2. Design the hip rafter for a rafter-ceiling joist roof construction (conventional practice).

Use a double 2x10 No. 2 Hem-fir hip rafter (i.e., hip rafter is one-size larger than rafters - rule of thumb). The double 2x10 may be lap-spliced and braced at or near mid-span; otherwise, a single 2x10 could be used to span continuously. The lap splice should be about 4 feet in length and both members face-nailed together with 2-10d common nails at 16 inches on center. Design is by inspection and common practice.

Note: The standard practice above applies only when the jack rafters are tied to the ceiling joists to resist outward thrust at the wall resulting from truss action of the framing system. The roof sheathing is integral to the structural capacity of the system; therefore, heavy loads on the roof before roof sheathing installation should be avoided, as is common. For lower roof slopes, a structural analysis (see next step) may be warranted because the folded-plate action of the roof sheathing is somewhat diminished at lower slopes. Also, it is important to consider connection of the hip rafter at the ridge. Usually, a standard connection using toe-nails is used, but in high wind or snow load conditions a connector or strapping should be considered.

3. Design the hip rafter by assuming a cathedral ceiling with bearing at the exterior wall corner and at a column at the ridge beam intersection

a. Assume the rafter is simply supported and ignore the negligible effect of loads on the small overhang with respect to rafter design.

b. Simplify the diamond-shaped tributary load area (see figure above) by assuming a roughly "equivalent" uniform rectangular load area as follows:

Tributary width ≈ 4 ft
w_{D+S} = (10 psf + 15 psf)(4 ft) = 100 plf

c. Determine the horizontal span of the hip rafter based on roof geometry:

$$\text{Horizontal hip span} = \sqrt{(14\,\text{ft})^2 + (11\,\text{ft})^2} = 17.8\ \text{ft}$$

d. Based on horizontal span (Method B, Figure 5.8), determine shear and bending moment:

Shear, V_{max} = 1/2 $w\ell$ = 1/2 (100 plf)(17.8 ft) = 890 lb
Moment, M_{max} = 1/8 $w\ell^2$ = 1/8 (100 plf)(17.8 ft)^2 = 3,960 ft-lb

f. Determine required section modulus assuming use of 2x12 No. 2 Hem-Fir

$$f_b = \frac{M}{S} = \frac{3{,}960\ \text{ft}-\text{lb}}{S}\ (12\ \text{in/ft}) = \frac{47{,}520\ \text{in}-\text{lb}}{S}$$

F_b' = $F_b C_D C_r C_F C_L$ (F_b from NDS-S, Table 4A)
F_b' = 850 psi (1.25)(1.0)(1.0)(1.0) = 1,063 psi
$f_b \le F_b$'

$$\frac{47{,}520\ \text{in}-\text{lb}}{S_{REQ'D}} = 1{,}063\ \text{psi}$$

$S_{REQ'D}$ = 44.7 in^3
S_{2x12} = 31.6 in^3

Therefore, 2-2x12s are required because of bending.

Try 2-2x10s,

F_b' = (850 psi)(1.25)(1.2)(1.1)(1.0) = 1,403 psi

$\frac{47{,}520 \text{ in} - \text{lb}}{S_{REQ'D}}$ = 1,403 psi

$S_{REQ'D}$ = 34 in^3

S_{2x10} = 21.39 in^3

Therefore, 2-2x10s are acceptable (2x21.39 in^3 = 42.8 in^3).

g. Check horizontal shear:

$$f_v = \frac{3V}{2A} = \frac{3\ (890\ \text{lb})}{2\ (2)(1.5\ \text{in})(9.25\ \text{in})} = 48.1\ \text{psi}$$

$f_v << F_v'$

OK by inspection

h. Consider deflection:

Deflection is OK by inspection. No method exists to accurately estimate deflection of a hip rafter that is subject to significant system stiffness because of the folded-plate action of the roof sheathing diaphragm.

Conclusion

Use 2-2x10 (No. 2 Hem-Fir) for the hip rafters for the cathedral ceiling condition (not considering sloped roof sheathing system effects). However, a cathedral ceiling with a hip roof is not a common occurrence. For traditional rafter-ceiling joist roof construction, a hip rafter one or two sizes larger than the rafters can be used, particularly if it is braced at or near mid-span. With a ceiling joist or cross-ties, the ridge member and hip rafter member need only serve as plates or boards that provide a connection interface, not a beam, for the rafters.