Framing a Complex Gambrel

by Patricia Hamilton

We recently completed an oceanfront house with a complex gambrel roof. The roof was a challenge to frame for two main reasons — not only were there four large cross gables intersecting the main ridge at various heights, but the lower sections of the gambrels were curved, to create "swept" eaves.

The roof was supported with structural ridge beams and purlins — an assortment of Parallams, flitch beams, and steel I-beams (see Figure 1). In most cases, the purlins of the secondary gambrels intersected and were supported by the purlins of the main roof; in one case, the ridge of the cross gambrel was much lower and intersected the purlin of the main roof.

To complicate matters, most of the secondary gambrels had different pitches and tighter curves than the main roof — making it hard for us to visualize the framing at the valleys.

In this article, I'll describe how we laid out, framed, and finished the curved roof sections, and share some of the hindsight we picked up along the way.

Full-scale layout proved essential in this roof full of radiused rafters and elliptical valleys

Drawing on the Deck

As we studied the roof plans, we knew that the best way to be sure we made the right cuts was to lay out each roof section at full scale on the plywood deck. Trying to pull measurements directly off the prints would have been too inaccurate for this roof. A full-scale drawing would allow us to adjust for any slight errors the architect might have made, and would also give us a pattern for cutting the curved rafters.

First, we snapped horizontal lines representing the tops of the ridge and purlin beams, and the top plate of the

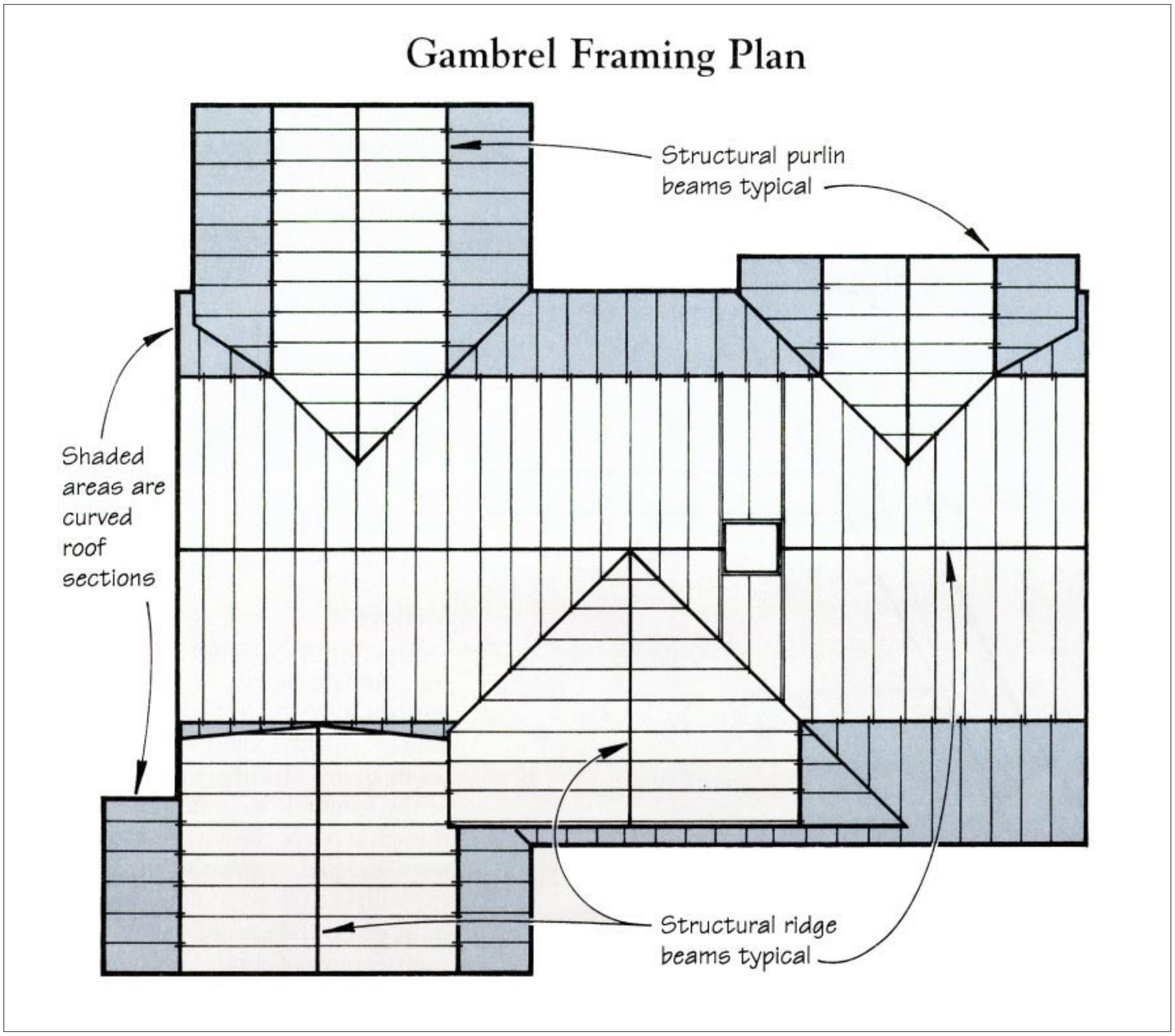

Figure 1. *This gambrel roof relies on structural ridges and purlin beams to carry the loads. The upper, flat roof planes all have a 7/12 pitch. The lower portions of the roof, from the purlins to the eaves (shaded areas), are curved sections of varying radii.*

outside bearing wall. We could pull most of these dimensions right off the drawings.

The rafters for the upper section of the roof are normal common rafters, running from the ridge to the purlin beam. We drew these at full scale, letting the tails run long.

Next, we snapped the straight sister rafter that supports the curved lower section of the gambrel (Figure 2). This rafter defines the inside ceiling and provides structural support for the curved section of the roof.

Now came the tricky stuff — scribing the curved rafters. The arc starts at the tail of the upper rafter and sweeps down to establish the eaves overhang. The curve had to stay above the plane of the straight sister rafter and clear the ends of the ceiling joists to provide a soffit. Although a radius was specified on the drawings, it took a bit of adjustment to establish the proper intersection with the top rafters and the right eaves overhang. This involved locating the center of the radius specified by the architect (Figure), scribing a test arc, then moving the center a few inches one way or another until the curve started and ended in the right place.

We found it easiest to scribe the arc using a tape measure and a pencil. The hook on the tape pivots nicely around the head of an 8d nail. We had to be careful to place our full-scale layout far enough from the edge of the deck so that we had enough room to pull the radius — the radius of the main roof curve was over 20 feet long.

Finally, we laid out the eaves and soffits, making sure we would clear windows, doors, and storm shutters below. We used the same process to lay out the smaller gambrels, changing pitch, radius, and ridge and purlin heights, as necessary.

Framing

We actually framed from the top down, starting with the common rafters in the top section of the gambrels. Next we installed the straight sister rafters, then moved on to the

Curved Rafter Construction

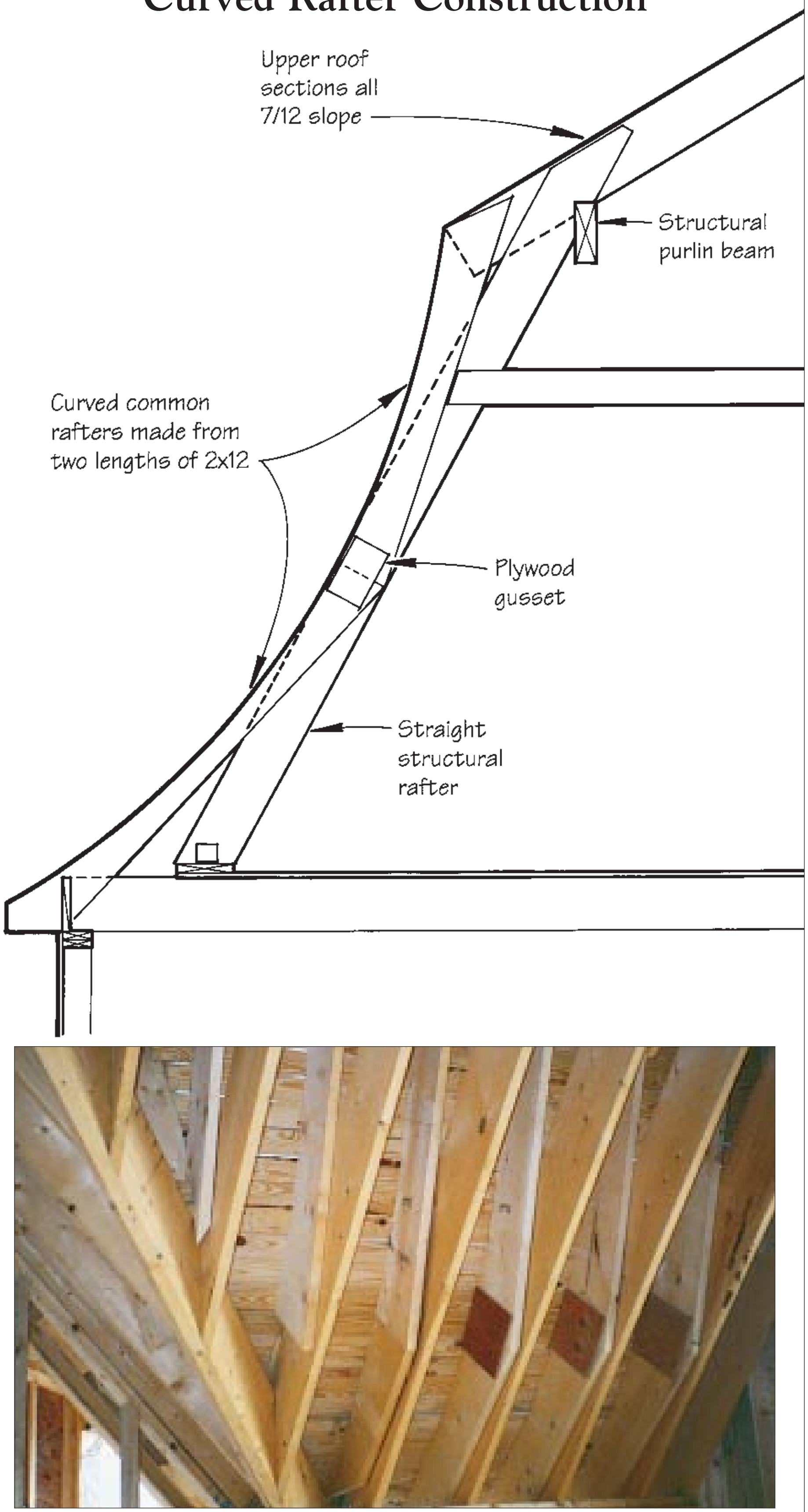

Figure 2. *To frame the curves of the main gambrel, the author first installed a straight structural rafter on the inside, running from the purlin to the floor system. She then sistered two band-sawn 2x12s, spliced in the middle with a plywood gusset (see photo), to establish the curve on the outside of the roof.*

curved sections. The straight rafter provided the structure, while the curved rafter provided nailing for the roof sheathing and shingles.

To cut the curved rafter sections, we transferred the layout lines to plywood templates, tacking the plywood to the deck and rescribing the arcs. We used $11\frac{1}{4}$-inch-wide strips of plywood, to match the 2x12 lumber we were using.

We manufactured the curved rafters off site with a band saw. The curved roof sections ranged from 12 to 16 feet in length. Rather than try to handle such long boards on the band saw, we made each curved rafter from two lengths of 2x12, spliced in the middle with a plywood gusset.

Valleys

The whole time we were installing the common rafters, we were scratching our heads, trying to figure out what the valleys would look like, and how to scribe them. The upper straight sections of the gambrels were no problem, even though most of the intersecting pitches were unequal. It was the curved part of the valleys that we couldn't visualize. In most cases, the curved valleys were the intersections of curves of different radii. Having the curved valleys in place first would have greatly sped the framing of these valleys. We later figured out a way to mathematically scribe the curved valley on the deck (see "Laying Out an Elliptical Valley), but it was too late to do us any good, on this job, anyway.

In the end, we used strings and straightedges to project the curve into the valley, after the curved common rafters on both sides were in place. To do this, we first put up a straight structural valley rafter — like the straight common rafters. We then tacked on pieces of 2x12 and scribed the curved valley rafter right in place. This worked okay, but was very tedious and broke the momentum of the framing crew.

Roof Sheathing

Once all the rafters were up, we turned to the mysteries of sheathing, flashing, and waterproofing the roof. For sheathing we used 1x4 southern pine, spaced to match the $5\frac{1}{2}$-inch shingle exposure. In valleys and on smaller dormers we laid the sheathing tight. Even in the tightest curves, the 1x4 laid into the curve smoothly.

Scribing a Curved Rafter

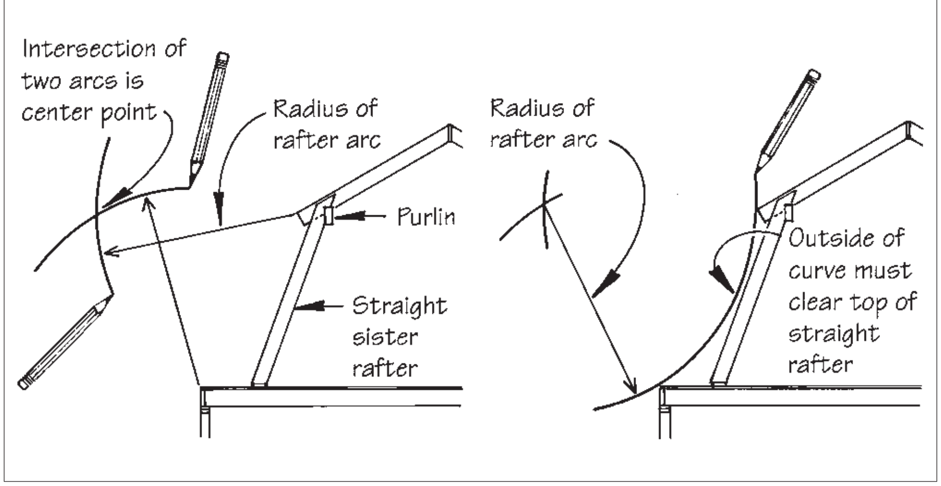

Figure 3. *To make a pattern for the curved rafters, the author laid out each gambrel at full scale on the deck. Working from the tail of the upper rafter and the edge of the floor framing, she then found the center for the radius specified on the blueprints (left) and scribed the curved rafter (right). Some adjustment of the radius was necessary to establish the correct soffit overhang.*

Figure 4. *The author's crew used string and a level to mark the cut for the rake overhang on the curved roof sections.*

The trickiest part was cutting the rake overhangs. The sheathing ran long to cover and support a rake crown molding. The end of each sheathing board had to be cut on the angle of the crown (42 degrees). Not so hard — except for snapping a chalk line on a curved, intermittent surface, 35 feet off the ground. We marked the line using a combination of string lines, straightedges, and levels — time-consuming but effective (Figure 4).

We trimmed the rakes with a 3¹/2-inch crown, which had to follow the curved sections of the roof. We use ZzzzFlex crown molding from Flex Trim Industries (11479 Sixth St., Rancho Cucamonga, CA 91730; 800/356-9060) for the curves, at a cost of around $9 per linear foot. To save money, we used a matching wood crown on the straight sections. The radius for the rake crown was ³/4 inch smaller than the radius for the rafters (since the top of the crown sits flush with the top of the sheathing). The manufacturer was very helpful in determining the right sizes to order, after the initial difficulty of describing the application. Flex Trim custom-forms the material at no extra charge to match the specific radius.

ZzzzFlex is a playful material — the carpenters likened it to installing a snake (Figure 5). Fitting the curved molding to the straight wood crown took a bit of trial and error, since the exact angle varied with each roof section. Positioning the ZzzzFlex in the chop saw was a little tricky, due to the preformed curve and the general floppiness of the material. It took two workers — one to help position the material and the other to make the cut.

The rake molding was supported at its top edge by the roof sheathing, and backed by a frieze board at the bottom.

Figure 5. *Special-order flexible molding saved the day when it came to trimming out the curved rakes. Angle blocks installed every few inches gave extra support to the floppy material.*

Figure 6. *For extra protection at valleys, the roofer first installed a self-adhering membrane, then wove a piece of flashing into every course of shingles. The shingles were scribed tight to the valley.*

Laying Out an

Here's how to lay out a curved valley rafter. But before starting in on the math, you need to understand that the valley intersection of two circular roof planes is a section of an ellipse. To picture this, take the cardboard tube from a roll of paper towels and cut it on an angle. The cut end is an ellipse. Now imagine two intersecting curved roofs as sections of giant cylinders — the valley would be a section of an ellipse (Figure A).

Scribing the Valley

You should also review the "string method" for laying out an ellipse (Figure B). This is the technique you would use to scribe an elliptical archway, for example. One caution — don't use string for job-site applications, because it stretches. Instead use a small-gauge steel wire for scribing.

To scribe the elliptical valley rafter, start with the full-size layout for the curved common rafter (Figure C). Snap two lines, one level and one vertical, through the center of the circle. Also snap level lines through the very ends of the curved common rafter. Make sure that you account for soffit overhangs. The bottom level line should go through the rafter tail, which is where the valley rafter will intersect — not where the rafter crosses the top plate.

To locate the foci, swing a radius from the bottom of the scribed circle (Point X in Figure C). Because we're dealing

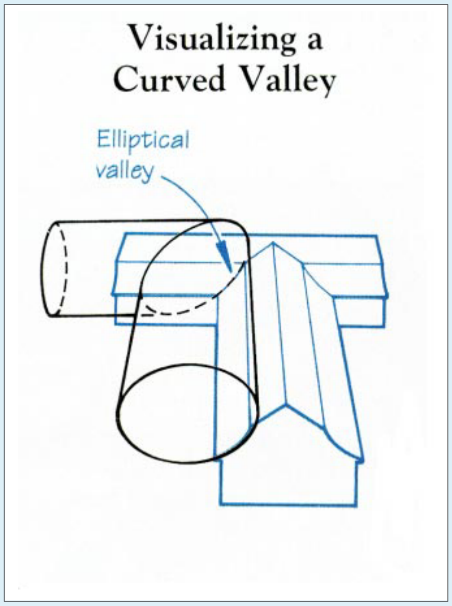

Figure A. *To visualize the elliptical valley formed by the intersection of curved roof planes, picture the roof planes as sections of giant cylinders. The end of a cylinder sliced at an angle is an ellipse.*

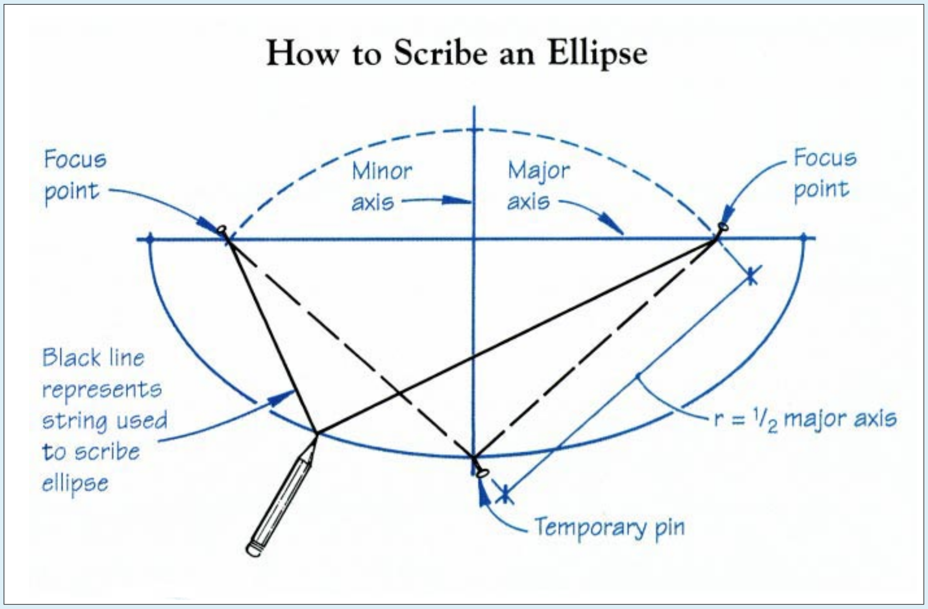

Figure B. *The size of an ellipse is defined by its minor axis and major axis. Rather than one center, an ellipse has two foci. To find the foci, swing a radius equal to 1/2 the major axis from one end of the minor axis. The two points where the radius crosses the major axis are the foci. Next, run a string from one foci around a temporary pin at one end of the minor axis to the other foci. Remove the temporary pin and use this string to scribe the ellipse.*

We also installed nailing blocks, cut at the 42-degree angle, about every 12 inches along the rake. We cut the curved frieze board sections from flat cedar stock with a jigsaw. It took two carpenters about two days to install the frieze, crown, and backer blocks on each gable end.

Flashing the Valleys

Valley flashing was a big concern, especially since we could find no literature anywhere on curved valleys. After calling consultants at the National Roofing Contractors Association (NRCA, 10255 W. Higgins Rd., Suite 600, Rosemont, IL 60018; 708/299-9070) and the Cedar Shake & Shingle Bureau (515 116th Ave. NE, Suite 275, Bellevue, WA 98004; 206/453-1323), we modified a closed valley system typically used for slate shingles. For peace of mind, we lined the valley with bituminous membrane, installed in overlapping 3-foot lengths, and installed a 10x10-inch piece of flashing behind each course of shingles. We held nails away from the valley as far as possible, and scribed the shingles for a tight fit (Figure 6).

The flashing throughout was lead-coated copper. It solders well, and the lead coating protects the copper from tannin stains from the cedar — a common problem in the oceanfront area where I build.

Shingles

We thought at first that the shingles would have to be soaked to bend them, but even dry they conformed nicely to the curve. On the tightest radius, the shingles had to bend in about $1^1/_2$ inches.

At valleys with unequal pitch and radii, the shingle exposure on the smaller roof had to be adjusted to match the exposure of the main roof. This was necessary because the distance along the tighter curves is less than the distance along the larger

Elliptical Valley

with equal-pitch roofs and a 45-degree valley, this radius equals the radius of the original circle (r) times 17/12:

$$\textit{radius of ellipse} = r \times 17/12$$

(Remember that a standard 45-degree valley rafter has a total run equal to 17/12 times the total run of the commons.)

You've now located the foci; note that they lie right on top of the circle. Attach the wire and scribe the ellipse. Where the ellipse crosses the level chalk lines defines the top and bottom of the valley rafter. You can now make a full-scale template for cutting the valley.

Unequal Valleys

Remember that with irregular valleys, the 17/12 ratio changes. If you're joining roofs with curves of different radii, the simplest solution is to figure out the total run of the valley and the total run of the commons for the smaller-radius roof. Express these numbers as the ratio of valley run (V) divided by common run (C). Substitute V/C for 17/12 in the formula above. For unequal valleys, the foci will fall inside or outside the original circle.

Always use the smaller-radius roof for scribing the ellipse, because you have less chance of running out of room on the deck. Keep in mind that you don't need enough space to scribe the total ellipse, just enough to set your foci points and scribe the relevant quadrant. — *P.H.*

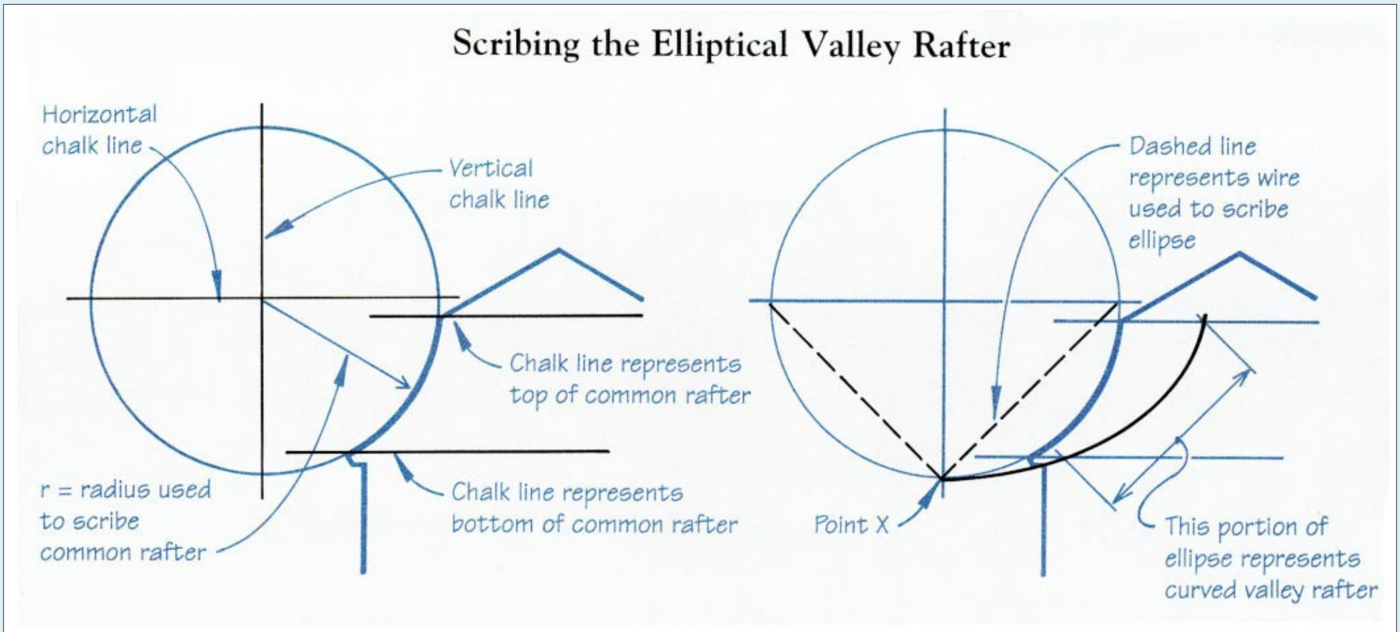

Figure C. *Starting with the full-scale layout for the curved commons, first snap a level and a vertical line through the center of the circle (left). Next. snap level lines representing the tip ends of the common rafter (remember to account for the eaves overhang). To locate the foci, swing the radius of the ellipse from the end of the minor axis (Point X in the righthand drawing). For 45-degree valleys, the radius of the ellipse equals the circle's radius times 17/12. Attach the wire at the foci as explained in Figure A and scribe the section of the ellipse that corresponds to the valley rafter.*

curves.

Where a curved roof section met a straight roof section, we used step flashing, treating those areas like a wall-roof intersection. We installed the shingles and step flashings on the lower straight rafters first, then installed the shingles on the upper roof over the step flashing. On some of the dormers, the curves created some roof sections with very low pitch. We completely covered the sheathing in these areas with membrane.

The job required so much special flashing that we paid a premium for the roof. In this area, cedar roofs normally install for $90 to $110 per square (labor only). We paid $120 per square on average — $140 on the curved roof sections and $100 on the upper straight sections.

Lessons Learned

This job required research, head scratching, and trial and error at every step of the way. This affected the schedule most significantly at the framing stage. Our framing crew is accustomed to building complex houses on pilings, but having to work out so many framing details as we went along sapped any sense of momentum. In retrospect, it would have been worthwhile to build a model ahead of time to resolve questions.

Building a model would also have helped us save lumber — the method we used for the rafters used twice to three times as much lumber as a straight gable roof would have required. With a model to help the planning process, we could have avoided sistering the rafters and instead added the curved sections right on top of the straight structural rafters. This would have saved a lot of lumber, but would have required precise planning. ■

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