3 1/2 x 9 1/2 LVL x 15ft Wood Beam Verification Calculations:

Surface Area Loading:

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

Beam Dimensions:

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

Shape: Use 3 1/2 x 9 1/2 Width: $b := 3.5\ in$ Depth: $d := 9.5\ in$

$A := b \cdot d = 33.25\ in^2$ $\quad S_{xx} := \frac{1}{6} \cdot b \cdot d^2 = 52.646\ in^3$ $\quad I_{xx} := \frac{1}{12} \cdot b \cdot d^3 = 250.068\ in^4$

Material: Use LVL E=2.0

$f_b := 2600\ psi$ $\quad f_v := 285\ psi$ $\quad E := 2000\ ksi$ $\quad E_{min} := 1016.535\ ksi$ $\quad Density := 35\ pcf$

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

$Dead := Roof_{Dead} \cdot T + A \cdot Density = 68.082\ plf$

$Snow := Roof_{Snow} \cdot T = 150\ plf$

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

$$W_{asd} := \begin{bmatrix} Dead \\ Dead + Snow \\ Dead + 0.75 \cdot Wind + 0.75 \cdot Snow \\ 0.6 \cdot Dead + 0.6 \cdot Wind \end{bmatrix} = \begin{bmatrix} 68.082 \\ 218.082 \\ 113.082 \\ -13.151 \end{bmatrix} plf$$

$$W_{LRFD} := \begin{bmatrix} 1.4 \cdot Dead \\ 1.2 \cdot Dead + 1.6 \cdot Snow \\ 1.2 \cdot Dead + 1.0 \cdot Wind + 0.5 \cdot Snow \\ 1.2 \cdot Dead + 0.5 \cdot Wind + 1.6 \cdot Snow \\ 0.9 \cdot Dead + 1.0 \cdot Wind \end{bmatrix} = \begin{bmatrix} 95.314 \\ 321.698 \\ 66.698 \\ 276.698 \\ -28.727 \end{bmatrix} plf$$

Reactions:

$$R_a := \left(W_{asd}\right) \cdot \frac{L}{2} = \begin{bmatrix} 0.511 \\ 1.636 \\ 0.848 \\ -0.099 \end{bmatrix} kip \qquad R_b := \left(W_{asd}\right) \cdot \frac{L}{2} = \begin{bmatrix} 0.511 \\ 1.636 \\ 0.848 \\ -0.099 \end{bmatrix} kip$$

Shear at distance "D" from supports:

$$V_{asd} := R_a - \left(W_{asd}\right) \cdot d = \begin{bmatrix} 0.457 \\ 1.463 \\ 0.759 \\ -0.088 \end{bmatrix} kip \qquad V_u := W_{LRFD} \cdot \frac{L}{2} - W_{LRFD} \cdot d = \begin{bmatrix} 0.639 \\ 2.158 \\ 0.447 \\ 1.856 \\ -0.193 \end{bmatrix} kip$$

Moment at Center of Beam:

$$M_{asd} := \frac{W_{asd} \cdot L^2}{8} = \begin{bmatrix} 1.915 \\ 6.134 \\ 3.18 \\ -0.37 \end{bmatrix} kip \cdot ft \qquad M_u := \frac{W_{LRFD} \cdot L^2}{8} = \begin{bmatrix} 2.681 \\ 9.048 \\ 1.876 \\ 7.782 \\ -0.808 \end{bmatrix} kip \cdot ft$$

Deflection:

$$\Delta_{asd} := \frac{5 \cdot W_{asd} \cdot L^4}{384 \cdot E \cdot I_{xx}} = \begin{bmatrix} 0.155 \\ 0.497 \\ 0.258 \\ -0.03 \end{bmatrix} in \qquad \Delta_{Limit} := \begin{bmatrix} 240 \\ 360 \\ 360 \\ 240 \end{bmatrix} \qquad \frac{L}{\Delta_{Limit}} = \begin{bmatrix} 0.75 \\ 0.5 \\ 0.5 \\ 0.75 \end{bmatrix} in \qquad \frac{\Delta_{asd}}{\frac{L}{\Delta_{Limit}}} = \begin{bmatrix} 0.207 \\ 0.993 \\ 0.515 \\ -0.04 \end{bmatrix}$$

Check ASD Shear Capacity:

$C_m := 1.0$ NDS 8.3.3

$C_t := 1.0$ NDS 8.3.4

$$C_d := \begin{bmatrix} 0.9 \\ 1.15 \\ 1.15 \\ 1.6 \end{bmatrix}$$ NDS 8.3.2 ASD Only

NDS 3.4-2 -> solve for V

$$V_{allowable} := \frac{2}{3} \cdot f_v \cdot b \cdot d \cdot C_d \cdot C_m \cdot C_t = \begin{bmatrix} 5.686 \\ 7.265 \\ 7.265 \\ 10.108 \end{bmatrix} kip$$

Check Demand vs Capacity:

$$\frac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0.08 \\ 0.201 \\ 0.104 \\ -0.009 \end{bmatrix}$$

Check LRFD Shear Capacity:

$C_m = 1$ NDS 8.3.3

$C_t = 1$ NDS 8.3.4

NDS Table 8.3.1 LRFD only: $K_f := 2.88$ $\quad \phi := 0.75$ $\quad \lambda := \begin{bmatrix} 0.6 \\ 0.8 \\ 0.8 \\ 0.8 \\ 1.0 \end{bmatrix}$

NDS 3.4-2 -> solve for V

$$\phi V_n := \frac{2}{3} \cdot f_v \cdot b \cdot d \cdot C_m \cdot C_t \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 8.187 \\ 10.917 \\ 10.917 \\ 10.917 \\ 13.646 \end{bmatrix} kip$$

Check Demand vs Capacity:

$$\frac{V_u}{\phi V_n} = \begin{bmatrix} 0.078 \\ 0.198 \\ 0.041 \\ 0.17 \\ -0.014 \end{bmatrix}$$

Check ASD Moment Capacity:

NDS 8.3.3 NDS 8.3.4 NDS 8.3.7 NDS Table 3.3.3

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

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

NDS 8.3.6

$$C_V := \left(\frac{12\ in}{d}\right)^{0.136} = 1.032$$

From LVL manufacturer

$$F_{b`} := C_d \cdot f_b \cdot C_m \cdot C_t \cdot C_r = \begin{bmatrix} 2340 \\ 2990 \\ 2990 \\ 4160 \end{bmatrix} psi$$

NDS table 8.3.1

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 16.027$$

NDS 3.3-5

$$F_{be} := \frac{1.2 \cdot E_{min} \cdot C_m \cdot C_t}{{R_b}^2} = 4749.258\ psi$$

$$C_L := \frac{1 + \dfrac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \dfrac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\dfrac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.957 \\ 0.933 \\ 0.933 \\ 0.865 \end{bmatrix}$$

NDS 3.3-6

Calculate factored moment capacity using factors in NDS Table 8.3.1.
Note Cv is used per NDS 8.3.6

$$M_{allowable} := \overrightarrow{\left(C_d \cdot f_b \cdot C_m \cdot C_t \cdot \text{if}\left(C_V \le 1, min\left(C_V, C_L\right), C_V \cdot C_L\right) \cdot C_r\right) \cdot S_{xx}} = \begin{bmatrix} 10.145 \\ 12.64 \\ 12.64 \\ 16.294 \end{bmatrix} kip \cdot ft$$

ASD Member Option Results:

```
Wood Member Size: 3 1/2 x 9 1/2
Wood Member Grade: LVL 2.0E

Moment Code Check = 0.49 at 7.50 ft
    M = 6.13 K*ft vs 12.64 K*ft
    for Dead + Snow
Shear Code Check = 0.20 at 0.79 ft
    V = 1.46 K vs 7.27 K
    for Dead + Snow
Deflection Code Check = 0.99 at 7.50 ft
    D = -0.497 in vs 0.500 in = L/360
    for Dead + Snow
```

Moment Demand: $M_{asd} = \begin{bmatrix} 1.915 \\ 6.134 \\ 3.18 \\ -0.37 \end{bmatrix} kip \cdot ft$

Check Demand vs Capacity: $\dfrac{M_{asd}}{M_{allowable}} = \begin{bmatrix} 0.189 \\ 0.485 \\ 0.252 \\ -0.023 \end{bmatrix}$

Shear Demand: $V_{asd} = \begin{bmatrix} 0.457 \\ 1.463 \\ 0.759 \\ -0.088 \end{bmatrix} kip$

Check Demand vs Capacity: $\dfrac{V_{asd}}{V_{allowable}} = \begin{bmatrix} 0.08 \\ 0.201 \\ 0.104 \\ -0.009 \end{bmatrix}$

LRFD Moment Capacity: $K_f := 2.54$ $\phi := 0.85$ Factors per NDS table 8.3.1 LRFD Only

Calculate factored bending stress with out beam stability factor

$$F_{b`} := f_b \cdot C_m \cdot C_t \cdot C_r \cdot K_f \cdot \phi \cdot \lambda = \begin{bmatrix} 3368.04 \\ 4490.72 \\ 4490.72 \\ 4490.72 \\ 5613.4 \end{bmatrix} \ psi$$

$$R_b := \sqrt{\frac{l_e \cdot d}{b^2}} = 16.027$$ NDS 3.3-5

$$F_{be} := \frac{1.2 \cdot E_{min} \cdot 1.76 \cdot \phi \cdot C_m \cdot C_t}{{R_b}^2} = 7104.89 \ psi$$

$$C_L := \frac{1 + \frac{F_{be}}{F_{b`}}}{1.9} - \sqrt{\left(\frac{1 + \frac{F_{be}}{F_{b`}}}{1.9}\right)^2 - \frac{\frac{F_{be}}{F_{b`}}}{0.95}} = \begin{bmatrix} 0.96 \\ 0.933 \\ 0.933 \\ 0.933 \\ 0.893 \end{bmatrix}$$ NDS 3.3-6

Calculate factored moment capacity using factors in NDS Table 8.3.1.
Note Cv and CL are used per NDS 8.3.6

$$\phi M_n := \overrightarrow{\left(f_b \cdot C_m \cdot C_t \cdot \text{if}\left(C_V \le 1, min\left(C_V, C_L\right), C_V \cdot C_L\right) \cdot C_r \cdot K_f \cdot \phi \cdot \lambda\right) \cdot S_{xx}} = \begin{bmatrix} 14.642 \\ 18.974 \\ 18.974 \\ 18.974 \\ 22.702 \end{bmatrix} \ kip \cdot ft$$

LRFD Member Option Results:

```
Wood Member Size: 3 1/2 x 9 1/2
Wood Member Grade: LVL 2.0E

Moment Code Check = 0.48 at 7.50 ft
    M = 9.05 K*ft vs 18.97 K*ft
    for 1.2 Dead + 1.6 Snow
Shear Code Check = 0.20 at 0.79 ft
    V = 2.16 K vs 10.92 K
    for 1.2 Dead + 1.6 Snow
Deflection Code Check = 0.99 at 7.50 ft
    D = -0.497 in vs 0.500 in = L/360
    for Dead + Snow
```

Moment Demand: $M_u = \begin{bmatrix} 2.681 \\ 9.048 \\ 1.876 \\ 7.782 \\ -0.808 \end{bmatrix} \ kip \cdot ft$

Check Demand vs Capacity: $\frac{M_u}{\phi M_n} = \begin{bmatrix} 0.183 \\ 0.477 \\ 0.099 \\ 0.41 \\ -0.036 \end{bmatrix}$

Shear Demand: $V_u = \begin{bmatrix} 0.639 \\ 2.158 \\ 0.447 \\ 1.856 \\ -0.193 \end{bmatrix} \ kip$

Check Demand vs Capacity: $\frac{V_u}{\phi V_n} = \begin{bmatrix} 0.078 \\ 0.198 \\ 0.041 \\ 0.17 \\ -0.014 \end{bmatrix}$