C6x13 x 10ft Steel Beam Verification Calculations:

Surface Area Loads:

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

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

Shape: Use C6x13 $\quad F_y := 36\ ksi$ $\quad E := 29000\ ksi$ $\quad A := 3.82\ in^2$ $\quad D := 6\ in$ $\quad b_f := 2.16\ in$

$t_w := 0.437\ in$ $\quad t_f := 0.343\ in$ $\quad hTw := 11.000$ $\quad I_x := 17.3\ in^4$ $\quad S_x := 5.78\ in^3$ $\quad Z_x := 7.29\ in^3$

$I_y := 1.05\ in^4$ $\quad r_y := 0.524\ in$ $\quad J := 0.237\ in^4$ $\quad C_w := 7.19\ in^6$

Check for compact flange Per AISC Table 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: $T := 10\ ft$

$Dead := Roof_{Dead} \cdot T + A \cdot 490\ pcf = 212.999\ plf$ $\quad Snow := Roof_{Snow} \cdot T = 500\ plf$

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

$$W_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 0.213 \\ 0.713 \\ 0.363 \\ -0.052 \end{bmatrix} klf \qquad W_{LRFD} := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 0.298 \\ 1.056 \\ 0.206 \\ 0.906 \\ -0.108 \end{bmatrix} klf$$

Reactions:

$$R_a := \left(W_{asd}\right) \cdot \frac{L}{2} = \begin{bmatrix} 1.065 \\ 3.565 \\ 1.815 \\ -0.261 \end{bmatrix} kip \qquad R_b := \left(W_{asd}\right) \cdot \frac{L}{2} = \begin{bmatrix} 1.065 \\ 3.565 \\ 1.815 \\ -0.261 \end{bmatrix} kip$$

Shear at support:

$$V_{asd} := R_a = \begin{bmatrix} 1.065 \\ 3.565 \\ 1.815 \\ -0.261 \end{bmatrix} kip \qquad V_u := W_{LRFD} \cdot \frac{L}{2} = \begin{bmatrix} 1.491 \\ 5.278 \\ 1.028 \\ 4.528 \\ -0.542 \end{bmatrix} kip$$

Moment at Center of Beam:

$$M_{asd} := \frac{W_{asd} \cdot L^2}{8} = \begin{bmatrix} 2.662 \\ 8.912 \\ 4.537 \\ -0.653 \end{bmatrix} kip \cdot ft \qquad M_u := \frac{W_{LRFD} \cdot L^2}{8} = \begin{bmatrix} 3.727 \\ 13.195 \\ 2.57 \\ 11.32 \\ -1.354 \end{bmatrix} kip \cdot ft$$

Deflection:

$$\Delta_{asd} := \frac{5 \cdot W_{asd} \cdot L^4}{384 \cdot E \cdot I_x} = \begin{bmatrix} 0.096 \\ 0.32 \\ 0.163 \\ -0.023 \end{bmatrix} \text{ in} \qquad \Delta_{Limit} := \begin{bmatrix} 240 \\ 360 \\ 360 \\ 240 \end{bmatrix} \qquad \frac{L}{\Delta_{Limit}} = \begin{bmatrix} 0.5 \\ 0.333 \\ 0.333 \\ 0.5 \end{bmatrix} \text{ in} \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.191 \\ 0.959 \\ 0.488 \\ -0.047 \end{bmatrix}$$

Shear Capacity: $k_v := 5.34$ No Web Stiffeners per AISC G2-3

$$C_{v1} := \text{if}\left(hTw \le 1.10 \cdot \sqrt{k_v \cdot \frac{E}{F_y}}, 1.0, 0\right) = 1 \qquad A_w := D \cdot t_w = 2.622 \text{ in}^2$$

$$V_n := 0.6 \cdot F_y \cdot A_w \cdot C_{v1} = 56.635 \text{ kip}$$ AISC G2-1

ASD Shear Capacity: $\Omega := 1.67$ $\frac{V_n}{\Omega} = 33.913 \text{ kip}$

LRFD Shear Capacity: $\phi := 0.9$ $\phi V_n := \phi \cdot V_n = 50.972 \text{ kip}$

Moment Capacity: $C_b := 1.30$ Per AISC Table 3-1

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 2.181 \text{ ft}$$ AISC F2-6 $$r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 0.689 \text{ in}$$ AISC F2-7

$$h_o := D - t_f = 5.657 \text{ in} \qquad c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.081$$ AISC F2-8b

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7\ F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o} + \sqrt{\left(\frac{J \cdot c}{S_x \cdot h_o}\right)^2 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E}\right)^2}} = 16.303 \text{ ft}$$ AISC F2-6

$$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2} = 116.559 \text{ ksi}$$ AISC F2-4

$$M_p := F_y \cdot Z_x = 21.87 \text{ kip} \cdot \text{ft}$$ AISC F2-1

$$M_n := \begin{Vmatrix} \text{if } L_b \le L_p \\ \quad \| M_p \\ \text{else if } L_p < L_b \le L_r \\ \quad \left\| min\left(C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right), M_p\right) \right. \\ \text{else} \\ \quad \| min\left(F_{cr} \cdot S_x, M_p\right) \end{Vmatrix} = 21.87 \text{ kip} \cdot \text{ft}$$ AISC F2-2

ASD Moment Capacity: $\Omega := 1.67$ $\frac{M_n}{\Omega} = 13.096 \text{ ft} \cdot \text{kip}$

LRFD Moment Capacity: $\phi := 0.9$ $\phi M_n := \phi \cdot M_n = 19.683 \text{ ft} \cdot \text{kip}$

ASD Shear Capacity: $\Omega := 1.67$ $\dfrac{V_n}{\Omega} = 33.913\ kip$ $V_{asd} = \begin{bmatrix} 1.065 \\ 3.565 \\ 1.815 \\ -0.261 \end{bmatrix} kip$

ASD Moment Capacity: $\Omega := 1.67$ $\dfrac{M_n}{\Omega} = 13.096\ ft \cdot kip$ $M_{asd} = \begin{bmatrix} 2.662 \\ 8.912 \\ 4.537 \\ -0.653 \end{bmatrix} kip \cdot ft$

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Steel Member Size: C6X13
Steel Member Grade: A36 36ksi

Moment Code Check = 0.68 at 5.00 ft
    M = 8.90 K*ft vs 13.10 K*ft (Cb = 1.30)
for Dead + Snow
Shear Code Check = 0.10 at 0.00 ft
    V = 3.56 K vs 33.91 K
    for Dead + Snow
Deflection Code Check = 0.96 at 5.00 ft
    D = -0.319 in vs 0.333 in = L/360
    for Dead + Snow
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$$\frac{V_{asd}}{\frac{V_n}{\Omega}} = \begin{bmatrix} 0.031 \\ 0.105 \\ 0.054 \\ -0.008 \end{bmatrix}$$

$$\frac{M_{asd}}{\frac{M_n}{\Omega}} = \begin{bmatrix} 0.203 \\ 0.681 \\ 0.346 \\ -0.05 \end{bmatrix}$$

$$\Delta_{asd} = \begin{bmatrix} 0.096 \\ 0.32 \\ 0.163 \\ -0.023 \end{bmatrix} in \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.191 \\ 0.959 \\ 0.488 \\ -0.047 \end{bmatrix}$$

LRFD Shear Capacity: $\phi := 0.9$ $\phi V_n := \phi \cdot V_n = 50.972\ kip$ $V_u = \begin{bmatrix} 1.491 \\ 5.278 \\ 1.028 \\ 4.528 \\ -0.542 \end{bmatrix} kip$

LRFD Moment Capacity: $\phi := 0.9$ $\phi M_n := \phi \cdot M_n = 19.683\ ft \cdot kip$ $M_u = \begin{bmatrix} 3.727 \\ 13.195 \\ 2.57 \\ 11.32 \\ -1.354 \end{bmatrix} kip \cdot ft$

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Steel Member Size: C6X13
Steel Member Grade: A36 36ksi

Moment Code Check = 0.67 at 5.00 ft
    M = 13.18 K*ft vs 19.68 K*ft (Cb = 1.30)
for 1.2 Dead + 1.6 Snow
Shear Code Check = 0.10 at 0.00 ft
    V = 5.27 K vs 50.97 K
    for 1.2 Dead + 1.6 Snow
Deflection Code Check = 0.96 at 5.00 ft
    D = -0.319 in vs 0.333 in = L/360
    for Dead + Snow
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$$\frac{V_u}{\phi V_n} = \begin{bmatrix} 0.029 \\ 0.104 \\ 0.02 \\ 0.089 \\ -0.011 \end{bmatrix}$$

$$\frac{M_u}{\phi M_n} = \begin{bmatrix} 0.189 \\ 0.67 \\ 0.131 \\ 0.575 \\ -0.069 \end{bmatrix}$$

$$\Delta_{asd} = \begin{bmatrix} 0.096 \\ 0.32 \\ 0.163 \\ -0.023 \end{bmatrix} in \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.191 \\ 0.959 \\ 0.488 \\ -0.047 \end{bmatrix}$$