W10x15 x 10ft Steel Beam Verification Calculations:

$Roof_{Dead} := 20\ psf$ $Roof_{Snow} := 50\ psf$ $Roof_{Wind} := -30\ psf$

Beam Dimensions: Span: $L := 10\ ft$ Unbraced Length: $L_b := \frac{L}{2} = 5\ ft$

Shape: Use W10x15 $F_y := 50\ ksi$ $E := 29000\ ksi$ $A := 4.41\ in^2$ $D := 9.99\ in$ $b_f := 4.00\ in$

$t_w := 0.230\ in$ $t_f := 0.270\ in$ $hTw := 38.5$ $I_x := 68.9\ in^4$ $S_x := 13.8\ in^3$ $Z_x := 16.0\ in^3$

$I_y := 2.89\ in^4$ $r_y := 0.810\ in$ $J := 0.104\ in^4$ $C_w := 68.3\ in^6$

Check for compact flange per AISC B4.1b:

$$\text{if}\left(\frac{b_f}{2 \cdot t_f} \le 0.38 \cdot \sqrt{\frac{E}{F_y}}, \text{“Compact”}, \text{if}\left(\frac{b_f}{2 \cdot t_f} \le 1.0 \cdot \sqrt{\frac{E}{F_y}}, \text{“NonCompact”}, \text{“Slender”}\right)\right) = \text{“Compact”}$$

Check for compact web: $$\text{if}\left(hTw \le 3.76 \cdot \sqrt{\frac{E}{F_y}}, \text{“Compact”}, \text{“Non Compact”}\right) = \text{“Compact”}$$

Roof Load Tributary Width: $T := 10\ ft$

$Dead := Roof_{Dead} \cdot T + A \cdot 490\ pcf = 215.006\ plf$ $Snow := Roof_{Snow} \cdot T = 500\ plf$

$Wind := Roof_{Wind} \cdot T = -300\ plf$

$$W_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} \qquad W_{LRFD} := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix}$$

Reactions:

$$R_a := (W_{asd}) \cdot \frac{L}{2} = \begin{bmatrix} 1.075 \\ 3.575 \\ 1.825 \\ -0.255 \end{bmatrix} kip \qquad R_b := (W_{asd}) \cdot \frac{L}{2} = \begin{bmatrix} 1.075 \\ 3.575 \\ 1.825 \\ -0.255 \end{bmatrix} kip$$

Shear at support:

$$V_{asd} := R_a = \begin{bmatrix} 1.075 \\ 3.575 \\ 1.825 \\ -0.255 \end{bmatrix} kip \qquad V_u := W_{LRFD} \cdot \frac{L}{2} = \begin{bmatrix} 1.505 \\ 5.29 \\ 1.04 \\ 4.54 \\ -0.532 \end{bmatrix} kip$$

Moment at Center of Beam:

$$M_{asd} := \frac{W_{asd} \cdot L^2}{8} = \begin{bmatrix} 2.688 \\ 8.938 \\ 4.563 \\ -0.637 \end{bmatrix} kip \cdot ft \qquad M_u := \frac{W_{LRFD} \cdot L^2}{8} = \begin{bmatrix} 3.763 \\ 13.225 \\ 2.6 \\ 11.35 \\ -1.331 \end{bmatrix} kip \cdot ft$$

Deflection:

$$\Delta_{asd} := \frac{5 \cdot W_{asd} \cdot L^4}{384 \cdot E \cdot I_x} = \begin{bmatrix} 0.024 \\ 0.081 \\ 0.041 \\ -0.006 \end{bmatrix} \text{ in} \qquad \Delta_{Limit} := \begin{bmatrix} 240 \\ 360 \\ 360 \\ 240 \end{bmatrix} \qquad \frac{L}{\Delta_{Limit}} = \begin{bmatrix} 0.5 \\ 0.333 \\ 0.333 \\ 0.5 \end{bmatrix} \text{ in} \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.048 \\ 0.242 \\ 0.123 \\ -0.011 \end{bmatrix}$$

Shear Capacity per AISC G2.1:

$$C_{v1} := \text{if}\left(hTw \le 2.24 \cdot \sqrt{\frac{E}{F_y}}, 1.0, 0\right) = 1 \qquad A_w := D \cdot t_w = 2.298 \text{ in}^2$$

$$V_n := 0.6 \cdot F_y \cdot A_w \cdot C_{v1} = 68.931 \text{ kip}$$

ASD Shear Capacity: $\Omega := 1.5$ $\quad \frac{V_n}{\Omega} = 45.954 \text{ kip}$

LRFD Shear Capacity: $\phi := 1.0$ $\quad \phi V_n := \phi \cdot V_n = 68.931 \text{ kip}$

Moment Capacity per AISC F2: $C_b := 1.30$ Per AISC Table 3-1 $c := 1$ AISC F2.8a

AISC F2-5 AISC F2-7

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 2.861 \text{ ft} \qquad r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.009 \text{ in} \qquad h_o := D - t_f = 9.72 \text{ in}$$

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7\ F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o} + \sqrt{\left(\frac{J \cdot c}{S_x \cdot h_o}\right)^2 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E}\right)^2}} = 8.6 \text{ ft} \qquad \text{AISC F2-6}$$

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = 115.931 \text{ ksi} \qquad \text{AISC F2-4}$$

$$M_p := F_y \cdot Z_x = 66.667 \text{ kip} \cdot \text{ft} \qquad \text{AISC F2-1}$$

$$M_n := \left\| \begin{array}{l} \text{if } L_b \le L_p \\ \quad \| \ M_p \\ \text{else if } L_p < L_b \le L_r \\ \quad \| \ min\left(C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right), M_p\right) \\ \text{else} \\ \quad \| \ min\left(F_{cr} \cdot S_x, M_p\right) \end{array} \right\| = 66.667 \text{ kip} \cdot \text{ft}$$

ASD Moment Capacity: $\Omega := 1.67$ $\quad \frac{M_n}{\Omega} = 39.92 \text{ ft} \cdot \text{kip}$

LRFD Moment Capacity: $\phi := 0.9$ $\quad \phi M_n := \phi \cdot M_n = 60 \text{ ft} \cdot \text{kip}$

ASD Shear Capacity: $\Omega := 1.5$ $\frac{V_n}{\Omega} = 45.954\ kip$ $V_{asd} = \begin{bmatrix} 1.075 \\ 3.575 \\ 1.825 \\ -0.255 \end{bmatrix} kip$

ASD Moment Capacity: $\Omega := 1.67$ $\frac{M_n}{\Omega} = 39.92\ ft \cdot kip$ $M_{asd} = \begin{bmatrix} 2.688 \\ 8.938 \\ 4.563 \\ -0.637 \end{bmatrix} kip \cdot ft$

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Steel Member Size: W10X15
Steel Member Grade: A992 Grade 50ksi

Moment Code Check = 0.22 at 5.00 ft
    M = 8.94 K*ft vs 39.92 K*ft (Cb = 1.30)
for Dead + Snow
Shear Code Check = 0.08 at 0.00 ft
    V = 3.57 K vs 45.95 K
    for Dead + Snow
Deflection Code Check = 0.24 at 5.00 ft
    D = -0.081 in vs 0.333 in = L/360
    for Dead + Snow
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$\frac{V_{asd}}{\frac{V_n}{\Omega}} = \begin{bmatrix} 0.026 \\ 0.087 \\ 0.044 \\ -0.006 \end{bmatrix}$

$\frac{M_{asd}}{\frac{M_n}{\Omega}} = \begin{bmatrix} 0.067 \\ 0.224 \\ 0.114 \\ -0.016 \end{bmatrix}$

$\Delta_{asd} = \begin{bmatrix} 0.024 \\ 0.081 \\ 0.041 \\ -0.006 \end{bmatrix} in$ $\frac{\frac{\Delta_{asd}}{L}}{\Delta_{Limit}} = \begin{bmatrix} 0.048 \\ 0.242 \\ 0.123 \\ -0.011 \end{bmatrix}$

LRFD Shear Capacity: $\phi := 1.0$ $\phi V_n := \phi \cdot V_n = 68.931$ ***kip***

$$V_u = \begin{bmatrix} 1.505 \\ 5.29 \\ 1.04 \\ 4.54 \\ -0.532 \end{bmatrix} \textit{kip}$$

LRFD Moment Capacity: $\phi := 0.9$ $\phi M_n := \phi \cdot M_n = 60$ ***ft*** $\cdot$ ***kip***

$$M_u = \begin{bmatrix} 3.763 \\ 13.225 \\ 2.6 \\ 11.35 \\ -1.331 \end{bmatrix} \textit{kip} \cdot \textit{ft}$$

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Steel Member Size: W10X15
Steel Member Grade: A992 Grade 50ksi

Moment Code Check = 0.22 at 5.00 ft
    M = 13.22 K*ft vs 60.00 K*ft (Cb = 1.30)
for 1.2 Dead + 1.6 Snow
Shear Code Check = 0.08 at 0.00 ft
    V = 5.29 K vs 68.93 K
    for 1.2 Dead + 1.6 Snow
Deflection Code Check = 0.24 at 5.00 ft
    D = -0.081 in vs 0.333 in = L/360
    for Dead + Snow
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$$\frac{V_u}{\phi V_n} = \begin{bmatrix} 0.022 \\ 0.077 \\ 0.015 \\ 0.066 \\ -0.008 \end{bmatrix}$$

$$\frac{M_u}{\phi M_n} = \begin{bmatrix} 0.063 \\ 0.22 \\ 0.043 \\ 0.189 \\ -0.022 \end{bmatrix}$$