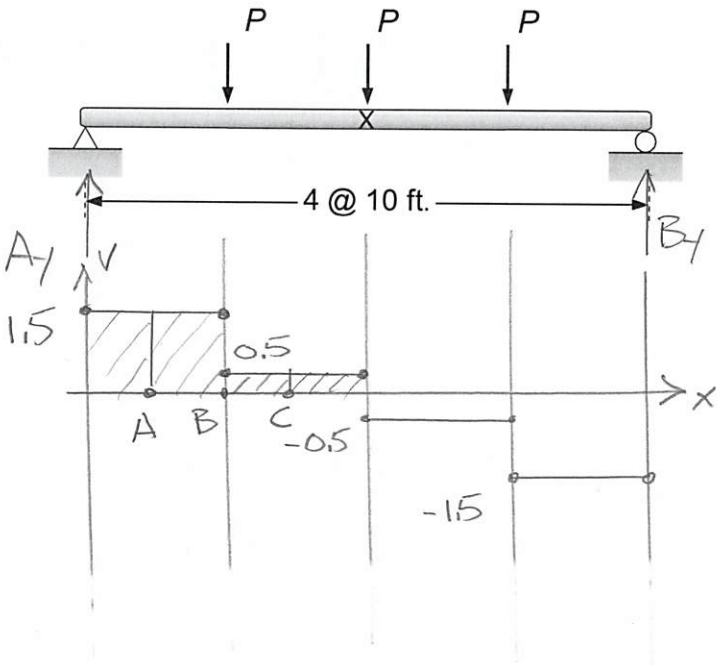
Classroom Problem 5.5-6: A **W18 x 86** of **A992** steel with F_y = 50 *ksi*; F_u = 65 *ksi* is used as a simply supported beam. The point loads are P_D = 6 *k* and P_L = 15 *k*. Ignore the beam weight. Also, the beam is laterally supported at each end and at 20 ft. What is the maximum service load that can be supported?



$L_b = 20\,ft$

$\circlearrowleft + \sum M_B = 0 = P(10\,ft + 20\,ft + 30\,ft) - A_y(40\,ft)$

$A_y = 1.5P$

$M_A = 1.5P(5\,ft) = 7.5P$

$M_B = 1.5P(10\,ft) = 15P$

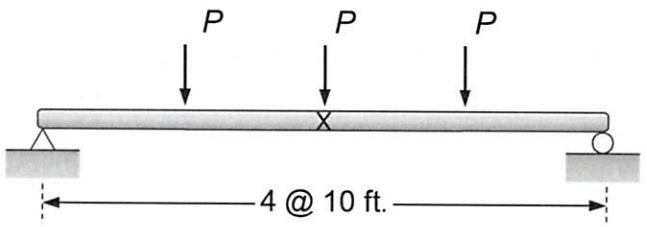
$M_C = 1.5P(10\,ft) + 0.5P(5\,ft) = 17.5P$

$M_{MAX} = M_C + 0.5P(5\,ft) = 20P$

$$C_b = \frac{12.5(20)}{2.5(20) + 3(7.5) + 4(15) + 3(17.5)} = 1.3514$$

$$M_U = M_{MAX} = 20P = 20(1.2(6k) + 1.6(15k)) = 624\,k\text{-}ft$$

Classroom Problem 5.5-6: A **W18 x 86** of **A992** steel with F_y = 50 *ksi*; F_u = 65 *ksi* is used as a simply supported beam. The point loads are P_D = 6 *k* and P_L = 15 *k*. Ignore the beam weight. Also, the beam is laterally supported at each end and at 20 ft. Does the beam have adequate moment strength?



$L_b = 20\,ft$ * FROM TABLE 3-2: $\phi_b M_p = 698\,k\,ft$, $L_p = 9.29\,ft$, $L_r = 28.6\,ft$

$\therefore L_p < L_b < L_r \Rightarrow$ F2-2

TABLE 1-1

$M_p = 775.56\,k\,ft$ $M_r = 0.7 F_y S_x = 0.7(50ksi)166\,in^3$

$= 5{,}810\,k\cdot in = 484.2\,k\,ft$

$$M_n = C_b\left[M_p - (M_p - M_r)\left[\frac{L_b - L_p}{L_r - L_p}\right]\right]$$

$$= 1.3514\left[775.56kft - (775.56kft - 484.2kft)\left[\frac{20 - 9.29}{28.6 - 9.29}\right]\right]$$

$= 829.71\,k\cdot ft > M_p \Rightarrow M_n = M_p = 775.56\,k\,ft$

$\phi M_n = 0.90(775.56kH) = 698.0\,k\,ft > M_u = 624\,k\,ft$ <u>O.K.</u>

5.5-6

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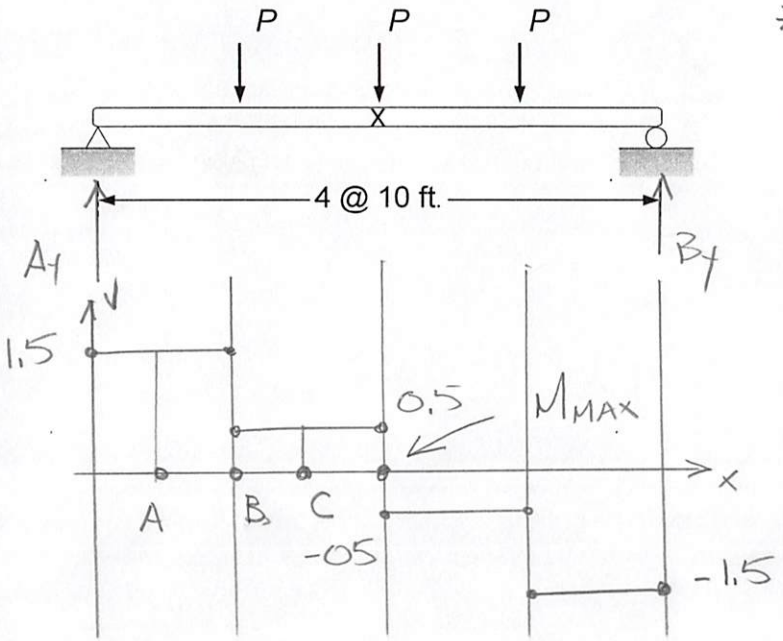

*COMPUTE C_b

$$+\circlearrowleft \sum M_B = 0 = P(10ft + 20ft + 30ft) - A_y(40ft)$$

$$A_y = 1.5P$$

$$M_A = 1.5P(5ft) = 7.5P$$

$$M_B = 1.5P(10ft) = 15P$$

$$M_C = 1.5P(10ft) + 0.5P(5ft) = 17.5P$$

$$M_{MAX} = 1.5P(10ft) + 0.5P(10ft) = 20P$$

$$C_b = \frac{12.5(20)}{2.5(20) + 3(7.5) + 4(15) + 3(17.5)} = 1.3514$$

$$M_u = 20P = 20(1.2(6k) + 1.6(15k)) = \underline{\underline{624k\,ft}}$$

CR PROBLEM 5.5-6

FROM TABLE 1-1 (1-22) $h/t = 33.4$ $b/2t = 7.2$ $Z_x = 186\ in^3$ 2/3

$S_x = 166\ in^3$ $r_y = 2.63\ in$ $r_{ts} = 3.05\ in$

$h_o = 17.6\ in$ $J = 4.1\ in^4$

* CHECK COMPACTNESS

$b/2t = 7.2 <$ LIMIT $0.38\sqrt{\frac{E}{F_y}} = 9.15$ COMPACT

$h/t = 33.4 <$ LIMIT $3.76\sqrt{\frac{E}{F_y}} = 90.55$ COMPACT

$L_b = 20\,ft\,(12\,in/ft) = 240\,in$

$L_p = 1.76\,r_y\sqrt{\frac{E}{F_y}} = 1.76(2.63\,in)\sqrt{\frac{29{,}000\,ksi}{50\,ksi}}$

$= 111.48\,in < L_b$

* COMPUTE L_r

$$\frac{J_c}{S_x h_o} = \frac{4.1\,in^4\,(1.0)}{166\,in^3\,(17.6\,in)} = 0.001403$$

$$L_r = 1.95(3.05\,in)\frac{29{,}000\,ksi}{0.7(50\,ksi)}\sqrt{\left(\frac{J_c}{S_x h_o}\right) + \sqrt{\left(\frac{J_c}{S_x h_o}\right)^2 + 6.76\left(\frac{0.7(50\,ksi)}{29{,}000\,ksi}\right)^2}} = 342.86\,in$$

$L_p < L_b < L_r$ $\therefore$ USE AISC EQ. F2-2

CR PROBLEM 5.5-6

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

$$M_p = F_y Z_x = 50\text{ksi}(186\text{in}^3) = 9{,}300\text{k·in}$$

$$= 1.3514\left[9{,}300\text{k·in} - (9{,}300\text{k·in} - 0.7(50\text{ksi})(186\text{in}^3))\left[\frac{240 - 111.48}{342.86 - 111.48}\right]\right] \leq M_p$$

$$= 9{,}938.01\text{k·in} \leq \underline{9{,}300\text{k·in}} = 775\text{k·ft}$$

$$\phi M_n = 0.90(775\text{kft}) = 697.5\text{kft} > M_u \qquad \underline{\text{O.K.}}$$