W21x44 x 10ft Steel Column With Slender Web Verification Calculations:

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

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

Shape: Use W21x44 $F_y := 50\ ksi$ $E := 29000\ ksi$ $A := 13.0\ in^2$ $t_w := 0.350\ in$ $t_f := 0.450\ in$

$r_x := 8.06\ in$ $r_y := 1.26\ in$ $hTw := 53.6$ $bTf := 7.22$ $I_x := 843\ in^4$ $I_y := 20.7\ in^4$

$G := 11200\ ksi$ $J := 0.770\ in^4$ $C_w := 2110\ in^6$ $W := 44\ plf$

Check for compact flange and web per AISC B4.1a:

$$\text{if}\left(bTf \le 0.56 \cdot \sqrt{\frac{E}{F_y}}, \text{“Compact”}, \text{“Slender”}\right) = \text{“Compact”}$$

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

Total column loads including self weight:

$Dead := R_{Dead} + W \cdot L = 31.515\ kip$ $Snow := R_{Snow} = 52.5\ kip$ $Wind := R_{Wind} = -1.5\ kip$

$$P_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 31.515 \\ 84.015 \\ 69.765 \\ 18.009 \end{bmatrix} kip$$

$$P_u := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 44.121 \\ 121.818 \\ 62.568 \\ 121.068 \\ 26.864 \end{bmatrix} kip$$

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

$$F_{e\_x} := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_x}{r_x}\right)^2} = 1291.235\ ksi \qquad F_{e\_y} := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_y}{r_y}\right)^2} = 31.556\ ksi$$

$$F_{e\_E3} := min\left(F_{e\_x}, F_{e\_y}\right) = 31.556\ ksi$$

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

Use minimum Fe from E3, E4

$$F_{e\_E4} := \left(\frac{\pi^2 \cdot E \cdot C_w}{\left(L_z\right)^2} + G \cdot J\right) \cdot \frac{1}{I_x + I_y} = 58.542\ ksi$$

$$F_e := min\left(F_{e\_E3}, F_{e\_E4}\right) = 31.556\ ksi$$

$$F_{cr} := \left\| \begin{array}{l} \text{if } \dfrac{F_y}{F_e} < 2.25 \\ \quad \left\| F_{cr\_1} \leftarrow 0.658^{\frac{F_y}{F_e}} \cdot F_y \right. \\ \text{else} \\ \quad \left\| F_{cr\_1} \leftarrow 0.877 \cdot F_e \right. \end{array} \right\| = 25.76\ ksi$$

AISC E3-2 and E3-3

$b := bTf \cdot t_f = 3.249\ in$ Get the official "b" since it's not in the AISC Manual

$h := hTw \cdot t_w = 18.76\ in$ Get the official "h" since it's not in the AISC Manual

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

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

$$\lambda := bTf = 7.22 \qquad \lambda_r := 0.56 \cdot \sqrt{\frac{E}{F_y}} = 13.487$$

$$b_e := \begin{array}{l} \text{if } \lambda \le \lambda_r \cdot \sqrt{\dfrac{F_y}{F_{cr}}} \\ \quad \| \; b \\ \text{else} \\ \quad \left\| \begin{array}{l} F_{el} \leftarrow \left(c_2 \cdot \dfrac{\lambda_r}{\lambda}\right)^2 \cdot F_y \\ min\left(b \cdot \left(1 - c_1 \cdot \sqrt{\dfrac{F_{el}}{F_{cr}}}\right) \cdot \sqrt{\dfrac{F_{el}}{F_{cr}}}, b\right) \end{array} \right. \end{array} = 3.249\ in$$

AISC E7-2 and E7-3

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

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

$$\lambda := hTw = 53.6 \qquad \lambda_r := 1.49 \cdot \sqrt{\frac{E}{F_y}} = 35.884$$

$$h_e := \begin{array}{l} \text{if } \lambda \le \lambda_r \cdot \sqrt{\dfrac{F_y}{F_{cr}}} \\ \quad \| \; h \\ \text{else} \\ \quad \left\| \begin{array}{l} F_{el} \leftarrow \left(c_2 \cdot \dfrac{\lambda_r}{\lambda}\right)^2 \cdot F_y \\ h_e \leftarrow min\left(h \cdot \left(1 - c_1 \cdot \sqrt{\dfrac{F_{el}}{F_{cr}}}\right) \cdot \sqrt{\dfrac{F_{el}}{F_{cr}}}, h\right) \end{array} \right. \end{array} = 17.86\ in$$

AISC E7-2 and E7-3

$A_e := A - 4 \cdot (b - b_e) \cdot t_f - (h - h_e) \cdot t_w = 12.685\ in^2$ $A = 13\ in^2$ Note there was an adjustment in the effective area

$F_{cr} = 25.76\ ksi$

$P_n := F_{cr} \cdot A_e = 326.769\ kip$ AISC E7-1

ASD Axial Capacity: $\Omega := 1.67$ $\frac{P_n}{\Omega} = 195.67\ kip$ $P_{asd} = \begin{bmatrix} 31.515 \\ 84.015 \\ 69.765 \\ 18.009 \end{bmatrix} kip$

```
Steel Member Size: W21X44
Steel Member Grade: A992 Grade 50ksi
Axial Code Check = 0.43 at 10.00 ft
    A = -84.02 K vs 195.67 K
    for Dead + Snow
    Horizontal Axis OK, KL/r = 95.24
No Moment Forces
No Shear Forces
No Deflection
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$$\frac{P_{asd}}{\frac{P_n}{\Omega}} = \begin{bmatrix} 0.161 \\ 0.429 \\ 0.357 \\ 0.092 \end{bmatrix}$$

LRFD Axial Capacity: $\phi := 0.9$ $\phi P_n := \phi \cdot P_n = 294.092\ kip$ $P_u = \begin{bmatrix} 44.121 \\ 121.818 \\ 62.568 \\ 121.068 \\ 26.864 \end{bmatrix} kip$

```
Steel Member Size: W21X44
Steel Member Grade: A992 Grade 50ksi
Axial Code Check = 0.41 at 10.00 ft
    A = -121.82 K vs 294.09 K
    for 1.2 Dead + 1.6 Snow
    Horizontal Axis OK, KL/r = 95.24
No Moment Forces
No Shear Forces
No Deflection
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$$\frac{P_u}{\phi P_n} = \begin{bmatrix} 0.15 \\ 0.414 \\ 0.213 \\ 0.412 \\ 0.091 \end{bmatrix}$$