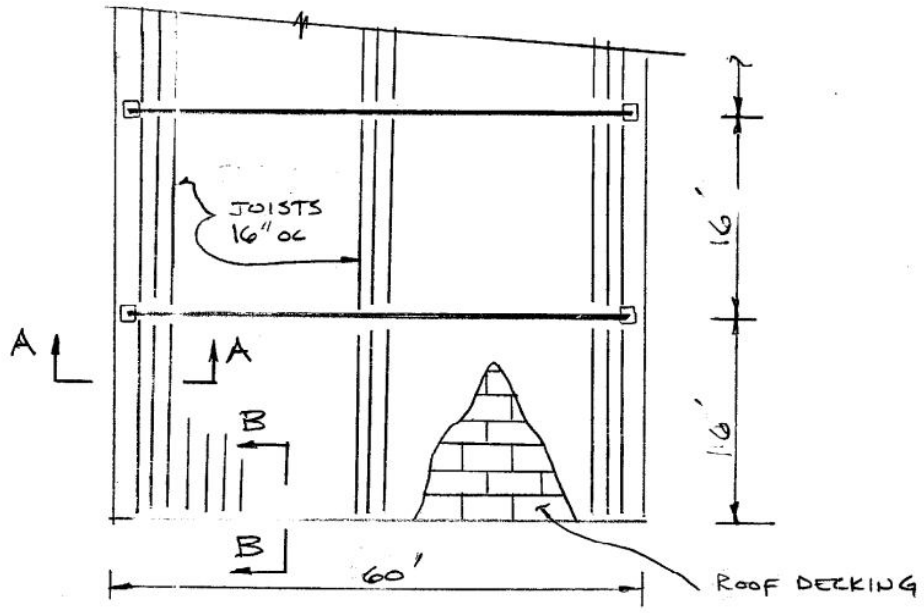
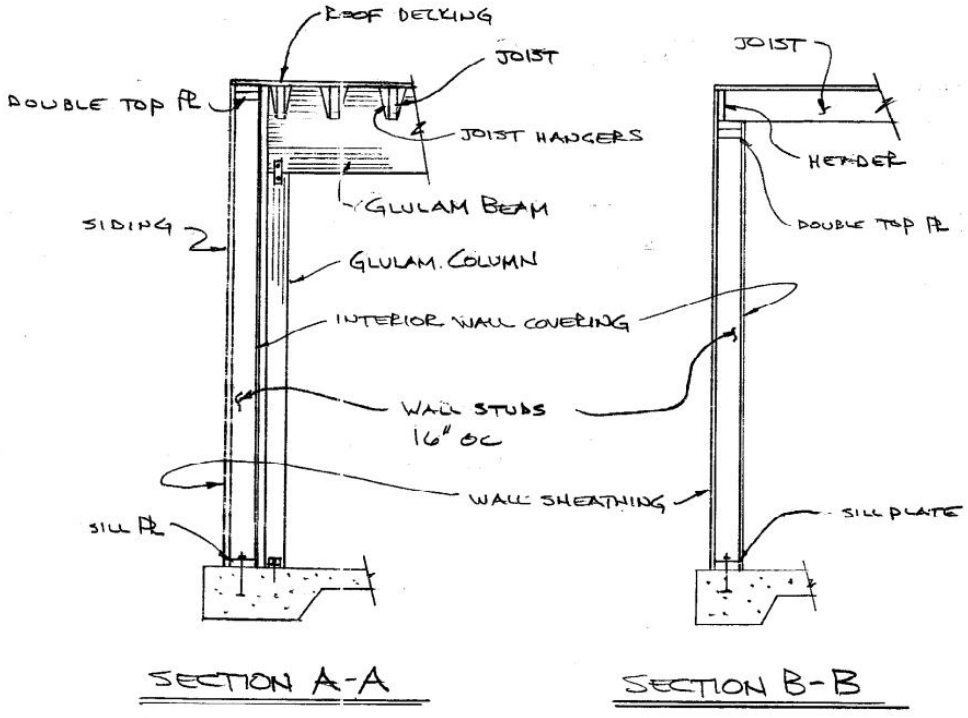
Given:

Roof Framing System:

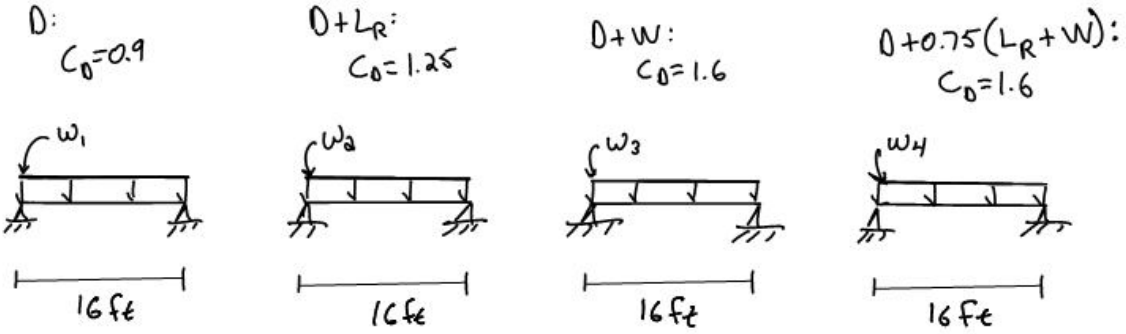




l := 16 ft

Design Loads:

- Assume Roof Dead Load: $D_L := 10$ psf
- Roof Live Load (TA < 150 ft^2): $L_R := 20$ psf
- Wind Load: 70.4 psf upward on 6 ft edge strips
  57.6 psf upward on interior
  19.4 psf downward
- Downward Load Conditions (Joists @ 16" o.c.):



Dead Load Only:

$$w_1 := \frac{16}{12}\cdot D_L = 13.333 \text{ plf}$$

Dead plus Roof Live:

$$w_2 := \frac{16}{12}\cdot (D_L + L_R) = 40 \text{ plf}$$

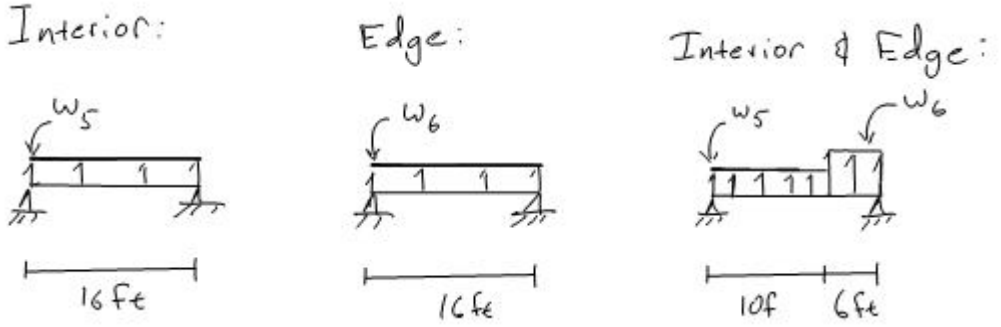
*Dead plus 0.6*Wind:*

$$w_3 := \frac{16}{12}\cdot (D_L + 0.6\cdot 19.4) = 28.853 \text{ plf}$$

*Dead plus 3/4 of (Roof Live plus 0.6*Wind):*

$$w_4 := \frac{16}{12}\cdot [10 + 0.75\cdot (20 + 0.6\cdot 19.4)] = 44.973 \text{ plf}$$

- Upward Load Conditions: 0.6*D+W [W-0.6*D upward] C_D=1.6



Interior: *Edge:*

$w_5 := \frac{16}{12} \cdot (57.6 - 0.6 \cdot 10) = 68.8$ plf $w_6 := \frac{16}{12} \cdot (70.4 - 0.6 \cdot 10) = 85.867$ plf

- Estimate Controlling Load Case:

Downward Load (C_L = 1.0):

Load Case:	Load (plf):	C_D:	Load/C_D:
1. D	13.33	0.9	14.81
2. D + L_R	40	1.25	32
5. D + 0.6*(W)	28.85	1.6	18.03
6a. D + 0.75*(0.6*(W)) + 0.75*L_R	44.97	1.6	28.11

Therefore $w_{down} := 40$ plf $C_{Ddown} := 1.25$

$$M_{down} := \frac{w_{down} \cdot l^2}{8} = 1.28 \times 10^3 \text{ ft·lb}$$

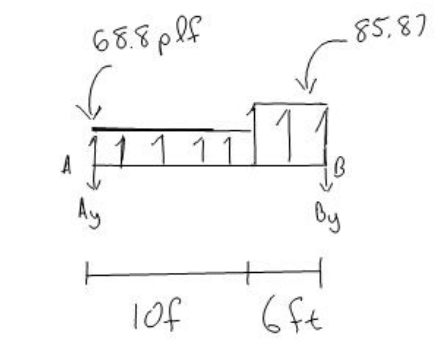
Upward Load ($C_L \neq 1.0$):

Load Condition:

Interior: $M_{up1} := \frac{w_5 \cdot l^2}{8} = 2.202 \times 10^3$ ft·lb

Edge: $M_{up2} := \frac{w_6 \cdot l^2}{8} = 2.748 \times 10^3$ ft·lb

Interior & Edge:



$+\circlearrowleft \Sigma M_A = 0:$

$$68.8\frac{lb}{ft}(10ft)(5ft) + 85.87\frac{lb}{ft}(6ft)(13ft) - B_y(16ft) = 0$$

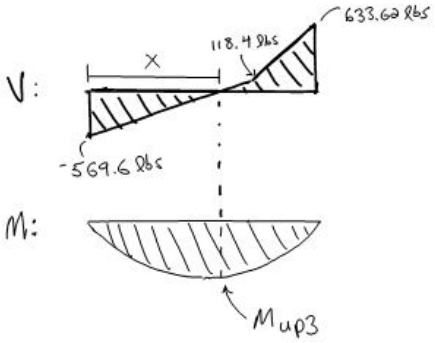
$$10,138\ lb\cdot ft - B_y(16ft) = 0$$

$$\therefore B_y = 633.62\ lbs$$

$+\uparrow \Sigma F_y = 0:$

$$-A_y + 68.8\frac{lb}{ft}(10ft) + 85.87\frac{lb}{ft}(6ft) - 633.62\ lbs = 0$$

$$\therefore A_y = 569.60\ lbs$$



$$\frac{10}{688} = \frac{x}{569.6} \rightarrow x = 8.28\ ft$$

$$M_{up3} := \frac{1}{2}\cdot(569.6)\cdot(8.28) = 2.358\times 10^{3}\ \ ft\cdot lb$$

- Determine Actual Bending Stresses:

*****Try #2 - 2X12 Southern Pine:** $d := 11.25\ in$ $b := 1.5\ in$ $S_x := 31.64\ in^3$

$E_{min} := 580000\ psi$ $F_b := 1500\ psi$

Downward Loads: $f_{bdown} := \frac{M_{down}\cdot(12)}{S_x} = 485.461\ \ psi$

Upward Loads: Interior $f_{bup1} := \frac{M_{up1}\cdot(12)}{S_x} = 834.994\ \ psi$

Edge $f_{bup2} := \frac{M_{up2}\cdot(12)}{S_x} = 1.042\times 10^{3}\ \ psi$

Interior and Edge $f_{bup3} := \frac{M_{up3}\cdot(12)}{S_x} = 894.366\ \ psi$

- Check Bending Strength of Member:

$F_b := 1500\ psi$		NDS Supplement 2005, Table 4B (P.38)
$C_{Ddown} = 1.25$		NDS 2005, Table 2.3.2 (P.9)
$C_{Dup} := 1.6$		NDS 2005, Table 2.3.2 (P.9)
$C_M := 1.0$	$EMC \le 19\%$	NDS Supplement 2005, Table 4B (P.37)
$C_t := 1.0$		NDS 2005, Table 2.3.3 (P.9)
$C_F := 1.0$	2X12	NDS 2005, Section 4.3.6
$C_{fu} := 1.0$	Major Axis Bending	NDS 2005, Section 4.3.7
$C_i := 1.0$	Untreated Lumber	NDS 2005, Section 4.3.8
$C_r := 1.15$		NDS 2005, Section 4.3.9
$C_{Ldown} := 1.0$		NDS 2005, Section 4.3.5

*****For upward loading try bracing at 1/3 points:**

$l_u := \frac{16}{3} \cdot 12 = 64 \quad in$ $\qquad \frac{l_u}{d} = 5.689$

$l_e := 2.06 \cdot l_u = 131.84 \quad in$ NDS 2005, Table 3.3.3 (P.14)

$R_B := \sqrt{\frac{l_e \cdot d}{b^2}} = 25.675$ NDS 2005, Section 3.3.3.6

$F_{be} := \frac{1.2 \cdot E_{min}}{R_B^{\,2}} = 1.056 \times 10^3$

$F_{b'} := F_b \cdot C_{Dup} \cdot C_r = 2.76 \times 10^3$

$$C_{Lup} := \frac{1 + \left(\frac{F_{be}}{F_{b'}}\right)}{1.9} - \sqrt{\left[\frac{1 + \left(\frac{F_{be}}{F_{b'}}\right)}{1.9}\right]^2 - \frac{\frac{F_{be}}{F_{b'}}}{0.95}} = 0.372$$ Eqn. (3.3-6)

Downward Loading:

$F'_{bdown} := F_b \cdot C_{Ddown} \cdot C_M \cdot C_t \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_r \cdot C_{Ldown}$ NDS 2005, Table 4.3.1 (P.27)

$F'_{bdown} = 2.156 \times 10^3$ psi > $f_{bdown} = 485.461$ psi

Upward Loading:

$F'_{bup} := F_b \cdot C_{Dup} \cdot C_M \cdot C_t \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_r \cdot C_{Lup}$ NDS 2005, Table 4.3.1 (P.27)

$F'_{bup} = 1.026 \times 10^3$ psi > $f_{bup1} = 834.994$ psi

< $f_{bup2} = 1.042 \times 10^3$ psi

> $f_{bup3} = 894.366$ psi

Since F`$_{bup}$ < f_{bup2} , then bracing at 1/3 points is not adequate for upward wind loads on roof edge. Therefore, for the joists in the 6 ft edge of the building need to be more adequately braced.

*****Retry with bracing at 1/4 points for joists on 6 ft roof edge:**

$l_u := \frac{16}{4} \cdot 12 = 48$ in $\frac{l_u}{d} = 4.267$

$l_e := 2.06 \cdot l_u = 98.88$ in NDS 2005, Table 3.3.3 (P.14)

$R_B := \sqrt{\frac{l_e \cdot d}{b^2}} = 22.235$ NDS 2005, Section 3.3.3.6

$F_{be} := \frac{1.2 \cdot E_{min}}{R_B^2} = 1.408 \times 10^3$ $F_{b'} := F_b \cdot C_{Dup} \cdot C_r = 2.76 \times 10^3$

$C_{Lup} := \frac{1 + \left(\frac{F_{be}}{F_{b'}}\right)}{1.9} - \sqrt{\left[\frac{1 + \left(\frac{F_{be}}{F_{b'}}\right)}{1.9}\right]^2 - \frac{\frac{F_{be}}{F_{b'}}}{0.95}} = 0.487$ Eqn. (3.3-6)

$F'_{bup} := F_b \cdot C_{Dup} \cdot C_M \cdot C_t \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_r \cdot C_{Lup} = 1.344 \times 10^3$ psi > $f_{bup2} = 1.042 \times 10^3$ psi

Therefore, joists in the 6 ft outer edge of roof use 1/4 point bracing [lateral bracing every 4 ft].

- Determine Actual Shear Stresses:

*****Try #2 - 2X12 Southern Pine:** $d := 11.25\ in$ $b := 1.5\ in$ $A := 16.88\ in^2$

$E_{min} := 580000\ psi$ $F_v := 175\ psi$

Downward Loads: $V_d := \frac{w_{down} \cdot l}{2} = 320\ lbs$

$f_{vdown} := \frac{3}{2} \cdot \frac{V_d}{A} = 28.436\ psi$

Upward Loads: $w_6 = 85.867\ plf > w_5 = 68.8\ plf$

$V_u := \frac{w_6 \cdot l}{2} = 686.933\ lbs$

$f_{vup} := \frac{3}{2} \cdot \frac{V_u}{A} = 61.043\ psi$

- Check Shear Strength of Member:

$F_v := 175\ psi$ NDS Supplement 2005, Table 4B (P.38)

$F'_{vdown} := F_v \cdot C_{Ddown} \cdot C_M \cdot C_t \cdot C_i$ NDS 2005, Table 4.3.1 (P.27)

$F'_{vdown} = 218.75\ psi > f_{vdown} = 28.436\ psi$

$F'_{vup} := F_v \cdot C_{Dup} \cdot C_M \cdot C_t \cdot C_i$ NDS 2005, Table 4.3.1 (P.27)

$F'_{vup} = 280\ psi > f_{vup} = 61.043\ psi$

Therefore, #2 2X12 is ok for shear.

- Determine Bearing Length at end of members:

$F_{cp} := 565$ psi — NDS Supplement 2005, Table 4B (P.38)

$C_b := 1.0$ Conservative — NDS 2005, Table 3.10.4 (P.22)

$F'_{cp} := F_{cp} \cdot C_M \cdot C_t \cdot C_i \cdot C_b$ — NDS 2005, Table 4.3.1 (P.27)

$$F'_{cp} = 565 \text{ psi}$$

The compression strength parallel to the grain is not computed with the C_D factor. Therefore, "Dead plus 3/4 of (Roof Live plus 0.6*Wind)" [w_4].

$$R := \frac{w_4 \cdot l}{2} = 359.787 \text{ lbs}$$

$$A_{reqd} := \frac{R}{F'_{cp}} = 0.637 \text{ in}^2$$

$$l_b := \frac{A_{reqd}}{b} = 0.425 \text{ in}$$

Therefore, use a bearing length of at least 1".

- Check Deflection Limits: 2007 FBC, Table 1604.3

Roof members supporting nonplaster ceiling:

D: $\Delta_D := \frac{l \cdot 12}{240} = 0.8$ in

W: $\Delta_W := \frac{l \cdot 12}{240} = 0.8$ in

D + L_R: $\Delta_{DLr} := \frac{l \cdot 12}{180} = 1.067$ in

Check Δ_L:

#2 2x12, Southern Pine: $E := 1600000$ psi 2005 NDS Supplement, Table 4B (P.38)

$I := 178$ in^4 2005 NDS Supplement, Table 1B (P.14)

$\Delta_L := \frac{5 \cdot 40 \cdot l^4}{E \cdot I} = 0.046$ in < 0.8 in Therefore, ok

Wind loads (w_6 controls):

Per FBC Table 1604.3, Note (f), use: (0.7 * Component and Cladding)

therefore:

$\Delta_w := \frac{5 \cdot (0.7 w_6) \cdot l^4}{E \cdot I} = 0.069$ in < 0.8 in Therefore, ok

Roof Live Load (L_R controls):

$\Delta_{DLr} := \frac{5 \cdot w_2 \cdot l^4}{E \cdot I} = 0.046$ < 0.8 in Therefore, ok

Summary:

- **Use a #2 2X12 Southern Pine @ 16" o.c. with a minimum bearing length of 1".**
- **Provide lateral blocking at 1/3 points (64") for the interior joists.**
- **Provide lateral blocking at 1/4 points (48") for the joists within the 6 ft edge of roof.**
- **For economic benefits you could check to see if smaller member works.**