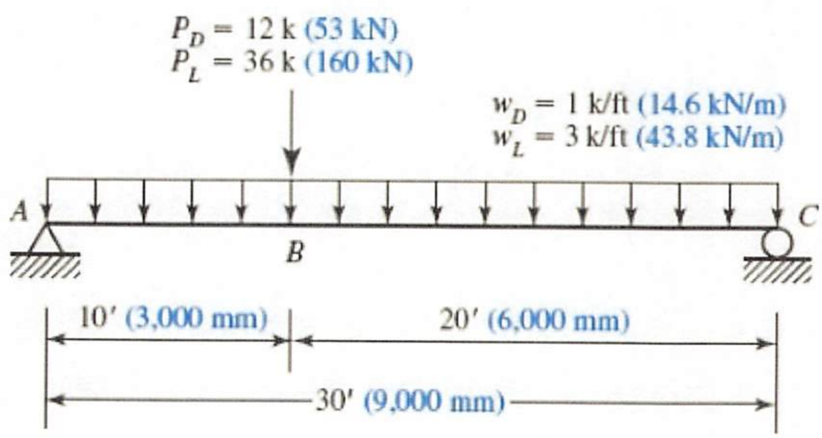
5.5-15 Determine whether a W24 × 104(W610 × 155) of A992 steel ($F_y = 50$ ksi(345 MPa)) is adequate for the beam shown in Figure P5.5-15. The uniform load does not include the weight of the beam. Lateral support is provided at A, B, and C.



FROM TABLE 1-1 (1-18)

$d = 24.1$ in $t_f = 0.76$ in $\frac{b_f}{2t_f} = 8.50$ $\frac{h}{t_w} = 43.1$ $S_x = 258$ IN^3

$Z_x = 289$ IN^3 $I_y = 259$ IN^4 $r_y = 2.91$ in $r_{ts} = 3.42$ in $h_o = 23.4$ in

$J = 4.72$ IN^4 $C_w = 35200$ IN^6

SECTION BC $L_b = 20\text{ ft} = 20\text{ ft}(12\text{ in}/\text{ft}) = 240\text{ in}$

$$L_p = 1.76 r_y \sqrt{E/F_y} = 1.76(2.91\text{ in})\sqrt{\frac{29{,}000}{50}} = 123.34 < L_b$$

COMPUTE L_r

$C = 1.0$ FOR I-SHAPES

$$\frac{Jc}{S_x h_o} = \frac{4.72\text{ IN}^4(1.0)}{258\text{ IN}^3(23.4\text{ in})} = 7.818 \times 10^{-4}$$

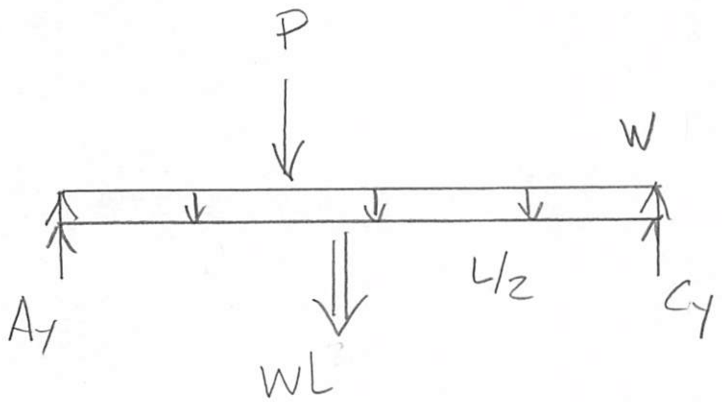
5.5-15

$$L_r = 1.95(3.42)\frac{29000}{0.7(50)}\sqrt{\frac{J_c}{S_x h_o} + \sqrt{\left(\frac{J_c}{S_x h_o}\right)^2 + 6.76\left(\frac{0.7F_y}{E}\right)^2}}$$

$$= 350.16 \text{ in} > L_b \Rightarrow \text{USE AISC EQN. F2-2}$$

$$^*M_n = C_B\left[M_p - (M_p - 0.7F_y S_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right]$$

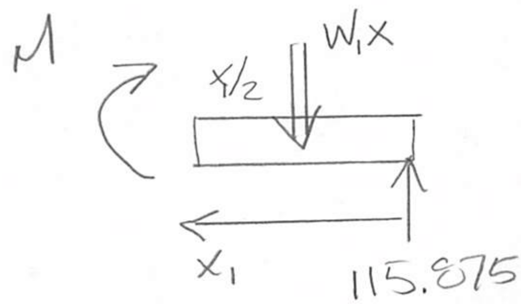
COMPUTE C_B



$P = 1.2(12^k) + 1.6(36^k) = 72^k$

$W = 1.2(1 + 0.104)$ k/ft $+ 1.6(3$ k/ft$) = 6.125$ k/ft

$\circlearrowleft + \sum M_A = 0 = -P(10') - W(30')(15') + C_y(30')$ $\quad C_y = 115.875^k$



$\circlearrowleft + \sum M_{CUT} = 0 = -M + 115.875x - 6.125(x)\frac{x}{2}$

$M = -3.0625x^2 + 115.875x$

$V = -6.125x + 115.875 = 0$

$x = 18.91$

$M_A(x = 15) = 1{,}049.06$ kft

$M_B(x = 10) = 852.5$ kft

$M_C(x = 5) = 502.81$ kft

$M_{MAX}(x = 18.9) = 1{,}096.1$ kft

$$C_B = \frac{12.5(1096)}{2.5(1096)+3(1049)+4(852.5)+3(502.8)} = 1.268$$

$$M_p = F_y Z_x = 50\,\text{ksi}(289\,\text{in}^3) = 14{,}450\,\text{k in}$$

$$M_n = C_B\left[M_p - (M_p - 0.7F_y S_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right]$$

$$= 1.268\left[14{,}450 - (14{,}450 - 0.7(50)(258))\left(\frac{240 - 123.34}{350.1 - 123.34}\right)\right]$$

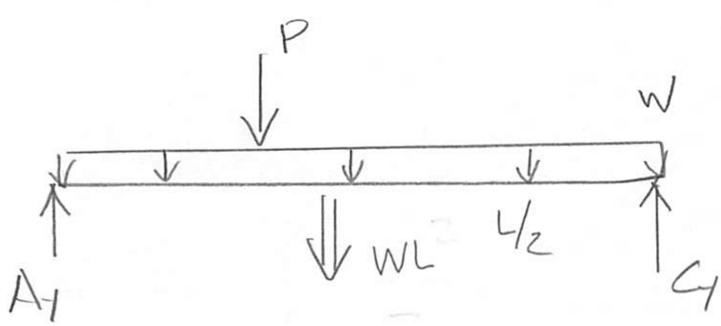
$$= 14{,}786.9 > M_p \Rightarrow M_n = M_p$$

$$\phi_b M_n = 0.9(14{,}450\,\text{k in}) = 13{,}005\,\text{k in} = \underline{1{,}083.75\,\text{k ft}}$$

$$M_u = 1{,}096\,\text{k ft} > \phi_b M_n \qquad \underline{\text{N.G.}}$$

b) ASD COMPUTE C_b

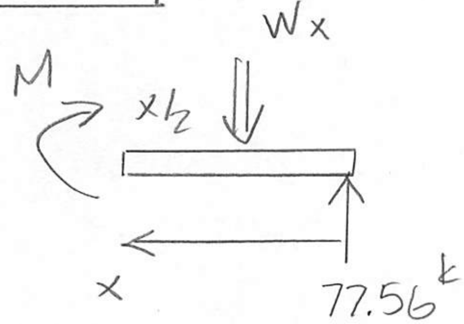
$$P = 12^k + 36^k = 48^k$$



$$W = (1 + 3 + 0.104)\,\text{k/ft}$$
$$= 4.104\,\text{k/ft}$$

$$\circlearrowleft + \sum M_A = 0 = -P(10') - W(30)(15) + G_y(30') \qquad G_y = 77.56\,\text{k}$$

5.5-15



$$\circlearrowleft^{+} \sum M_{CUT} = 0 = -M - \frac{wx^2}{2} + 77.56(x)$$

$$M = -2.052x^2 + 77.56x$$

$$V = 4.104x + 77.56 = 0$$

$$x = 18.9'$$

$$M_A(x = 15') = 701.7\text{ kft}$$

$$M_B(x = 10') = 570.4\text{ kft}$$

$$M_C(x = 5') = 336.5\text{ kft}$$

$$M_{MAX}(x = 18.9) = 732.99\text{ kft}$$

$$C_B = \frac{12.5(733)}{2.5(733) + 3(702) + 4(570) + 3(336.5)} = 1.268$$

$$M_p = F_y Z_x = 50\text{ ksi}(289\text{ in}^3) = 14{,}450\text{ k}\cdot\text{in} = 1{,}204.17\text{ k}\cdot\text{ft}$$

$$M_n = M_{n\,LRFD} = 14{,}787 > M_p \Rightarrow M_n = M_p \;*$$

$$\frac{M_n}{\Omega_b} = \frac{1{,}204.17\text{ kft}}{1.67} = \underline{721.05\text{ kft} < M_u = 733\text{ kft}}$$

N.G.