W8x10 x 10ft Steel Column With Slender Web Verification Calculations:

$R_{Dead} := 1.075\ kip + 30\ kip$ $\quad R_{Snow} := 2.50\ kip + 50\ kip$ $\quad R_{Wind} := -1.5\ kip$

Column Dimensions: Length: $L := 10\ ft$ Unbraced Length: $L_x := L = 10\ ft$ $\quad L_y := L = 10\ ft$

Shape: Use W8x10 $\quad F_y := 50\ ksi$ $\quad E := 29000\ ksi$ $\quad A := 2.96\ in^2$ $\quad t_w := 0.170\ in$ $\quad t_f := 0.205\ in$

$r_x := 3.22\ in$ $\quad r_y := 0.841\ in$ $\quad hTw := 40.5$ $\quad bTf := 9.61$ $\quad I_x := 30.8\ in^4$ $\quad I_y := 2.09\ in^4$

$G := 11200\ ksi$ $\quad J := 0.0426\ in^4$ $\quad C_w := 30.9\ in^6$ $\quad W := 10\ plf$

Check for compact flange and web: $\text{if}\left(bTf \le 0.56 \cdot \sqrt{\frac{E}{F_y}}, \text{“Compact”}, \text{“Slender”}\right) = \text{“Compact”}$

$\text{if}\left(hTw \le 1.49 \cdot \sqrt{\frac{E}{F_y}}, \text{“Compact”}, \text{“Slender”}\right) = \text{“Slender”}$

Total column loads including self weight:

$Dead := R_{Dead} + W \cdot L = 31.175\ kip$ $\quad Snow := R_{Snow} = 52.5\ kip$ $\quad Wind := R_{Wind} = -1.5\ kip$

$$P_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 31.175 \\ 83.675 \\ 69.425 \\ 17.805 \end{bmatrix} kip$$

$$P_u := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 43.645 \\ 121.41 \\ 62.16 \\ 120.66 \\ 26.558 \end{bmatrix} kip$$

Axial Capacity - Section E7: $\quad K := 1.0$

$$F_{e\_x} := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_x}{r_x}\right)^2} = 206.085\ ksi \qquad F_{e\_y} := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_y}{r_y}\right)^2} = 14.058\ ksi$$

$F_{e\_E3} := min\left(F_{e\_x}, F_{e\_y}\right) = 14.058\ ksi$

Torsional Buckling Length: $L_z := L = 10\ ft$

Use minimum Fe from E3, E4

$$F_{e\_E4} := \left(\frac{\pi^2 \cdot E \cdot C_w}{\left(L_z\right)^2} + G \cdot J\right) \cdot \frac{1}{I_x + I_y} = 33.18\ ksi$$

$F_e := min\left(F_{e\_E3}, F_{e\_E4}\right) = 14.058\ ksi$

$$F_{cr} := \begin{array}{|l} \text{if } \frac{F_y}{F_e} < 2.25 \\ \quad F_{cr\_1} \leftarrow 0.658^{\frac{F_y}{F_e}} \cdot F_y \\ \text{else} \\ \quad F_{cr\_1} \leftarrow 0.877 \cdot F_e \end{array} = 12.329\ ksi$$

AISC E3-2
and E3-3

$b := bTf \cdot t_f = 1.97\ in$ $\quad$ $b_e := b = 1.97\ in$

$h := hTw \cdot t_w = 6.885\ in$ $\quad$ $h_e := h = 6.885\ in$

From table E7.1 assign the Effective Width Imperfection Adjustment Factors:

$$c_1 := 0.22 \qquad c_2 := \frac{1-\sqrt{1-4 \cdot c_1}}{2 \cdot c_1} = 1.485$$

$$\lambda := bTf = 9.61 \qquad \lambda_r := 0.56 \cdot \sqrt{\frac{E}{F_y}} = 13.487$$

$$b_e := \begin{array}{l} \text{if } \lambda \le \lambda_r \cdot \sqrt{\frac{F_y}{F_{cr}}} \\ \quad \| \; b \\ \text{else} \\ \quad \| \; F_{el} \leftarrow \left(c_2 \cdot \frac{\lambda_r}{\lambda}\right)^2 \cdot F_y \\ \quad \| \; min\left(b \cdot \left(1 - c_1 \cdot \sqrt{\frac{F_{el}}{F_{cr}}}\right) \cdot \sqrt{\frac{F_{el}}{F_{cr}}}, b\right) \end{array} = 1.97\ in$$

AISC E7-2 and E7-3

From table E7.1 assign the Effective Width Imperfection Adjustment Factors:

$$c_1 := 0.18 \qquad c_2 := \frac{1-\sqrt{1-4 \cdot c_1}}{2 \cdot c_1} = 1.308$$

$$\lambda := hTw = 40.5 \qquad \lambda_r := 1.49 \cdot \sqrt{\frac{E}{F_y}} = 35.884$$

$$h_e := \begin{array}{l} \text{if } \lambda \le \lambda_r \cdot \sqrt{\frac{F_y}{F_{cr}}} \\ \quad \| \; h \\ \text{else} \\ \quad \| \; F_{el} \leftarrow \left(c_2 \cdot \frac{\lambda_r}{\lambda}\right)^2 \cdot F_y \\ \quad \| \; h_e \leftarrow min\left(h \cdot \left(1 - c_1 \cdot \sqrt{\frac{F_{el}}{F_{cr}}}\right) \cdot \sqrt{\frac{F_{el}}{F_{cr}}}, h\right) \end{array} = 6.885\ in$$

AISC E7-2 and E7-3

$A_e := A - 4 \cdot (b - b_e) \cdot t_f - (h - h_e) \cdot t_w = 2.96\ in^2$ $\quad$ $A = 2.96\ in^2$

Note there was not an adjustment here. Fcr would need to be higher for this to happen. Shortening the column would increase Fcr and at some point will trigger the reduction of A.

$F_{cr} = 12.329\ ksi$

$P_n := F_{cr} \cdot A_e = 36.494\ kip$

ASD Axial Capacity: $\Omega := 1.67$ $\frac{P_n}{\Omega} = 21.853\ kip$ $P_{asd} = \begin{bmatrix} 31.175 \\ 83.675 \\ 69.425 \\ 17.805 \end{bmatrix} kip$

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Steel Member Size: W8X10
Steel Member Grade: A992 Grade 50ksi
Axial Code Check = 3.83 at 10.00 ft
    A = -83.68 K vs 21.85 K
    for Dead + Snow
    Horizontal Axis OK, KL/r = 142.69
No Moment Forces
No Shear Forces
No Deflection
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$$\frac{P_{asd}}{\frac{P_n}{\Omega}} = \begin{bmatrix} 1.427 \\ 3.829 \\ 3.177 \\ 0.815 \end{bmatrix}$$

LRFD Axial Capacity: $\phi := 0.9$ $\phi P_n := \phi \cdot P_n = 32.844\ kip$ $P_u = \begin{bmatrix} 43.645 \\ 121.41 \\ 62.16 \\ 120.66 \\ 26.558 \end{bmatrix} kip$

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Steel Member Size: W8X10
Steel Member Grade: A992 Grade 50ksi
Axial Code Check = 3.70 at 10.00 ft
    A = -121.41 K vs 32.84 K
    for 1.2 Dead + 1.6 Snow
    Horizontal Axis OK, KL/r = 142.69
No Moment Forces
No Shear Forces
No Deflection
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$$\frac{P_u}{\phi P_n} = \begin{bmatrix} 1.329 \\ 3.697 \\ 1.893 \\ 3.674 \\ 0.809 \end{bmatrix}$$