5 1/8 x 9 GLB 24F-V4 x 15 ft Wood Beam Verification Calculations:

Surface Area Loads:

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

Beam Dimensions:

Span: $L := 15\ ft$ Unbraced Length: $l_u := L = 15\ ft$

Shape: Use 5 1/8 x 9 Width: $b := 5.125\ in$ Depth: $d := 9\ in$

$A := b \cdot d = 46.125\ in^2$ $S_{xx} := \frac{1}{6} \cdot b \cdot d^2 = 69.188\ in^3$ $I_{xx} := \frac{1}{12} \cdot b \cdot d^3 = 311.344\ in^4$

Material: Use 24F-V4 $Density := 35\ pcf$

$f_{b\_bottom} := 2400\ psi$ $f_{b\_top} := 1850\ psi$ $f_v := 265\ psi$ $E := 1800\ ksi$ $E_{min} := 950\ ksi$

Roof Load Tributary Width: $T := 3\ ft$

$Dead := Roof_{Dead} \cdot T + A \cdot Density = 71.211\ plf$ $Snow := Roof_{Snow} \cdot T = 150\ plf$

$Wind := Roof_{Wind} \cdot T = -90\ plf$

$$W_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 71.211 \\ 221.211 \\ 116.211 \\ -11.273 \end{bmatrix} plf$$

$$W_{LRFD} := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 99.695 \\ 325.453 \\ 70.453 \\ 280.453 \\ -25.91 \end{bmatrix} plf$$

Reactions:

$$R_a := (W_{asd}) \cdot \frac{L}{2} = \begin{bmatrix} 0.534 \\ 1.659 \\ 0.872 \\ -0.085 \end{bmatrix} kip \qquad R_b := (W_{asd}) \cdot \frac{L}{2} = \begin{bmatrix} 0.534 \\ 1.659 \\ 0.872 \\ -0.085 \end{bmatrix} kip$$

Shear at distance "D" from supports:

$$V_{asd} := R_a - (W_{asd}) \cdot d = \begin{bmatrix} 0.481 \\ 1.493 \\ 0.784 \\ -0.076 \end{bmatrix} kip \qquad V_u := W_{LRFD} \cdot \frac{L}{2} - W_{LRFD} \cdot d = \begin{bmatrix} 0.673 \\ 2.197 \\ 0.476 \\ 1.893 \\ -0.175 \end{bmatrix} kip$$

Moment at Center of Beam:

$$M_{asd} := \frac{W_{asd} \cdot L^2}{8} = \begin{bmatrix} 2.003 \\ 6.222 \\ 3.268 \\ -0.317 \end{bmatrix} kip \cdot ft \qquad M_u := \frac{W_{LRFD} \cdot L^2}{8} = \begin{bmatrix} 2.804 \\ 9.153 \\ 1.981 \\ 7.888 \\ -0.729 \end{bmatrix} kip \cdot ft$$

Deflection:

$$\Delta_{asd} := \frac{5 \cdot W_{asd} \cdot L^4}{384 \cdot E \cdot I_{xx}} = \begin{bmatrix} 0.145 \\ 0.45 \\ 0.236 \\ -0.023 \end{bmatrix} \textit{in} \qquad \Delta_{Limit} := \begin{bmatrix} 240 \\ 360 \\ 360 \\ 240 \end{bmatrix} \qquad \frac{L}{\Delta_{Limit}} = \begin{bmatrix} 0.75 \\ 0.5 \\ 0.5 \\ 0.75 \end{bmatrix} \textit{in} \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.193 \\ 0.899 \\ 0.472 \\ -0.031 \end{bmatrix}$$

Check ASD Shear Capacity:

NDS 5.3.3 NDS 5.3.4 $C_d := \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$ Factors from NDS table 5.3.1

$C_m := 1.0$ $C_t := 1.0$

Calculate factored allowable shear from NDS 3.4-2 and factors from NDS 5.3.1

$$V_{allowable} := \frac{2}{3} \cdot f_v \cdot b \cdot d \cdot C_d \cdot C_m \cdot C_t = \begin{bmatrix} 7.334 \\ 9.371 \\ 9.371 \\ 13.038 \end{bmatrix} \textit{kip} \qquad V_{asd} = \begin{bmatrix} 0.481 \\ 1.493 \\ 0.784 \\ -0.076 \end{bmatrix} \textit{kip} \qquad \frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0.066 \\ 0.159 \\ 0.084 \\ -0.006 \end{bmatrix}$$

Check LRFD Shear Capacity:

NDS 5.3.3 NDS 5.3.4 $K_f := 2.88$ $\phi := 0.75$ $\lambda := \begin{bmatrix} 0.6 \\ 0.8 \\ 0.8 \\ 0.8 \\ 1.0 \end{bmatrix}$ Factors from NDS table 5.3.1

$C_m = 1$ $C_t = 1$

Calculate factored allowable shear from NDS 3.4-2 and factors from NDS 5.3.1

$$\phi V_u := \frac{2}{3} \cdot f_v \cdot b \cdot d \cdot C_m \cdot C_t \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 10.561 \\ 14.081 \\ 14.081 \\ 14.081 \\ 17.601 \end{bmatrix} \textit{kip} \qquad V_u = \begin{bmatrix} 0.673 \\ 2.197 \\ 0.476 \\ 1.893 \\ -0.175 \end{bmatrix} \textit{kip} \qquad \frac{V_u}{\phi V_u} = \begin{bmatrix} 0.064 \\ 0.156 \\ 0.034 \\ 0.134 \\ -0.01 \end{bmatrix}$$

Check ASD Moment Capacity:

NDS 5.3.3 NDS 5.3.4 NDS 5.3.6

$C_m := 1$ $C_t := 1$ $C_V := min\left(\left(\frac{21\ ft}{L}\right)^{\frac{1}{10}} \cdot \left(\frac{12\ in}{d}\right)^{\frac{1}{10}} \cdot \left(\frac{5.125\ in}{b}\right)^{\frac{1}{10}}, 1.0\right) = 1$

Use NDS table 3.3.3 for effective length:

$$l_e := \begin{cases} \text{if } \frac{l_u}{d} < 7 \\ \quad \text{return } 2.06 \cdot l_u \\ \text{else if } 7 \le \frac{l_u}{d} \le 14.3 \\ \quad \text{return } 1.63 \cdot l_u + 3 \cdot d \\ \text{else if } \frac{l_u}{d} > 14.3 \\ \quad \text{return } 1.84 \cdot l_u \end{cases} = 27.6\ ft$$

$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 10.653$ NDS 3.3-5

$F_{be} := \frac{1.2 \cdot E_{min} \cdot C_m \cdot C_t}{R_b{}^2} = 10045.227\ psi$

Calculate factored allowable bending stress without CL

$F_{b`} := C_d \cdot f_{b\_top} \cdot C_m \cdot C_t = \begin{bmatrix} 1665 \\ 2127.5 \\ 2127.5 \\ 2960 \end{bmatrix} psi$

Calculate CL per NDS 3.3-6

$C_L := \frac{1 + \frac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.99 \\ 0.987 \\ 0.987 \\ 0.98 \end{bmatrix}$

Calculate how Cv and CL are to be used (See NDS 5.3.5, NDS 5.3.6):

$i := \text{ORIGIN} .. \text{last}(C_L)$ $C_{LV_i} := \overrightarrow{min\left(C_V, C_{L_i}\right)} = \begin{bmatrix} 0.99 \\ 0.987 \\ 0.987 \\ 0.98 \end{bmatrix}$

$M_{allowable} := \overrightarrow{\left(C_d \cdot f_{b\_bottom} \cdot C_m \cdot C_t \cdot C_{LV}\right)} \cdot S_{xx} = \begin{bmatrix} 12.333 \\ 15.706 \\ 15.706 \\ 21.699 \end{bmatrix} kip \cdot ft$

ASD Member Option Results:

```
Wood Member Size: 5 1/8 x 9
Wood Member Grade: DF GLB 24F-V4

Moment Code Check = 0.40 at 7.50 ft
    M = 6.22 K*ft vs 15.71 K*ft
    for Dead + Snow
Shear Code Check = 0.16 at 0.75 ft
    V = 1.49 K vs 9.37 K
    for Dead + Snow
Deflection Code Check = 0.90 at 7.50 ft
    D = -0.450 in vs 0.500 in = L/360
    for Dead + Snow
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$V_{asd} = \begin{bmatrix} 0.481 \\ 1.493 \\ 0.784 \\ -0.076 \end{bmatrix} kip$ $\frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0.066 \\ 0.159 \\ 0.084 \\ -0.006 \end{bmatrix}$

$M_{asd} = \begin{bmatrix} 2.003 \\ 6.222 \\ 3.268 \\ -0.317 \end{bmatrix} kip \cdot ft$ $\frac{M_{asd}}{M_{allowable}} = \begin{bmatrix} 0.162 \\ 0.396 \\ 0.208 \\ -0.015 \end{bmatrix}$

LRFD Moment Capacity:

NDS 5.3.3 NDS 5.3.4 NDS 5.3.6 NDS Table 5.3.1 LRFD Only

$C_m = 1$ $C_t = 1$ $C_V = 1$ $K_f := 2.54$ $\phi := 0.85$ $\lambda = \begin{bmatrix} 0.6 \\ 0.8 \\ 0.8 \\ 0.8 \\ 1 \end{bmatrix}$

Calculate factored allowable bending stress without CL

$F_{b`} := f_{b\_top} \cdot C_m \cdot C_t \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 2396.49 \\ 3195.32 \\ 3195.32 \\ 3195.32 \\ 3994.15 \end{bmatrix}$ *psi*

$l_e = 27.6$ *ft* Per NDS Table 3.3.3 (see above)

$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 10.653$ NDS 3.3-5

Calculate CL per NDS 3.3-6

$F_{be} := \frac{1.2 \cdot E_{min} \cdot 1.76 \cdot \phi \cdot C_m \cdot C_t}{R_b{}^2} = 15027.66$ *psi*

$C_L := \frac{1 + \frac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.991 \\ 0.987 \\ 0.987 \\ 0.987 \\ 0.983 \end{bmatrix}$

Calculate how Cv and CL are to be used (See NDS 5.3.5, NDS 5.3.6):

$i := \text{ORIGIN} .. \text{last}(C_L)$ $C_{LV_i} := \overrightarrow{min(C_V, C_{L_i})} = \begin{bmatrix} 0.991 \\ 0.987 \\ 0.987 \\ 0.987 \\ 0.983 \end{bmatrix}$

$\phi M_n := \overrightarrow{(f_{b\_bottom} \cdot C_m \cdot C_t \cdot C_{LV} \cdot K_f \cdot \phi \cdot \lambda) \cdot S_{xx}} = \begin{bmatrix} 17.758 \\ 23.587 \\ 23.587 \\ 23.587 \\ 29.356 \end{bmatrix}$ *kip · ft*

LRFD Member Option Results:

```
Wood Member Size: 5 1/8 x 9
Wood Member Grade: DF GLB 24F-V4

Moment Code Check = 0.39 at 7.50 ft
    M = 9.15 K*ft vs 23.59 K*ft
    for 1.2 Dead + 1.6 Snow
Shear Code Check = 0.16 at 0.75 ft
    V = 2.20 K vs 14.08 K
    for 1.2 Dead + 1.6 Snow
Deflection Code Check = 0.90 at 7.50 ft
    D = -0.450 in vs 0.500 in = L/360
    for Dead + Snow
```

$V_u = \begin{bmatrix} 0.673 \\ 2.197 \\ 0.476 \\ 1.893 \\ -0.175 \end{bmatrix}$ *kip* $\frac{V_u}{\phi V_u} = \begin{bmatrix} 0.064 \\ 0.156 \\ 0.034 \\ 0.134 \\ -0.01 \end{bmatrix}$

$M_u = \begin{bmatrix} 2.804 \\ 9.153 \\ 1.981 \\ 7.888 \\ -0.729 \end{bmatrix}$ *kip · ft* $\frac{M_u}{\phi M_n} = \begin{bmatrix} 0.158 \\ 0.388 \\ 0.084 \\ 0.334 \\ -0.025 \end{bmatrix}$