4X6 DF#2 x 10ft Column with Biaxial Wind Load Verification Calculations:

Surface Area Loading for beam transferring load to column:

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

Beam Transferring Load To This Column: Span: $L_{beam} := 10\ ft$

Shape: 4x10 Width: $b := 3.5\ in$ Depth: $d := 9.25\ in$ $Density := 35\ pcf$

$A := b \cdot d = 32.375\ in^2$ $S_{xx} := \frac{1}{6} \cdot b \cdot d^2 = 49.911\ in^3$ $I_{xx} := \frac{1}{12} \cdot b \cdot d^3 = 230.84\ in^4$

Roof Load Tributary Width: $T := 4\ ft$

$Dead := Roof_{Dead} \cdot T + A \cdot Density = 87.869\ plf$ $Snow := Roof_{Snow} \cdot T = 200\ plf$

$Wind := Roof_{Wind} \cdot T = -120\ plf$

$$W_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 87.869 \\ 287.869 \\ 147.869 \\ -19.279 \end{bmatrix} plf$$

$$W_{LRFD} := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 123.016 \\ 425.443 \\ 85.443 \\ 365.443 \\ -40.918 \end{bmatrix} plf$$

Reactions: $R_a := \left(W_{asd}\right) \cdot \frac{L_{beam}}{2} = \begin{bmatrix} 0.439 \\ 1.439 \\ 0.739 \\ -0.096 \end{bmatrix} kip$ $R_b := \left(W_{asd}\right) \cdot \frac{L_{beam}}{2} = \begin{bmatrix} 0.439 \\ 1.439 \\ 0.739 \\ -0.096 \end{bmatrix} kip$

Column Dimensions: Length: $L := 10\ ft$

Unbraced Length Horizontal: $L_{u\_x} := 10\ ft$ Unbraced Length Vertical: $L_{u\_y} := 10\ ft$

Shape: Use 4x6 Width: $b := 3.5\ in$ Depth: $d := 5.5\ in$

$A := b \cdot d = 19.25\ in^2$ $S_{xx} := \frac{1}{6} \cdot b \cdot d^2 = 17.646\ in^3$ $I_{xx} := \frac{1}{12} \cdot b \cdot d^3 = 48.526\ in^4$

Material: DF #2 Dimensional Lumber $F_b := 900\ psi$ $F_c := 1350\ psi$ $F_v := 180\ psi$

$E := 1600\ ksi$ $E_{min} := 580\ ksi$ $Density := 35\ pcf$

Loading (ASD):

Load factors for each load case:

Add self weight of column to loads:

$$R_{asd} := (W_{asd}) \cdot \frac{L_{beam}}{2} = \begin{bmatrix} 0.439 \\ 1.439 \\ 0.739 \\ -0.096 \end{bmatrix} kip \qquad f := \begin{bmatrix} 1.0 \\ 1.0 \\ 1.0 \\ 0.6 \end{bmatrix} \qquad P_{asd} := R_{asd} + f \cdot A \cdot Density \cdot \frac{L}{2} = \begin{bmatrix} 0.463 \\ 1.463 \\ 0.763 \\ -0.082 \end{bmatrix} kip$$

Loading (LRFD):

$$R_{LRFD} := (W_{LRFD}) \cdot \frac{L_{beam}}{2} = \begin{bmatrix} 0.615 \\ 2.127 \\ 0.427 \\ 1.827 \\ -0.205 \end{bmatrix} kip \qquad f := \begin{bmatrix} 1.6 \\ 1.2 \\ 1.2 \\ 1.2 \\ 0.9 \end{bmatrix} \qquad P_u := R_{LRFD} + f \cdot A \cdot Density \cdot \frac{L}{2} = \begin{bmatrix} 0.653 \\ 2.155 \\ 0.455 \\ 1.855 \\ -0.184 \end{bmatrix} kip$$

Check Slenderness: $K := 1.0$ NDS 3.7.1.4

$$\text{if}\left(\frac{L_{u\_x}}{d} > 50, \text{“Slender”}, \text{“OK”}\right) = \text{“OK”} \qquad \text{if}\left(\frac{L_{u\_y}}{d} > 50, \text{“Slender”}, \text{“OK”}\right) = \text{“OK”}$$

Calculation of the Column Stability Factor (Cp) and Compression Capacity per NDS 3.7.1:

$c := 0.8$ For Sawn Lumber $l_{e\_x} := K \cdot L_{u\_x} = 10\ ft$ $l_{e\_y} := K \cdot L_{u\_y} = 10\ ft$

$$l_e := \text{if}\left(\frac{l_{e\_x}}{b} < \frac{l_{e\_y}}{d}, l_{e\_y}, l_{e\_x}\right) = 10\ ft \qquad d_e := \text{if}\left(\frac{l_{e\_x}}{b} < \frac{l_{e\_y}}{d}, d, b\right) = 3.5\ in$$

Check ASD Axial Capacity:

NDS 4.3.3 NDS 4.3.4 NDS 4.3.8 NDS Table 4A

$C_m := 1.0$ $C_t := 1.0$ $C_i := 1.0$ $C_F := 1.1$

$$C_d := \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$$

NDS Table 4.3.1 ASD Only

$$F_{cE} := \frac{0.822 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i}{\left(\frac{l_e}{d_e}\right)^2} = 405.577\ psi$$

Column Stability factor per NDS 3.7-1

$$F_{c`} := C_d \cdot F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_i = \begin{bmatrix} 1336.5 \\ 1707.75 \\ 1707.75 \\ 2376 \end{bmatrix} psi \qquad C_P := \frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c} - \sqrt{\left(\frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c}\right)^2 - \frac{\frac{F_{cE}}{F_{c`}}}{c}} = \begin{bmatrix} 0.281 \\ 0.224 \\ 0.224 \\ 0.164 \end{bmatrix}$$

$$P_{allowable} := \overrightarrow{A \cdot C_d \cdot F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_P \cdot C_i} = \begin{bmatrix} 7.24 \\ 7.38 \\ 7.38 \\ 7.512 \end{bmatrix} kip \qquad P_{asd} = \begin{bmatrix} 0.463 \\ 1.463 \\ 0.763 \\ -0.082 \end{bmatrix} kip \qquad \frac{P_{asd}}{P_{allowable}} = \begin{bmatrix} 0.064 \\ 0.198 \\ 0.103 \\ -0.011 \end{bmatrix}$$

Check LRFD Axial Capacity:

NDS 4.3.3 — $C_m = 1$

NDS 4.3.4 — $C_t = 1$

NDS Table 4A — $C_F = 1.1$

NDS Table 4.3.1 ASD Only — $K_f := 2.40$

$\phi := 0.9$

$$\lambda := \begin{bmatrix} 0.6 \\ 0.8 \\ 1.0 \\ 0.8 \\ 1.0 \end{bmatrix}$$

$$F_{cE} := \frac{0.822 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i \cdot 1.76 \cdot 0.85}{\left(\frac{l_e}{d_e}\right)^2} = 606.743 \ psi$$

$$F_{c`} := F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 1924.56 \\ 2566.08 \\ 3207.6 \\ 2566.08 \\ 3207.6 \end{bmatrix} psi$$

Column Stability factor per NDS 3.7-1

$$C_P := \frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c} - \sqrt{\left(\frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c}\right)^2 - \frac{\frac{F_{cE}}{F_{c`}}}{c}} = \begin{bmatrix} 0.291 \\ 0.224 \\ 0.181 \\ 0.224 \\ 0.181 \end{bmatrix}$$

$$\phi P_n := \overrightarrow{A \cdot F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_P \cdot C_i \cdot K_f \cdot \phi \cdot \lambda} = \begin{bmatrix} 10.793 \\ 11.044 \\ 11.185 \\ 11.044 \\ 11.185 \end{bmatrix} kip \qquad P_u = \begin{bmatrix} 0.653 \\ 2.155 \\ 0.455 \\ 1.855 \\ -0.184 \end{bmatrix} kip \qquad \frac{P_u}{\phi P_n} = \begin{bmatrix} 0.06 \\ 0.195 \\ 0.041 \\ 0.168 \\ -0.016 \end{bmatrix}$$

Out of plane lateral loads: $Wall_{Dead} := 0 \ psf$ $\quad Wall_{Snow} := 0 \ psf$ $\quad Wall_{Wind} := 25 \ psf$

Column Wind Tributary Width: $T := 4 \ ft$

$Dead := Wall_{Dead} \cdot T = 0 \ plf$ $\quad Snow := Wall_{Snow} \cdot T = 0 \ plf$ $\quad Wind := Wall_{Wind} \cdot T = 100 \ plf$

$$W_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 75 \\ 60 \end{bmatrix} plf$$

$$W_{LRFD} := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 100 \\ 50 \\ 100 \end{bmatrix} plf$$

Horizontal Reactions: $R_a := \left(W_{asd}\right) \cdot \frac{L}{2} = \begin{bmatrix} 0.000 \\ 0.000 \\ 0.375 \\ 0.300 \end{bmatrix} kip$ $\qquad R_b := \left(W_{asd}\right) \cdot \frac{L}{2} = \begin{bmatrix} 0 \\ 0 \\ 0.375 \\ 0.3 \end{bmatrix} kip$

Shear at supports: $V_{asd} := R_a = \begin{bmatrix} 0 \\ 0 \\ 0.375 \\ 0.3 \end{bmatrix} kip$ $\qquad V_u := W_{LRFD} \cdot \frac{L}{2} = \begin{bmatrix} 0 \\ 0 \\ 0.5 \\ 0.25 \\ 0.5 \end{bmatrix} kip$

Moment at Center of Column:

$$M_{asd} := \frac{W_{asd} \cdot L^2}{8} = \begin{bmatrix} 0 \\ 0 \\ 0.9375 \\ 0.75 \end{bmatrix} \mathit{kip} \cdot \mathit{ft} \qquad M_u := \frac{W_{LRFD} \cdot L^2}{8} = \begin{bmatrix} 0 \\ 0 \\ 1.25 \\ 0.625 \\ 1.25 \end{bmatrix} \mathit{kip} \cdot \mathit{ft}$$

Deflection:

$$\Delta_{asd} := \frac{5 \cdot W_{asd} \cdot L^4}{384 \cdot E \cdot I_{xx}} = \begin{bmatrix} 0 \\ 0 \\ 0.217 \\ 0.174 \end{bmatrix} \mathit{in} \qquad \Delta_{Limit} := \begin{bmatrix} 240 \\ 360 \\ 360 \\ 240 \end{bmatrix} \qquad \frac{L}{\Delta_{Limit}} = \begin{bmatrix} 0.5 \\ 0.333 \\ 0.333 \\ 0.5 \end{bmatrix} \mathit{in} \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0 \\ 0 \\ 0.652 \\ 0.348 \end{bmatrix}$$

Check ASD Shear Capacity:

$$C_m = 1 \qquad C_t = 1 \qquad C_i = 1 \qquad C_d = \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$$

Factors from NDS table 4.3.1

Calculate factored allowable shear capacity:

$$V_{allowable} := \frac{2}{3} \cdot F_v \cdot b \cdot d \cdot C_d \cdot C_m \cdot C_t \cdot C_i = \begin{bmatrix} 2.079 \\ 2.657 \\ 2.657 \\ 3.696 \end{bmatrix} \mathit{kip} \qquad V_{asd} = \begin{bmatrix} 0 \\ 0 \\ 0.375 \\ 0.3 \end{bmatrix} \mathit{kip} \qquad \frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0 \\ 0 \\ 0.141 \\ 0.081 \end{bmatrix}$$

Check LRFD Shear Capacity:

$$C_m = 1 \qquad C_t = 1$$

NDS Table 4.3.1 LRFD only factors: $K_f := 2.88$ $\quad \phi := 0.75$ $\quad \lambda = \begin{bmatrix} 0.6 \\ 0.8 \\ 1 \\ 0.8 \\ 1 \end{bmatrix}$

Calculate factored allowable shear capacity:

$$\phi V_n := \frac{2}{3} \cdot F_v \cdot b \cdot d \cdot C_m \cdot C_t \cdot C_i \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 2.994 \\ 3.992 \\ 4.99 \\ 3.992 \\ 4.99 \end{bmatrix} \mathit{kip} \qquad V_u = \begin{bmatrix} 0 \\ 0 \\ 0.5 \\ 0.25 \\ 0.5 \end{bmatrix} \mathit{kip} \qquad \frac{V_u}{\phi V_n} = \begin{bmatrix} 0 \\ 0 \\ 0.1 \\ 0.063 \\ 0.1 \end{bmatrix}$$

Check ASD Moment Capacity: $l_u := L_{u\_x} = 10\ ft$

$C_m = 1$ $C_t = 1$ $C_i = 1$ $C_r := 1.0$

$C_F := 1.3$ NDS Table 4a

Calculate the effective length:

$$l_e := \begin{array}{l} \text{if } \dfrac{l_u}{d} < 7 \\ \quad \text{return } 2.06 \cdot l_u \\ \text{else if } 7 \le \dfrac{l_u}{d} \le 14.3 \\ \quad \text{return } 1.63 \cdot l_u + 3 \cdot d \\ \text{else if } \dfrac{l_u}{d} > 14.3 \\ \quad \text{return } 1.84 \cdot l_u \end{array} = 18.4\ ft$$ NDS Table 3.3.3

Calculate factored allowable bending stress without Beam Stability Factor:

$$F_{b`} := C_d \cdot F_b \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot C_r = \begin{bmatrix} 1053 \\ 1345.5 \\ 1345.5 \\ 1872 \end{bmatrix} psi$$

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 9.957$$ NDS 3.3-5

$$F_{be} := \frac{1.2 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i}{{R_b}^2} = 7020.751\ psi$$ NDS 3.3.3.7

$$C_L := \frac{1 + \dfrac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \dfrac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\dfrac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.991 \\ 0.988 \\ 0.988 \\ 0.983 \end{bmatrix}$$ NDS 3.3-6

Calculate factored allowable moment capacity with factors from NDS table 4.3.1

$$M_{allowable} := \overrightarrow{\left(C_d \cdot F_b \cdot C_m \cdot C_t \cdot C_L \cdot C_F \cdot C_i \cdot C_r\right) \cdot S_{xx}} = \begin{bmatrix} 1.535 \\ 1.956 \\ 1.956 \\ 2.705 \end{bmatrix} kip \cdot ft$$

Moment Demand: $M_{asd} = \begin{bmatrix} 0 \\ 0 \\ 0.938 \\ 0.75 \end{bmatrix} kip \cdot ft$

Check Demand vs Capacity: $\dfrac{M_{asd}}{M_{allowable}} = \begin{bmatrix} 0 \\ 0 \\ 0.479 \\ 0.277 \end{bmatrix}$

LRFD Moment Capacity:

NDS table 4.3.1 LRFD Only

$C_m = 1 \quad C_t = 1 \quad C_i = 1 \quad C_r = 1 \quad C_F = 1.3 \quad K_f := 2.54 \quad \phi := 0.85 \quad \lambda = \begin{bmatrix} 0.6 \\ 0.8 \\ 1 \\ 0.8 \\ 1 \end{bmatrix}$

Calculate factored allowable bending stress without Beam Stability Factor:

$$F_{b`} := F_b \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot C_r \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 1515.618 \\ 2020.824 \\ 2526.03 \\ 2020.824 \\ 2526.03 \end{bmatrix} psi$$

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 9.957$$ NDS 3.3-5

$$F_{be} := \frac{1.2 \cdot E_{min} \cdot 1.76 \cdot \phi \cdot C_m \cdot C_t \cdot C_i}{{R_b}^2} = 10503.043\ psi$$ NDS 3.3.3.7

$$C_L := \frac{1 + \frac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.992 \\ 0.988 \\ 0.985 \\ 0.988 \\ 0.985 \end{bmatrix}$$ NDS 3.3-6

Calculate factored allowable moment capacity with factors from NDS table 4.3.1

$$\phi M_n := \overrightarrow{\left(F_b \cdot C_m \cdot C_t \cdot C_L \cdot C_F \cdot C_i \cdot C_r \cdot K_f \cdot \phi \cdot \lambda\right) \cdot S_{xx}} = \begin{bmatrix} 2.21 \\ 2.937 \\ 3.658 \\ 2.937 \\ 3.658 \end{bmatrix} kip \cdot ft$$

Moment Demand: $M_u = \begin{bmatrix} 0 \\ 0 \\ 1.25 \\ 0.625 \\ 1.25 \end{bmatrix} kip \cdot ft$

Check Demand vs Capacity: $\frac{M_u}{\phi M_n} = \begin{bmatrix} 0 \\ 0 \\ 0.342 \\ 0.213 \\ 0.342 \end{bmatrix}$

ASD Combined Axial + Bending per NDS 3.9.2:

ASD Axial Portion: $C_m = 1$ $C_t = 1$ $C_F := 1.1$ NDS Table 4A $C_i = 1$ $C_d = \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$

$$F_{c`} := C_d \cdot F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_i = \begin{bmatrix} 1336.5 \\ 1707.75 \\ 1707.75 \\ 2376 \end{bmatrix} \; psi$$

NDS table 4.3.1 Calculate without Cp

Calculate for each buckling direction per NDS 3.9.2:

$$F_{cE1} := \frac{0.822 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i}{\left(\frac{l_{e\_y}}{d}\right)^2} = 1001.527 \; psi \qquad F_{cE2} := \frac{0.822 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i}{\left(\frac{l_{e\_x}}{b}\right)^2} = 405.577 \; psi$$

$$F_{cE} := min\left(F_{cE1}, F_{cE2}\right) = 405.577 \; psi$$

Use minimum value

Calculate axial stress: $f_c := \frac{P_{asd}}{A} = \begin{bmatrix} 24.038 \\ 75.986 \\ 39.623 \\ -4.278 \end{bmatrix} \; psi$

Calculate Cp per NDS 3.7.1

$$C_P := \frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c} - \sqrt{\left(\frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c}\right)^2 - \frac{\frac{F_{cE}}{F_{c`}}}{c}} = \begin{bmatrix} 0.281 \\ 0.224 \\ 0.224 \\ 0.164 \end{bmatrix}$$

Calculate factored allowable compressive stress per NDS Table 4.3.1

$$F_{c`} := \overrightarrow{C_d \cdot F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_P \cdot C_i} = \begin{bmatrix} 376.117 \\ 383.381 \\ 383.381 \\ 390.239 \end{bmatrix} \; psi$$

ASD Bending Portion:

$C_m = 1$ $C_t = 1$ $C_F := 1.3$ NDS Table 4A $C_i = 1$ $C_r = 1$ $C_d = \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$

$$F_{b`} := C_d \cdot F_b \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot C_r = \begin{bmatrix} 1053 \\ 1345.5 \\ 1345.5 \\ 1872 \end{bmatrix} \; psi$$

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 9.957$$

NDS 3.3-5

$$F_{bE} := \frac{1.2 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i}{{R_b}^2} = 7020.751 \; psi$$

$$C_L := \frac{1 + \frac{F_{bE}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{bE}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{bE}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.9913 \\ 0.9884 \\ 0.9884 \\ 0.9826 \end{bmatrix}$$

NDS 3.3-6

Calculate Bending Stress:

$$f_b := \frac{M_{asd}}{S_{xx}} = \begin{bmatrix} 0 \\ 0 \\ 637.544 \\ 510.035 \end{bmatrix} \; psi$$

Calculate factored allowable bending stress per Table 4.3.1

$$F_{b`} := \overrightarrow{C_d \cdot F_b \cdot C_m \cdot C_t \cdot C_L \cdot C_F \cdot C_i \cdot C_r} = \begin{bmatrix} 1043.884 \\ 1329.959 \\ 1329.959 \\ 1839.352 \end{bmatrix} \; psi$$

Calculate limits per NDS 3.9.2 equation 3.9-3

$$Combined\_1 := \overrightarrow{\left(\frac{f_c}{F_c`}\right)^2 + \frac{f_b}{F_b` \cdot \left(1 - \frac{f_c}{F_{cE1}}\right)}} = \begin{bmatrix} 0.004085 \\ 0.039284 \\ 0.509799 \\ 0.276231 \end{bmatrix} \qquad Combined\_2 := \overrightarrow{\frac{f_c}{F_{cE2}} + \left(\frac{f_b}{F_{bE}}\right)^2} = \begin{bmatrix} 0.059 \\ 0.187 \\ 0.106 \\ -0.005 \end{bmatrix}$$

$$P_{asd} = \begin{bmatrix} 0.463 \\ 1.463 \\ 0.763 \\ -0.082 \end{bmatrix} \mathbf{kip} \qquad P_{allowable} = \begin{bmatrix} 7.24 \\ 7.38 \\ 7.38 \\ 7.512 \end{bmatrix} \mathbf{kip} \qquad \frac{P_{asd}}{P_{allowable}} = \begin{bmatrix} 0.064 \\ 0.198 \\ 0.103 \\ -0.011 \end{bmatrix}$$

$$V_{asd} = \begin{bmatrix} 0 \\ 0 \\ 375 \\ 300 \end{bmatrix} \mathbf{lbf} \qquad V_{allowable} = \begin{bmatrix} 2079 \\ 2656.5 \\ 2656.5 \\ 3696 \end{bmatrix} \mathbf{lbf} \qquad \frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0 \\ 0 \\ 0.141 \\ 0.081 \end{bmatrix}$$

$$M_{asd} = \begin{bmatrix} 0 \\ 0 \\ 0.938 \\ 0.75 \end{bmatrix} \mathbf{kip \cdot ft} \qquad M_{allowable} = \begin{bmatrix} 1.535 \\ 1.956 \\ 1.956 \\ 2.705 \end{bmatrix} \mathbf{kip \cdot ft} \qquad \frac{M_{asd}}{M_{allowable}} = \begin{bmatrix} 0 \\ 0 \\ 0.479 \\ 0.277 \end{bmatrix}$$

Combine worst case unity equation into one set of results:

$$maxResults\left(Combined\_1, Combined\_2, \frac{P_{asd}}{P_{allowable}}, \frac{M_{asd}}{M_{allowable}}\right) = \begin{bmatrix} 0.0639 \\ 0.1982 \\ 0.5098 \\ 0.2773 \end{bmatrix}$$

```
Wood Member Size: 4x6
Wood Member Grade: Dim Lumber - DF No. 2
Axial Code Check = 0.20 at 10.00 ft
    A = -1.49 K vs 7.38 K
    for Dead + Snow
    Horizontal Axis OK, Rc = 34.29
Moment Code Check = 0.51 at 5.00 ft
    M = 0.94 K*ft vs 1.96 K*ft
    for Dead + 0.75 Snow + 0.75 Wind
Shear Code Check = 0.14 at 0.00 ft
    V = 0.38 K vs 2.66 K
    for Dead + 0.75 Snow + 0.75 Wind
Deflection Code Check = 0.65 at 5.00 ft
    D = -0.217 in vs 0.333 in = L/360
    for Dead + 0.75 Snow + 0.75 Wind
```

LRFD Combined Axial + Bending:

LRFD Axial Portion: $C_m = 1 \quad C_t = 1 \quad C_F := 1.1$ NDS Table 4A $K_f := 2.4 \quad \phi := 0.9 \quad \lambda = \begin{bmatrix} 0.6 \\ 0.8 \\ 1 \\ 0.8 \\ 1 \end{bmatrix}$

$$F_{cE1} := \frac{0.822 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i \cdot 1.76 \cdot 0.85}{\left(\frac{l_{e\_y}}{d}\right)^2} = 1498.285 \; psi$$ NDS 3.9.2

Use minimum value

$$F_{cE2} := \frac{0.822 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i \cdot 1.76 \cdot 0.85}{\left(\frac{l_{e\_x}}{b}\right)^2} = 606.743 \; psi$$

$$F_{cE} := min\left(F_{cE1}, F_{cE2}\right) = 606.743 \; psi$$

Calculate factored allowable compressive stress without Cp:

$$F_{c`} := F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 1924.56 \\ 2566.08 \\ 3207.6 \\ 2566.08 \\ 3207.6 \end{bmatrix} psi$$ NDS 3.7-1 use all factors except Cp

$$C_P := \frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c} - \sqrt{\left(\frac{1 + \frac{F_{cE}}{F_{c`}}}{2 \cdot c}\right)^2 - \frac{\frac{F_{cE}}{F_{c`}}}{c}} = \begin{bmatrix} 0.291 \\ 0.224 \\ 0.181 \\ 0.224 \\ 0.181 \end{bmatrix}$$ NDS 3.7-1

Calculate compressive stress:

$$f_c := \frac{P_u}{A} = \begin{bmatrix} 33.897 \\ 111.963 \\ 23.651 \\ 96.379 \\ -9.534 \end{bmatrix} psi$$

Calculate factored allowable bending stress per Table 4.3.1

$$F_{c`} := \overrightarrow{F_c \cdot C_m \cdot C_t \cdot C_F \cdot C_P \cdot C_i \cdot K_f \cdot \phi \cdot \lambda} = \begin{bmatrix} 560.651 \\ 573.704 \\ 581.036 \\ 573.704 \\ 581.036 \end{bmatrix} psi$$

Bending Portion: $C_m = 1 \quad C_t = 1 \quad C_F := 1.3$ NDS Table 4A $K_f := 2.54 \quad \phi := 0.85 \quad \lambda = \begin{bmatrix} 0.6 \\ 0.8 \\ 1 \\ 0.8 \\ 1 \end{bmatrix}$

$$F_{b`} := F_b \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot C_r \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 1515.618 \\ 2020.824 \\ 2526.03 \\ 2020.824 \\ 2526.03 \end{bmatrix} psi$$

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 9.957$$ NDS 3.3-5

$$F_{bE} := \frac{1.2 \cdot E_{min} \cdot 1.76 \cdot \phi \cdot C_m \cdot C_t \cdot C_i}{{R_b}^2} = 10503.043 \; psi$$

$$C_L := \frac{1 + \frac{F_{bE}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{bE}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{bE}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.992 \\ 0.988 \\ 0.985 \\ 0.988 \\ 0.985 \end{bmatrix}$$

Calculate compressive stress:

$$f_b := \frac{M_u}{S_{xx}} = \begin{bmatrix} 0 \\ 0 \\ 850.059 \\ 425.03 \\ 850.059 \end{bmatrix} psi$$

Calculate factored allowable bending stress per Table 4.3.1

$$F_{b`} := \overrightarrow{F_b \cdot C_m \cdot C_t \cdot C_L \cdot C_F \cdot C_i \cdot C_r \cdot K_f \cdot \phi \cdot \lambda} = \begin{bmatrix} 1503.067 \\ 1997.372 \\ 2487.434 \\ 1997.372 \\ 2487.434 \end{bmatrix} psi$$

$$Combined\_1 := \overrightarrow{\left(\frac{f_c}{F_c`}\right)^2 + \frac{f_b}{F_b` \cdot \left(1 - \frac{f_c}{F_{cE1}}\right)}} = \begin{bmatrix} 0.0037 \\ 0.0381 \\ 0.3489 \\ 0.2556 \\ 0.3398 \end{bmatrix}$$

$$Combined\_2 := \overrightarrow{\frac{f_c}{F_{cE2}} + \left(\frac{f_b}{F_{bE}}\right)^2} = \begin{bmatrix} 0.0559 \\ 0.1845 \\ 0.0455 \\ 0.1605 \\ -0.0092 \end{bmatrix}$$

$$P_u = \begin{bmatrix} 0.653 \\ 2.155 \\ 0.455 \\ 1.855 \\ -0.184 \end{bmatrix} \mathbf{kip} \qquad \phi P_n = \begin{bmatrix} 10.793 \\ 11.044 \\ 11.185 \\ 11.044 \\ 11.185 \end{bmatrix} \mathbf{kip} \qquad \frac{P_u}{\phi P_n} = \begin{bmatrix} 0.0605 \\ 0.1952 \\ 0.0407 \\ 0.168 \\ -0.0164 \end{bmatrix}$$

$$V_u = \begin{bmatrix} 0 \\ 0 \\ 500 \\ 250 \\ 500 \end{bmatrix} \mathbf{lbf} \qquad \phi V_n = \begin{bmatrix} 2993.76 \\ 3991.68 \\ 4989.6 \\ 3991.68 \\ 4989.6 \end{bmatrix} \mathbf{lbf} \qquad \frac{V_u}{\phi V_n} = \begin{bmatrix} 0 \\ 0 \\ 0.1 \\ 0.063 \\ 0.1 \end{bmatrix}$$

$$M_u = \begin{bmatrix} 0 \\ 0 \\ 1.25 \\ 0.625 \\ 1.25 \end{bmatrix} \mathbf{kip \cdot ft} \qquad \phi M_n = \begin{bmatrix} 2.21 \\ 2.937 \\ 3.658 \\ 2.937 \\ 3.658 \end{bmatrix} \mathbf{kip \cdot ft} \qquad \frac{M_u}{\phi M_n} = \begin{bmatrix} 0 \\ 0 \\ 0.3417 \\ 0.2128 \\ 0.3417 \end{bmatrix}$$

$$maxResults\left(Combined\_1, Combined\_2, \frac{P_u}{\phi P_n}, \frac{M_u}{\phi M_n}\right) = \begin{bmatrix} 0.0605 \\ 0.1952 \\ 0.3489 \\ 0.2556 \\ 0.3417 \end{bmatrix}$$

```
Wood Member Size: 4x6
Wood Member Grade: Dim Lumber - DF No. 2
Axial Code Check = 0.20 at 10.00 ft
    A = -2.18 K vs 11.04 K
    for 1.2 Dead + 1.6 Snow
    Horizontal Axis OK, Rc = 34.29
Moment Code Check = 0.35 at 5.00 ft
    M = 1.25 K*ft vs 3.66 K*ft
    for 1.2 Dead + 1.0 Wind + 0.5 Snow
Shear Code Check = 0.10 at 0.00 ft
    V = 0.50 K vs 4.99 K
    for 0.9 Dead + 1.0 Wind
Deflection Code Check = 0.65 at 5.00 ft
    D = -0.217 in vs 0.333 in = L/360
    for Dead + 0.75 Snow + 0.75 Wind
```