5.5-6 A W12 × 30(W310 × 44.5) of A992 steel ($F_y = 50$ ksi(345 MPa)) has an unbraced length of 10 feet (3,000 mm). Using $C_b = 1.0$,

**a.** Compute $L_p$ and $L_r$. Use the equations in Chapter F of the AISC Specification. Do not use any of the design aids in the *Manual*.

**b.** Compute the flexural design strength, $\phi_b M_n$.

**c.** Compute the allowable flexural strength $M_n/\Omega_b$.

FROM TABLE 1-1 (1-26) $A = 8.79\,\text{IN}^2$ $d = 12.3\,\text{IN}$

$t_f = 0.440\,\text{in}$ $S_x = 38.6\,\text{IN}^3$

$I_y = 20.3\,\text{IN}^4$ $J = 0.457\,\text{IN}^4$

$C_W = 720\,\text{IN}^6$ $r_y = 1.52\,\text{IN}$

$Z_x = 43.1\,\text{IN}^3$

$$L_p = 1.76\, r_y \sqrt{E/F_y} = 1.76(1.52\text{in})\sqrt{\frac{29{,}000\text{ ksi}}{50\text{ksi}}} = 64.43\text{in}$$

$$L_b = 10\text{ft}(12\text{in}/\text{ft}) = 120\,\text{IN} > L_p$$

COMPUTE $L_r$

$$r_{ts}^2 = \frac{\sqrt{I_y C_W}}{S_x} = \frac{\sqrt{20.3\text{IN}^4(720\text{IN}^6)}}{38.6\text{in}^3} = 3.132\,\text{IN}^2$$

$C = 1.0$ FOR DOUBLY SYMMETRIC I SHAPES

$$h_o = d - t_f = 12.3\text{in} - 0.44\text{in} = 11.86\text{in}$$

$$\frac{Jc}{S_x h_o} = \frac{0.457\text{IN}^4(1.0)}{38.6\text{IN}^3(11.86\text{in})} = 0.0010$$

$$L_r = 1.95 r_{ts} \frac{E}{0.7F_Y}\sqrt{\frac{Jc}{S_x h_o} + \sqrt{\left(\frac{Jc}{S_x h_o}\right)^2 + 6.76\left(\frac{0.7F_Y}{E}\right)^2}}$$

$$= 1.95(1.7697\text{ in})\frac{29{,}000}{0.7(50)}\sqrt{0.0010 + \sqrt{(0.0010)^2 + 6.76\left(\frac{0.7(50)}{29000}\right)^2}}$$

$$= 187.31 \text{ IN}$$

$L_b < L_r \Rightarrow$ USE AISC EQN. F2-2

$$M_n = C_b\left[M_p - (M_p - 0.75 F_y S_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \le M_p$$

CHECK FOR COMPACT

$\frac{b_f}{2t_f} = 7.41 \qquad 0.38\sqrt{E/F_y} = 9.15 \qquad \lambda < \lambda_p$ COMPACT

$\frac{h}{t_w} = 41.8 \qquad 3.76\sqrt{E/F_y} = 90.55 \qquad \lambda < \lambda_p$ COMPACT

$$M_p = F_y Z_x = 50\text{ksi}(43.1\text{IN}^3) = 2{,}155 \text{ k}\cdot\text{IN}$$

$$M_n = 1.0\left[2{,}155\text{k}\cdot\text{IN} - (2155\text{kin} - 0.7(50\text{ksi})(38.6\text{IN}^3))\left[\frac{120 - 64.43}{187.31 - 64.43}\right]\right]$$

$$= 1{,}791.12 \text{ K}\cdot\text{IN} \qquad \phi_b M_n = 1{,}612.0 \text{ k}\cdot\text{in} = \underline{\underline{134.33 \text{ kft}}}$$