4x10 DF#2 x 10ft Wood Beam Verification Calculations:

Surface Loading:

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

Beam Dimensions:

Span: $L := 10\ ft$ Unbraced Length: $l_u := L = 10\ ft$

Shape: Use 4x10 Width: $b := 3.5\ in$ Depth: $d := 9.25\ in$

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

Material: Use DF #2 Dimensional Lumber

$f_b := 900\ psi$ $f_v := 180\ psi$ $E := 1600\ ksi$ $E_{min} := 580\ ksi$ $Density := 35\ pcf$

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:

$$R_a := (W_{asd}) \cdot \frac{L}{2} = \begin{bmatrix} 0.439 \\ 1.439 \\ 0.739 \\ -0.096 \end{bmatrix} kip \qquad R_b := (W_{asd}) \cdot \frac{L}{2} = \begin{bmatrix} 0.439 \\ 1.439 \\ 0.739 \\ -0.096 \end{bmatrix} kip$$

Shear at distance "D" from supports:

$$V_{asd} := R_a - (W_{asd}) \cdot d = \begin{bmatrix} 0.372 \\ 1.217 \\ 0.625 \\ -0.082 \end{bmatrix} kip \qquad V_u := W_{LRFD} \cdot \frac{L}{2} - W_{LRFD} \cdot d = \begin{bmatrix} 0.52 \\ 1.799 \\ 0.361 \\ 1.546 \\ -0.173 \end{bmatrix} kip$$

Moment at Center of Beam:

$$M_{asd} := \frac{W_{asd} \cdot L^2}{8} = \begin{bmatrix} 1.098 \\ 3.598 \\ 1.848 \\ -0.241 \end{bmatrix} kip \cdot ft \qquad M_u := \frac{W_{LRFD} \cdot L^2}{8} = \begin{bmatrix} 1.538 \\ 5.318 \\ 1.068 \\ 4.568 \\ -0.511 \end{bmatrix} kip \cdot ft$$

Deflection:

$$\Delta_{asd} := \frac{5 \cdot W_{asd} \cdot L^4}{384 \cdot E \cdot I_{xx}} = \begin{bmatrix} 0.054 \\ 0.175 \\ 0.09 \\ -0.012 \end{bmatrix} \textit{in} \qquad \Delta_{Limit} := \begin{bmatrix} 240 \\ 360 \\ 360 \\ 240 \end{bmatrix} \qquad \frac{L}{\Delta_{Limit}} = \begin{bmatrix} 0.5 \\ 0.333 \\ 0.333 \\ 0.5 \end{bmatrix} \textit{in} \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.107 \\ 0.526 \\ 0.27 \\ -0.023 \end{bmatrix}$$

Check ASD Shear Capacity:

$C_m := 1.0$ $C_t := 1.0$ $C_i := 1.0$ $C_d := \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$ NDS table 4.3.1

Calculate factored allowable shear capacity per NDS Table 4.3.1

$$V_{allowable} := \frac{2}{3} \cdot f_v \cdot b \cdot d \cdot C_d \cdot C_m \cdot C_t \cdot C_i = \begin{bmatrix} 3.497 \\ 4.468 \\ 4.468 \\ 6.216 \end{bmatrix} \textit{kip} \qquad V_{asd} = \begin{bmatrix} 0.372 \\ 1.217 \\ 0.625 \\ -0.082 \end{bmatrix} \textit{kip} \qquad \frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0.106 \\ 0.272 \\ 0.14 \\ -0.013 \end{bmatrix}$$

Check LRFD Shear Capacity:

$C_m = 1$ $C_t = 1$ $K_f := 2.88$ $\phi := 0.75$ $\lambda := \begin{bmatrix} 0.6 \\ 0.8 \\ 0.8 \\ 0.8 \\ 1.0 \end{bmatrix}$ NDS table 4.3.1

Calculate factored allowable shear capacity per NDS Table 4.3.1

$$\phi V_n := \frac{2}{3} \cdot f_v \cdot b \cdot d \cdot C_m \cdot C_t \cdot C_i \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 5.035 \\ 6.713 \\ 6.713 \\ 6.713 \\ 8.392 \end{bmatrix} \textit{kip} \qquad V_u = \begin{bmatrix} 0.52 \\ 1.799 \\ 0.361 \\ 1.546 \\ -0.173 \end{bmatrix} \textit{kip} \qquad \frac{V_u}{\phi V_n} = \begin{bmatrix} 0.103 \\ 0.268 \\ 0.054 \\ 0.23 \\ -0.021 \end{bmatrix}$$

Check ASD Moment Capacity:

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

$C_F := 1.2$ NDS Table 4a

$F_{b`} := C_d \cdot f_b \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot C_r = \begin{bmatrix} 972 \\ 1242 \\ 1242 \\ 1728 \end{bmatrix}$ *psi*

NDS table 3.3.3

$$l_e := \left\| \begin{array}{l} \text{if } \frac{l_u}{d} < 7 \\ \quad \text{return } 2.06 \cdot l_u \\ \text{else if } 7 \le \frac{l_u}{d} \le 14.3 \\ \quad \text{return } 1.63 \cdot l_u + 3 \cdot d \\ \text{else if } \frac{l_u}{d} > 14.3 \\ \quad \text{return } 1.84 \cdot l_u \end{array} \right\| = 18.613 \ ft$$

$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 12.987 \qquad F_{be} := \frac{1.2 \cdot E_{min} \cdot C_m \cdot C_t \cdot C_i}{{R_b}^2} = 4126.84 \ psi$ NDS 3.3-5

$$C_L := \frac{1 + \frac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.985 \\ 0.98 \\ 0.98 \\ 0.967 \end{bmatrix}$$ NDS 3.3-6

Calculate allowable moment capacity per NDS table 4.3.1

$M_{allowable} := \overrightarrow{\left(C_d \cdot f_b \cdot C_m \cdot C_t \cdot C_L \cdot C_F \cdot C_i \cdot C_r\right) \cdot S_{xx}} = \begin{bmatrix} 3.983 \\ 5.06 \\ 5.06 \\ 6.951 \end{bmatrix}$ *kip · ft* NDS Table 4.3.1

ASD Member Option Results:

```
Wood Member Size: 4x10
Wood Member Grade: Dim Lumber - DF No. 2

Moment Code Check = 0.71 at 5.00 ft
    M = 3.60 K*ft vs 5.06 K*ft
    for Dead + Snow
Shear Code Check = 0.27 at 9.23 ft
    V = -1.22 K vs 4.47 K
    for Dead + Snow
Deflection Code Check = 0.53 at 5.00 ft
    D = -0.175 in vs 0.333 in = L/360
    for Dead + Snow
```

$V_{asd} = \begin{bmatrix} 0.372 \\ 1.217 \\ 0.625 \\ -0.082 \end{bmatrix}$ *kip*

$\frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0.106 \\ 0.272 \\ 0.14 \\ -0.013 \end{bmatrix}$

$M_{asd} = \begin{bmatrix} 1.098 \\ 3.598 \\ 1.848 \\ -0.241 \end{bmatrix}$ *kip · ft*

$\frac{M_{asd}}{M_{allowable}} = \begin{bmatrix} 0.276 \\ 0.711 \\ 0.365 \\ -0.035 \end{bmatrix}$

LRFD Moment Capacity: $K_f := 2.54$ $\phi := 0.85$ Table 4.3.1 LRFD Factors Only

$$F_{b`} := f_b \cdot C_m \cdot C_t \cdot C_F \cdot C_i \cdot C_r \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 1399.032 \\ 1865.376 \\ 1865.376 \\ 1865.376 \\ 2331.72 \end{bmatrix} \ psi$$

Use factors from NDS table 4.3.1 except CL

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 12.987 \qquad F_{be} := \frac{1.2 \cdot E_{min} \cdot 1.76 \cdot \phi \cdot C_m \cdot C_t \cdot C_i}{{R_b}^2} = 6173.753 \ psi$$ NDS 3.3-5

$$C_L := \frac{1 + \frac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.986 \\ 0.979 \\ 0.979 \\ 0.979 \\ 0.972 \end{bmatrix}$$ NDS 3.3-6

Calculate allowable moment capacity per NDS table 4.3.1

$$\phi M_n := \overrightarrow{\left(f_b \cdot C_m \cdot C_t \cdot C_L \cdot C_F \cdot C_i \cdot C_r \cdot K_f \cdot \phi \cdot \lambda\right) \cdot S_{xx}} = \begin{bmatrix} 5.736 \\ 7.599 \\ 7.599 \\ 7.599 \\ 9.425 \end{bmatrix} \ kip \cdot ft$$

LRFD Member Option Results:

```
Wood Member Size: 4x10
Wood Member Grade: Dim Lumber - DF No. 2

Moment Code Check = 0.70 at 5.00 ft
    M = 5.32 K*ft vs 7.60 K*ft
    for 1.2 Dead + 1.6 Snow
Shear Code Check = 0.27 at 9.23 ft
    V = -1.80 K vs 6.71 K
    for 1.2 Dead + 1.6 Snow
Deflection Code Check = 0.53 at 5.00 ft
    D = -0.175 in vs 0.333 in = L/360
    for Dead + Snow
```

$$V_u = \begin{bmatrix} 0.52 \\ 1.799 \\ 0.361 \\ 1.546 \\ -0.173 \end{bmatrix} \ kip$$

$$\frac{V_u}{\phi V_n} = \begin{bmatrix} 0.103 \\ 0.268 \\ 0.054 \\ 0.23 \\ -0.021 \end{bmatrix}$$

$$M_u = \begin{bmatrix} 1.538 \\ 5.318 \\ 1.068 \\ 4.568 \\ -0.511 \end{bmatrix} \ kip \cdot ft$$

$$\frac{M_u}{\phi M_n} = \begin{bmatrix} 0.268 \\ 0.7 \\ 0.141 \\ 0.601 \\ -0.054 \end{bmatrix}$$