-4-1 Grade 65

Select the lightest W or M section to carry a uniformly distributed dead load of 0.2 kip/ft superimposed (i.e., in addition to the beam weight) and 0.8 kip/ft live load. The simply supported span (Fig. 7.4.2) is 20 ft. The compression flange of the beam is fully supported against lateral movement. Use Load and Resistance Factor Design, and select for the following steels: A36; A992; and A572 Grade 65.

Solution



@ LRFD - Design $\phi_b = 0.90$

$w_D = 0.20$ K/F

$w_L = 0.8$ K/F

$\boxed{L_b = 0}$

© A572 steel

$F_y = 65$ ksi

$w_{ult} = 1.2(0.2) + 1.6(0.8) = 1.52$ K/Ft

$M_{ult} = W_U \frac{L^2}{8} = \frac{1.52}{8}(20)^2 = 76$ FT.kips

check λ_F, λ_w

check $M_{ult} \le \phi_b M_n$

Prepared by Eng.Maged Kamel.

Find F_y from Table 2-4

CM #15

Table 2-4
Applicable ASTM Specifications for Various Structural Shapes

Steel Type	ASTM Designation		F_y Yield Stress[a] (ksi)	F_u Tensile Stress[a] (ksi)	Applicable Shape Series									
					W	M	S	HP	C	MC	L	HSS		
												Rect.	Round	Pipe
	A572	Gr. 42	42	60										
		Gr. 50	50	65										
		Gr. 55	55	70										
		Gr. 60[e]	60	75										
		Gr. 65[e]	65	80										

A572 Grade 65 $F_y = 65$ ksi

Use A572

© A572 $F_y = 65$ ksi

Design

$M_u = 76$ Ft.kips → without own wt

$\phi_b = 0.90$

$\phi M_n \geq M_{ult}$

if we let $M_{ult} = \phi_b F_y Z_x$

$Z_x = \dfrac{76(12)}{0.9(65)} = 15.589 \text{ inch}^3$

Go to table 3_2 check for $Z_x > 15.60 \text{ inch}^3$

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$\boxed{W12 \times 14}$

Z_x

Table 3-2 (continued)
W-Shapes
Selection by Z_x

$F_y = 50$ ksi

Shape	Z_x	M_{px}/Ω_b	$\phi_b M_{px}$	M_{rx}/Ω_b	$\phi_b M_{rx}$	BF/Ω_b	$\phi_b BF$	L_p	L_r	I_x	V_{nx}/Ω_v	$\phi_v V_{nx}$
		kip-ft	kip-ft	kip-ft	kip-ft	kips	kips				kips	kips
	in.^{3}	ASD	LRFD	ASD	LRFD	ASD	LRFD	ft	ft	in.^{4}	ASD	LRFD
W12×14[v]	17.4	43.4	65.3	26.0	39.1	3.43	5.17	2.66	7.73	88.6	42.8	64.3
W8×18	17.0	42.4	63.8	26.5	39.9	1.74	2.61	4.34	13.5	61.9	37.4	56.2

Z_x selected $= 17.4 \text{ inch}^3 > Z_{x\,required}$

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Element	λ	λ_p	λ_r
Flange	$\frac{b_f}{2t_f}$	$0.38\sqrt{\frac{E}{F_y}}$	$1.0\sqrt{\frac{E}{F_y}}$
Web	$\frac{h}{t_w}$	$3.76\sqrt{\frac{E}{F_y}}$	$5.70\sqrt{\frac{E}{F_y}}$

c) $F_y = 65$ ksi

$\lambda_{Fp} = 0.38\sqrt{\frac{29000}{65}} = 8.03$

$\lambda_{Fr} = 1.0\sqrt{\frac{29000}{65}} = 21.12$

Flange

$\lambda_{wp} = 3.76\sqrt{\frac{29000}{65}} = 79.42$

$\lambda_{wr} = 5.70\sqrt{\frac{29000}{65}} = 120.40$

Web

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W12 X 14 $F_y = 65$ ksi

Table 1-1 (continued)
W-Shapes
Properties

$Z_x = 17.40$ inch^3
$S_x = 14.90$ inch^3

W14–W12

Nom-inal Wt.	Compact Section Criteria		Axis X-X				Axis Y-Y				r_{ts}	h_o	Torsional Properties	
	$\frac{b_f}{2t_f}$	$\frac{h}{t_w}$	I	S	r	Z	I	S	r	Z			J	C_w
lb/ft			in.^{4}	in.^{3}	in.	in.^{3}	in.^{4}	in.^{3}	in.	in.^{3}	in.	in.	in.^{4}	in.^{6}
22	4.74	41.8	156	25.4	4.91	29.3	4.66	2.31	0.848	3.66	1.04	11.9	0.293	164
19	5.72	46.2	130	21.3	4.82	24.7	3.76	1.88	0.822	2.98	1.02	11.9	0.180	131
16	7.53	49.4	103	17.1	4.67	20.1	2.82	1.41	0.773	2.26	0.983	11.7	0.103	96.9
14	8.82	54.3	88.6	14.9	4.62	17.4	2.36	1.19	0.753	1.90	0.961	11.7	0.0704	80.4

$\frac{b_f}{2t_f} = 8.82 > \underset{\lambda_{p}}{8.03}$ Flange is not Compact

$h/t_w = 54.30 < \underset{\lambda_{wp}}{79.42} \rightarrow$ web is Compact

Lateral Torsional Buckling:

Select the lightest W or M section to carry a uniformly distributed dead load of 0.2 kip/ft superimposed (i.e., in addition to the beam weight) and 0.8 kip/ft live load. The simply supported span (Fig. 7.4.2) is 20 ft. The compression flange of the beam is fully supported against lateral movement. Use Load and Resistance Factor Design, and select for the following steels: A36; A992; and A572 Grade 65.

$L_b = 0 \Rightarrow$ given as

Compression Flange is fully supported against Lateral movement

W12x14 Non Compact

Required to Find M_n

$\lambda_F = 8.82$

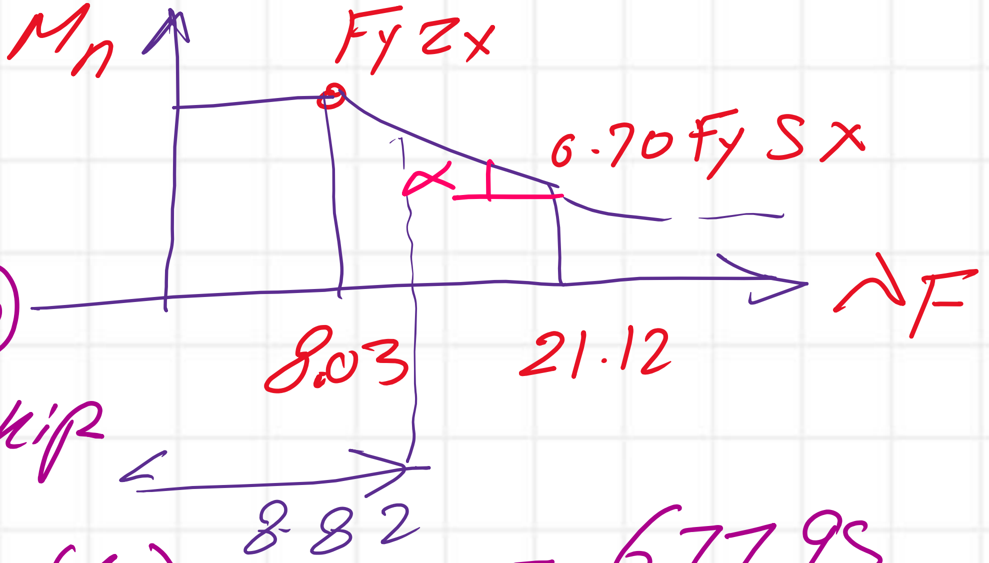
$F_y = 65$ ksi

$\lambda_{Fp} : 8.03 \Rightarrow M_n = F_y Z_x$

$\lambda_{Fr} : 21.12 \Rightarrow M_n = 0.7 F_y S_x$

$Z_x : 17.4$ inch^3

$S_x : 14.90$ inch^3



$F_y Z_x = 65(17.40)$

$= 1131$ inch.kip

$(0.70 F_y) S_x = (0.70)(65)\ 14.90 = 677.95$ inch.kips

Difference $= 1131 - 677.95$

VL $= 453.05$ inch.kip

HL $= 21.12 - 8.03$

$= 13.09$

$\tan\alpha = 453.05/13.09 = 34.61$ inch.kip

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W12x14 Non Compact

Required to Find M_n

$\lambda_{Fp} : 8.03 \Rightarrow M_n = F_y Z_x$

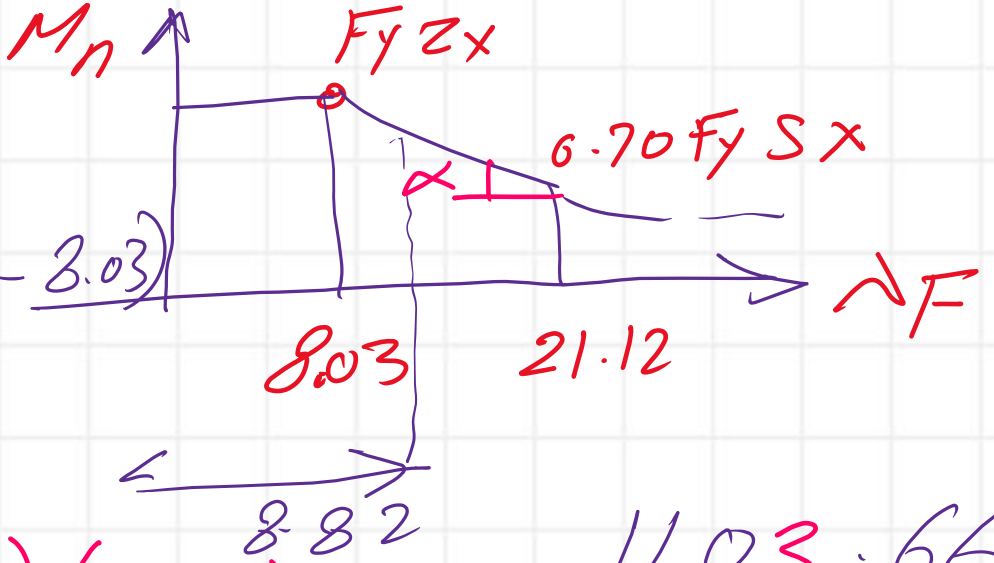
$\lambda_{Fr} : 21.12 \Rightarrow M_n = 0.7 F_y S_x$

$Z_x : 17.4 \text{ inch}^3$

$S_x : 14.90 \text{ inch}^3$

Slope = 34.61

$M_n = 1131 - S(8.82 - 8.03)$



$M_n = 1131 - (34.61)(0.79) = 1103.66$ inch.kips

$M_n = 1103.66 / 12 = 91.97$ FT.kips ≈ 92 FT.kips

$\phi_b M_n = 0.90(92) = 82.80$ FT.kips

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Estimate Final Mult as

$$\frac{W\,12 \times 14}{\text{own wt} = 0.014\ \text{K/F}}$$

$\ell = 20'$

$$W_{ult} = 1.2(0.2 + 0.014) + 1.6(0.8)$$

$$= 1.537\ \text{K/FT}$$

$$M_{ult} = 1.537\,(20)^2/8 = 76.84\ \text{FT.kips}$$

$$\simeq 77\ \text{FT.kip}'$$

$$\phi M_n = 82.80\ \text{FT.kips}$$

$$\simeq 83\ \text{FT.kips} > M_{ult} \quad \text{OK}$$