Flexural Design Example

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Example Problem

Determine the LRFD flexural design strength for a W10x12 beam with an unbraced length of 2 ft.

1. Determine if Section is Compact

$\lambda_{flange} = 9.43 \;\; \text{(AISC Table 1-1)}$

$\lambda_{web} = 46.6 \;\; \text{(AISC Table 1-1)}$

2. Determine the limiting ratios (AISC Table B4.1b)

Check Flange

$E = 29000 \text{ ksi}$

$F_y = 50 \text{ ksi}$

$$\lambda_{pf} = 0.38 \cdot \sqrt{\frac{E}{F_y}} = 0.38 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 9.15 \;\; \text{(Case 10)}$$

$$\lambda_r = 1 \cdot \sqrt{\frac{E}{F_y}} = 1 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 24.08$$

$\left(\lambda_{pf} < \lambda_{flange} < \lambda_r\right) = (9.15 < 9.43 < 24.08) = 1 \quad \therefore$ Noncompact Flange

Check Web

$$\lambda_{pw} = 3.76 \cdot \sqrt{\frac{E}{F_y}} = 3.76 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 90.55 \;\; \text{(Case 10)}$$

$\left(\lambda_{web} < \lambda_{pw}\right) = (46.6 < 90.55) = 1 \quad \therefore$ Compact Web

3. Calculate the LB strength with AISC Spec F3

$S_x = 10.9\ \text{inch}^3$ (AISC Table 1-1)

$Z_x = 12.6\ \text{inch}^3$ (AISC Table 1-1)

$M_p = F_y \cdot Z_x = 50\ \text{ksi} \cdot 12.6\ \text{inch}^3 = 52.5\ \text{ft kip}$

$$M_{nLB} = M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \frac{\lambda_{flange} - \lambda_{pf}}{\lambda_r - \lambda_{pf}}$$

$$= 52.5\ \text{ft kip} - \left(52.5\ \text{ft kip} - 0.7 \cdot 50\ \text{ksi} \cdot 10.9\ \text{inch}^3\right) \cdot \frac{9.43 - 9.15}{24.08 - 9.15}$$

$$= 52.11\ \text{ft kip}$$

4. Calculate LTB strength with AISC spec F2.2

$L_b = 2\ \text{ft}$

$r_y = 0.78\ \text{inch}$

$$L_p = 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 1.76 \cdot 0.78\ \text{inch} \cdot \sqrt{\frac{29000\ \text{ksi}}{50\ \text{ksi}}} = 2.77\ \text{ft}$$

$\left(L_p > L_b\right) = (2.77\ \text{ft} > 2\ \text{ft}) = 1$ $\therefore$ Full Plastic Behavior

$M_{nLTB} = M_p = 52.5\ \text{ft kip}$

5. Design Strength

$M_n = \min\left(M_{nLTB}, M_{nLB}\right) = \min\left(52.5\ \text{ft kip}, 52.11\ \text{ft kip}\right) = 52.11\ \text{ft kip}$

$\phi_b = 0.9$

$\phi M_n = \phi_b \cdot M_n = 0.9 \cdot 52.11\ \text{ft kip} = 46.9\ \text{ft kip}$