3. Determine relevant adjustments to property values assuming a 2x8 will be used (Section 5.2.4):

C_D = 1.6 (wind load combinations)
= 1.25 (snow load combination)
C_r = 1.15 (2x8, 24 inches on center)
C_H = 2.0
C_F = 1.2 (2x8)
C_L = 1.0 (inward bending, D + S, laterally braced on compression edge)
= 0.32 (outward bending, 0.6 D + W, laterally unbraced on compression edge)*

*Determined in accordance with NDS•3.3.3

$\ell_e = 1.63\ \ell_u + 3d$
$= 1.63\ (14.4\ ft) + 3\ (7.25\ in)(1\ in/12ft)$
$= 25.3\ ft$

$$R_B = \sqrt{\frac{\ell_e d}{b^2}} = \sqrt{\frac{(25.5\ ft)(12\ in/ft)(7.25\ in)}{(1.5\ in)^2}}$$

$= 31 < 50$ (OK)

$K_{bE} = 0.439$ (visually graded lumber)

$$F_{bE} = \frac{K_{bE} E'}{R_B^2} = \frac{0.439\,(1.6x10^6\ psi)}{(31)^2} = 730\ psi$$

$F_b^* = F_b C_D C_r C_F$
$= 900\ psi\ (1.6)(1.15)(1.2) = 1{,}987\ psi$

$$C_L = \frac{1+(F_{bE}/F_b^*)}{1.9} - \sqrt{\left[\frac{1+(F_{bE}/F_b^*)}{1.9}\right]^2 - \frac{F_{bE}/F_b^*}{0.95}}$$

$C_L = 0.36$ (2x8)

4. Determine rafter transverse bending load, shear, and moment for the wind uplift load case (using Method A of Figure 5.8).

The wind load acts transverse (i.e., perpendicular) to the rafter; however, the snow load acts in the direction of gravity and must be resolved to its transverse component. Generally, the axial component of the gravity load along the rafter (which varies unknowingly depending on end connectivity) is ignored and has negligible impact considering the roof system effects that are also ignored. Also, given the limited overhang length, this too will have a negligible impact on the design of the rafter itself. Thus, the rafter can be reasonably analyzed as a sloped, simply supported bending member. In analyzing wind uplift connection forces at the outside bearing of the rafter, the designer should consider the additional uplift created by the small overhang, though for the stated condition it would amount only to about 20 pounds additional uplift load.

The net uniform uplift load perpendicular to the rafter is determined as follows:

$w_{D,\ transverse} = w_D (\cos\theta)$
$= (10\ psf)(1.33\ ft)(\cos 33.7°)$
$= 11\ plf$
$w_{w,\ transverse} = (12.7\ psf)(1.33\ ft) = 17\ plf$ (uplift)
$w_{total,\ transverse} = 17\ plf - 11\ plf = 6\ plf$ (net uplift)

$$\text{Shear, } V_{max} = \frac{w\ell}{2} = \frac{(6\ plf)(14.4\ ft)}{2} = 44\ lbs$$

$\text{Moment, } M_{max} = 1/8\ w\ell^2$
$= 1/8\ (6\ plf)(14.4\ ft)^2 = 156\ ft\text{-}lb$

5. Determine bending load, shear, and moment for the gravity load case (D + S) using Method B of Figure 5.8 (horizontal span):

w_D = (10 psf)(14.4 ft)(1.33 ft)/12 ft-horizontal = 16 plf
w_S = (20 psf)(12 ft)(1.33 ft)/12 ft-horizontal = 27 plf
w_{total} = 43 plf
w_{total} = (43 plf)(cos 33.7°) = 36 plf

$$\text{Shear, } V_{max} = \frac{(36 \text{ plf})(12 \text{ ft})}{2} = 216 \text{ lb}$$

$$\text{Moment, } M_{max} = 1/8\ (36 \text{ plf})(12 \text{ ft})^2 = 648 \text{ ft-lb}$$

6. Check bending stress for both loading cases and bending conditions

Outward Bending ($0.6D + W_u$)

$$f_b = \frac{M}{S}$$

$$= \frac{156 \text{ ft}-\text{lb}}{13.14 \text{ in}^3}(12 \text{ in/ft}) = 142 \text{ psi}$$

F_b' = $F_bC_DC_rC_FC_L$
= 900 psi (1.6)(1.15)(1.2)(0.36) = 715 psi
f_b << F_b' OK, 2x8 works and no lateral bracing of bottom compression edge is required

Inward Bending (D + S)

$$f_b = \frac{M}{S}$$

$$= \frac{648 \text{ ft}-\text{lb}}{13.14 \text{ in}^3}(12 \text{ in/ft}) = 591 \text{ psi}$$

F_b' = $F_bC_DC_rC_FC_L$
= 900 psi (1.25)(1.15)(1.2)(1.0) = 1,553 psi
f_b << F_b' (OK)

7. Check horizontal shear

V_{max} = 216 lb (see Step 5)

$$f_v = \frac{3V}{2A} = \frac{3(216 \text{ lb})}{2(1.5 \text{ in})(7.25 \text{ in})} = 30 \text{ psi}$$

F_v' = $F_vC_DC_H$ = 95 psi (1.25)(2.0) = 238 psi
f_v << F_v' (OK)

8. Check bearing

OK by inspection.