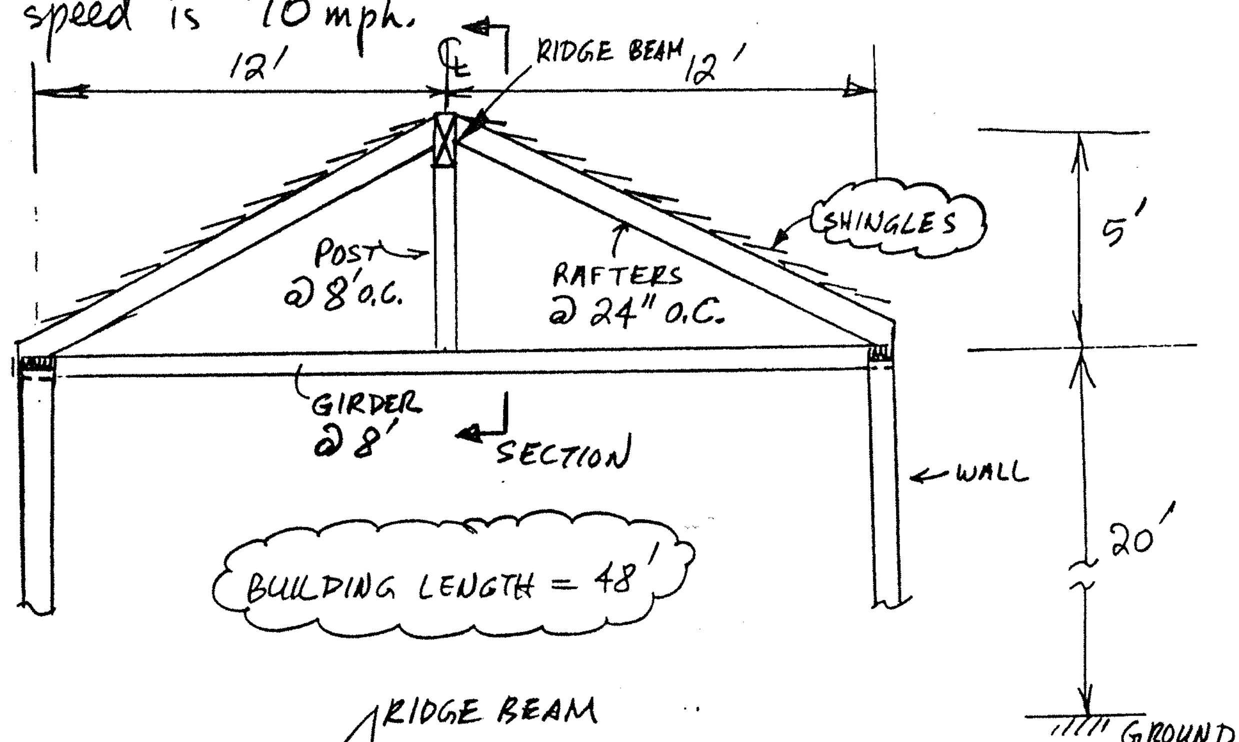
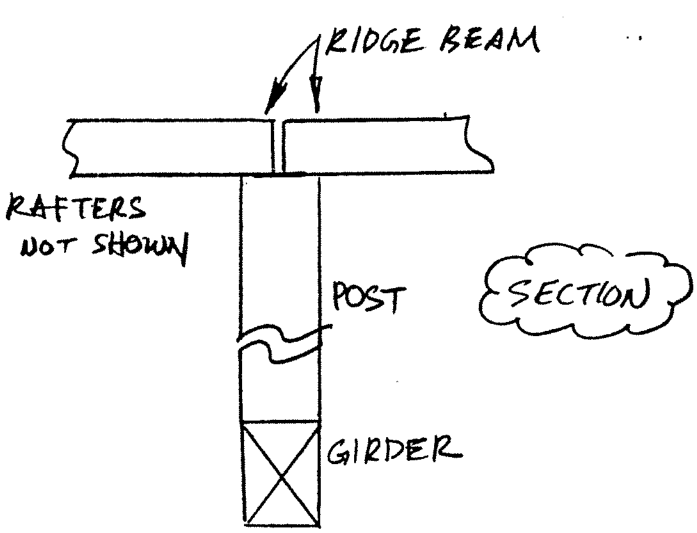
EXAMPLE

The shown timber dwelling has a roof consisting of rafters placed at 24 inch intervals and supported at the centerline by a ridge beam. The ridge beam is supported by posts placed at 8 foot intervals. Each post is supported by a girder. All connections are simple, that is, they do not transfer moment.

Roof dead load = 20 psf (includes self weight of framing). The structure is located in an area that is densely forested with ground snow load of 40 psf. Basic wind speed is 70 mph.





Determine :

a) Maximum bending moment in rafters
b) Maximum axial load in post
c) Maximum bending moment in girder

Consider dead load, dead load + snow load, or dead load + wind load whichever dominates in each case.

Directions:

Load is collected by the rafters and transferred to the ridge beam and supporting wall. Ridge beam is supported by posts, which are supported by girders. This represents the load path. It will be useful in sequencing your analysis.

Note that different loading combinations may be critical for the various members. For example, dead plus unbalanced snow load may be critical for one member, whereas dead plus balanced snow load may be critical for another member.

You do not have to do calculations for every single case of loading and combination of loadings. Use engineering judgement to exclude some of these loadings (however, explain the rationale).

SNOW LOAD CALCULATIONS (PER ASCE 7-93)

$p_g = 40$ psf, $C_e = 1.2$ (densely forested), $C_t = 1.0$ (dwelling)
$I = 1$ regular structure

$$p_f = 0.7\, C_e C_t I p_g = 0.7 \times 1.2 \times 1.0 \times 1.0 \times 40 = 33.6 \text{ psf}$$

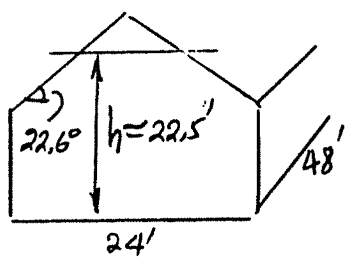
SLOPE 5 ON 12 OR $\underline{22.6°}$, NON-SLIPPERY - WARM ROOF $\Rightarrow C_s = 1.0$

BALANCED SNOW LOAD $\quad P_s = \underline{33.6 \text{ psf}}$

UNBALANCED —— // —— $\quad 1.5 p_s / C_e = 1.5 \times 33.6 / 1.2 = \underline{42 \text{ psf}}$

WIND LOAD CALCULATIONS (PER ASCE 7-93)

CALCULATE ONLY ROOF PRESSURE/SUCTION



EXPOSURE B : WOODED AREA

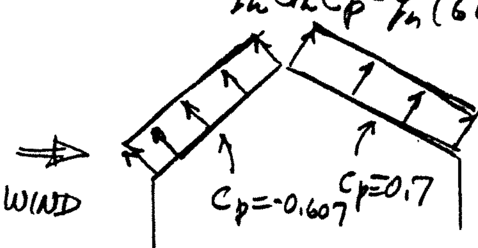
I = 1 (NO HURRICANES)

$$q_h = q_{z=h} = 0.00256\, \underset{0.44}{K_z} (I \overset{70\,mph}{V})^2 = 5.52 \text{ psf}$$

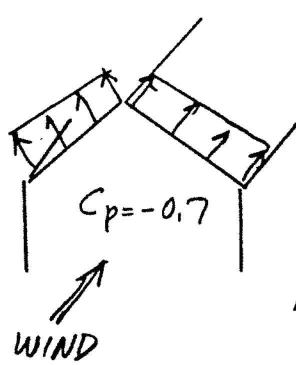
$G_h = 1.565$

$GC_{pi} = \pm 0.25 \Rightarrow q_h (G C_{pi}) = \pm 1.38$ ps

$q_h G_h C_p - q_h (G C_{pi})$



$\theta = 22.6°$
$h/L = 22.5/24 \lesssim 1$ $\Big\}\ C_p = -0.607$

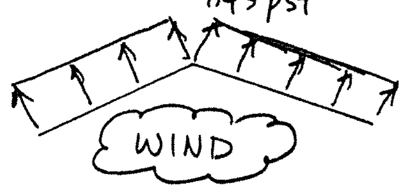


$h/B,\ h/L < 2.5$

SINCE WIND LOADING ON ROOF IS SUCTION (THAT IS, IT COUNTERACTS EFFECT OF WEIGHT), OF INTEREST IS ITS <u>MAXIMUM</u> VALUE. IT MAY BE LARGE ENOUGH TO REVERSE MOMENT IN RAFTERS AND THUS DOMINATE OVER DEAD + SNOW LOAD (THOUGH UNLIKELY).

WORST CASE IS WIND BLOWING PARALLEL TO RIDGE WITH OVERPRESSU INTERNALLY:

$$\text{SUCTION} = q_h G_h \underset{0.7}{C_p} + q_h (GC_{pi}) = 5.52 \times 1.565 \times 0.7 + 1.38 = \underline{\underline{7.43 \text{ psf}}}$$

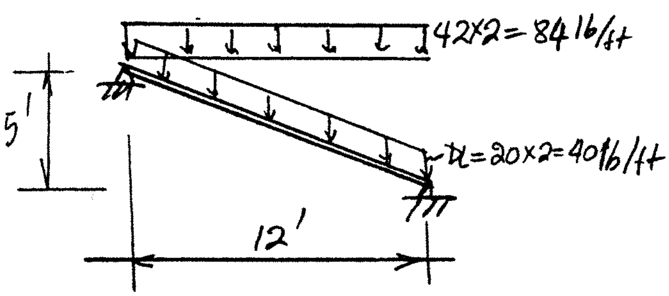


• THE MINIMUM 10 psf WIND LOADING CAUSED PRESSURE ON ROOF RAFTERS BUT THE EFFECT IS MUCH LESS THAN UNBALANCED SNOW LOAD ⇒ NO NEED TO CONSIDER.

RAFTERS

LOADINGS TO CONSIDER

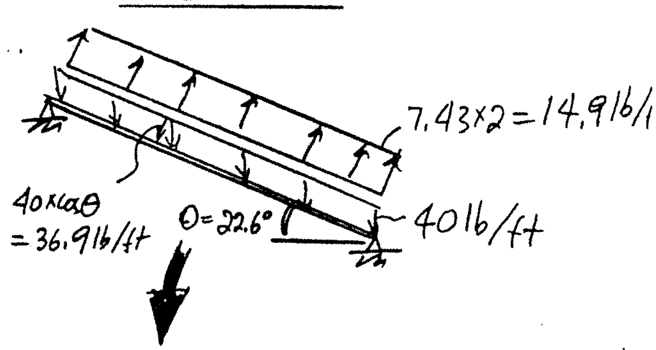
<u>DL + UNBAL. SNOW</u>



TRIBUTARY WIDTH = 2'

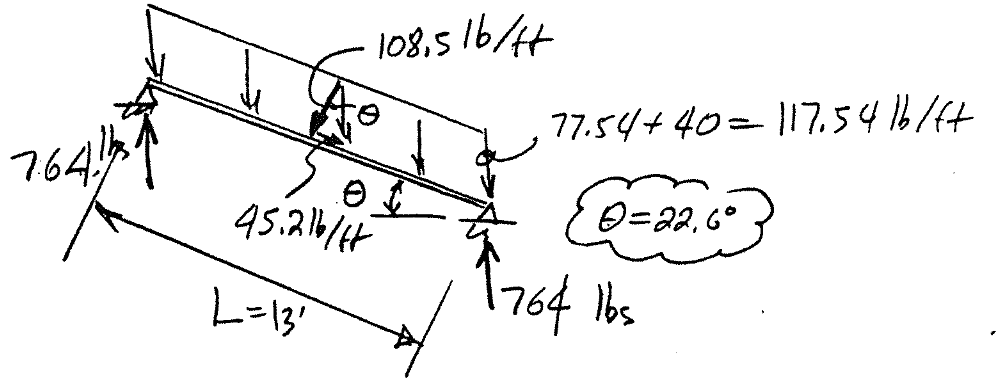
RAFTER LENGTH = 13'

<u>DL + WIND</u>



NET EFFECT IS DOWNWARD LOAD ON RAFTER ⇒ LESS THAN DL + UN. SNOW.
<u>DO NOT</u> CONSIDER WIND.

UNBALANCED S.L. / ACTUAL LENGTH = $84 \times 12/13 = 77.54$ lb/ft



RAFTER SUBJECTED TO PERPENDICULAR LOAD OF 108.5 lb/ft = w

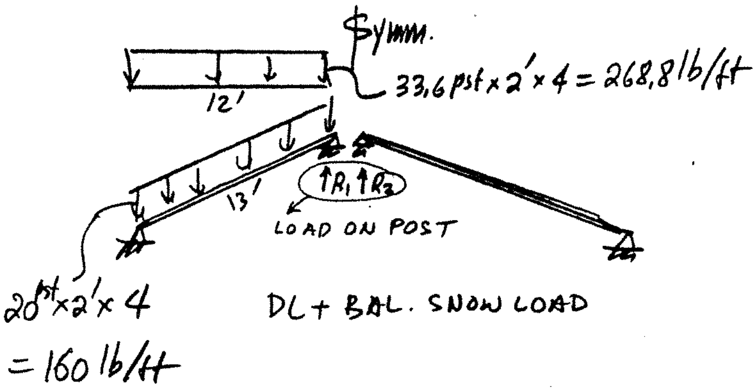
$$\Rightarrow M_{max} = M_{\mathfrak{c}} = \frac{wL^2}{8} = \frac{108.5 \times 13^2}{8} = \underline{\underline{2.3^{\ 1-K}}}$$

MAX. MOMENT IN RAFTER

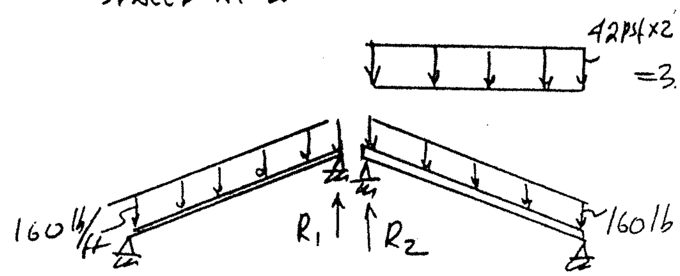
POST

POST RECEIVES LOAD FROM 4 RAFTERS ON LEFT & 4 RAFTER ON RIGHT

SPACED AT 8'   SPACED AT 2'



DL + BAL. SNOW LOAD



DL + UNBAL. SNOW LOAD

$R_1 = R_2 = 268.8 \times 12/2 + 160 \times 13/2$

$= 2652.8$ lbs

LOAD ON POST $= R_1 + R_2 = 5305.6$ lbs

$R_1 = 160 \times 13/2 = 1040$ lbs

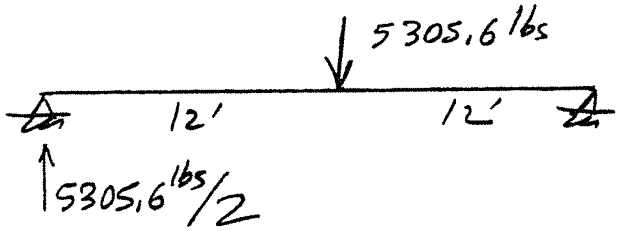
$R_2 = 160 \times 13/2 + 336 \times 12/2 = 2016$

LOAD ON POST $= R_1 + R_2 = 3056$ lbs.

$\Rightarrow$ $\underline{\underline{\text{AXIAL FORCE IN POST} = 5305.6 \text{ lbs COMPR.}}}$

GIRDER

GIRDER IS LOADED BY POST AXIAL FORCE



$$\Rightarrow M_{max} = M_{℄} = \frac{5305.6^{lb}}{2} \times 12' = \underline{\underline{31.8^{1\text{-}K}}}$$

MAX. MOMENT IN GIRDER.