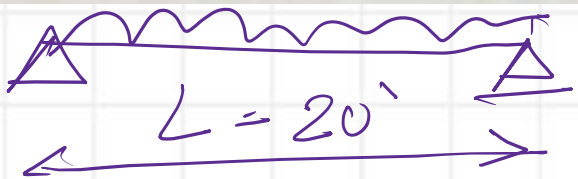
Design

SALmon 7-4-1

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 $\phi_b = 0.90$

$L_b = 0$

$w_D = 0.20$ K/F

$w_L = 0.8$ K/F

A36 steel $\Rightarrow F_y = 36$ 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 $M_{ult} \le \phi_b M_n$

Find Fy

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.	HSS Round	HSS Pipe
High-Strength Low-Alloy	A572	Gr. 42	42	60	■	■	■	■	■	■	■			
		Gr. 50	50	65	■	■	■		■	■	■			
		Gr. 55	55	70	■	■	■	■	■	■	■			
		Gr. 60[e]	60	75	■	■	■	■	■	■	■			
		Gr. 65[e]	65	80	■	■	■	■	■	■	■			
	A618[f]	Gr. Ia[k], Ib & II	50[g]	70[g]								■	■	
		Gr. III	50	65								■	■	
	A709	50	50	65	■	■	■	■	■	■	■			
		50S	50–65	65	■	■	■	■	■	■	■			
		50W	50	70	■	■	■	■	■	■	■			
	A913	50	50[h]	65[h]	■	■	■	■	■	■	■			
		60	60	75	■	■	■	■	■	■	■			
		65	65	80	■	■	■	■	■	■	■			
		70	70	90	■	■	■	■	■	■	■			
	A992		50[i]	65[i]	■									
	A1065[k]	Gr. 50[l]	50	60								■		

→ A992 Fy = 50 ksi

From Table 2-4

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.	HSS Round	HSS Pipe
Carbon	A36		36	58–80[b]	■	■	■	■	■	■	■			
	A53 Gr. B		35	60										■
	A500	Gr. B	42	58									■	
			46	58								■		
		Gr. C	46	62									■	
			50	62								■		
	A501	Gr. A	36	58								■	■	
		Gr. B	50	70								■	■	

A36 ⇒ Fy = 36 ksi

$F_y = 36$ ksi:

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	$\frac{h}{t_w}$	$3.76\sqrt{\frac{E}{F_y}}$	$5.70\sqrt{\frac{E}{F_y}}$

$\lambda_{wr} \rightarrow 922.141$

$\lambda_{wp} = 3.76\sqrt{\frac{29000}{36}} = 106.717$

Flange

$\lambda_{Fp} = 0.38\sqrt{\frac{29000}{36}} = 10.79$

$\lambda_{Fr} = 1\sqrt{\frac{29000}{36}} = 28.88$

Required Z_x

From $M_{ult} \leq \phi M_n \leq \phi_b F_y \cdot Z_x$

check From table 3-2 W Shapes sorted by Z_x

$M_{ult} = 76$ FT. kips $\xrightarrow{\times 12} 912$ inch.kip.

$\phi_b = 0.90$

$Z_x = \frac{M_{ult}}{\phi_b F_y} = \frac{76(12)}{0.9(36)} = 28.15$ inch^3

Z_x required 28.15 inch3

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Table 3-2 (continued)

W-Shapes

Selection by Z_x

$F_y = 50$ ksi

Z_x

web is compact

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
W12×22	29.3	**73.1**	110	**44.4**	66.7	**4.68**	7.06	**3.00**	**9.13**	**156**	**64.0**	95.9
W8×28	27.2	67.9	102	42.4	63.8	1.67	2.50	5.72	21.0	98.0	45.9	68.9
W10×22	**26.0**	**64.9**	97.5	**40.5**	60.9	**2.68**	4.02	**4.70**	**13.8**	**118**	**49.0**	73.4
W12×19	**24.7**	**61.6**	92.6	**37.2**	55.9	**4.27**	6.43	**2.90**	**8.61**	**130**	**57.3**	86.0
W8×24	23.1	57.6	86.6	36.5	54.9	1.60	2.40	5.69	18.9	82.7	38.9	58.3
W10×19	**21.6**	**53.9**	81.0	**32.8**	49.4	**3.18**	4.76	**3.09**	**9.73**	**96.3**	**51.0**	76.5
W8×21	20.4	50.9	76.5	31.8	47.8	1.85	2.77	4.45	14.8	75.3	41.4	62.1

Select W12X22

Required $Z_x = 29.3$ inch^3 > 28.15 inch^3

$F_y = 36$ ksi

$\lambda_{Fp} = 10.79$

$\lambda_{Fr} = 28.38$

$\lambda_{wF} = 106.717$

$\lambda_{wr} = 922.141$

Prepared by Eng.Maged Kamel.

we

W12X22

Table 1-1 (continued)
W-Shapes
Properties

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

$\frac{bf}{2tf} = 4.74 < \lambda Fp$

$h/tw = 41.8 < \lambda wp$ } Compact section

$Fy = 36$ ksi

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

Section : W12 X22

After selecting the W section → add the own wt

$Z_x = 29.30\ inch^3$

$W_{ult} = 1.2\,DL + 1.6\,L.L = 1.2(0.2) + 1.6(0.80) = 1.52\ kips/ft$

$W_{ult} = 1.52 + (1.2)\left(\frac{22}{1000}\right) = 1.55\ kips/ft \rightarrow M_u = \frac{1.55}{8}(20)^2 = 77.32\ Ft.kips$

added own wt

Check

$M_{ult} \leq \phi M_p$

$\phi F_y Z_x = 0.90(36)\left(\frac{29.30}{12}\right)\left[\frac{Lb}{inch^2}\cdot\frac{inch^3}{12\,inch}\,Ft\right]$

$= 79.11\ Ft.kips$

$\phi M_n = 79.11\ Ft\,kips > 77.32\ Ft.kips$:- Safe

M_{ult} Final

$F_y = 36\ Ksi$

Case – A

Part Design For A992

(b) A992 $F_y = 50$ ksi, $M_u = 76$ Ft.kips } Part b $F_y = 50$ ksi;

$\phi M_n \geq M_{ult}$

$0.90(F_y)(Z_x) \geq M_{ult}$

$Z_x \Rightarrow$ required $\Rightarrow Z_x = \dfrac{76(12)}{0.9(50)} = 20.22 \text{ inch}^3$

Go to table 3_2 check For $Z_x > 20.22 \text{ inch}^3$

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W10 X19

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
W10×19	21.6	53.9	81.0	32.8	49.4	3.18	4.76	3.09	9.73	96.3	51.0	76.5
W8×21	20.4	50.9	76.5	31.8	47.8	1.85	2.77	4.45	14.8	75.3	41.4	62.1

Z_x Selected $= 21.6 \text{ inch}^3 > Z_x$ required

Case (b)

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	$\frac{h}{t_w}$	$3.76\sqrt{\frac{E}{F_y}}$	$5.70\sqrt{\frac{E}{F_y}}$

(b) $F_y = 50$ ksi.

$\lambda_{Fp} = 0.38\sqrt{\frac{29000}{50}} = 9.15$

$\lambda_{Fr} = 1.0\sqrt{\frac{29000}{50}} = 24.09$

$\lambda_{wp} = 3.76\sqrt{\frac{29000}{50}} = 90.55$

$\lambda_{wr} = 5.70\sqrt{\frac{29000}{50}} = 137.27$

W10 X19

Fy = 50 ksi

Table 1-1 (continued)
W-Shapes
Properties

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}
19	5.09	35.4	96.3	18.8	4.14	21.6	4.29	2.14	0.874	3.35	1.06	9.81	0.233	104
17	6.08	36.9	81.9	16.2	4.05	18.7	3.56	1.78	0.845	2.80	1.04	9.77	0.156	85.1
15	7.41	38.5	68.9	13.8	3.95	16.0	2.89	1.45	0.810	2.30	1.01	9.72	0.104	68.3
12	9.43	46.6	53.8	10.9	3.90	12.6	2.18	1.10	0.785	1.74	0.983	9.66	0.0547	50.9

$\frac{bf}{2tf} = 5.09 < 5.12$

$h/tw = 41.8 < 90.55$

Compact section

Fy = 50 ksi

For W 10x19

$Z_x = 21.60\ inch^3$

$F_y = 50\ ksi$

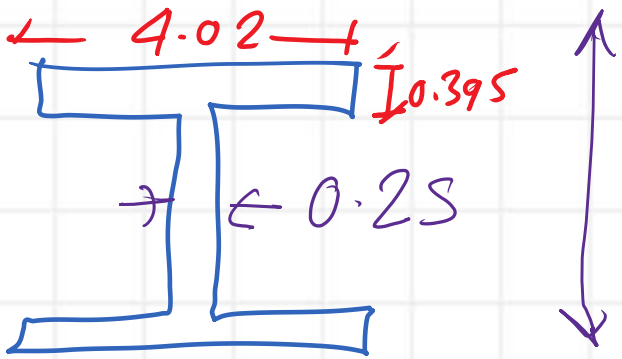

Table 1-1

Compare M_{ult} with ϕM_n

$$\phi M_n = 0.90(50)(21.60)\left(\frac{1}{12}\right) = 81.00\ Ft\ kips$$

add own wt

$$M_{ult} = 76 + \left[1.2\left(\frac{19}{1000}\right)\frac{(20)^2}{8}\right] = 77.14\ Ft\text{-}kips$$

$\phi M_n > M_{ult}$ OK

⇓ Final ⇒ DL Load Part