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Framing Roofs



FROM THE EDITORS OF **Fine Homebuilding**

BUILDER-TESTED | CODE APPROVED

FRAMING ROOFS

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The Taunton Press

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CONTENTS



Introduction	3
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PART 1: STICK FRAMING

Cutting and Setting Common Rafters	4
Framing a Gable Roof	14
Framing a Roof Valley	26
Using a Rafter Square	36
A Different Approach to Rafter Layout	38
Framing a Hip Roof	50
Hip-Roof Framing Made Easier	60
Framing a Gambrel Roof	68
Roof Framing with Engineered Lumber	76
Cordless Framing Nailers	84



PART 2: DORMERS AND BAYS

Doghouse Dormers	90
Framing a Classic Shed Dormer	102
Framing a Dramatic Dormer	108
A Gable-Dormer Retrofit	118
Framing an Elegant Dormer	130
Framing a Bay-Window Roof	142

PART 3: TRUSS FRAMING

Raising Roof Trusses	150
Rolling Roof Trusses	162
Building Hip and Valley Roofs with Trusses	172
Credits	184
Index	185

INTRODUCTION

I often tell myself that building a new house is much easier than remodeling an old one. By “often,” I mean whenever I’m having trouble with a remodeling project, which happens most weekends. The exception to this excuse occurs when I’m working on my roof. With all of its angles and math, roof framing is intimidating. I’m much more comfortable cutting into a roof to find things where they should be, straight and square, than trying to build one that way myself.

One of my early assignments at *Fine Homebuilding* was to work with Rick Arnold on a story about framing roof valleys. When I arrived at the job site, Rick had already determined the lengths and necessary bevel cuts for the valley and jack rafters. It took Rick less time to cut all the components of the valley on the ground than it did for his crew to carry them to the roof. Watching each rafter slip perfectly into place was one of the most remarkable feats I’d seen on a job site.

Rick’s article, which you’ll find on p. 26 of this book, turned out to be more than a lesson in geometry. It was a great example of how a veteran builder plans ahead and uses modern tools, like the construction calculator, and modern materials, like the LVL ridge board and valley rafter, to simplify tricky details and improve the end result. At *Fine Homebuilding*, we’re proud to be a conduit for experienced craftsmen to share their knowledge with readers like you. Whether you’re looking to learn the basics of laying out a rafter or improve your skills on more complex roof details, there is a lot to learn in this collection of our best roof-framing articles.

—Brian Pontolilo, editor
Fine Homebuilding

Cutting and Setting Common Rafters

■ JOHN SPIER

If building a staircase is the test of a master carpenter, then building a simple gable roof must be the test of an apprentice. The gable roof is the foundation, so to speak, for almost every roof a carpenter will learn to build, from sheds to gambrels. Just about every gable roof begins with common rafters, those simple framing members that stretch from plate to ridge. There are many ways to approach cutting and installing common rafters; here's the one I use most often.

Start with Straight, Plumb Walls

Every good roof starts with good wall framing. The bearing walls that carry the rafters and the roof need to be straight, square, plumb, and parallel to each other. If they're not, fix them now, or the roof framing will never be right.

I start by checking the distance between the plates at the ends of each roof section, both at the floor and at the top plate (see photo 1 on p. 6). With the wall corners braced plumb, all four measurements should

be the same. If the floor is square to begin with and the walls are either sheathed or braced so that they can't rack diagonally, the top plates should also be square to each other. I check for square by measuring the diagonals, which should also be the same or at least within a 1/4-in. tolerance.

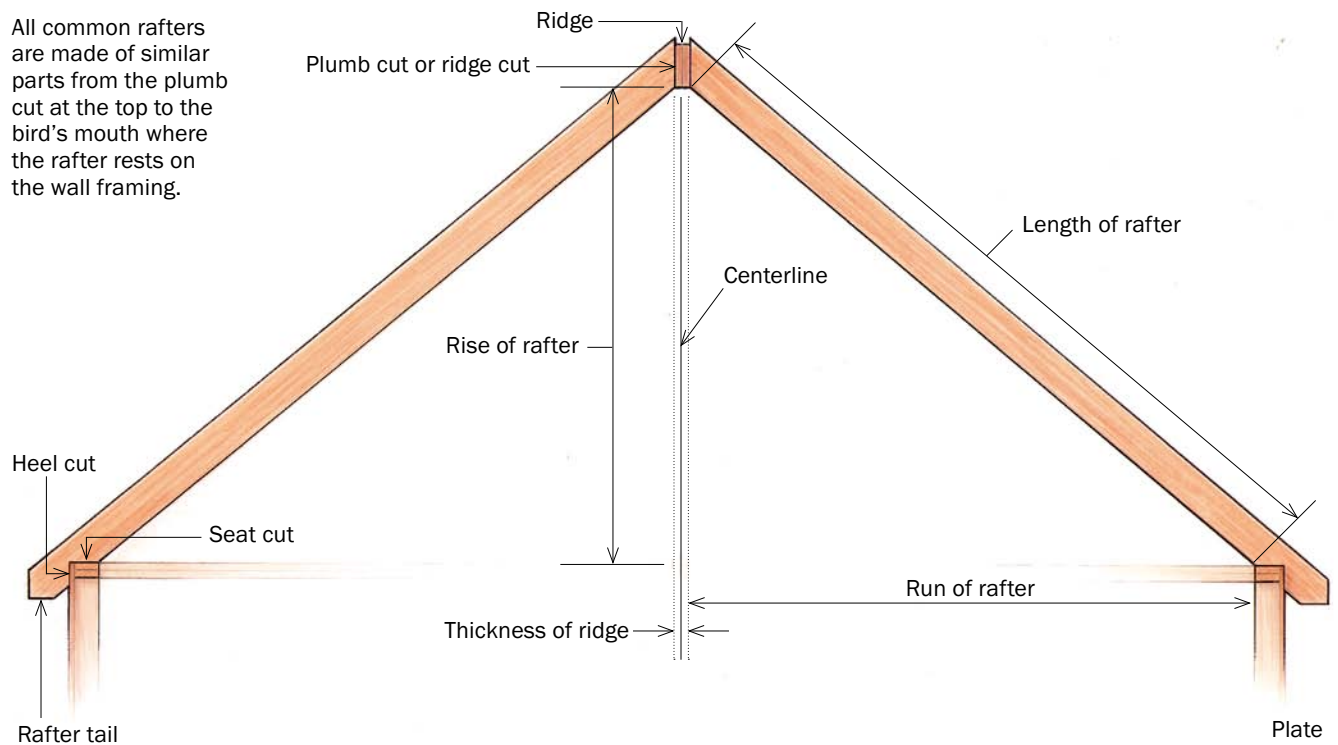
Next I stretch a line (usually yellow mason's string; see photo 2 on p. 6) inside the top plates of each wall. I use blocks at each end to space the string away from the wall. A third block makes a quick gauge to check the straightness of the wall (see photo 3 on p. 6). The walls then are held plumb and straight with 2x braces every 8 ft. or so. If interior walls have top plates that lap over outside walls, I put diagonal braces on them.

Simple Math and a Calculator

There are many ways to lay out common rafters, but I stick to the simplest approach using math, geometry, and a calculator (photo on the facing page). I also work from the

Common-Rafter Elements

All common rafters are made of similar parts from the plumb cut at the top to the bird's mouth where the rafter rests on the wall framing.



bottom edge of the rafter rather than working from the theoretical line traditionally used when calculating rafters. With my approach, the length I find is between two definite measurable points: the bottom corner of the ridge cut and the beginning of the seat cut. To find the length of the bottom edge of the rafter, I start with the desired roof pitch and the inside plate-to-plate measurement.

From that measurement, I subtract the thickness of the ridge and divide that number in half to give me the run dimension for the rafter (see “Let’s Do the Numbers” at right). Next I set up a simple proportion using the roof pitch to find the rise dimension. Once I’ve determined the rise and run of the rafter, I use geometry to find the rafter length. Square the rise, square the run, add the two, and take the square root of the sum.

Construction calculators are programmed to do this automatically and have the benefit of calculating in feet and inches, but any calculator with a square-root function will do.

LET’S DO THE NUMBERS

Find run of rafter

$$\begin{aligned} &277\frac{5}{8}\text{ in.} \quad (\text{plate to plate}) \\ &- 3\frac{1}{2}\text{ in.} \quad (\text{double LVL ridge}) \\ &274\frac{1}{8}\text{ in.} \\ &\div 2 \\ &137\frac{1}{16}\text{ in.} \quad (\text{run of rafter}) \end{aligned}$$

Find rise of rafter

Set up a proportion, cross-multiply, and divide

$$\begin{aligned} \frac{X}{137\frac{1}{16}\text{ in.}} &= \frac{10}{12} \quad (\text{roof pitch}) \\ 12 \times X &= 10 \times 137\frac{1}{16}\text{ in.} \\ X &= (10 \times 137\frac{1}{16}\text{ in.}) \div 12 \\ X &= 114\frac{1}{4}\text{ in.} \quad (\text{rise of rafter}) \end{aligned}$$

Find length of rafter

$$\begin{aligned} (137\frac{1}{16}\text{ in.})^2 + (114\frac{1}{4}\text{ in.})^2 &= 31839.19 \\ \sqrt{31839.19} &= 178\frac{7}{16}\text{ in.} \end{aligned}$$

Handy Tip: If you don’t have a calculator, pick a big room with square walls. Measure rise along one wall and run along another. Then string a tape between the two points for the length of rafter.



Here are the rafter calculations for the roof featured in this article.

Straighten the Walls First

Before the rafters can be cut and installed, the walls have to be straight, plumb, and square. First, plate-to-plate measurements are taken at both ends of each roof section at the inside of the plates (photo 1). Lines stretched along the walls (photo 2) are gauged straight with a block (photo 3).



The First Rafter Is a Pattern

Armed with these figures, I'm ready to lay out the first rafter. I select a nice, straight piece of rafter stock for a pattern (see photo 1 on the facing page) and mark the direction of the crown, or the bend along the edge, if any.

Every common rafter has a ridge cut or a plumb cut at one end and a bird's mouth and a tail at the other end where the rafter fits over the wall plate. The roof pitch deter-

mines the plumb-cut angle, which I mark using a triangular rafter square (see photo 2 on the facing page), such as a Speed® Square.

Today's framing codes require that the bottom of the rafter's ridge cut must bear fully on the ridge, although the top point of the cut may be left as much as an inch high to facilitate ridge-venting. The length of the plumb cut determines the minimum width of the material needed for the ridge.

Measuring along the bottom edge of the rafter from the short point on the plumb cut, I mark the rafter length on the stock.

The Pattern Rafter: A Template for the Roof

After finding the length of the rafter, a straight piece of rafter stock is selected (photo 1). A rafter square sets the angle for the ridge cut (photo 2), and the length of the rafter is measured down from the short point. The bird's mouth and rafter tail are drawn full scale with all the trim and soffit detail (photo 3) before the pattern is cut to make sure all the details fit properly.



This mark is where I begin the seat cut for the bird's mouth of the rafter. The angle of the seat cut, or the flat part of the notch, is the complement of the plumb-cut angle. The roof in this project had a 10-in-12 pitch with a plumb cut of 40° . So the seat-cut angle, or complement, is 90° minus 40° , or 50° .

The length of the seat cut is the width of the wall plate plus the thickness of the sheathing. Another plumb cut, called the heel cut, for the outside of the wall, completes the bird's mouth.

The rafter tail is the part that carries the roof overhang and trim. I lay out the tail by drawing a full-scale picture of the roof-trim and soffit details on the pattern rafter (see photo 3 above). Details include the vent, subfascia, blocking, frieze, and anything else that affects the framing. When my drawing is complete, I cut out the pattern rafter and mark it as such.

Laying Out the Ridge and Plates



Rafters Should Align with the Studs

A good roof-framing layout starts on the first floor. I always try to line up the studs in the second-floor walls with those on the first floor and then have the rafters land directly over the studs (see photo 1 above). A unified layout all the way through the house simplifies work for the subs and trim carpenters, provides good nailing for code-required steel

connectors, and improves the structural integrity of the house.

On the wall plates, I lay out all the common-rafter locations, and also the double and triple common rafters for openings such as skylights, cupolas, chimneys, and dormers. I then transfer all these layout marks to the ridge (see photo 2 above), making sure to keep track of which side of the ridge goes where. When the layout is finished, I count the number of rafters I need.



To keep the house framing consistent, rafters should fall directly over the studs and joists (photo 1). Rafter layout is transferred to the ridge (photo 2). The ridge is then set on temporary posts (photo 3), and a test fit of the first two rafters braces the ridge while it's eyeballed for straightness (photo 4).



Setting the Stage

If the roof has ceiling joists that sit directly on the bearing walls, I can put the joists on now and use them as staging. If not, or if the ridge is too high to reach comfortably, I take the time to set up staging.

I like to be able to walk along each side of the ridge with the tops of the rafters just about head high so that I can nail the rafters comfortably but still duck under them easily. A couple of sections of pipe staging with

planks is the easiest approach, but I've also set many ridges on simple staging site-built out of 2x6s and extra rafter stock.

If you're short or if the bearing walls are more than 5 ft. tall, it's also helpful to have staging set up for lifting and nailing the rafters onto the walls, either from the inside or from the outside. We often set up wall brackets outside at a height convenient for installing sheathing, trim, and roofing.

Production Rafter Cutting

After the pattern rafter has been tested, plywood blocks are nailed to each end (photo 1). The blocks register the pattern on the rafter stock while a crew member at each end traces the pattern (photo 2). The ends are then cut at the same time (photo 3), and the finished rafter is set aside.





Test Rafters Brace the Ridge

Our ridges used to be a single thickness of 2x lumber, often toenailed together or gusseted with scraps of plywood. With today's wind-loading codes and cathedral-ceiling spaces, ridges are more likely to be built-up assemblies of LVLs or other materials engineered to carry some of the roof load.

If posts are incorporated into the gables or interior walls that support the ridge, I build and stand them now, using temporary braces to hold them plumb. If there are no permanent posts in the structure, I cut temporary props to hold the ridge and to keep it from sagging until the roof is sheathed (see photo 3 on p. 8). The post height equals the rise of the rafter plus the height of the walls. I like to have the first couple of rafters cut at this point.

In theory, my pattern rafter is perfect, but before I cut a whole pile of stock, I test-fit a couple of rafters to make sure I haven't made any stupid mistakes. And because I also hate to waste time by moving anything twice, the first two rafters are used to brace the ridge in place (see photo 4 on p. 9). If I'm not ready to set the ridge, I test the rafters by inserting a small block of wood the same thickness as the ridge between the ridge cuts.

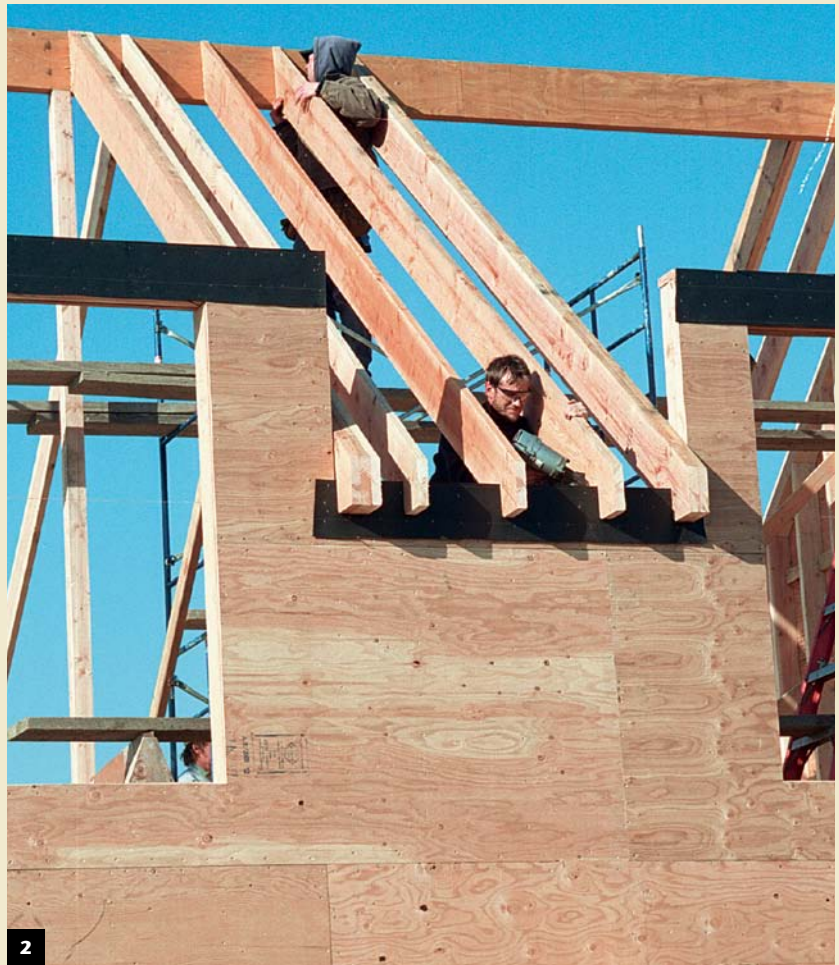


Rafter Cutting, Tag-Team Style

When I'm satisfied that my pattern rafter is good, I set up the rafter-cutting operation. First, I nail blocks (usually plywood scraps) on the top edge of the pattern rafter at each end, one directly over the ridge cut and the other over the seat of the bird's mouth (see photo 1 on the facing page). These blocks ensure that each rafter is uniform so that the ridge and eave stay straight and that differences in rafter width and crown don't affect the finished frame.

The Rafters Go In

It's easiest to set rafters with three crew members (photo 1): one at the ridge, one at the plate, and another passing up the rafters. The plate end is nailed in first while the ridge end is held up slightly (photo 2). When the rafters are in, steel connecting plates are installed (photo 3), followed by the ceiling joists (photo 4).



Now I set up an on-site rafter factory. Two of the crew members mark the crown on the stock and then stack it near the cutting station. Any pieces with excessive crown or bow are rejected.

At the cutting station, stock is stacked on sawhorses with the crowns facing the same direction. The pattern rafter is placed on each piece with the crown at the top edge, and the cuts are marked (see photo 2 on pp. 10–11). Then one crew member makes the plumb cut while the other cuts the bird's mouth and rafter tail (see photo 3 on pp. 10–11). These cuts have to be accurate; sloppy cuts translate into humps or hollows in the roof, which my competitors will gleefully discuss at the coffee shop.

When I'm cutting the bird's mouth, it's generally acceptable to overcut with the circular saw to finish the notch. The exceptions to this rule are when the notch goes more than two-thirds of the way across the rafter and when the tail has to support a wide roof overhang. In these two cases, I cut to the corner with a circular saw and finish with a sharp handsaw.

Nail the Bird's Mouth First

Setting rafters is best done as a team with one person at the ridge, another at the eave, and a third lifting the rafters into position (see photo 1 on the facing page). I like to set an opposing pair of rafters every 6 ft. to 8 ft. to hold the ridge straight at intermittent points. Then I check the ridge for straightness, by eye or with a stringline.

It's best to nail the lower end of each rafter first while the person at the ridge holds the rafter slightly high (see photo 2 on the facing page). Nailing the ridge first tends to push the bird's mouth outward. After the ridge is stabilized and straight, I fill in the remaining commons, alternating from side to side every few rafters. Once the rafters are in place, I cast a critical eye along the ridge

and eaves. Now is the last easy chance to fix or replace any rafters that are not in line or in plane with the rest.

Final Framing Details

When all the common rafters are in place, I install the metal rafter ties (see photo 3 on the facing page), and I put in as many of the cathedral-ceiling joists as possible (see photo 4 on the facing page). I then turn my attention to the rest of the roof-framing details such as chimney and skylight openings and dormers. Getting the common rafters right goes a long way toward getting the rest of the roof right, and many of the same concepts and methods apply to other parts of the roof as well.

John Spier builds and renovates custom homes and is a frequent contributor to Fine Homebuilding magazine. He and his wife, Kerri, own and operate Spier Construction, a general-contracting company on Block Island, Rhode Island.

Setting rafters is best done as a team with one person at the ridge, another at the eave, and a third lifting the rafters into position.

Framing a Gable Roof

■ LARRY HAUN

One of my earliest and fondest memories dates from the 1930s. I remember watching a carpenter laying out rafters, cutting them with a handsaw, and then, over the next several days, artfully and precisely constructing a gable roof. His work had a fascinating, almost Zen-like quality to it. In a hundred imperceptible ways, the roof became an extension of the man.

But times change, and the roof that took that carpenter days to build now takes pieceworkers (craftspersons who get paid by the piece and not by the hour) a matter of hours. Since they first appeared on job sites, pieceworkers have given us new tools, ingenious new methods of construction, and many efficient shortcuts. But what skilled pieceworkers haven't done is sacrifice sound construction principles for the sake of increased production. The opposite is true; they've developed solid construction procedures that allow them to keep up with demand, yet still construct a well-built home.

The secret to successful piecework, from hanging doors to framing roofs, is to break down a process into a series of simple steps. To demonstrate just how easy roof framing can be (with a little practice), I'll describe how to cut and stack a gable roof the way pieceworkers do it.

The Rafter Horse

To begin with, pieceworkers try to avoid cutting one piece at a time. They'll build a pair of simple horses out of 2x stock so that they can stack the rafters on edge and mark and cut them all at once. To build the rafter horses, lay four 3-ft.-long 2x6s flat and nail a pair of 2x blocks onto each, with a 1½ in. gap between them so that you can slip in a long 2x6 or 2x8 on edge (see the bottom photo on the facing page). An alternate method is to cut a notch 1½ in. wide by about 4 in. deep into four scraps of 4x12. Then you can slip a long 2x6 or 2x8 on edge into these notches. Either of these horses can easily be broken down and carried from job to job. The horses hold the rafters off the ground, providing plenty of clearance for cutting.

Cutting the Rafters

Rafters can be cut using a standard 7¼-in. sidewinder or worm-drive circular saw. This isn't the first choice for most pieceworkers, who prefer to use more specialized tools (especially when cutting simple gable roofs). But it is the more affordable choice for most custom-home builders. If you are using a



The key to production roof framing is to minimize wasted motion. Here, carpenters nail gable studs plumb by eye—there's no need to lay out the top plates. The next step is to snap a line across the rafter tails and cut the tails off with a circular saw.



TIP

If you are using a standard circular saw, load rafter stock on the horses with their crowns, or convex edges, facing up—same as the rafters will be oriented in the roof frame.

Pieceworkers typically build a pair of simple portable rafter horses. The horses allow them to stack rafters off the ground on edge so that they can mark and cut the rafters all at once.



One way to lay out rafters is with a site-built rafter tee. The fence on top of the tee allows easy scribing of the ridge cuts and bird's mouths. When laid out this way, rafters are cut one at a time with a circular saw.

standard circular saw, load rafter stock on the horses with their crowns, or convex edges, facing up—same as the rafters will be oriented in the roof frame.

Determine which end of the stack will receive the plumb cuts for the ridge and flush this end. An easy way to do this is to hold a stud against the ends and pull all the rafters up against it. Then measure down from this end on the two outside rafters in the stack and make a mark corresponding to the heel cut of the bird's mouth (the notch in the rafter that fits over the top plate and consists of a plumb heel cut and a level seat cut). Snap a line across the tops of the rafters to connect the marks.

Next, make a rafter pattern, or layout tee, for scribing the ridge cuts and bird's mouths (see the photo above). I usually start with a 2-ft.-long 1x the same width as the rafters. Using a triangular square such

as a Speed Square from Swanson® Tool Co., scribe the ridge cut at one end of the template. Then move down the template about one foot and scribe the heel cut of the bird's mouth, transferring this line across the top edge of the template. This will serve as your registration mark when laying out the bird's mouths.

The layout of the bird's mouth on the tee depends on the size of the rafters. For 2x4 rafters, which are still used occasionally around here, measure 2½ in. down the plumb line and scribe the seat cut of the bird's mouth perpendicular to the plumb line. Leaving 2½ in. of stock above the plate ensures a strong rafter tail on 2x4 rafter stock. One drawback to this is that for roof pitches greater than 4-in-12, 2x4 rafters will have less than a 3½-in.-long seat cut. Consequently, the rafters won't have full bearing on a 2x4 top plate. However, this presents



To save time, ridges can be gang-cut with a 16-in. beam saw. Though these saws won't cut all the way through anything wider than a 2x4 at a 4-in-12 pitch, where necessary each cut can be completed using a standard circular saw.

no problems structurally as long as the rafters are stacked, nailed, and blocked properly (check your local building code for the minimum bearing). For 2x6 or larger rafters, you can make the seat cuts $3\frac{1}{2}$ in. long without weakening the tails.

Once the layout tee is marked and cut, nail a 1x2 fence to the upper edge of the tee. This allows you to place the tee on a rafter and mark it quickly and accurately. Make sure you position the fence so that it won't keep you from seeing the ridge cut or your registration mark. Use the layout tee to mark the ridge cut and bird's mouth on each rafter. Scribe all the ridges first at the flush ends of the stock, sliding the rafters over one at a time. Then do the same for the seat cuts, aligning the registration mark on the template with the chalk marks on the rafters.

Next, with the rafters on edge, cut the ridges with your circular saw, again moving the rafters over one at a time. Then flip the rafters on their sides and make the seat cuts, overcutting just enough to remove the bird's mouths.



An alternate method for making ridge cuts is to use a Linear Link® saw, a Skil® worm-drive saw fitted with a bar and chain.



One method for gang-cutting bird's mouths is to cut the heels with a worm-drive saw (above) and the seats with a worm-drive saw fitted with a swing table, an accessory base that adjusts from -5° to 68° (right).

Cutting common rafters with production tools is both fast and easy.

Production Rafter Cutting

Cutting common rafters with production tools is both faster and easier than the method I've just described. In this case, you'll want to stack the rafters on edge but with their crowns facing down. Flush up the rafters on one end and snap a chalkline across them about 3 in. down from the flush ends (the greater the roof pitch and rafter width, the greater this distance). The chalkline corresponds to the short point of the ridge plumb cut. Snap another line the appropriate distance (the common-rafter length) from this point to mark the heel cuts of the bird's mouths. Then measure back up from this mark about $2\frac{1}{2}$ in. and snap a



third line to mark the seat cut of the bird's mouth. This measurement will vary depending on the size of the rafters, the pitch of the roof, and the cutting capacity of your saw (more on that later).

Now gang-cut the ridge cuts using a beam saw (see the top photo on p. 17). Blocks nailed to the top of the rafter horses will help hold the stack upright. My 16-in. Makita® beam saw will cut through a 2x4 on edge at more than an 8-in-12 pitch and will saw most of the way through a 2x6 at a 4-in-12 pitch. To determine the angle at which to set your saw, use a calculator with a tangent key or, just as easy, look up the angle in your rafter-table book.

For steeper pitches or wider stock, make a single pass with the beam saw (or a standard circular saw) and then finish each cut with a standard circular saw, moving the rafters over one at a time. This way the only mark needed is the chalkline. The kerf from the first cut will accurately guide the second cut.

To make the process go even faster, apply paraffin to the sawblade and shoe. Also try to stay close to your power source. If you have to roll out 100 ft. of cord or more, the saw will lose some power and won't operate at its maximum efficiency.

Another method for cutting ridges is to use the Linear Link model VCS-SK12 saw (see the bottom photo on p. 17). The model VCS-SK12 is a Skil worm-drive saw fitted with a bar and cutting chain that lets the saw cut to a depth of 12 in. at 90°. It's adjustable to cut angles up to 45°. You can buy the saw or a conversion kit that will fit any Skil worm drive.

With the right tools, the bird's mouths can also be gang-cut with the rafters on edge. Gang-cutting bird's mouths works especially well because you needn't overcut the heel or the seat cut, which weakens the tail. For the heel cuts, set your worm-drive saw to the same angle as the ridge cut and to the proper depth, and then make a single cut across all the rafters (see the left photo on the facing page).

Seat cuts are made using a 7¼ in. or, better yet, 8¼-in. worm-drive saw fitted with a swing table. A swing table replaces the saw's standard saw base and allows the saw to be tilted to angles up to 68° (see the right photo on the facing page). I bought mine from Pairis Enterprises and Manufacturing. Set the swing table to 90° minus the plumb-cut angle (for example, 63½° for a 6-in-12 roof) and make the seat cuts, again in one pass.

The only drawback to using a swing table with a worm-drive saw is that it won't allow a substantial depth of cut at sharp angles, so it limits the amount of bearing that the rafters will have on the top plates (about 2½ in. maximum with an 8¼-in. saw). Again, this is of little concern if the roof is framed properly. Once you get used to working with these production tools, you'll find that it takes longer to stack the rafters than to cut them. With the rafters cut, you can now carry them over to the house and lean them against the walls, ridge-end up. The rafter tails will be cut to length in place later.

Staging and Layout

Now it's time to prepare a sturdy platform from which to frame the roof. The easiest way is to simply tack 1x6s or strips of plywood across the joists below the ridge line to create a catwalk (the joists are usually installed before the roof framing begins). Run this catwalk the full length of the building. If the ridge works out to be higher than about 6 ft., pieceworkers will usually frame and brace the bare bones of the roof off the catwalk and then install the rest of the rafters while walking the ridge.

For added convenience, most roof stackers install a hook on their worm-drive saws that allows them to hang their saw from a joist or rafter. When not in use, the hook folds back against the saw and out of the way.

The next step is to lay out the ridge. Most codes require the ridge to be one size larger than the rafters to ensure proper bearing

Most codes require the ridge to be one size larger than the rafters to ensure proper bearing.

No layout is necessary on the top plates for the rafters.

(2x4 rafters require a 1x6 or 2x6 ridge). Make sure to use straight stock for the ridge. In the likely event that more than one ridge board is required to run the length of the building, cut the boards to length so that each joint falls in the center of a rafter pair. The rafters will then help to hold the ridge together. Let the last ridge board run long—it will be cut to length after the roof is assembled.

Be sure to align the layout of the ridge to that of the joists so that the rafters and joists will tie together at the plate line. If the rafters and joists are both spaced 16 in. o.c., each rafter will tie into a joist. If the joists are spaced 16 in. o.c. and the rafters 24 in. o.c., then a rafter will tie into every fourth joist. Regardless, no layout is necessary on the top plates for the rafters. Rafters will either fall next to a joist or be spaced the proper distance apart by frieze blocks installed between them. Once the ridge is marked and cut, lay the boards end to end on top of the catwalk.

Nailing It Up

Installation of the roof can be accomplished easily by two carpenters. The first step is to pull up a rafter at the gable end. While one carpenter holds up the rafter at the ridge, the other toenails the bottom end of the rafter to the plate with two 16d nails on one side and one 16d nail (or backnail) on the other. The process is repeated with the opposing rafter. The two rafters meet in the middle and hold each other up temporarily, unless, of course, you're framing in a Wyoming wind. If that's so, nail a temporary 1x brace diagonally from the rafters to a joist.

Next, move to the opposite end of the first ridge section and toenail another rafter pair in the same way. Now reach down and pull up the ridge between the two rafter pairs. There is no need to predetermine the ridge height. Drive two nails straight through the ridge and into the end of the first rafter, then angle two more through the ridge into the opposing rafter. To keep from dulling a sawblade when you're sheathing

the roof, avoid nailing into the top edge of a rafter. At this point, nail a 2x4 leg to the ridge board at both ends to give it extra support. If these legs need to be cut to two different lengths to fit beneath the ridge, it means that the walls probably aren't parallel and, consequently, that the ridge board isn't level. In this case, yank the nails out of the rafter pair at the top plate on the high end of the ridge and slide out the rafters until the ridge is level. The key to avoiding all this hassle is, of course, to make sure the walls are framed accurately in the first place.

Next, plumb this ridge section. This can be accomplished in a couple of ways. One way is to nail a 2x4 upright to the gable end ahead of time so that it extends up to the height of the ridge. This allows you to push the end rafters against the upright and to install a 2x4 sway brace extending from the top plate to the ridge at a 45° angle. This is a permanent brace. Nail it in between the layout lines at the ridge.

A second method is to use your eye as a gauge. Sighting down from the end of the ridge, align the outboard face of the end rafters with the outside edges of the top and bottom plates, and then nail up a sway brace. Either way, the ridge can be plumbed without using a level. This means carrying one less tool up with you when you stack the roof.

With the bare bones of the first ridge section completed, raise the remaining ridge sections in the same way, installing the minimum number of rafter pairs and support legs to hold them in place. When you reach the opposite end of the building, eyeball the last rafter pair plumb, scribe the end cut on the ridge (if the ridge is to be cut at the plate line), slide the rafters over a bit, and cut the ridge to length with a circular saw. Then reposition the rafters and nail them to the ridge. Install another sway brace to stabilize the entire structure.

Now stack the remaining rafters, installing the frieze blocks as you go. Nail through the sides of the rafters into the blocks, using two 16d nails for up to 2x12 stock and three



Pieceworkers don't waste time predetermining the ridge height. Instead, they toenail a pair of rafters to the top plates at either end of the ridge board, then raise the ridge board between the rafters and nail the rafters to it with 16d nails. A 2x4 sway brace is installed before the intermediate rafters are nailed up.

16d nails for wider stock. Where a rafter falls next to a joist, drive three 16d nails through the rafter into the joist to form a rigid triangle that helps tie the roof system together.

Blocking a Gable Roof

In some parts of the country, blocking is not installed between the rafters at the plate. But in many areas, building codes require blocks. I think they're important. They stabilize the rafters, provide perimeter nailing for roof sheathing, and tie the whole roof system

together. They also provide backing or act as a stop for siding or stucco. If necessary, they can easily be drilled and screened for attic vents.

There are two methods for blocking a gable roof (see the drawings on p. 23). The first is to install the blocking plumb so that it lines up with the outside edge of the top plate, allowing the blocks to serve as backing for the exterior siding or stucco. This requires the blocking to be ripped narrower than the rafters. The other method is to

TIP

To keep from dulling a sawblade when you're sheathing the roof, avoid nailing into the top edge of a rafter.

Roof Framing Tips

Check your blueprints for the roof pitch, lengths of overhangs, rafter spacing, and size of the framing members, but *don't* rely on the blueprints to determine the span. Instead, measure the span at the top plates. Measure both ends of the building to make sure the walls are parallel; accurate wall framing is crucial to the success of production roof framing.

Once you've determined the length of the rafters, compensate for the thickness of the ridge by subtracting one half the ridge thickness from the length of the rafters. Though theoretically this reduction should be measured perpendicular to the ridge cut, in practice for roofs pitched 6-in-12 and under with 2x or smaller ridges, measuring along the edge of the rafters is close enough. For 2x ridge stock, that means subtracting $\frac{3}{4}$ in. from the rafter length. An alternative is to subtract the total thickness of the ridge from the span of the building before consulting your rafter book.

Once you've figured the common-rafter length, determine the number of common rafters you need. If the rafters are spaced 16 in. o.c., divide the length of the building in feet by four, multiply that figure by three, and then add one more. That will give you the number of rafters on each side of the roof. If there are barge rafters, add four more rafters. If the rafters are spaced 24 in. o.c., simply take the length of the building in feet and add two, again adding four more to the total if barge rafters are called for.

install the blocking perpendicular to the rafters just outside the plate line. The blocking provides a stop for the siding or stucco, eliminating the need to fit either up between the rafters. Also, there's no need to rip the blocking with this method, which saves time. Either way, blocks are installed as the rafters are nailed up. Sometimes blocks need to be cut a bit short to fit right. Rafter thickness can vary from region to region (usually it's related to moisture content), so check your rafter stock carefully.

Collar Ties and Purlins

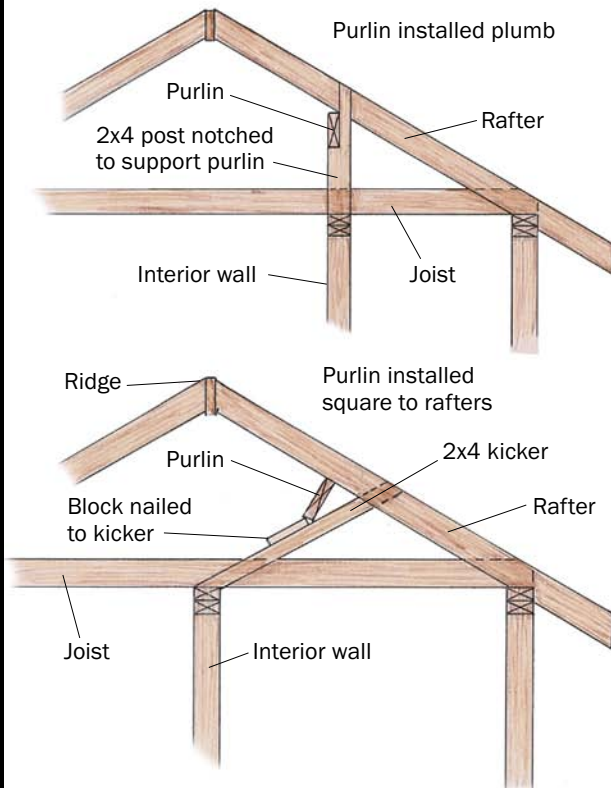
In some cases, building codes require the use of collar ties to reinforce the roof structure or purlins to reduce the rafter span (see the drawings on p. 23). Collar ties should be installed horizontally on the upper third of the rafter span. They're usually made of 1x4 or wider stock, placed every 4 ft., and secured with five 8d nails on each end so that they tie the opposing rafters together.

Purlins should be placed near the middle of the rafter span. They can be toenailed to the rafters either plumb or square. If there's an interior wall beneath the center of the rafter span, install the purlin plumb and directly over the wall. This makes it easy to support the purlin with several 2x4 posts that bear on the top plate of the interior wall. The 2x4s are notched so that they both support the purlin and are nailed to the sides of the rafters.

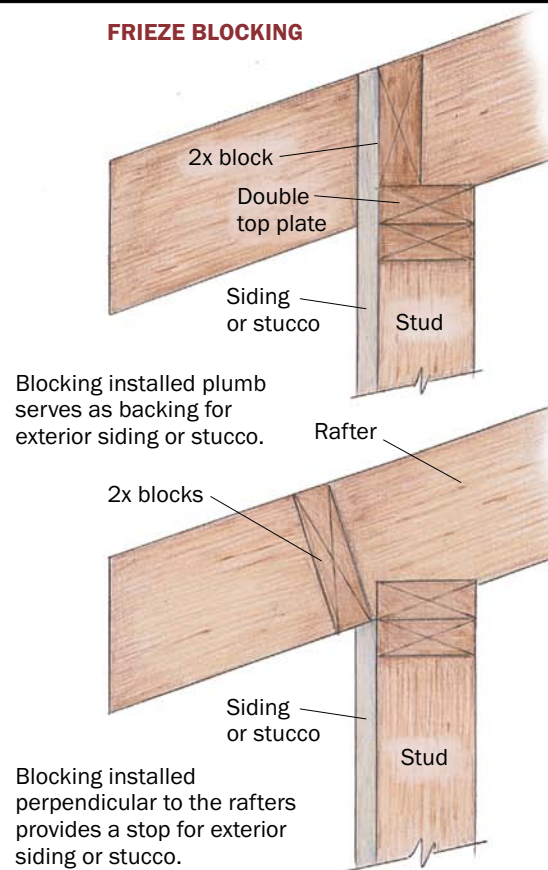
If there isn't a wall beneath the center of the rafter span, toenail the purlin square to the rafters and install 2x4 kickers up from the nearest parallel wall at an angle not exceeding 45°. A block nailed to each kicker below the purlin will hold the purlin in place. Kickers are typically installed every 4 ft. Large purlins such as 2x12s require fewer kickers.

Purlins and Blocking

PURLIN INSTALLATION



FRIEZE BLOCKING



In some parts of the country, rafters have to be tied to the top plates or blocking with framing anchors or hurricane ties for added security against earthquakes or high winds. Check your local codes.

Framing the Gable Ends

Gable ends are filled in with gable studs spaced 16 in. o.c. Place the two center studs (on either side of the ridge) 14 in. apart. This leaves enough room for a gable vent, which allows air to circulate in the attic. Measure the lengths of these two studs, then calculate the common difference of the gable studs, or the difference in length between successive studs. Then you can quickly determine the lengths of the remaining studs. A pocket calculator makes it easy.

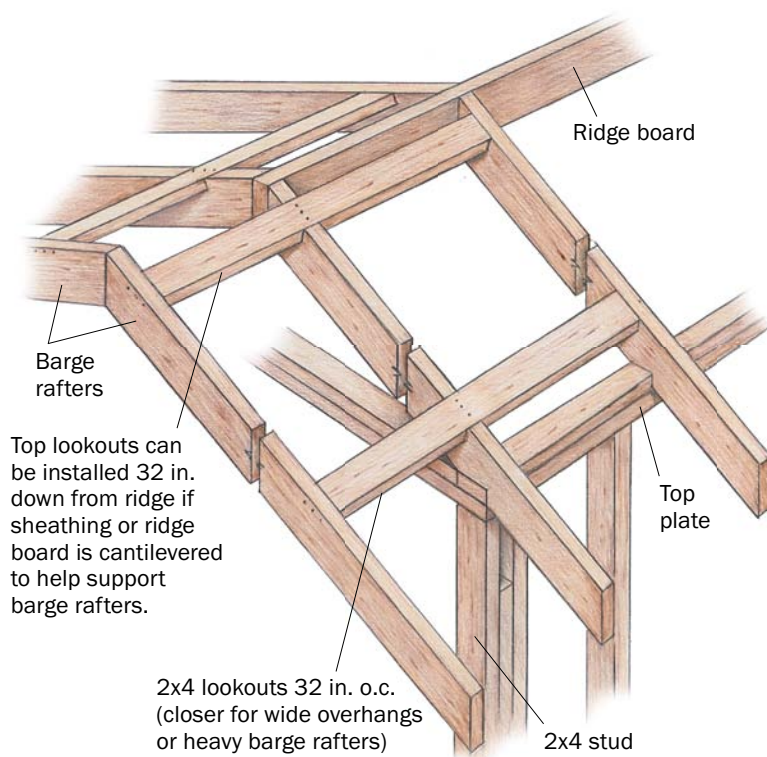
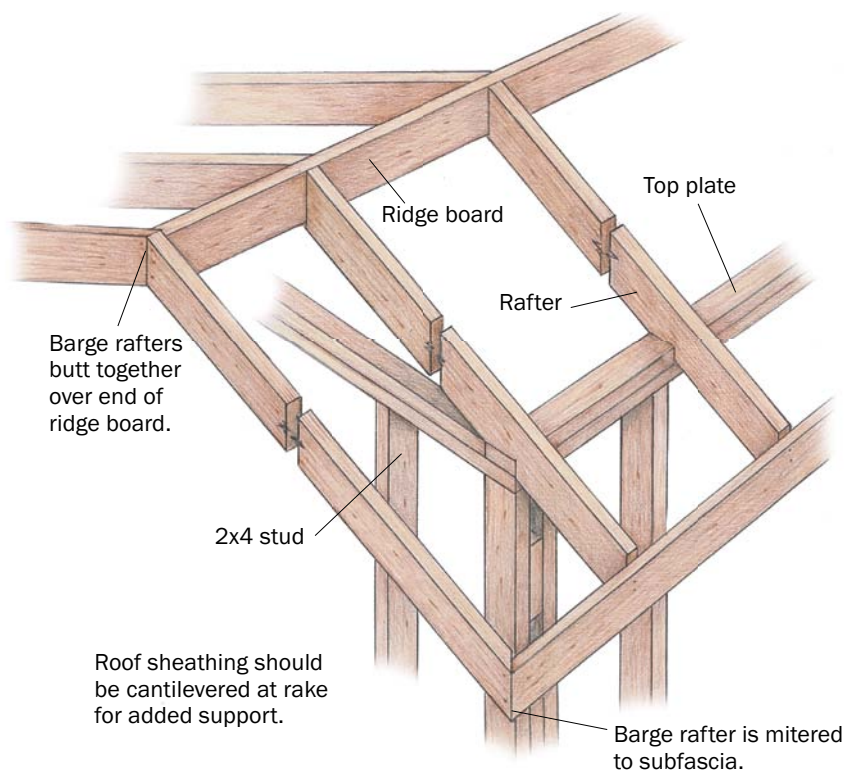
For a 4-in-12 roof pitch, the equation goes like this: $4 \div 12 \times 16 = 5.33$. Four equals the rise, 12 the run, and 16 the on-center spacing. The answer to the problem, 5.33, or $5\frac{3}{8}$ in., is the common difference. Another way to calculate this is to divide the unit rise by three and add the answer and the unit rise together. For a 4-in-12 pitch, $4 \div 3 = 1.33 + 4 = 5.33$. For the angle cuts, set your saw to the same angle as that of the plumb cut on the rafters. Cut four gable studs at each length, and you'll have all the gable studs you'll need for both gable ends.

Once the gable studs are cut, nail them plumb using your eye as a gauge. There is no need to lay out the top plates or to align the gable studs with the studs below. Be careful not to put a crown in the end rafters when you're nailing the gable studs in place.

TIP

In some parts of the country, rafters have to be tied to the top plates or blocking with framing anchors or hurricane ties for added security against earthquakes or high winds. Check your local codes.

Two Methods for Supporting Barge Rafters



Finishing the Overhangs

The next step is to install the *barge rafters* if the plans call for them; these are rafters that hang outside the building and help support the rake. Sometimes barge rafters are supported by the ridge, fascia, and roof sheathing. In this case, the ridge board extends beyond the building line so that the opposing barge rafters butt together over its end and are face nailed to it. At the bottoms the barge rafters are mitered to the subfascia boards, which also extend beyond the building line. The roof sheathing cantilevers out and is nailed to the tops of the barge rafters.

Another way to support barge rafters is with lookouts. A lookout is a 2x4 laid flat that butts against the first inboard rafter, passes through a notch cut in the end rafter, and cantilevers out to support the barge rafter (see the drawing on the facing page). Lookouts are usually installed at the ridge, at the plate line, and 32 in. o.c. in between (closer for wide overhangs or heavy barge rafters). If the roof sheathing cantilevers out over the eaves (adding extra support for the barge rafters), then the top lookouts can be placed 32 in. down from the ridge.

The notches in the rake rafters are most easily cut when you're working at the rafter horses. Pick out four straight rafters and lay out the notches while you're laying out for the bird's mouths and ridge cuts. Cut these notches by first making two square crosscuts with a circular saw 1½ in. deep across the top edges of the rafters. Then turn the rafters on their sides and plunge cut the bottom of the notch.

Lookouts are cut to length after they're nailed up. Snap a line and cut them off with a circular saw. That done, the barge rafters are face nailed to the ends of the lookouts with 16d nails.

The final step in framing a gable roof is to snap a line across the rafter tails and cut them to length. Cutting the rafters in place ensures that the fascia will be straight. Use the layout tee or a bevel square to mark the plumb cut. If the rafters are cut square, use a triangular square. Then, while walking the plate or a temporary catwalk nailed to the rafter tails, lean over and cut off the tails with a circular saw.

Larry Haun, author of *The Very Efficient Carpenter* and *Habitat for Humanity: How to Build a House* (The Taunton Press), lives and works in Coos Bay, Oregon.

The notches in the rake rafters are most easily cut when you're working at the rafter horses.

Sources

Big Foot Tools

Henderson, NV 89011
(702) 565-9954
(888) 798-4499
www.bigfoottools.com
sales@bigfootsaws.com
Swing table, head cutter

Pairis Products

P.O. Box 292772
Phelan, CA 92329
(760) 868-0973
www.bestconstructiontools.com
penny@bestconstructiontools.com

Swanson Tool Co.

211 Ontario St.
Frankfort, IL 60423
(815) 469-9453
www.swansontoolco.com

TimberTech

(Distributor of Linear Link)
11618 Hwy. 5
St. Maries, ID 83861
(800) 635-5465
www.linearlink.com
Linear Link
VCS-SK12 saw

Framing a Roof Valley

■ BY RICK ARNOLD

Framing a complex roof is one of the trickiest parts of home building. But it doesn't have to be. If you begin with accurate, as-built measurements and use a construction calculator to do the math (see the sidebar on p. 35), you can cut all of the rafters for most roofs on the ground in just one shot.

This roof valley is a perfect example. To understand the concept and how all the pieces are laid out and cut, I picture the roof two-dimensionally, in plan view (see the drawing on pp. 28–29). Then I use a construction calculator to find the correct length of each rafter.

To get started, I need to know only two things. The first is the pitch of the roof. On this project, the roof is a 12 pitch, or 12-in-12. The second thing that I need to know is the total run of the common rafters (see the drawing on p. 29).

As a house is framed, measurements can vary slightly from the design, so I disregard the plans when finding the run of the common rafters, and instead take my own measurements. I measure the width of the building first, including the sheathing. The run of the common rafters is equal to half of this measurement, less half the thickness of the ridge board. Once I have the run of the common rafters, I use the calculator to find the

lengths of all the rafters (see the examples on pp. 30–31).

The Valley Rafter has a Different Pitch

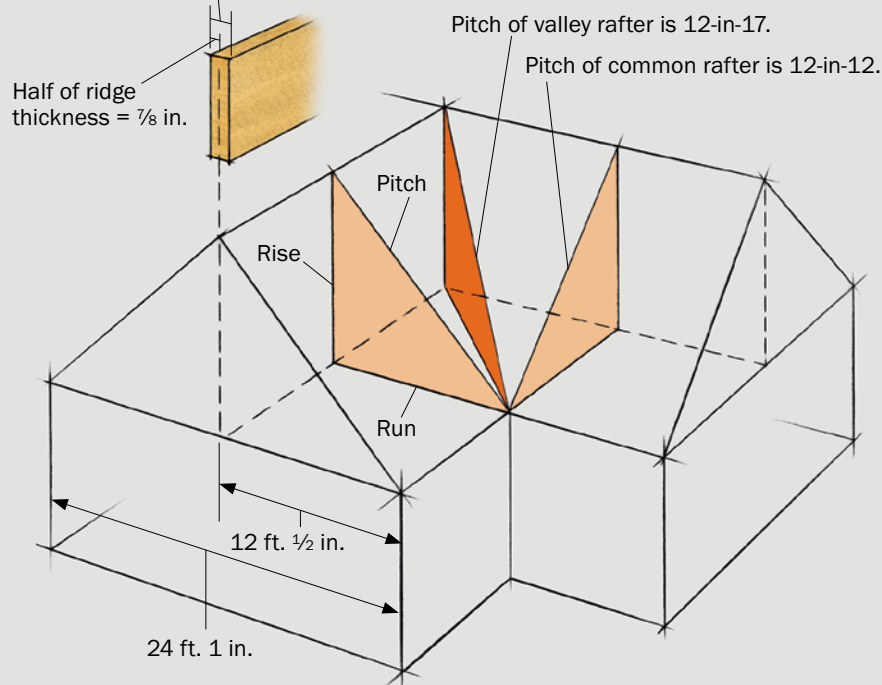
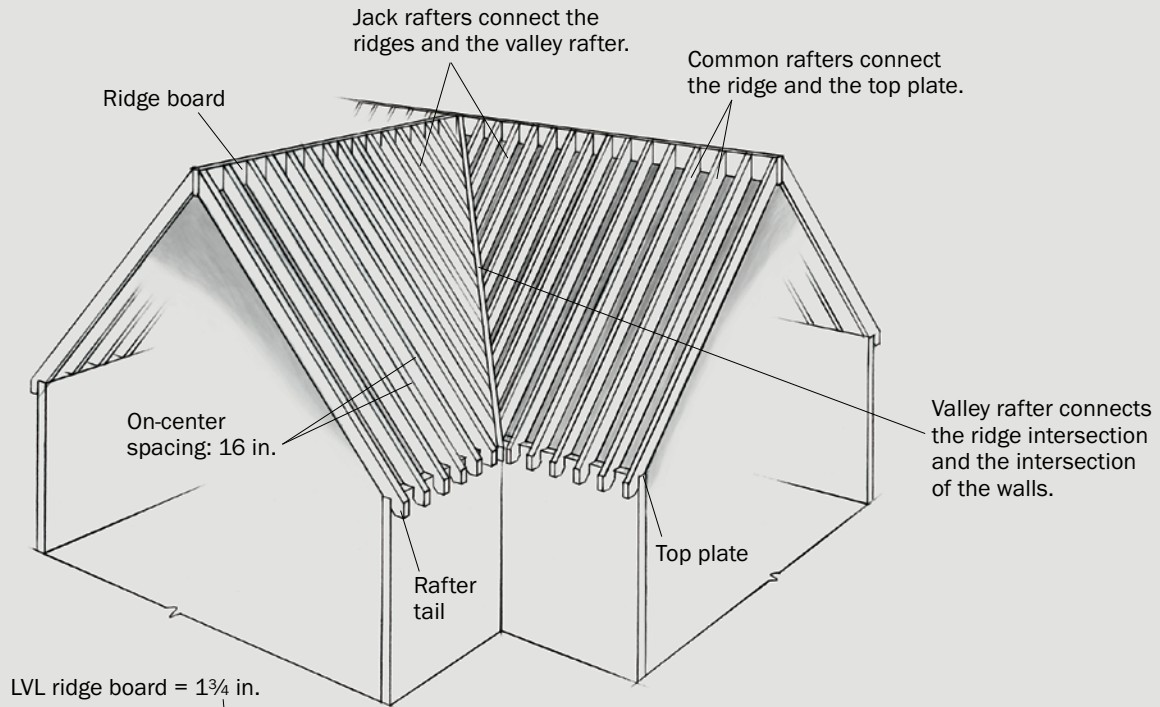
The run of the valley rafter is longer than the run of the common rafters, so it takes 17 in. of run for the valley rafter to rise the same distance that the common rafters rise in 12 in. Therefore, the pitch of the valley rafter is 12-in-17.

The first cut that I make on both the common rafters and the valley rafter is the plumb cut, where the rafter will meet the ridge cut, where the rafter will meet the ridge board. On the common rafters, the plumb cut is marked with a framing square for a 12-in-12 pitch (45°) and cut square (i.e., no bevel) (see “Laying Out the Rafters” on pp. 30–31). The valley rafter is marked for a 12-in-17 pitch and then cut with a double bevel to fit into the ridge intersection (see the top photos on p. 31). Because most framing lumber is not perfectly straight, I check each piece and mark the crown before I start cutting the lumber into rafters. Keeping all of the crowns pointing up prevents waves from marring the finished roof.



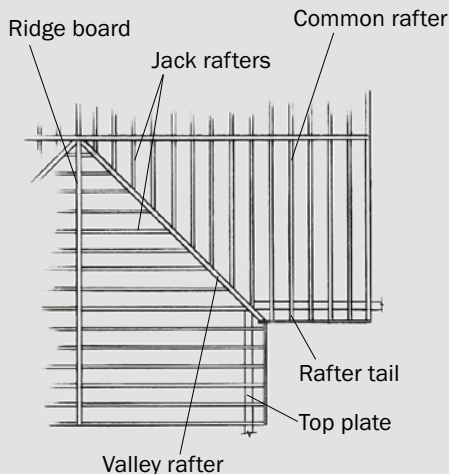
Determining the Rise, Run, and Pitch

With a regular valley, where the walls meet at right angles and the roof pitches are the same, the valley rafter intersects the building diagonally at 45°; hence, the jack rafters intersecting the valley require a 45° bevel cut. The plan view makes it clear that the run of the valley rafter is longer than the run of the common rafters.

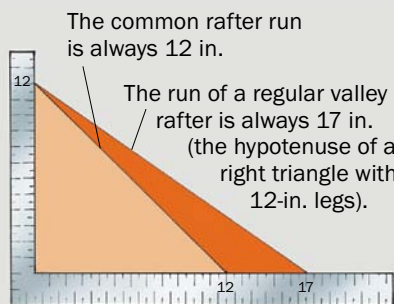


The Valley's Bird's Mouth and Tail are a Little Tricky

PLAN VIEW



Because the run of the valley rafter is longer than the run of the common rafters, but the rise is the same, the pitch of the valley rafter changes from 12-in-12 to 12-in-17 in this case.



The run of the common rafters is equal to half the width of the house. But because the rafters are nailed to the face of the ridge board, and the ridge board bisects the house, half the thickness of the ridge is subtracted from the run.

Find the Run of the Common Rafters

12 ft. $\frac{1}{2}$ in. (half building width) – $\frac{7}{8}$ in. (half of ridge thickness) = 11 ft. $11\frac{1}{8}$ in. (run of common rafters)

The key to cutting the tail end of the valley rafter is to make sure it will work with the common rafters to form the plane of the roof, soffit, and fascia (see the bottom drawing on p. 31). Therefore, the layout of the common rafters acts as a starting point. On both the common and valley rafters, I measure the length along the top of the rafter and mark a plumb line. To form the bird's mouth—a triangular shape cut in the bottom of the valley rafter where it sits on the top plate—I mark a line for the seat cut, perpendicular to the heel cut. On the common rafters, the seat cut is the same length as the top plate and sheathing. On the valley rafter, the seat cut is located to maintain the same height above plate (HAP) as the common rafters (see the drawing on p. 31).

In a perfect world, the heel cut on the valley rafter would mimic the ridge cut and form a point that fits into the intersection of the top plates. However, with a single-member valley rafter, I don't bother with this cut. (Valley rafters are structural members of the roof, so sometimes they are doubled up. Consult an engineer if you are unsure how to size a valley rafter.) Instead, I simply extend the heel cut so that its sides fit snugly against the sheathing. To form a consistent plane for the soffit and fascia, the length of the overhang on the valley rafter is adjusted so that the tail projects the same distance from the house as the tail of the common rafters. To align the tail of the valley rafter with the tail of the common rafters, I simply extend the overhang half the thickness of the valley rafter and then cut the tail with a 45° bevel (see the bottom drawing on p. 31).

Laying Out the Rafters



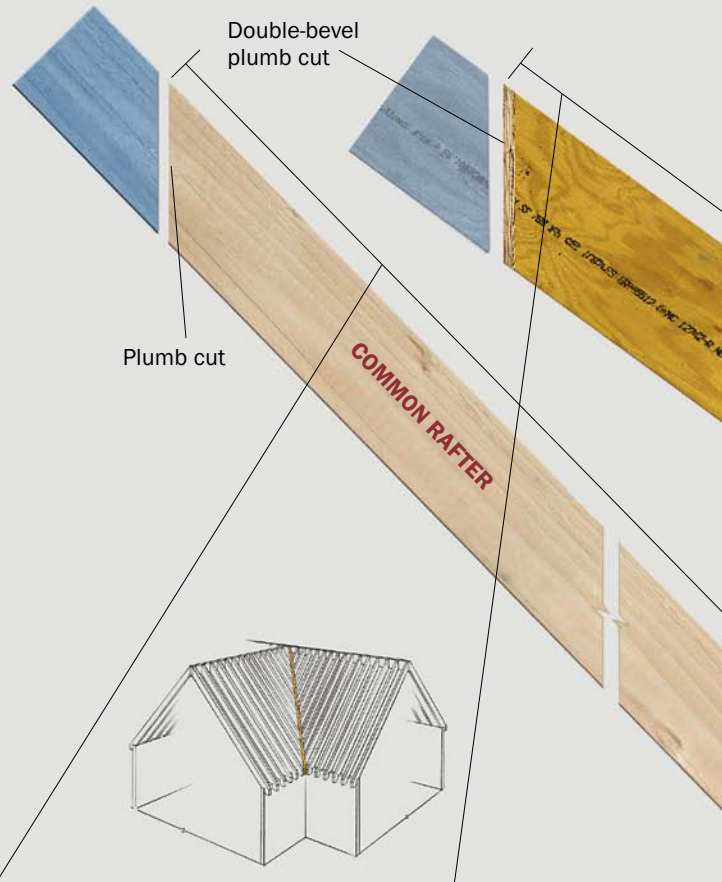
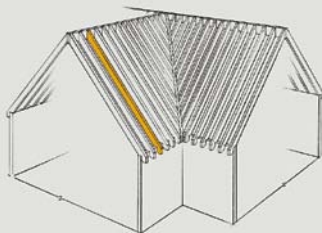
1. LAY OUT THE COMMON RAFTERS

Make a plumb cut that reflects the 12-in-12 pitch of the roof on one end of the rafter. Then measure the length (see calculation below) from the long point of the plumb cut, and mark a plumb line to locate the heel cut of the bird's mouth. The seat cut is perpendicular to the heel cut and equal to the width of the top plate and sheathing. The overhang, taken from the blueprints, is measured perpendicular to the heel cut.



Find the Length of the Common Rafter

Enter: 11 ft. 11⁵/₈ in.
Press: Run
Enter: 12 in.
Press: Pitch
Press: Diag
Result: 16 ft. 11¹/₈ in.
 (length of common rafter)



Find the Length of the Valley Rafter

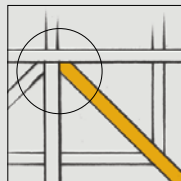
Enter: 11 ft. 11⁵/₈ in.
Press: Run
Enter: 12 in.
Press: Pitch
Press: Diag
Result: 16 ft. 11¹/₈ in.
 (length of common rafter)
Press: Hip/V
Result: 20 ft. 8³/₄ in.
 (length of valley rafter)

2. LAY OUT THE VALLEY RAFTER

The plumb cut on the valley rafter, also called the ridge cut, is marked for the 12-in-17 pitch of the valley rafter and cut with a double bevel to fit into the intersection of two ridge boards (see above). Starting with the length of the common rafters, find the length of the valley rafter on the construction calculator (see above).

A Quick Way to Make the Double-Bevel Plumb Cut

Mark two plumb lines the same distance apart as the thickness of the valley rafter. Set the saw to 45° and make the first cut so that the outside line becomes the long point. Cut the inside line in the other direction but with the same bevel.



3. LAY OUT BIRD'S MOUTH AND RAFTER TAIL

The valley rafter is measured and marked with a plumb line for the heel cut. The seat cut is located along the heel-cut line so that the height above plate is consistent with the common rafter. The heel cut is moved half the thickness of the valley rafter ($\frac{7}{8}$ in.) so that it fits into the intersection of the top plates. The end of the rafter gets a beveled plumb cut for the fascia and a level cut for the soffit. The overhang of the valley rafter is calculated as the diagonal of the common-rafter overhang.



Find the Length of the Valley Overhang

Enter: 10½ in. (length of the common overhang)

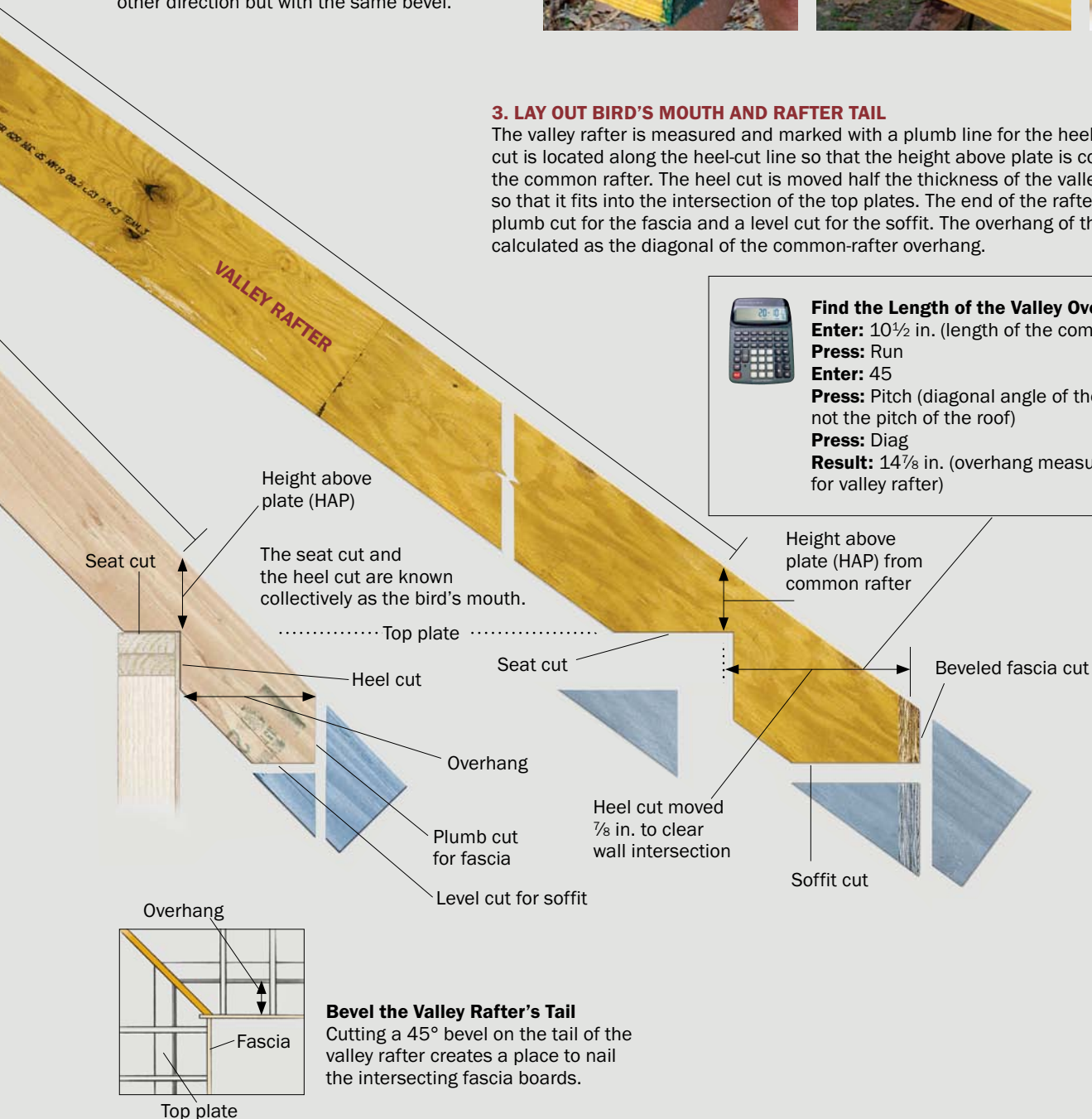
Press: Run

Enter: 45

Press: Pitch (diagonal angle of the valley rafter, not the pitch of the roof)

Press: Diag

Result: 14⅞ in. (overhang measurement for valley rafter)



Bevel the Valley Rafter's Tail

Cutting a 45° bevel on the tail of the valley rafter creates a place to nail the intersecting fascia boards.

Jack Rafters are Beveled to Meet the Valley Rafter

The tops of the jack rafters are marked and cut identical to the common rafters, but the bottoms have a 45° beveled, or cheek, cut that fits against the diagonal valley rafter. For each length of the jack rafters, I cut two rafters with opposing bevels on the cheek cut (see the drawing on the facing page). I use the first jack rafter as a pattern to mark another one the same length (see the photo at right). But when I cut the cheek on the second rafter, I cut in the opposite direction, reversing the bevel.

Keep the Valley Rafter Straight During Installation

With the ridges in place, the valley rafter is nailed into position. It is important to double-check the HAP with the valley rafter in position. If the HAP is short, it may be possible to adjust it with a shim between the top plate and seat cut. If it is long, the seat cut will have to be adjusted. The valley rafter then is nailed into the ridge intersection and into the top plate. To straighten out the valley rafter and keep it straight, I first install a pair of jack rafters about halfway down the valley (see the photo on p. 34). If there is more than one valley, I install jack rafters at the midpoint of all the valleys to avoid creating uneven pressure that could throw the ridge boards and valley rafters out of alignment.

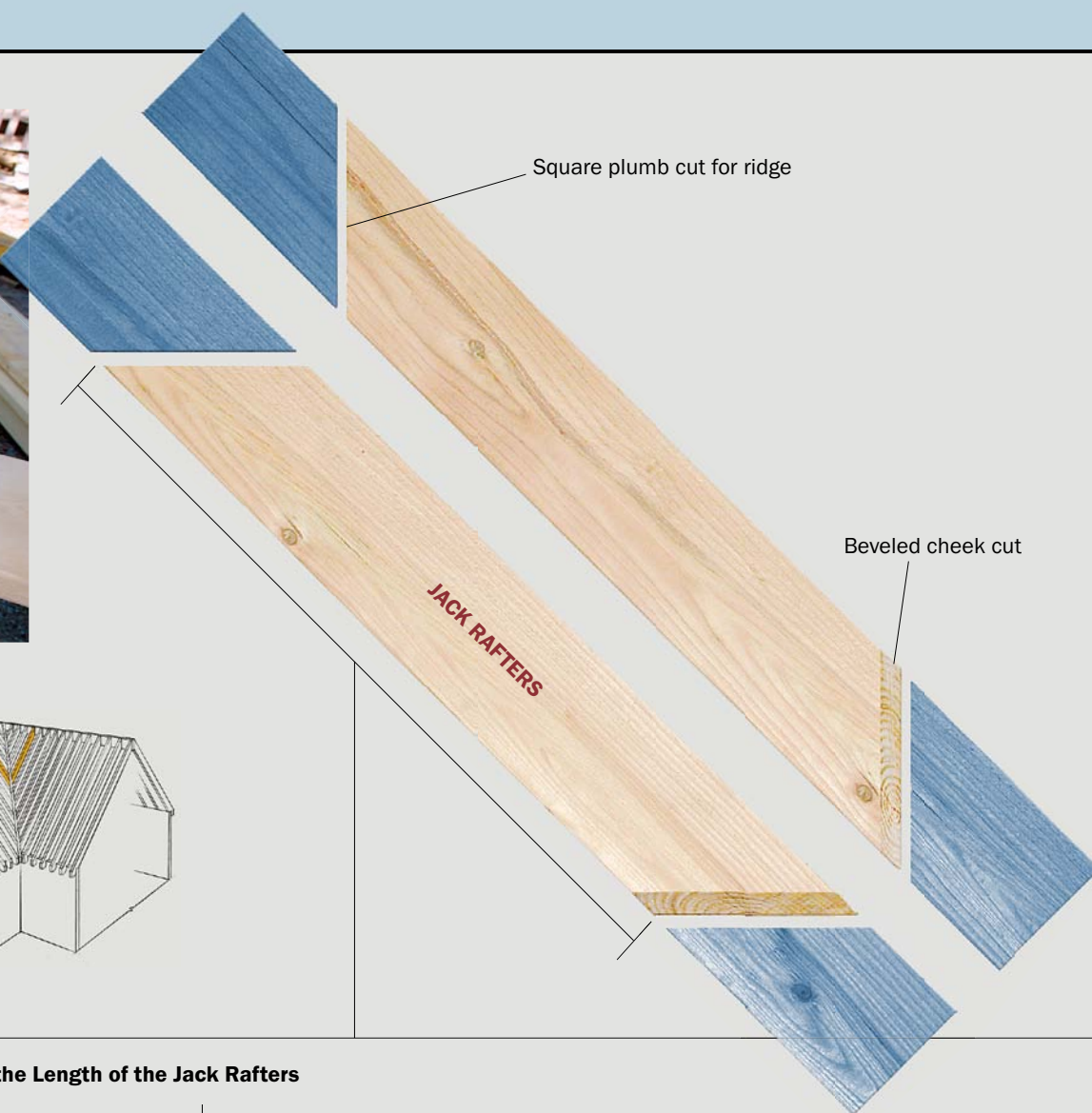
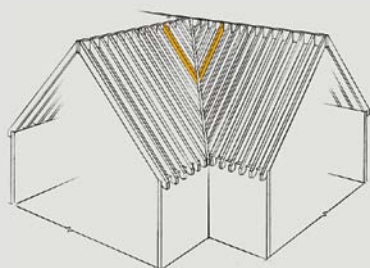
I nail the tops of the jack rafters to the ridge board first, holding the bottoms in position along the valley rafter. When I nail the bottoms, I hold the top edge of the cheek cut above the top edge of the valley rafter (see the photo on p. 35). The tops of the jack rafters must be higher than the top of the valley rafter so that the plywood sheathing meets in the middle of the valley, preventing a flat spot in the valley.

Cutting the Jack Rafters



4. CUT JACK RAFTERS IN PAIRS

Both cuts on the jack rafters are marked plumb for the 12-in-12 pitch of the roof, but the cheek cut, where the jack rafter meets the valley rafter, is beveled 45°. The length of the jack rafters given by the calculator is the theoretical length measured to the center of the valley rafter, so the jacks need to be shortened. To calculate the theoretical lengths of the jack rafters from shortest to longest, use the on-center spacing (16 in., 32 in., etc.) as the run. Then subtract half the diagonal thickness of the valley rafter to get the actual length.



Find the Length of the Jack Rafters

THEORETICAL LENGTH

Enter: 12 in.
Press: Pitch
Enter: 16 in.
 (32, 48, etc., for subsequent rafters)
Press: Run
Press: Diag
Result: 22 $\frac{5}{8}$ in.
Press: Feet
Result: 1 ft. 10 $\frac{5}{8}$ in.
 (theoretical length)

ACTUAL LENGTH

Step 1: Use half the valley-rafter thickness as the run to figure out how much the jack rafters need to be shortened. Step 2: Adjust for roof pitch.

Step 1

Enter: $\frac{7}{8}$ in.
Press: Run
Enter: 45
Press: Pitch
Press: Diag
Result: 1 $\frac{1}{4}$ in.
Press: Clear

Step 2

Enter: 1 $\frac{1}{4}$ in.
Press: Run
Enter: 12 in.
Press: Pitch
Press: Diag
Result: 1 $\frac{3}{4}$ in. (length to subtract from theoretical length of each jack rafter to get actual length)
Actual length: 1 ft. 10 $\frac{5}{8}$ in. – 1 $\frac{3}{4}$ in. = 1 ft. 8 $\frac{7}{8}$ in.

Installing the Jack Rafters



5. LAY OUT JACK-RAFTER SPACING

The key to laying out the jack rafters along the ridge boards is to begin the layout at the center of their intersection. On the valley rafter, the on-center spacing needs to be adjusted for pitch. Use 16-in. o.c. spacing as the run to do the calculations (see below).



Find Jack-Rafter Spacing

Enter: 16 in.

Press: Run

Enter: 12 in.

Press: Pitch

Press: Hip/V

Result: 27¹⁴/₁₆ in.

(This measurement is the location of the first jack rafter, measured from the intersection of the ridges, and it's the on-center spacing for subsequent jacks.)



Install the jacks high. Raise the jack rafters above the edge of the valley rafter so that the roof sheathing will meet in the middle. A scrap of wood makes an ideal gauge to make sure each jack is installed the same.

Why Use a Construction Calculator?

A construction calculator simplifies the math associated with building and carpentry projects.

It allows users to work in feet and inches, and has keys labeled with common building terms such as rise and run, and the names of framing members, such as valley rafter and jack rafter, rather than mathematical terms. Follow the examples throughout this chapter to see how a calculator is used to frame a valley roof. Construction calculators are available at most hardware stores, or from Calculated Industries (800-854-8075; www.calculated.com).



To figure out how high to hold the jack rafter, I put a straightedge on the top of the jack rafter and adjust it until the straight-edge hits in the center of the valley rafter. Then I nail the jack in place and measure its height above the valley rafter. Once the first jack rafter is installed, I make a gauge the same thickness as the height difference and use it for the rest of the jacks. I install the rest of the jack rafters from the bottom of the valley. Working from the bottom allows me to create a ladder with the jacks, which I can climb as I install consecutively higher rafters. The work's not over yet, though. Shingling a valley also can be a brainteaser.

***Rick Arnold** is a veteran contractor and contributing editor to Fine Homebuilding magazine. He is the author of numerous articles and books on home construction and remodeling. He is a well-known and sought-after speaker and presenter at home shows and building seminars around the country.*

Using a Rafter Square

■ GREG ZIOMEK

After a coworker of mine bought and inspected a new rafter square, he became upset that not all the scales were in $\frac{1}{16}$ -in. or $\frac{1}{8}$ -in. increments. He insisted that the tenth and twelfth scales on the back of his square were useless and that he would always have to fumble for the front of the square to use it.

His assumptions were not completely correct. The twelfth scales, located on the back of most rafter squares, have many uses on framing jobs. They're especially handy for solving basic right-triangle problems and theoretical roof calculations, as well as for performing simple division and multiplication.

A Rafter Square Has Two Different Sides

A rafter square is composed of two arms of different lengths that meet at a right angle. The smaller arm, the tongue, measures $1\frac{1}{2}$ in. wide by 16 in. long. The larger arm, the blade, is 2 in. wide by 24 in. long. (Notice that all these dimensions are convenient sizes of layout work.) The two arms meet at a 90° angle and form the heel of the square. The front side of the square is stamped with the rafter table and octagon table; the lumber table and brace table are located on the back. The tenth and twelfth scales are on the

back as well. (Note that not all rafter squares have the tenth and twelfth scales.)

The twelfth scales, stamped on squares since the late 1800s, were intended as a means to calculate carpentry equations in feet and inches, thereby skipping the conversion of fractions to linear units. Because each inch is divided into 12 parts, it is possible to reduce layout work to $\frac{1}{12}$ of its original scale and still maintain the original proportions. With these scales, an inch mark can represent 12 ft., 1 ft., or 1 in.

The Key to Accurate Calculations Is a Sharp, Straight Line

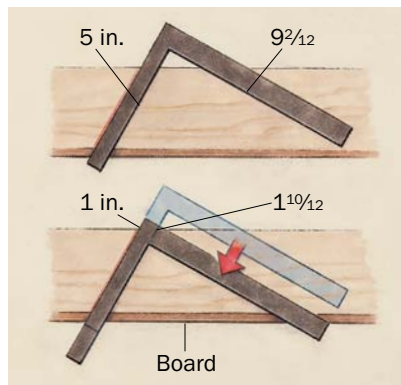
To perform calculations with a rafter square, you'll need a square, a sharp pencil, and a straight piece of 1x or 2x stock with crisp, sharp edges, the wider the better. A flat piece of plywood will also work; snap a chalkline down its center and use the line as you would the edge of a board. On the facing page, you will find examples of rafter-square math. Grab a square and follow along.

Greg Ziomek is an architect and owns and operates an architecture firm in Chicago, Illinois.

Functions of a Rafter Square

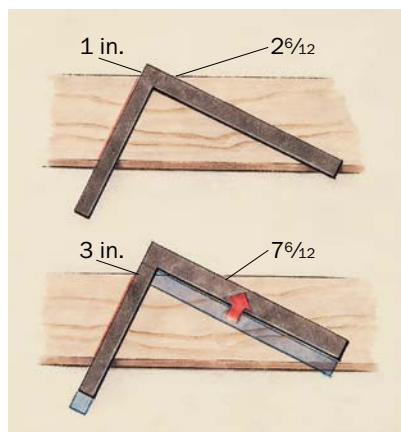
1. DIVIDING FEET AND INCHES WITHOUT CONVERSIONS

If I want to divide a wall that's 9 ft. 2 in. long into five equal bays, I position the square so that $9\frac{2}{12}$ on the blade and 5 in. on the tongue intersect the edge of the board. I then draw a line along the tongue and slide the square along this line until the 1-in. mark on the tongue intersects the edge of the board. The answer, $1\frac{10}{12}$, or 22 in., is read on the blade. Thus, $9\text{ ft. }2\text{ in.} \div 5 = 22\text{ in.}$



2. MULTIPLICATION FOR SOLVING SIMPLE BUILDING PROBLEMS

Here, we'll use the example of 2 ft. 6 in. multiplied by 3. Position the square so that $2\frac{6}{12}$ (2 ft. 6 in.) on the blade and the 1-in. mark on the tongue intersect the edge of the board. Draw a line along the tongue, and move along this line until the 3-in. mark intersects the edge of the board. The answer, $7\frac{6}{12}$, or 7 ft. 6 in., is read on the blade. Thus, $2\text{ ft. }6\text{ in.} \times 3 = 7\text{ ft. }6\text{ in.}$



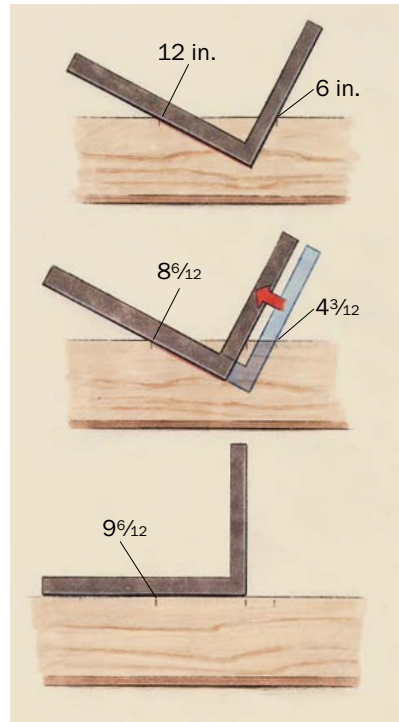
3. A QUICK WAY TO ESTIMATE THE LENGTH OF ROOF RAFTERS

Let's say your roof has a total run of 8 ft. 6 in. and a pitch of 6-in-12. Position the square so that the 6 on the tongue and the 12 on the blade are touching the board edge (12 in.

equals the run; 6 in. represents the rise).

Draw a line along the blade and slide the square along this line until $8\frac{6}{12}$ intersects the edge of the board. The total rise is read at the intersection of the tongue and board, $4\frac{3}{12}$, or 4 ft. 3 in.

Now, mark the intersecting points of the square and board, then measure the distance between these marks with the twelfth scale. The distance is $9\frac{6}{12}$, or 9 ft. 6 in., the theoretical length of the rafter.

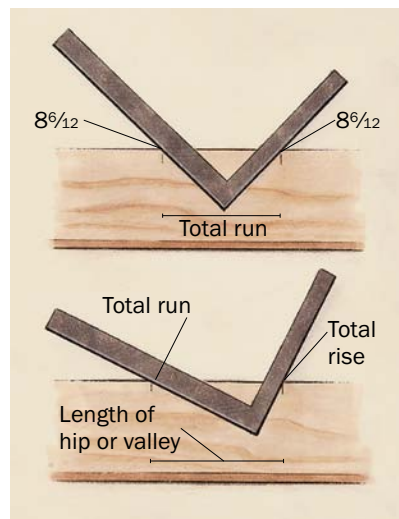


4. FIGURING THE RUN AND THE LENGTH OF HIP AND VALLEY RAFTERS

To determine the run of a hip or valley rafter, position the square on a board with the run of the common rafter ($8\frac{6}{12}$) on the blade and the tongue. Mark these two points and measure between them with the twelfth scale. The distance

is $12\frac{25}{12}$ in., or a total run of 12 ft. $\frac{1}{4}$ in.

To find the theoretical length of the hip or valley rafter, position the square with the total run on the blade and the total rise on the tongue. The distance between these points is the theoretical length of the hip.



A Different Approach to Rafter Layout

■ JOHN CARROLL

I helped my friend Steve build a 12-ft. by 16-ft. addition to his house. A few days before we got to the roof frame, I arrived at his place with a rafter jig that I'd made on a previous job. I'm a real believer in the efficiency of this jig, so I told Steve that it would enable me to lay out the rafters for his addition in 10 minutes.

His look suggested that I had already fallen off one too many roofs. "Come on, John," he said. "Ten minutes?" I bet him a six pack of imported beer, winner's choice, that I could do it.

Like most builders, I have a long and painful history of underestimating the time different jobs require. In this case, however, I was so certain that I agreed to all Steve's conditions. In the allotted time, I would measure the span of the addition; calculate the exact height that the ridge should be set; measure and mark the plumb cut and the bird's mouth on the first rafter; and lay out the tail of the rafter to shape the eaves.

When the moment of reckoning arrived, we set a watch, and I went to work. Eight minutes later, I was done and in the process

secured the easiest six bottles of Bass Ale® in my life. With this layout in hand, we framed the roof in 5½ hours.

Why Should It Take an Hour to Do a Ten-Minute Job?

That evening, as we enjoyed my beer, Steve's wife asked him how long he would have taken to do the same layout. "An hour," he said, "at least." Steve is a seasoned carpenter who now earns a living as a designer and construction manager. So why does a 10-minute job require 60, or possibly 90, minutes of his time? The answer is that Steve, like many builders, is confused by the process.

The first framing crew I worked with simply scaled the elevation of the ridge from

Laying out rafters doesn't need to be complicated or time-consuming. Using a jig makes the process quick and easy.





Rafter jig doubles as a cutting guide. Scaled to the 12-in-12 roof pitch, and with a 1x3 fence nailed to both sides of one edge, this plywood jig is used to lay out plumb and level cuts on the rafters. Notice that the fence is cut short to make room for the circular saw to pass by when the jig is used as a cutting guide. The jig will be used later to lay out plywood for the gable-end sheathing.

the blueprint and then installed the ridge at that height. Once the ridge was set, they held the rafter board so that it ran past both the ridge and the top plate of the wall, then scribed the top and bottom cuts. Then they used this first rafter as a pattern for the rest. This technique worked. And because it's so simple and graphic, I'm convinced that it still is a widespread practice.

A Nontraditional Technique

There are several reasons why I retired this method decades ago. To begin with, I haven't always had a drawing with an elevation of the roof system, which means that I couldn't always scale the height of the ridge. Second, it's just about impossible to scale the ridge with any degree of precision. Because of this fact, these roofs usually end up merely close to the desired pitch. Third,

this method typically leaves the layout and cutting of the rafter tail for later, after the rafters are installed.

My technique is also different from the traditional approach espoused in most carpentry textbooks, which I've always found to be obscure and confusing. In rafter-length manuals and in booklets that come with rafter squares, dimensions are generally given in feet, inches, and fractions of inches. I use inches only and convert to decimals for my calculations. To convert a fraction to a decimal, divide the numerator (the top number) by the denominator (the bottom number). To convert a decimal to sixteenths, multiply the decimal by 16 and round to the nearest whole number.

Another difference in my approach is the measuring line I use. As the drawing on the facing page shows, the measuring line I employ runs along the bottom edge of the rafter. In contrast, most rafter-length manuals use a theoretical measuring line that runs

from the top outside corner of the bearing wall to a point above the center of the ridge. A final thing that I do differently is use a site-built jig instead of a square to lay out the cuts on the rafter (see the photos on the facing page).

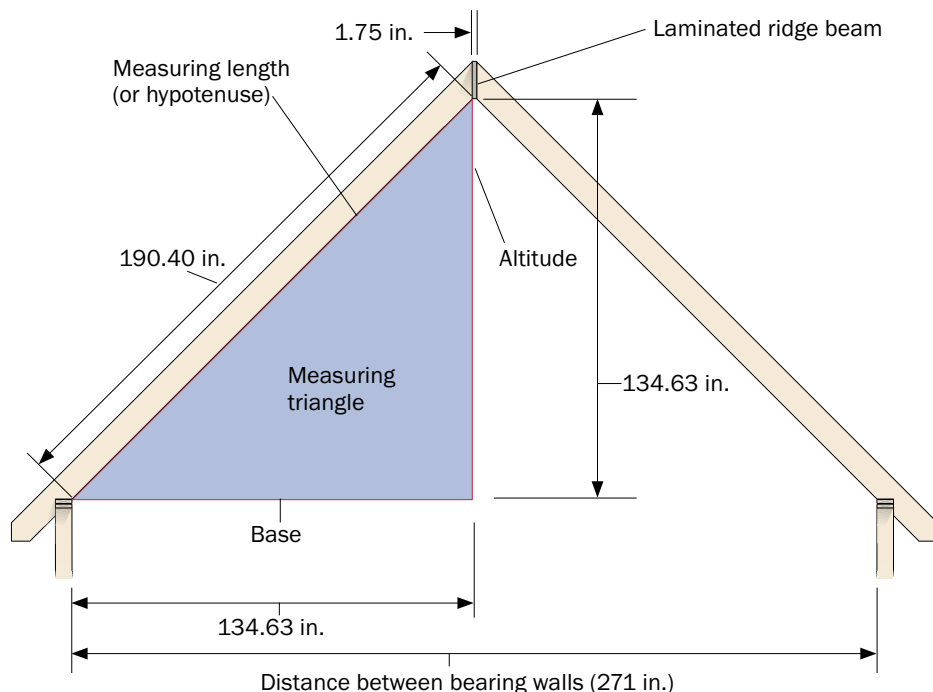
There are lots of ways to lay out rafters, and if you already have a method that works well, your way might be faster than mine. But if you've always been vexed by roof framing, I think you'll find my way easier to understand than most.

Run and Roof Pitch Determine the Measuring Triangle

Framing a roof can be a little intimidating. Not only are you leaving behind the simple and familiar rectangle of the building, but you're starting a job where there is a disconcerting lack of tangible surfaces to measure from and mark on. Most of this job is done in midair. So where do you start?

Use the Measuring Triangle to Find the Rafter Length

1. Find the base of the measuring triangle (the run of the roof). Measure between bearing walls and subtract width of ridge, then divide by 2 ($271 - 1.75 = 269.25$; $269.25 \div 2 = 134.63$).
2. Find the altitude of the measuring triangle (ridge height). Divide the base of the measuring triangle by 12 and multiply the result by the rise of the roof pitch. For a 12-in-12 pitch, the base and the altitude are the same. ($134.63 \text{ in.} \div 12 = 11.22$; $11.22 \times 12 = 134.63$). (Editor's note: To present a set of consistent figures, we rounded to 134.63.)
3. Find the hypotenuse (rafter length). Divide the base of the triangle by 12 and multiply the result by the hypotenuse of the roof pitch, which is listed as length of common rafter on the rafter square (photo p. 43). ($134.63 \text{ in.} \div 12 = 11.22$; $11.22 \times 16.97 = 190.40$).



If you've always been vexed by roof framing, you may find my way easier to understand than most.

There are only two things you need to lay out a gable roof—a choice of pitch and a measurement.

There are only two things you need to lay out a gable roof. One is a choice of pitch, and the other is a measurement. Usually the choice of pitch was made before the foundation was poured. The measurement is the distance between the bearing walls (see the drawing on p. 41).

After taking this measurement, deducting the thickness of the ridge, and dividing the remainder in half, you have the key dimension for laying out the rafters. This dimension could be called the “run” of the rafter; but because it is slightly different from what is called the run in traditional rafter layout, I use a different term: the base of the measuring triangle. The measuring triangle is a concept that I use to calculate both the correct height of the ridge and the proper distance between the top and bottom cuts of the rafter, which I call the measuring length.

Working with this measuring triangle takes a little getting used to. The biggest problem is that when you start the roof layout, only one-third of the measuring triangle exists. As we’ve just seen, you find the base of the measuring triangle by measuring existing conditions. Then you create the altitude and the hypotenuse (same as the measuring length) by using that base and some simple arithmetic.

To see how this works, let’s look at the steps I followed to frame the roof of a 12-ft. by 24-ft. addition I recently finished.

Build the Rafter Jig First

While the rest of the crew finished nailing down the second-floor decking, I began fabricating a rafter jig based on the pitch of the roof (see the left photo on p. 40). The desired pitch was 12-in-12 (the roof rises 12 in. vertically for every 12 in. of run horizontally). The basic design of this jig was simple, and the cost was reasonable: three scraps of wood and 10 minutes of time.

The first step in making this jig was finding a scrap of plywood about 30 in. wide,

preferably with a factory-cut corner. Next, I measured and marked 24 in. out and 24 in. up from the corner to form a triangle. After connecting these marks with a straight line, I made a second line, parallel to and about 2½ in. above the first—the 1x3 fence goes between the lines—then cut the triangular-shaped piece along this second line. To finish the jig, I attached a 1x3 fence on both sides of the plywood between these two lines. I cut the fence short so that it didn’t run all the way to the top on one side. That allowed me also to use the plywood as a cutting jig running my circular saw along one edge without the motor hitting the fence and offsetting the cut (see the right photo on p. 40).

Here I should pause and note an important principle. The jig was based on a 12-in-12 pitch, but because I wanted a larger jig, I simply multiplied both the rise and run figures by the same number—two—to get the 24-in. measurement. This way, I enlarged the jig without changing the pitch. This principle holds true for all triangles. Multiply all three sides by the same number to enlarge any triangle without changing its proportions, its shape, or its angles.

To use this jig, I hold the fence against the top edge of the rafter and scribe along the vertical edge of the plywood jig to mark plumb lines and along the horizontal edge to mark level lines.

There are at least four reasons why I go to the trouble to make this jig. First, I find it easier to visualize the cuts with the jig than with any of the manufactured squares made for this purpose. Second, identical layouts for both the top (ridge) and bottom (eave) cuts can be made in rapid succession. Third, I use the plumb edge as a cutting guide for my circular saw. Finally, I use the jig again when I’m framing and sheathing the gable end, finishing the eaves and rake, and installing siding on the gable. I also save the jig for future projects.

Step One: Determining the Base of the Measuring Triangle

The base of the measuring triangle is the key dimension for roof layout. In my system, the base of the triangle extends from the inside edge of the bearing wall to a point directly below the face of the ridge. In this addition, the distance between the bearing walls was 271 in. So to get the base of the measuring triangle, I subtracted the thickness of the ridge from 271 in. and divided the remainder by 2. Because the ridge was 1¾-in.-thick laminated beam, the base of the measuring triangle turned out to be 134.63 in. ($271 - 1.75 = 269.25$; $269.25 \div 2 = 134.63$).

Step Two: Determining the Altitude of the Measuring Triangle

With the base of the measuring triangle in hand, it was easy to determine both the altitude and the hypotenuse. The altitude of this measuring triangle was, in fact, too easy to be useful as an example. Because we wanted to build a roof with a 12-in-12 pitch, the altitude had to be the same number as the base, or 134.63 in.

Let's pretend for a moment that I wanted a slightly steeper roof, one that had a 14-in-12 pitch. In a 14-in-12 roof, there are 14 in. of altitude for every 12 in. of base. To get the altitude of the measuring triangle, then, I would find out how many 12-in. increments there are in the base, then multiply that number by 14. In other words, divide 134.63 by 12, then multiply the result by 14. Here's what the math would look like: $134.63 \text{ in.} \div 12 = 11.22$; $11.22 \times 14 = 157.08 \text{ in.}$ Wouldn't it be nice if finding the hypotenuse of the measuring triangle was so simple? It is.

Step Three: Determining the Hypotenuse of the Measuring Triangle

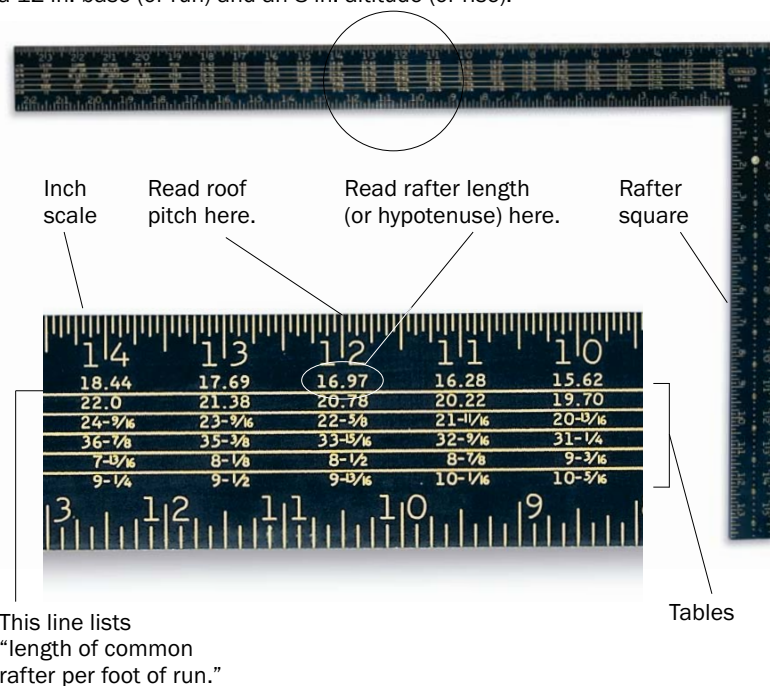
Now let's return to our 12-in-12 roof. The base and the altitude of the measuring triangle are both 134.63 in. But what's the hypotenuse? One way to solve the problem of finding the hypotenuse is to use the Pythagorean theorem: $A^2 + B^2 = C^2$ (where A and B are the legs of the triangle and C is the hypotenuse).

There are other ways to solve this problem—with a construction calculator, with rafter manuals, with trigonometry—but I usually use the principle mentioned in step one. According to this principle, you can expand a triangle without changing the angles by multiplying all three sides by the same number.

The base of the measuring triangle is the key dimension for roof layout.

Rafter Square Gives You the Hypotenuse

Find the number for your roof pitch on the inch scale (8 in. for an 8-in-12 pitch). The first number under that is the hypotenuse of a right triangle with a 12-in. base (or run) and an 8-in. altitude (or rise).



For over a century, carpenters have used the rafter tables stamped on rafter squares. The common table shows the basic proportions of triangles for 17 different pitches (see the photo on p. 43).

The base of all these triangles is 12; the altitude is represented by the number in the inch scale above the table. And the hypotenuse is the entry in the table. Under the number 12, for example, the entry is 16.97. This is the hypotenuse of a right triangle with a base and an altitude of 12.

To use this information to create the larger measuring triangle I needed for this roof, I simply multiplied the altitude and the hypotenuse by 11.22. This, you may recall, was the number I obtained in step two when I divided the base, 134.63 in., by 12. Now multiply the altitude and the hypotenuse of the small triangle by 11.22: 11.22×12 gives us an altitude of 134.63 in.; and 11.22×16.97 gives us a hypotenuse of 190.40 in.

So here is the technique I use for any gable roof. I find the base of the measuring triangle, divide it by 12, and multiply the result by the rise of the pitch to get the altitude of the measuring triangle (which determines the height to the bottom of the ridge). To get the hypotenuse, I divide the base of the triangle by 12 and multiply that by the hypotenuse of the pitch, which is found in the common rafter table.

Say the roof has an 8-in-12 pitch with a base of 134.63. I divide that number by 12 to get 11.22, then multiply that by 8 to get the ridge height of 89.76 in. To get the length of the rafter, I multiply 11.22 by 14.42 (the number found under the 8-in. notation on the rafter table), for a length between ridge and bearing wall of 161.79 in.

The only time I waver from this routine is when a bird's mouth cut the full depth of the wall leaves too little wood to support the eaves. How little is too little depends on the width of the rafter and the depth of the eave overhang, but I generally like to have at least 3 in. of uncut rafter running over the bird's mouth. If I have too little wood, I let the bottom edge of the rafter land on top of

the wall rather than aligning with the wall's inside edge. Then I determine how far the rafter will sit out from the inside edge of the bearing wall and use that inside point as the start of my measuring triangle.

Step Four: Setting the Ridge

I determined that the altitude of the measuring triangle was 134.63 in. This meant that the correct height to the bottom of the ridge was $134\frac{5}{8}$ in. above the top plate of the wall. (Note: I usually hold the ridge board flush to the bottom of the rafter's plumb cut rather than the top.) To set the ridge at this height, we cut two posts, centered them between the bearing walls, and braced them plumb. Before we installed the posts, we fastened scraps of wood to them that ran about 10 in. above their tops. Then, when we set the ridge on top of the posts (see the photo on the facing page), we nailed through the scrap into the ridge. We placed one post against the existing house and the other about 10 in. inside the gable end of the addition. This kept it out of the way later when I framed the gable wall.

Perfectly centering the ridge is not as important as getting it the right height. If opposing rafters are cut the same length and installed identically, they will center the ridge.

Step Five: Laying Out the Main Part of the Rafter

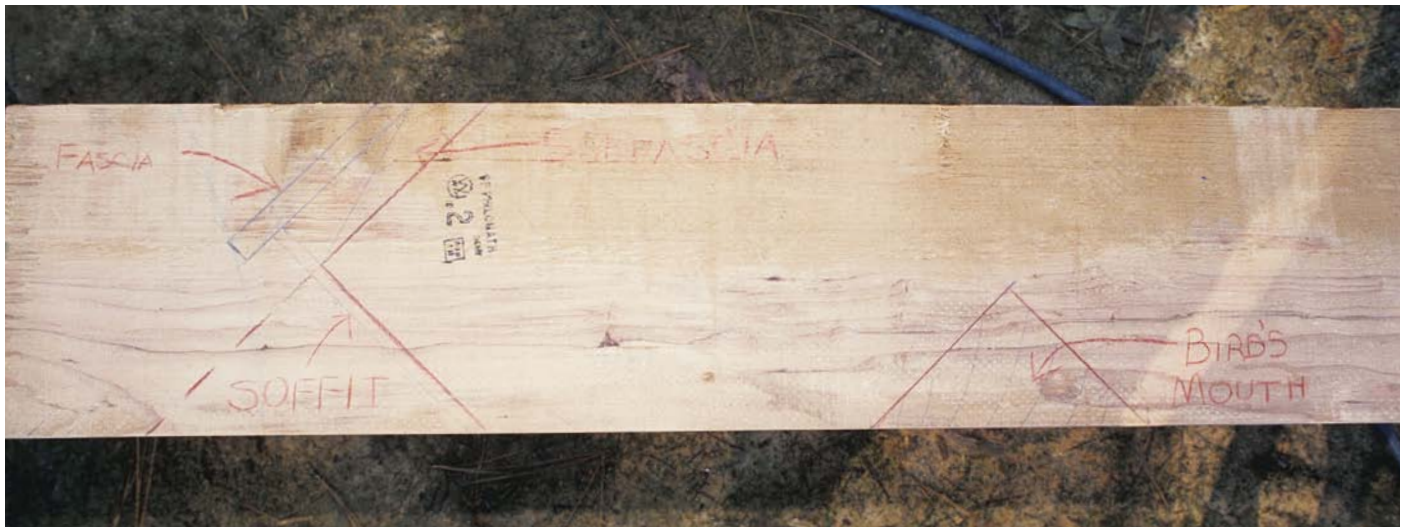
I calculated a measuring length (or hypotenuse) for the rafter of 190.40 in., then used the jig as a cutting guide and made the plumb cut. I measured $190\frac{3}{8}$ in. (converted from 190.40 in.) from the heel of the plumb cut and marked along the bottom of the rafter. Rather than have another carpenter hold the end of the tape, I clamp a square across the heel of the plumb cut, then pull the tape from the edge of the square (see the photo on p. 46) to determine where the bird's mouth will be.



Setting the ridge. Temporary posts are set up to hold the ridge at the right height. The posts are braced 2x4s with a 2x4 scrap nailed to the top that rises 10 in. above the top of the post. The ridge is set on top of the post and nailed to the scrap of wood.



A clamped square serves as an extra pair of hands. It's easy to measure along the bottom of the rafter if you clamp a square to the bottom of the plumb cut and run your tape from there.



Visualizing the bird's mouth and rafter tail. Red lines on this marked-up rafter show where cuts will be made for the bird's mouth, at right, and rafter tail, at left. To determine the correct cut for the tail, the author marked out the subfascia, soffit, and fascia board.

Once I marked where the bird's mouth would be, I used the jig to mark a level line out from the mark. This would be the heel cut, or the portion of the rafter that sits on top of the bearing wall.

After scribing a level line, I measured in the thickness of the wall, which was $5\frac{1}{2}$ in., and marked. I slid the jig into place and scribed along the plumb edge from the mark to the bottom edge of the rafter. This completed the bird's mouth and, thus, the layout for the main portion of the rafter.

Step Six: Laying Out the Rafter Tail

The eaves on the existing house measure 16 in. out from the exterior wall, which meant I would make the eaves on the addition 16 in. wide. To lay out the rafter tail, I started with the finished dimension of 16 in. and then drew in the parts of the structure as I envisioned it (see the photo above). In this way, I worked my way back to the correct rafter-tail layout.

I began by holding the jig even with the plumb line of the bird's mouth. With the jig

in this position, I measured and marked 16 in. in from the corner along the level edge. Then I slid the jig down to this mark and scribed a vertical line. This line represented the outside of the fascia. Next I drew in a 1x6 fascia and a 2x subfascia. I also drew in the $\frac{3}{8}$ -in. soffit I would use. This showed me where to make the level line on the bottom of the rafter tail.

Step Seven: Preserving the Layout

The only dimension for this layout that I had to remember was $190\frac{3}{8}$ in., the hypotenuse of the triangle and the measuring length of the rafter. I wrote the number where I could see it as I worked. To preserve the other three critical dimensions—one for the plumb cut of the bird's mouth and the other two for the rafter tail—I used the rafter jig to extend reference points to the bottom edge of the rafter; then I transferred these marks to a strip of wood, or measuring stick (see the photo on p. 48). I was ready to begin cutting the rafters.



Marking the bird's mouth and tail. Once the start of the heel cut was determined by measuring from the bottom of the plumb cut, this measuring stick was used to transfer the dimensions of the bird's mouth and rafter tail. The cutting lines were marked using the rafter jig.

Step Eight: Marking and Cutting the Rafters

Some carpenters lay out and cut one rafter, then use it as a pattern for the rest, and I'll often do that on a smaller roof. On this roof, where the rafters were made of 20-ft.-long 2x10s and where I was laying them out by myself, this method would have meant a lot of heavy, awkward, unnecessary work. Instead of using a 100-lb. rafter as a template, I

used my jig, my tape measure, and the measuring stick.

Moving to the end of the 2x12, I clamped the jig in place and made the plumb cut. (The steep pitch of this roof made clamping the jig a good idea. Usually, I just hold it to the rafter's edge the way you would when using a framing square as a cutting guide.) Then I clamped my square across the heel of that cut, pulled a $19\frac{3}{8}$ -in. measurement from that point, and marked along the bottom edge of the board. Next I aligned the first mark on the measuring stick with the



A rafter jig does the hard work. Once the location of the bird's mouth is determined, the rafter jig is used to mark the level and plumb cuts of the bird's mouth and rafter tail.

190 $\frac{3}{8}$ -in. mark and transferred the other three marks on the measuring stick to the bottom edge of the rafter (see the photo on the facing page).

To finish the layout, I used the jig to mark the level and plumb lines of the bird's mouth and the rafter tail (see the photo above). For all four of these lines, I kept the jig in the same position and simply slid it up or down the rafter until either the plumb or level edge engaged the reference mark. It was quick and easy. It was fun.

The two cuts that formed the rafter tail were simple, straight cuts that I made with my circular saw. To cut the bird's mouth, I cut as far as I could with my circular saw without overcutting, then finished the cut with my jigsaw.

John Carroll is a mason and builder in Durham, North Carolina. He is the author of two books published by The Taunton Press: *Measuring, Marking & Layout* (1998) and *Working Alone* (2001).

Framing a Hip Roof

■ LARRY HAUN

I built my first hip roof in 1951 while in the Navy being trained as a carpenter. I dutifully laid out my rafters by stepping them off with a framing square. When I was finished, the commons were fine, but the hips came out short. Ever since then, I've relied on a book of rafter tables to determine rafter lengths rather than trust my ability to count steps with a square. Having framed hip roofs for so many years, I'm surprised that so many carpenters seem reluctant to build hip roofs. Maybe they're afraid that the framing is too complicated or beyond their abilities. I think that once you've learned to frame a gable (see pp. 14–25), cutting and building a hip roof requires few additional skills.

A hip roof has the advantage of being inherently stronger than a gable roof. The hip rafters act as braces in the roof to resist the destructive forces of earthquakes, and the roof sloping up from all four sides of a hip roof offers no flat ends to catch high winds. Another advantage to hip roofs is that

changing the roof style from gable to hip can transform the appearance of a house, offering a nice variation from the gable roof.

A Hip Roof Begins with Common Rafters

Hip rafters extend from the corners of the building up to the ridge. On both sides of the hips, common rafters, called king commons, meet the ridge at the same point as the hips (see the drawing on p. 52). The side and end king commons and the hip rafters are the main framing components of the hip roof.

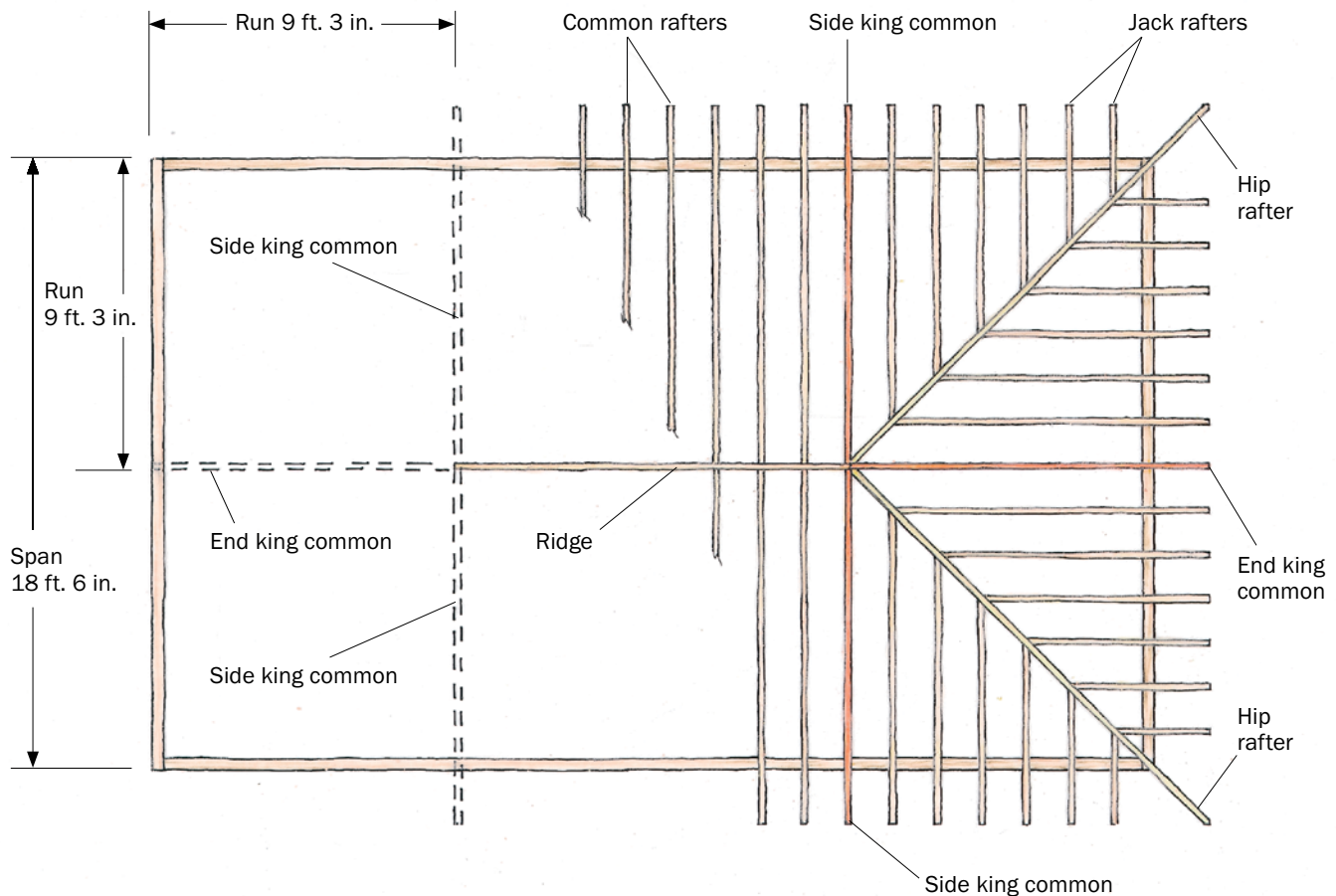
The end king common runs from the middle of the end wall to the ridge. This rafter is the same pitch as the rest of the roof, and it is the key to the hip roof's ending with a pitched plane instead of the more common vertical gable. The hip rafters form the line of intersection between the side-roof and end-roof planes. The first step in framing a hip roof is determining the span

Fitting together pieces of the hip-roof puzzle. If all of the rafters have been cut properly, assembling a hip roof should be a painless process. Here, the author lines up a jack rafter for nailing.



Anatomy of a Hip Roof

The hip rafters run at a 45° angle from the corners of the building to the ridge. These rafters are flanked with the side and end king commons, and the triangular spaces left are filled with jack rafters. Common rafters complete the framing down the length of the building. The total width of the building is the rafter span, and the distance from the outside of the building to the ridge is the run of the common rafters. The run also determines the position of the king commons.



A hip roof has the advantage of being inherently stronger than a gable roof.

of the king commons. The garage featured in the photos in this article is 18 ft. 6 in. wide. The end king common, which is at the exact center of the span, is 9 ft. 3 in. from the outside of the garage. This number also represents the run of the rafters. After marking the location of the end king commons, I measure down the sides of the building the same distance, and then I mark the position of the side king commons (see the drawing above). Next I lay out the rafter locations on the double-wall plates.

Rafter Templates Streamline Measurement and Layout

The roof of our garage has a 4-in-12 pitch, which means that the common rafters rise 4 in. vertically for every 12 in. they run horizontally. Because hip rafters run at a 45° angle to their neighboring commons in plan view, hip rafters must run 17 in. for

every 4 in. of rise. (By the way, 17 in. is the hypotenuse of a right triangle with 12-in. legs.)

When cutting rafters for any type of roof, especially a hip roof, rafter templates are a great way to speed the layout process. These neat little site-built aids have the rafter plumb cut on one end and the bird's mouth layout on the other. For this project I will need templates with pitches of 4-in-12 for the common rafters and 4-in-17 for the hips.

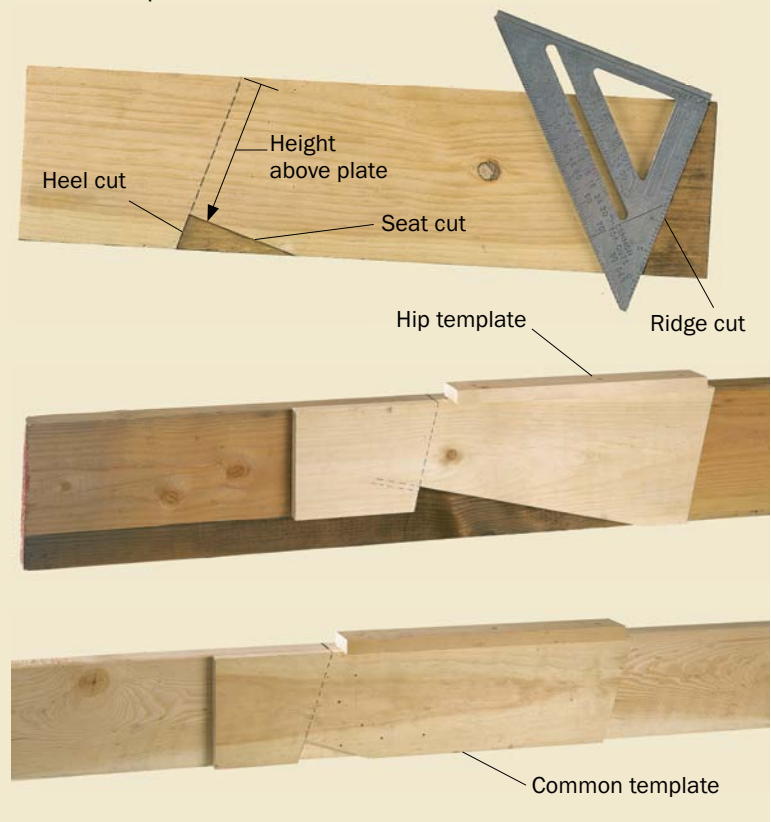
For the common-rafter template, I use a 2-ft. long piece of 1x6, which is the same width as my rafter stock (see the photos at right). I place my rafter square, or triangle square, on the template stock, pivot it to the correct pitch number (4) on the row of numbers marked "common," and mark the ridge plumb cut along the pivot side. I then slide the square down the template about 1 ft. and make a second plumb mark for the heel cut of the bird's mouth. I square this line across the top edge of the template so that I can use the line as a reference when marking the rafters.

A level seat cut combines with the plumb heel cut to make up the bird's mouth of the rafter. The seat cut of the bird's mouth lands directly on the 2x4 top plate, so I make the seat cuts about 3½ in. long, squared off to the heel-cut line. The plumb distance from the seat cut of the bird's mouth to the top edge of the rafter is the height above plate and must be the same for both hip-rafter and common-rafter templates in order to maintain the plane of the roof sheathing. Hip rafters are cut out of stock that is 2 in. wider than the commons so that the jack rafters will have full bearing on the hip. The hip template is also cut out of wider stock, in this case 1x8. The ridge cut is laid out the same as for the common-rafter template except that the square is pivoted to 4 and 17 if you're using a framing square or 4 on the hip-valley index of a triangle square. Again, I move the square down the template about 1 ft. and scribe a second plumb mark for the heel cut, with the line squared across the

Templates Facilitate Rafter Layout

Making templates is easy with a triangle square. Line up the correct pitch number with the edge of the template stock to mark the ridge plumb cut and the heel cut of the bird's mouth. The seat cut is just wide enough to bear fully on the 2x4 top wall plate. The shaded area is waste (top). After the template is cut, a narrow fence is mounted on top for alignment with the rafter stock.

Two templates are necessary for hip-roof layout, the hip based on a 4-in-17 pitch (middle) and the common template set up on a 4-in-12 pitch (bottom). Each has a plumb cut on the ridge end and a bird's mouth on the other. A line squared across the top of the template is used as a reference to position the template on the rafters.



top. Next, I mark off the height above plate on the heel plumb line of the hip template and scribe the level seat-cut line at a right angle from this point.

Hip Rafters Need to be Lowered at the Seat Cut

The height above plate for the hip rafters is measured from the centerline of the rafter. Because the two roof planes intersect at an angle, the top edge of the hip rafter needs to be beveled slightly from the centerline to maintain the roof planes (see the drawing below). This process of beveling a hip rafter (or a valley rafter) is known as backing.

A more efficient solution to this problem is lowering the hip rafter slightly (called “dropping the hip”) by simply cutting the seat deeper. The size of the drop depends on the thickness of the rafter stock and the pitch of the roof. I determine this distance by using a framing square (see the drawing at right on the facing page). For this 4-in-12 pitch roof, I need to drop the hip about $\frac{1}{4}$ in.

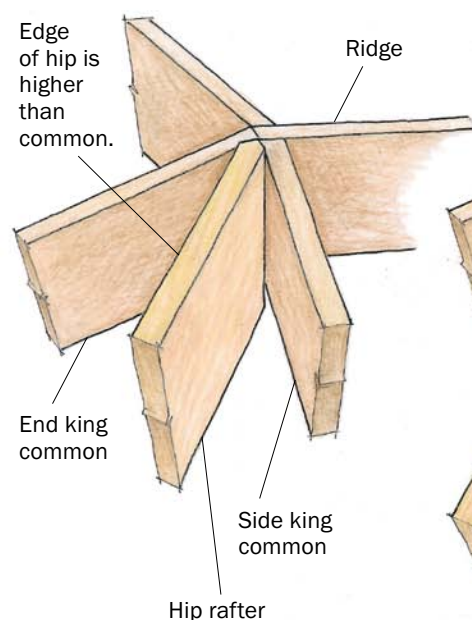
I subtract that $\frac{1}{4}$ in. from the height above plate on my hip-rafter template and make a new level seat-cut line at this point. When my layouts are complete, I cut out the templates carefully to ensure their accuracy. After cutting the bird’s mouth in the hip-rafter template, I rip the tail section to the same width as the common rafters, which allows the soffit material to be properly aligned. I finish the templates by nailing a 1x2 fence to the upper edge of the template.

The Quickest Way to Get Rafter Lengths Is from Tables

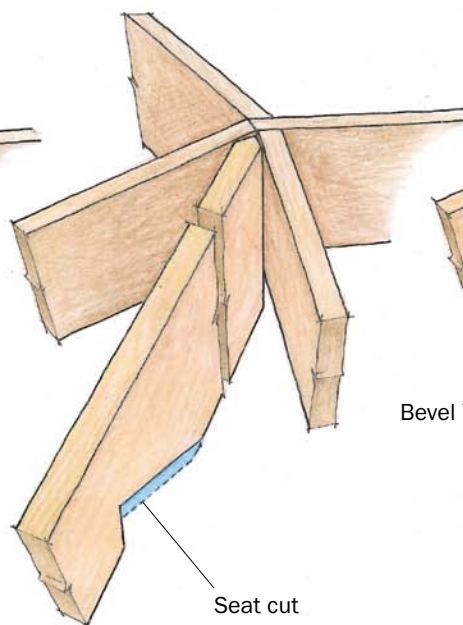
All of the information needed to calculate rafter lengths is right there on any framing square. But out here in southern California, I don’t know of any framers who still use one for this purpose. Some framers determine rafter length using a feet-inch calculator

Two Ways of Dealing with Hip Rafters

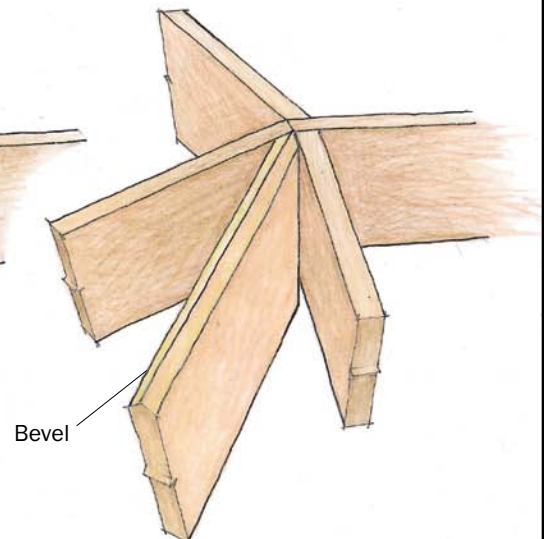
The problem. Without modification, the top edges of the hip rafter would be higher than the king commons.



Dropping the hip. The entire rafter can be lowered by deepening the seat cut. See the drawing at right on the facing page.

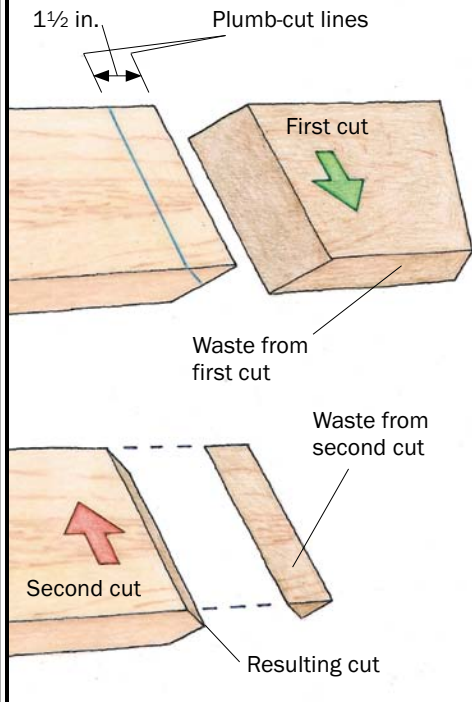


Backing the hip. The top edge of the hip rafter can be beveled slightly from the centerline to the outer edge.



The Hip-Rafter Ridge Cut

A double side cut on the ridge end of the hip rafter lets it fit nicely between the side and end king commons. To make this cut, scribe two parallel plumb-cut lines from the ridge end of the hip template $1\frac{1}{2}$ in. apart. With the sawblade set at 45° , saw along both lines in opposite directions.



like the Construction Master (Calculated Industries Inc., www.calculated.com; 800-854-8075). However, I prefer to get my figures from a book of rafter tables, such as *Full Length Rafter Framer* by A. F. Riechers.

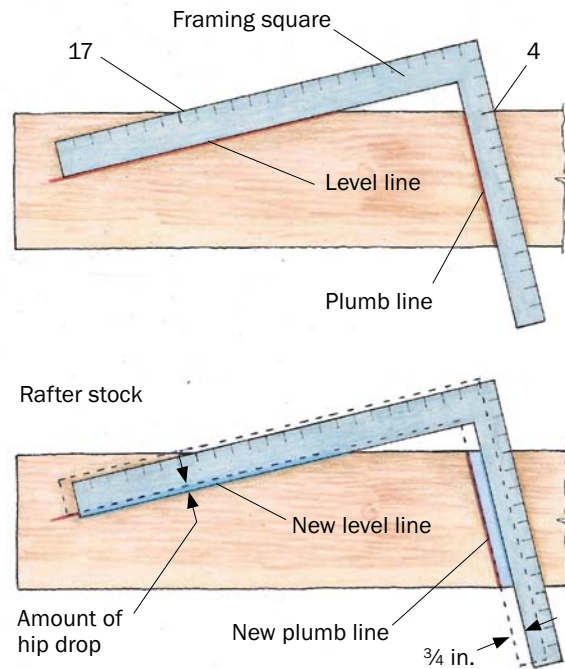
First, I find the page in the book that lists the rafter lengths for a 4-in-12 pitch roof. The length of a common rafter for a span of 18 ft. 6 in. is listed as 9 ft. 9 in. The length of the hip rafter for the same span is 13 ft. $5\frac{1}{4}$ in. These distances are from the plumb cut at the center of the ridge to the plumb heel cut of the bird's mouth at the outside of the wall. If the calculation method is based on run instead of span, don't forget to split the span figure in half.

Because these lengths are figured to the center of the ridge, the actual rafter length has to be shortened by half the thickness of the ridge (see the drawing on p. 56). For a

Finding the Hip-Rafter Drop

Hip rafters can be lowered slightly to put their edges in the same plane as the common rafters.

Step 1. Using a framing square, lay out a 4-in-17 pitch along the edge of any piece of rafter stock.

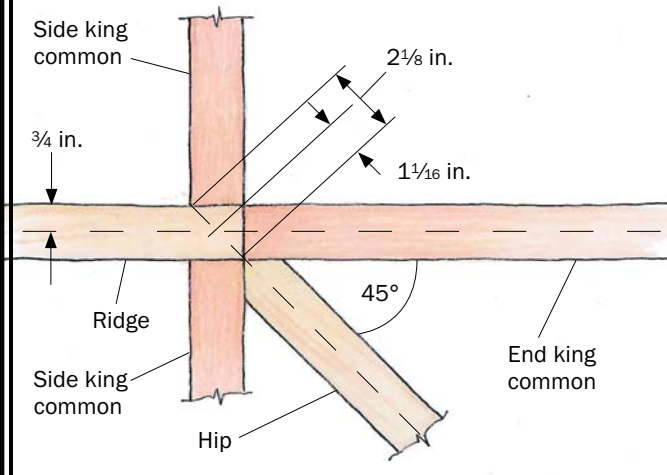


Step 2. Keeping the square set at the same pitch, draw a second set of lines with the new plumb line $\frac{3}{4}$ in., or half of the thickness of the rafter stock, from the first. The resulting distance between the two level lines is the amount the hip rafters will need to be lowered.

2x ridge, common rafters must be shortened $\frac{3}{4}$ in., and because hip rafters meet the ridge at a 45° angle, they have to be shortened $1\frac{1}{6}$ in. These amounts are subtracted from the rafter by measuring out at 90° to the ridge plumb cut.

Detail at Ridge, Hip Intersection

Because rafter length is measured from the center of the ridge, half of the thickness of the ridge must be subtracted. Our ridge is a 2x, so the commons have to be shortened by $\frac{3}{4}$ in. But the hips intersect the ridge at a 45° angle, so they must be shortened by $1\frac{1}{16}$ in.



Because pairs of jacks land on opposite sides of the hip, the 45° plumb cuts have to be laid out on opposite sides of each pair of rafters.

Lay Out Rafters in Stacks of Similar Lengths

Once all of the rafter lengths have been determined, it's time to lay out my stock for cutting. I usually use the house plans to get a count of the rafters, keeping in mind that a hip roof has an extra common rafter on each end. Using a pair of low site-built horses, I rack up all of the commons on edge with the crowns up. Next, I flush the ridge ends by holding the face of a 2x4 against the end of the rafters and pulling the rafters up to it one at a time with my hammer claw. From the flushed end, I measure down my length on the two outside rafters, shortening my rafter measurement for the ridge. I snap a chalkline across the tops of the rafters as a registration mark for aligning the bird's mouth on the rafter template.

I then place my common-rafter template against the first rafter flush with the ridge end and scribe the ridge plumb-cut line. I slide this rafter to one side and continue down the line, leaving all of the rafters on

edge. Next, I align the bird's mouth registration mark on the template with the chalkline on the rafters and mark my bird's mouth cutlines on each rafter. When all of the rafters are marked, I cut the ridges, moving the rafters over one at a time. Next, I flip the rafters onto their sides and cut the bird's mouths, overcutting my lines just enough to remove the wedge without weakening the tail section (see the photo below). I leave the rafter tails long and cut them to length after all of the rafters are in place.

A Double Cut Brings the End of the Hip Rafter to a Point

I try to pick out long, straight stock for the hips. The hip rafters need to be long enough to include the overhanging tail, which is longer than the tails on the commons. Most carpenters like to give hip rafters a double-side (or bevel) cut at the ridge so that they will fit nicely into the corner formed by the end and side king commons (see the drawing above). I do this by laying the hip-rafter template on the rafter stock and marking the ridge cut (see the drawing at left on p. 55). I then slide the pattern down $1\frac{1}{2}$ in. and make a second mark parallel to the first. With my saw set at 45° , I cut along the



Bird's mouths are overcut. A wedge shape is cut out of each rafter to give it a place to land on the plate. These bird's mouths can be overcut just enough to remove the wedge.

first line in one direction and the second in the opposite direction, which leaves me a pointed end that will fit in between the king common rafters.

I set the hip stock on edge and flush up the pointed ridge ends (see the top photo at right). Then I measure down from these points and make my plumb-heel-cut reference marks, shortening the rafters $1\frac{1}{16}$ in. for the 2x ridge. Now the registration mark on my hip template can be aligned with the marks on my rafters, and I can scribe the bird's mouths.

To scribe the hip-rafter tails to the proper width, I hold a pencil against the tail part of the hip template and slide the template along the length of the tail. The bird's mouth of the hip rafters is cut just like the common rafters, and the tails are ripped to complete the cutting.

Jack Rafters Are Cut in Pairs

Jack rafters run parallel to the king commons and frame in the triangular roof sections between the king commons and the hip rafters. They are nailed in pairs into both sides of the hip rafter with each pair cut successively shorter as they come down the hip. The difference in length between each pair of jack rafters is constant (it's called the common difference), and it can be found in the rafter tables. For jack rafters spaced at 16 in. o.c. at a 4-in-12 pitch, the difference in length is 1 ft. $4\frac{7}{8}$ in. For 24-in. spacing, the difference is 2 ft. $1\frac{1}{4}$ in.

I lay out the jacks by racking together eight pieces of rafter stock the same width but slightly shorter than the common rafter (see the bottom photo at right). (I rack eight pieces because there is a pair of jacks of equal length for each of the four hips.) Next to these I rack eight more pieces a foot or so shorter than the first eight and so on for each set of jack rafters. When the jack-rafter stock is laid out, I flush up the tail ends this time. The tails of the jack rafters are the



All four hip rafters are laid out and cut at the same time. Short site-built sawhorses hold the rafter stock for layout and cutting. With all of the boards stacked together, only one set of measurements needs to be taken. Templates (see the photos on p. 53) do the rest.



Jack rafters are laid out four pairs at a time. Jacks oppose each other in pairs along both sides of the hip rafter. Each successive pair is shorter by a specified length than the pair above it. Diagonal marks remind the author to make his 45° cuts in opposite directions.

The hips and king commons come together at the ridge.

The end of the ridge is the meeting point for all of the major framing members of the hip roof. After the end king common is nailed in, the hip rafters are installed, and the ends of the side king commons are nailed in next to the hips.



If the roof is long, additional ridge sections may be installed using other pairs of common rafters for support.

same length as the tails of the commons, so I snap a line at that distance across all of the edges for my plumb heel cuts.

Next, I lay an unshortened common rafter alongside my rack, lining up its heel-cut line with the heel-cut line on the jack stock. From the ridge cut of this common, I measure down the common difference. I shorten this first set of eight jacks by $1\frac{1}{16}$ in. just like the hip rafter and make diagonal marks in opposite directions on each pair of jacks to remind me which way my cuts will go (see the bottom photo on p. 57). For each successive set of jacks, I measure down the common difference in length from the previous set. These measurements do not need to be shortened by the width of the hip rafter because I subtracted $1\frac{1}{16}$ in. from my first measurement.

Using the common-rafter template, I mark the plumb side cut and the bird's mouth cut. Because pairs of jacks land on opposite sides of the hip, the 45° plumb cuts

have to be laid out on opposite sides of each pair of rafters.

Assemble Common Rafters First

If everything is cut accurately, the roof members should fit together like a puzzle (see the photo on p. 51). I always tack down plywood sheets on top of the ceiling joists for a safe place to work. The ridge length and rafter layout can be taken directly from layout on the wall plate, but I prefer to bring up a ridge section and begin my rafter layout about 6 in. from one end. I like having this extra length to compensate for any discrepancies in my layout.

With a partner, I set up my first pair of side king commons and nail them to the plate and into the ceiling joist. (In high-wind areas, rafters may need to be tied to the plates with metal framing anchors.)

Next, I go to the other end of the ridge and nail in another set of commons.

The ridge board then gets pulled up between the two sets of commons and nailed in place. I just tack the side king commons to the ridge until the end common has been installed. At this point I make sure the ridge is level by measuring from the tops of the ceiling joists at each end. I support the end of the ridge with a 2x4 leg down to a ceiling joist or to an interior wall and run a diagonal sway brace to keep everything in place temporarily. Next, I slide one of my side king commons out of the way, hold the end king common next to the ridge, and mark the end of the ridge. After the ridge is cut to length, I nail my end king common in place.

Next, a hip rafter is toenailed to the wall plate directly over the outside corner. The side cut on the ridge end gets nailed to the end common next to the ridge. I nail the opposing hip in place, and the two side king commons can be slid back against the hips and nailed in permanently.

If the roof is long, additional ridge sections may be installed using other pairs of common rafters for support. Again, I make sure additional ridge sections are level. At the other end of the building, I mark and cut the ridge and assemble the hips and side king commons as at the first end.

Frieze Blocks Stabilize the Rafters

Before nailing in the jack rafters, I sight down the hip rafter and make sure it is straight from the ridge to the plate. If it's bowed, I brace it straight temporarily until the jacks are in. I start with the longest pair of jacks and nail them to the plate along with frieze blocks, which are nailed in between the rafters at the plate (see the photo on p. 51).

Local codes don't always call for frieze blocks, but I use them to stabilize rafters and provide perimeter nailing for roof sheathing. If necessary, they can be drilled and screened

for ventilation and are a good way to use scrap lumber. I cut a bunch of blocks ahead of time to either 14½ in. or 22½ in., depending on my rafter spacing.

Frieze blocks can be installed flush with the wall, where they serve as backing for the exterior siding. However, with this method the blocks need to be ripped to fit below the roofline. Another method is installing the blocks perpendicular to the rafter just outside the plate line. I like this second method because it requires no ripping and provides a stop for the top of siding.

I nail in the frieze blocks as I install the remaining pairs of jack rafters. Each jack is nailed securely to the hip rafter; I take care not to create a bow. Once all of the pairs of jacks are installed, the hip will be permanently held in place.

The corner frieze blocks get an angled side cut to fit tight against the hips. Once all of the jacks and commons are nailed in, the rafter tails can be measured, marked, and trimmed to length. Remember to measure the overhang out from the wall and not down along the rafter. For this building the overhang is 20 in., and the fascia stock is 2x (1½ in. thick). I mark a point on the top edge of the rafters 18½ in. straight out from the walls at both ends of the building and snap a line across the rafters between my marks. I extend my chalklines out over the tails of the hip rafters to mark the overhang at the corners. When marking the plumb cut on the rafter tails, use the common-rafter template on the commons and the hip template on the hips.

Larry Haun, author of *The Very Efficient Carpenter and Habitat for Humanity: How to Build a House* (The Taunton Press), lives and works in Coos Bay, Oregon.

Hip-Roof Framing Made Easier

■ JOHN CARROLL

Framing a hip roof is a head-scratcher for most carpenters, but it doesn't have to be. The process became a whole lot easier for me when I realized that the primary challenge in building a hip roof is one of layout, not math. And the key to layout is to know exactly where to begin and end measurements.

In my approach, all the measurements are along the bottom edge of the rafter, short point to short point. This is not the way I learned how to do it, but once I started thinking about the bottom plane of the rafters instead of the top (or instead of some theoretical middle line), everything fell into place. Because I measure and mark along the bottom of the rafters, where I measure to is where I cut from; and because there are fewer steps, there are fewer chances for mistakes.

Another advantage of my approach is that I don't have to deal with dropping the hip because I use the same dimensional lumber for all the rafters and I align the bottom edges. On this roof, I used 2x6 lumber for the hips, jacks, and commons. This left the

tops of the jacks $\frac{1}{4}$ in. above the hip, which allows the sheathing to clear the hip and allows air to flow over the hip and up to the ridge vent. If I had wanted to have both the bottom and top edges in plane, I could have ripped down a 2x8 to a width of $5\frac{3}{4}$ in.

I also don't have to make adjustments for measuring from the center of the board because I take all my measurements from the edge of the board.

The other thing I do that's a little different is that I put down my English measuring tape when I finish framing the walls and pick up a metric tape to frame the roof. In my approach, the metric system is easier to use when math is involved because there are no fractions to deal with. The math itself is simple to calculate because every rafter position and measurement can be explained with right triangles and dimensions that are based on the Pythagorean theorem (see the center drawing on p. 63).

Before I consider any of this, though, the first thing I do on a new job site is get acquainted with the details and visualize how the parts fit together. The project

Parts of a Hip Roof

HIP RAFTER

The hip is always at a shallower pitch than the commons. For this 6-in-12 roof, the hip rafter has a 6-in-17 pitch. On this building, 2x6 stock was used for all rafters, including the hips.

JACK RAFTER

These shorter rafters meet the hip rafter rather than the ridge and have the same pitch as common rafters.

RIDGE

In this building, the ridge is the same dimensional lumber as the rafters.

COMMON RAFTERS

These rafters run uninterrupted from the top plate to the ridge.

KING-COMMON RAFTERS

Three common rafters meet at each end of the ridgeboard. They are called the king commons.



shown here is a simple storage shed. Because the roof is small and all the framing is 2x6 dimensional lumber, I don't have to make adjustments for a larger ridge beam or hip rafters.

Two Tools Make the Job Easier

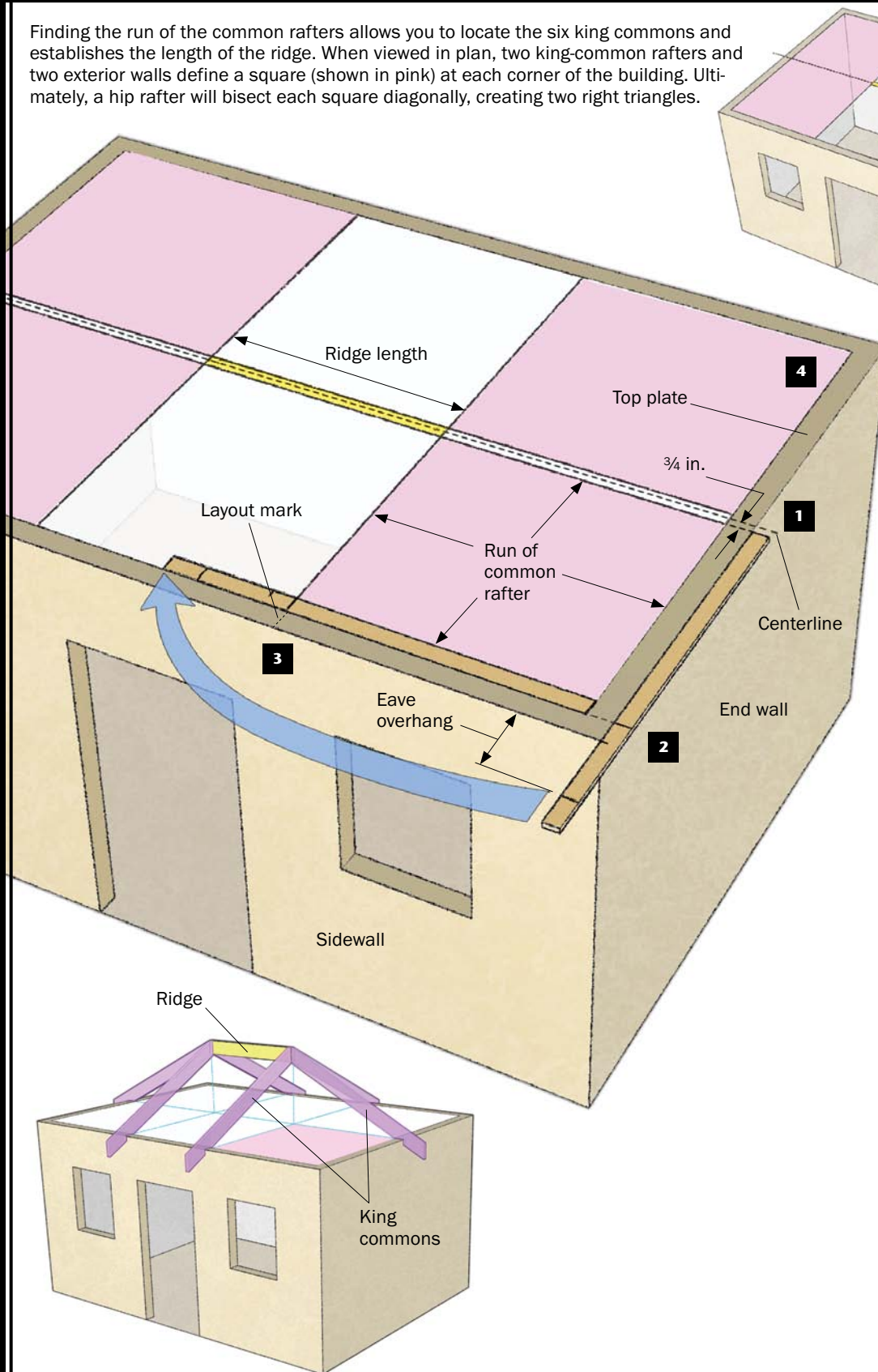
First, I make a story stick out of a 2-in.-wide rip of plywood. I lay it on the top plate of the end wall and mark out the common-rafter run, the wall thickness (for the seat cut), and the eave overhang (see the center drawing on p. 62). The beauty of the story stick is that I can have all the initial measurements I need to frame the roof in one place. Then I can take the story stick down to the cut station and use it to make all the cuts without having to waste time running back and forth.

The second tool is a table of multipliers that give the ratio of hypotenuse to run for given roof pitches (see the table on p. 63). One column is for common rafters, and one is for hip rafters. In other words, the table serves as my cheat sheet for figuring rafter lengths. The multiplier times the run is the rafter length. I write this table in my job-site notebook, but you also can find these values in any good roof-framing book.

If you're on a roof that falls in between two values on the table, say, a 6½-in-12 roof pitch, you can resort to the equation $a^2+b^2=c^2$ (see p. 63). Tip: If math is really not your thing, try thinking of the equation in plain language; i.e., the run times itself plus the rise times itself is the rafter length squared.

Locate the Six King-Common Rafters

Finding the run of the common rafters allows you to locate the six king commons and establishes the length of the ridge. When viewed in plan, two king-common rafters and two exterior walls define a square (shown in pink) at each corner of the building. Ultimately, a hip rafter will bisect each square diagonally, creating two right triangles.



Use a story stick rather than a tape to minimize errors

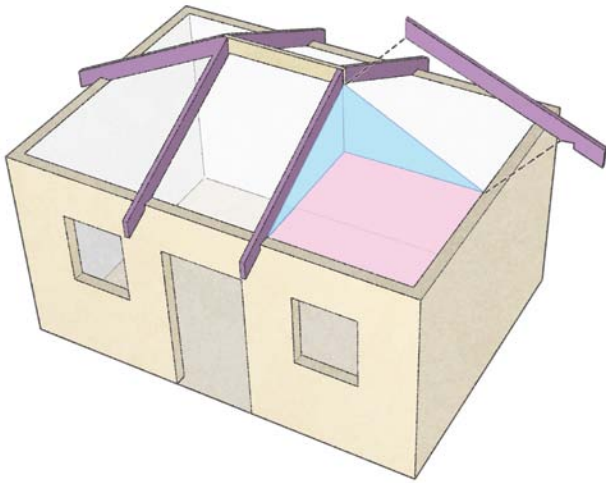
1. On the end-wall top plate, mark the centerline. Then measure back half the thickness of the ridge (in this case, $\frac{3}{4}$ in.), and mark the first king-common-rafter layout line.

2. Align the end of the story stick with the king-common layout line you just made. At the other end of the story stick, mark the inside of the sidewall. This is the common-rafter run. Also mark the outside of the wall and the eave overhang. You'll use this later to figure the tail length.

3. Flip the story stick over onto the sidewall, and mark the rafter run from the inside corner of the top plate. This is the second king-common layout line.

4. Repeat these steps in the three remaining corners. This will locate the end of the ridge and the king-common rafters.

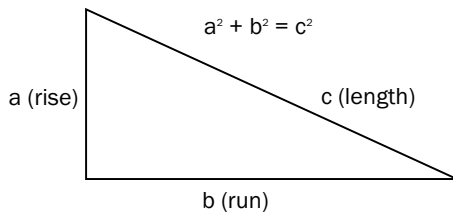
Use a Multiplier to Find the Common-Rafter Length



There are many ways to find a rafter length, but basically, you need to take the rafter run and convert it to the rafter length. You can use the Pythagorean theorem (explained below), or you can use the shortcut in the multiplier table. To use the multiplier, you need to know the run and the roof pitch.

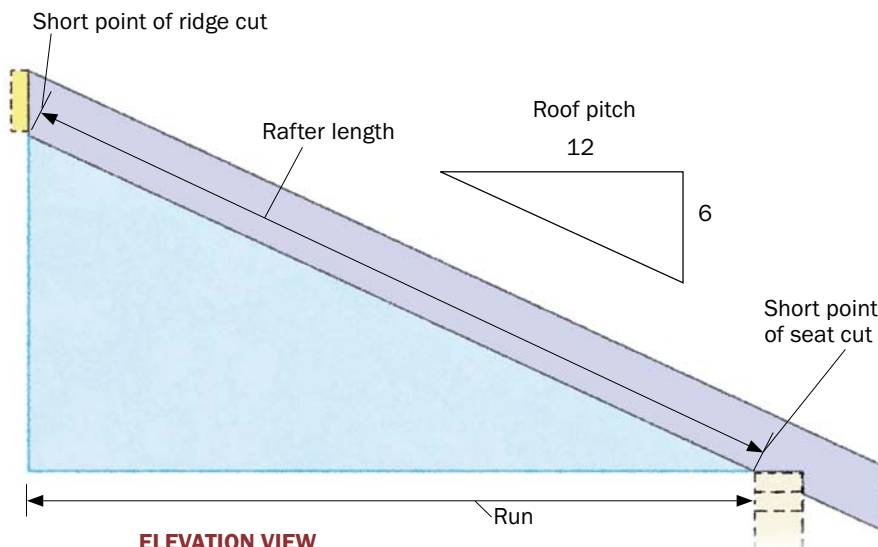
1. Measure the common-rafter run on your story stick (see the facing page). Find the multiplier on the table below that corresponds to the roof pitch. Multiply the run times the multiplier to get the rafter length.

If the roof pitch is between the values in the table, say a 6.5-in-12, you can use the Pythagorean theorem. Get the run from the story stick. Get the rise by multiplying the run times the roof pitch expressed as a fraction (e.g., $6.5 \div 12 = 0.54$; $0.54 \times \text{run} = \text{rise}$). Then solve for length with the Pythagorean theorem.



Roof pitch	Common-rafter multiplier	Hip-rafter multiplier
3-in-12	1.031	1.016
4-in-12	1.054	1.027
5-in-12	1.083	1.043
6-in-12	1.118	1.061
7-in-12	1.158	1.082
8-in-12	1.202	1.106
9-in-12	1.25	1.131
10-in-12	1.302	1.161
11-in-12	1.357	1.192
12-in-12	1.414	1.225

2. Measure the rafter length along the bottom edge of the rafter (see the sidebar on pp. 66–67 for the cut sequence). In my approach, the rafter length is the distance from the short point of the ridge cut to the short point of the seat cut.



3. Multiply the tail run by the multiplier to get the tail length.

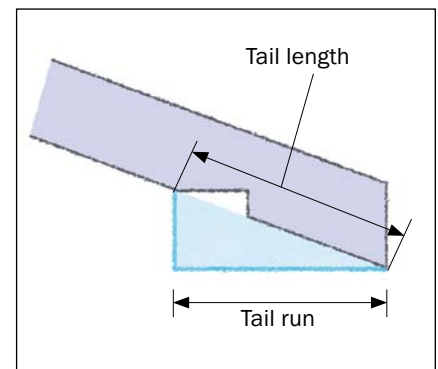
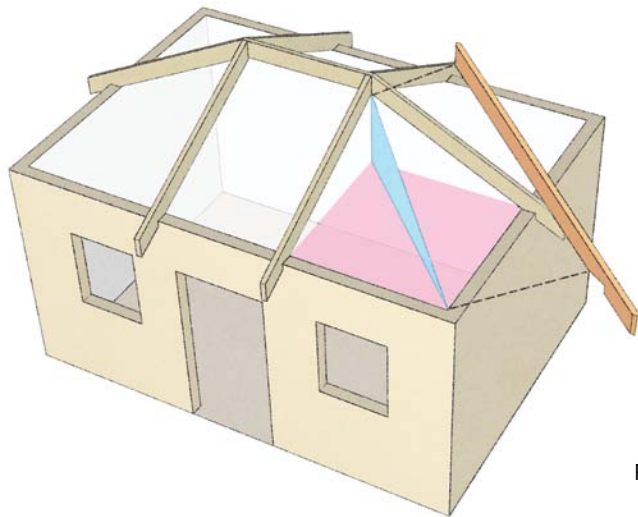
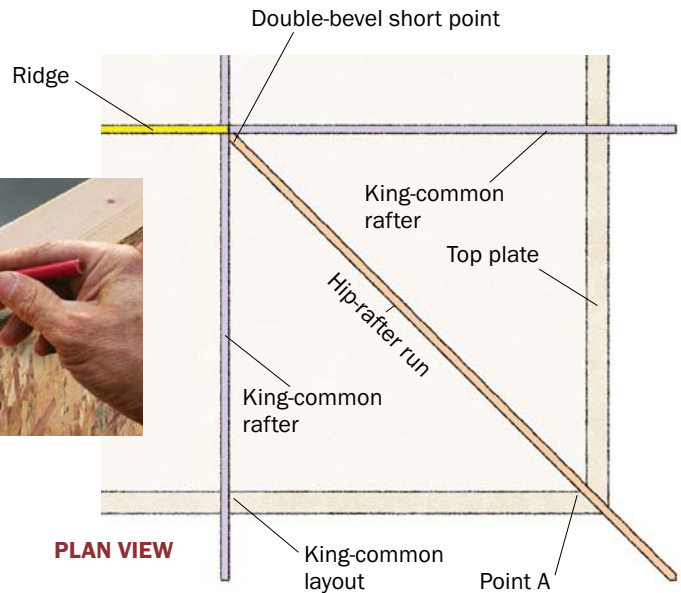
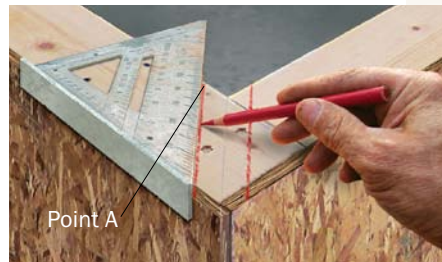


Figure Hip-Rafter Run, then Length

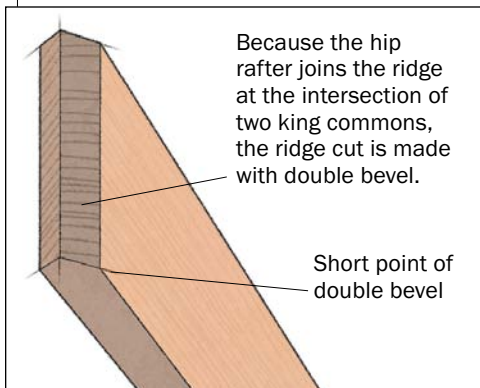
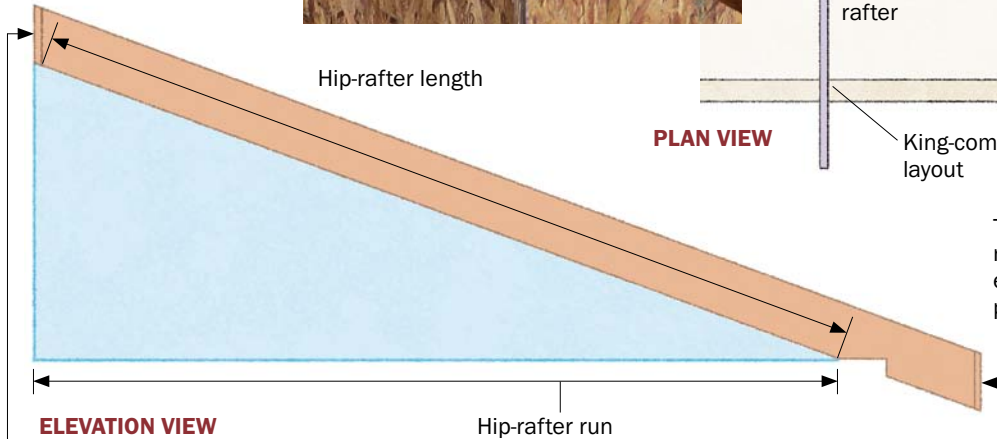


The hip rafter is a little different from a common rafter: It has a shallower pitch, a double-bevel ridge cut, a longer run, and typically a longer seat cut. Find the run first (see plan view below), then use the hip-rafter multiplier (see the table on p. 63) to get the rafter length and the tail length.

1. Mark the hip-rafter layout on the top plate (see the photo below). Establish Point A where the hip-rafter layout line intersects the inside of the top plate. Measure back to the nearest king common (this is the layout line you already made with the story stick). Multiply this distance by the square root of 2 (1.414) to get the hip-rafter run.

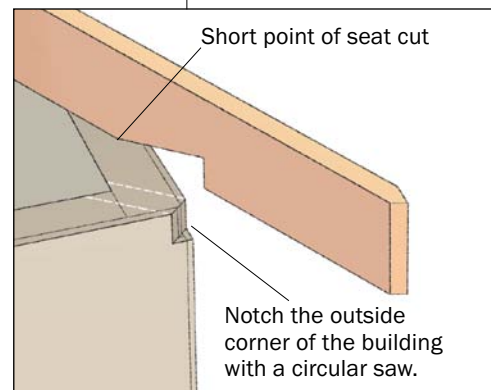


The hip rafter, king-common rafter, and top plate make an equal-sided right triangle in plan view.

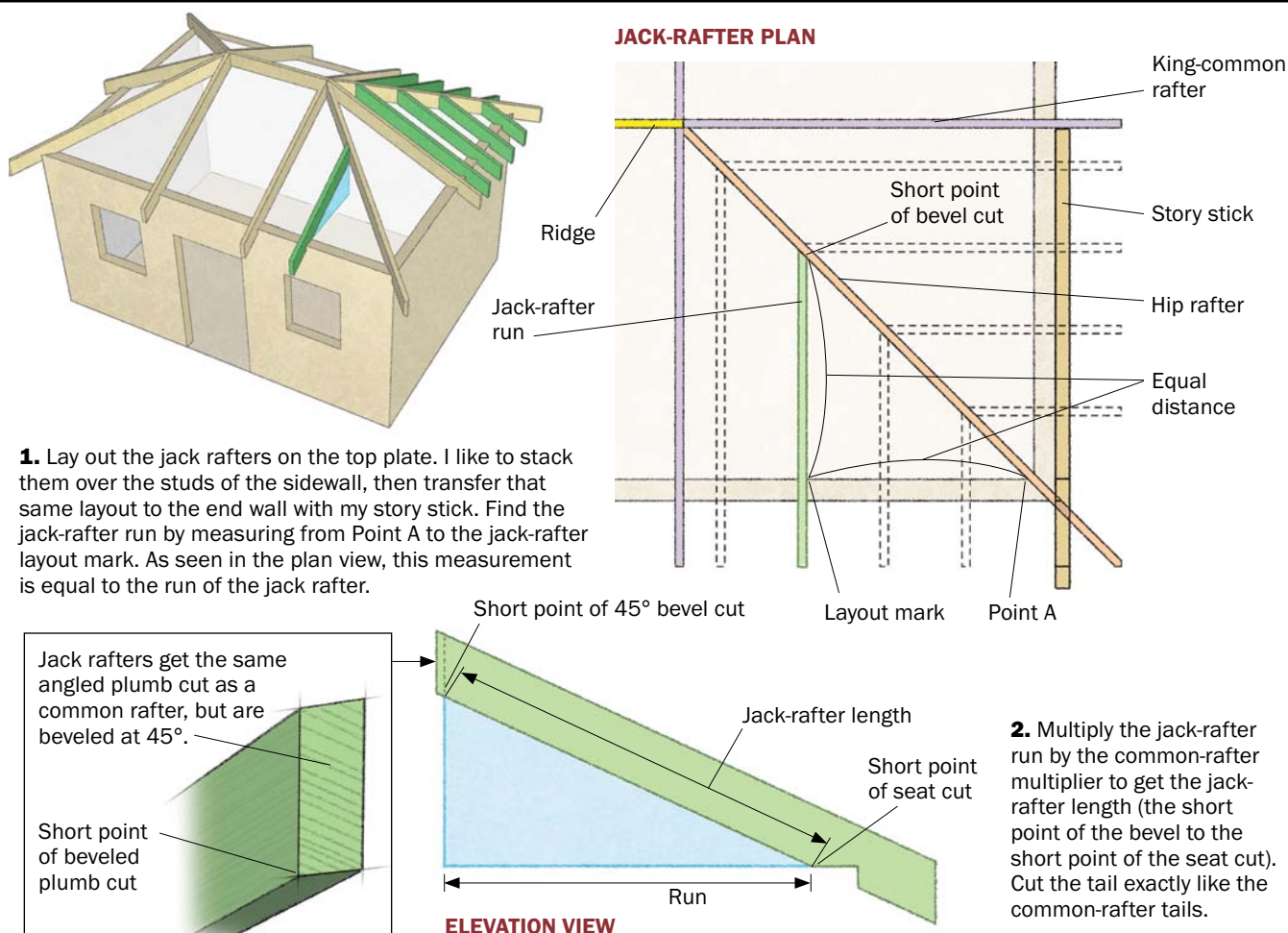


2. Multiply the hip-rafter run times the multiplier (see the table on p. 63) to get the hip-rafter length.

3. To lay out the hip-rafter tail, multiply the common-rafter tail run you already calculated times the square root of 2 (1.414). Then use the multiplier to get the hip-rafter tail length, measured from the short point of the seat cut to the short point of the double-bevel tail cut.



Find the Jack-Rafter Run, then Get the Length with the Common-Rafter Multiplier



Look at the Roof in Plan View

Laying out hip rafters is one of those situations where a 3-D image is not as clear as a two-dimensional drawing. If you look at the roof from a plan view, you can see that the hip-rafter run is the hypotenuse of a simple 90° triangle with equal sides (see the drawing, center right on the facing page).

Use a Speed Square to lay out both sides of the hip rafter on the plate. Establish Point A where the layout line meets the inside edge of the top plate (see the photo on the facing page). Measure from Point A to the layout of the nearest king-common rafter. Use this measurement to calculate first the

run and then the length of the hip rafter as explained on the facing page.

Once you've got the hip rafter's length, go back to thinking in 3-D. The rafter length just calculated represents a line along the bottom edge of the board from the short point of the double-bevel cut to the short point of the seat cut. For this roof, I worked through the seat cut and the tail in the same way as the common rafters except that instead of extending the seat cut far enough to clear the top plate, I notched the corner of the double top plate to get a clean fit and to strengthen the hip rafter's tail.

Metric vs. English system

Lumber is sized and sold based on the English system, so it makes sense to build with an English tape measure—most of the time. However, when I'm doing a framing project that involves complicated math, I like to use the metric system because it's easier to add, subtract, and multiply. When I first started using a metric tape measure, I thought there would be an adjustment period. But there wasn't: Most of us are used to looking at units divided into 10 equal increments, like the degree scale on a miter saw. Metric tapes are sold at most hardware stores or online.



Metric decimal tape

Jack Rafters Have the Common-Rafter Pitch

To keep the layout simple and 16 in. on center, I retain the layout from the sidewalls and use the story stick to create a mirror image on the end walls. This method will add some redundancy, but the important thing is to have each pair of jack rafters meeting at the same spot on the hip rafter.

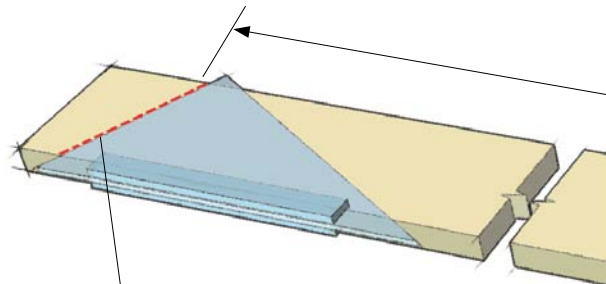
A plan view shows that the distance from the short point of the hip rafter's seat cut (Point A) to the jack-rafter layout mark is also the run of the jack rafter to the short point of the bevel cut.

Use the common-rafter multiplier to calculate the lengths of the jack rafters, and lay out the seat cuts and tails exactly the same

Use a Jig to Mark and Cut



Tip: Clamp the Speed Square to the rafter so that you can hook the tape at the short point of the plumb cut.



Plumb ridge cut

way as you figured out the common rafters. The plumb cut then is made with your saw set at a 45° bevel, creating the jack rafter's bevel cut.

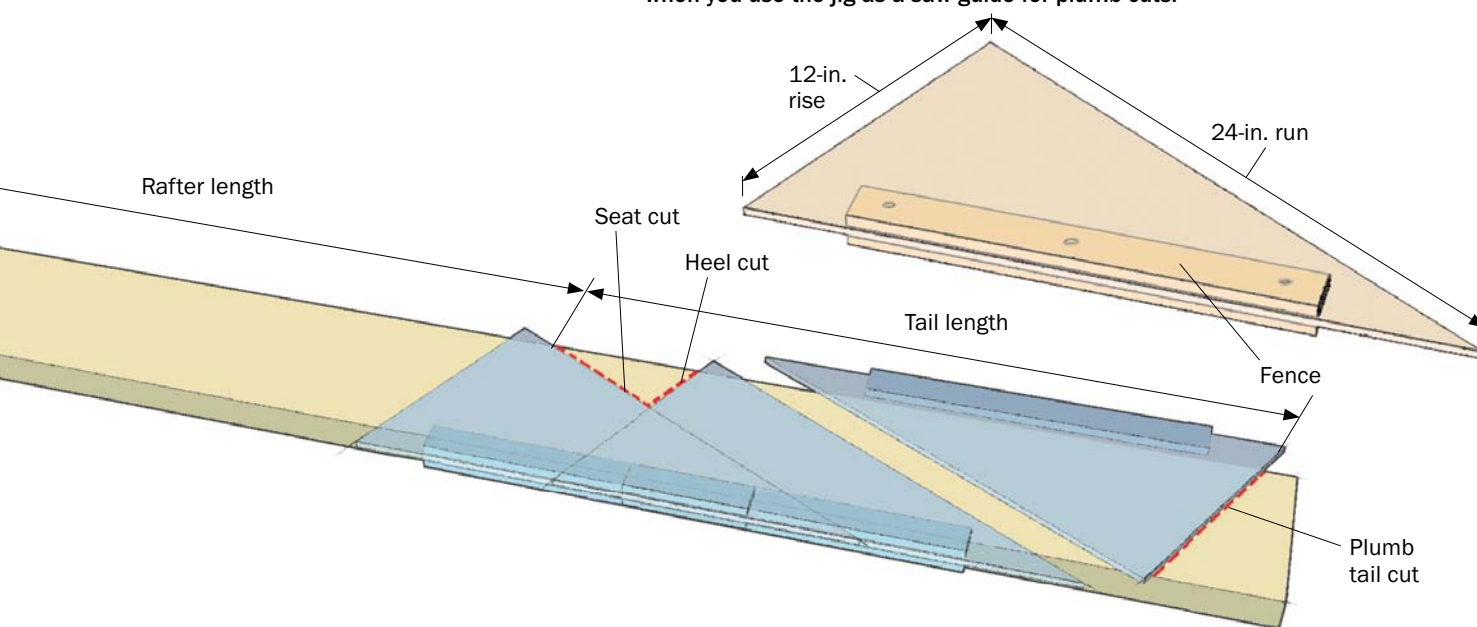
John Carroll is a mason and builder in Durham, North Carolina. He is the author of two books published by The Taunton Press: Measuring, Marking & Layout (1998) and Working Alone (2001).

the Rafters

Once you've taken all the measurements and written them on the story stick, you're ready to cut common rafters, hip rafters, and jack rafters. Make this layout jig and cutting guide from a piece of plywood that has a square factory corner. For the common-rafter jig (shown here), just double the roof pitch in inches. For a 6-in-12 roof, mark 12 in. on one side for the rise and 24 in. on the other edge for the run. Connect the marks to complete the triangle. After cutting the plywood, affix a 1x2 fence to the long side. When you finish the jig, write the multiplier on it in red. For the hip-rafter jig, the rise is 6 in., but the run is 17 in. Instead of doubling the rise and run for the hip-rafter jig, multiply them by 1.5, which makes the jig easier to handle.



Tip: Stop the fence short of the jig's plywood edge. This way, the saw can clear when you use the jig as a saw guide for plumb cuts.



Framing a Gambrel Roof

■ JOE STANTON

Gambrel roofs can be a challenge. Dealing with two roof pitches instead of one seems to complicate matters disproportionately. Also, most gambrel roofs require a kneewall to support the knuckle, or the joint between the upper and lower roof slopes. You have to build the kneewall first, then brace it straight and work around the wall and its braces while installing two sets of rafters. The work is cumbersome, and when you're done, this kneewall takes away from the available floor space below the gambrel.

However, I recently framed a gambrel designed by Michael McKinley (see the sidebar on p. 75) using site-built trusses (see the drawing on p. 70) and found that this method offers several benefits over conventional framing. Site-built gambrel trusses go together quickly and negate the need for a supporting kneewall under the knuckle. (A short kneewall, added after the roof was framed, maintained some gambrel roofline as the ceiling while providing a plumb wall for hanging pictures.) Be aware that gambrel trusses may require an architect's or structural engineer's stamp of approval.

Lay Out Trusses Full Size on the Floor

With the upper floor sheathed, I snapped chalklines for the 2x6 plates on which the trusses would stand. This step is no different than if I were framing walls. Next, however, I laid out the gambrel trusses full scale on the floor, taking the dimensions directly from the architect's plans (see the bottom left photo on p. 71).

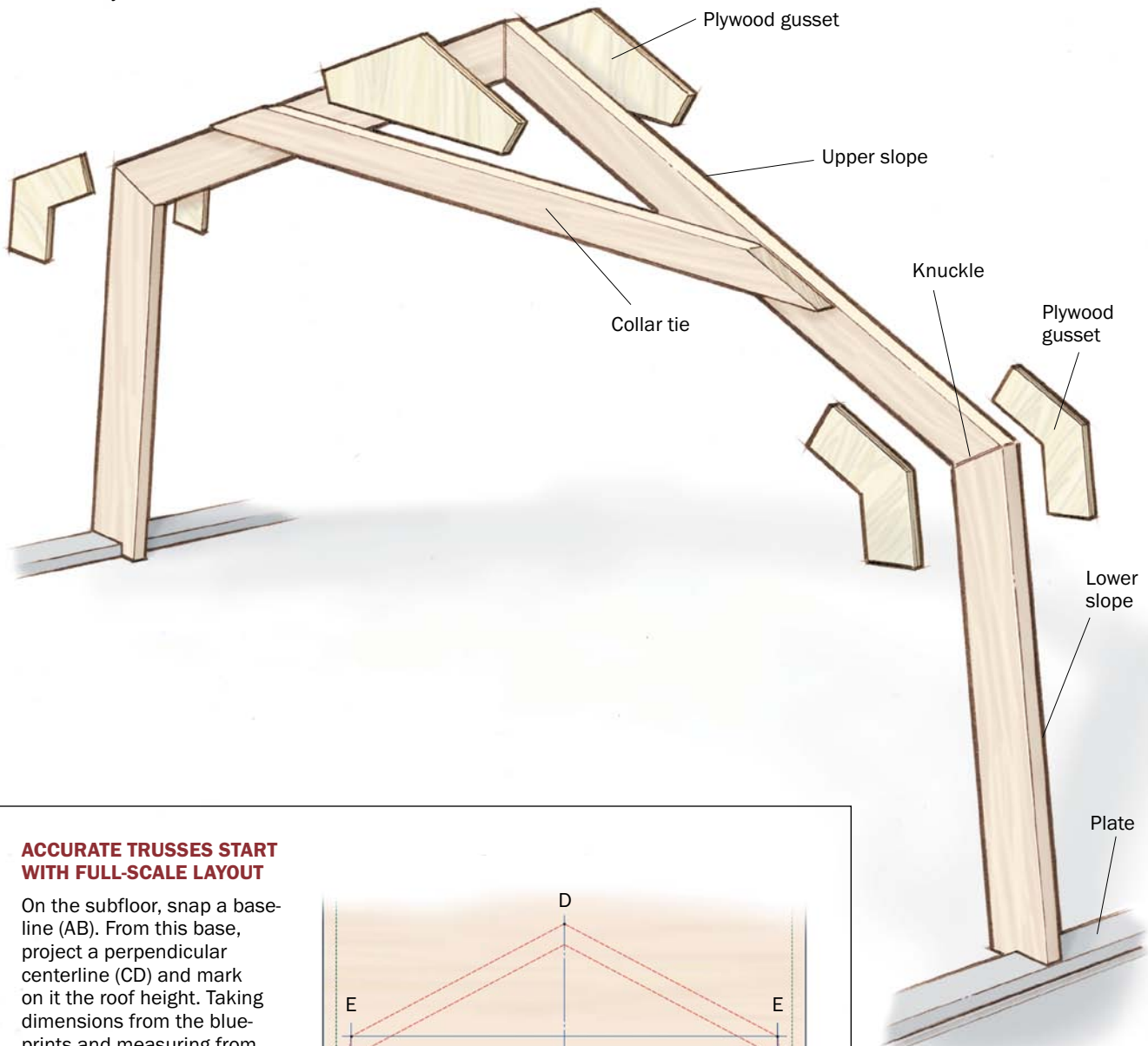
To facilitate the layout, I snapped a baseline square to the sidewalls and added a centerline perpendicular to the baseline (see the drawing on p. 70). From these lines, I measured to locate the knuckle and peak. With these points set, I snapped chalklines that represent the trusses' framing members (see the top photo on p. 71), then measured the length and miter angles of the rafters that would be assembled into trusses.

Precision is key for trusses. The author uses full-scale layout to make templates for gussets and rafters. After cutting these members, he builds the trusses, guided by stop blocks nailed on the layout.



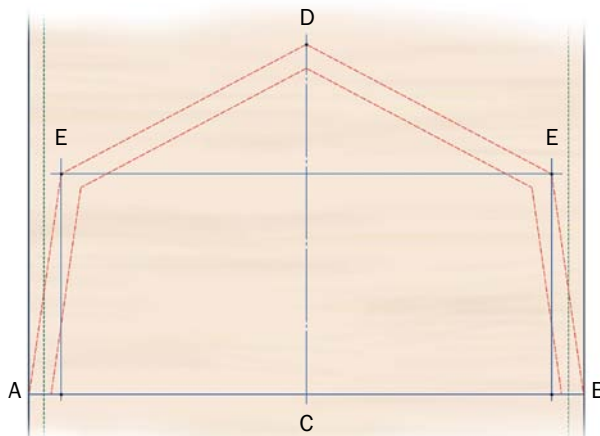
Anatomy of a Gambrel Roof

Unlike most roofs, gambrels have an upper and a lower slope. The intersection of these slopes means a joint in the rafters that must be supported. A kneewall commonly provides this support. In this case, however, to gain more floor space, a simple truss was engineered with plywood gussets and a collar tie providing all the necessary reinforcement.



ACCURATE TRUSSES START WITH FULL-SCALE LAYOUT

On the subfloor, snap a base-line (AB). From this base, project a perpendicular centerline (CD) and mark on it the roof height. Taking dimensions from the blue-prints and measuring from these centerlines and base-lines, mark the outside point of the knuckle (E). Then snap lines representing the upper and lower slopes of the truss from which you take the angles for gusset and rafter templates (see the photos on the facing page).



Full-Scale Layout Gets the Angles Right

Laying out the multiple angles of a gambrel roof using a framing square is a frustrating task. Full-scale layout on the floor ensures precision.

- 1.** Start by taking the roof dimensions from the blueprints. Such dimensions as wall and ceiling height and room width are critical. Transfer them correctly from the plans, and the roof angles will necessarily follow.
- 2.** Lay out the points of the peak, knuckle, and truss seat on the floor. From these points, the author snaps lines representing the truss tops and bottoms.
- 3.** Guided by the snapped lines, the author creates templates for the truss members and gussets.



I also used the full-scale layout to make a cardboard pattern for the $\frac{3}{4}$ -in. plywood gussets that reinforce the knuckle and the peak joints (see the bottom right photo above). The pattern is then copied onto more-durable Masonite. These gussets are 32 in. long, a size that's structurally adequate and that minimizes plywood waste.

I selected some straight stock and made a pair of pattern rafters, or templates. To

double-check these templates, I placed them on the layout lines and verified the fit. Then I cut a pile of rafters. The seat cut where the rafter meets the plate is critical. To stop lateral motion, the 2x8 rafters are notched to fit the inside of the 2x6 plates (see the bottom photo on p. 73).

Gambrel Trusses are Raised Like Regular Trusses

1. Plumb and brace the gable truss first. Strapping made of 1x3s is used to space and brace succeeding trusses.

2. Joist hangers tie the ridge for a conventionally framed dormer to trusses. The dormer roof is simply an extension of the upper gambrel.

3. The seat-cut detail keeps trusses from spreading outward. The inner tail of the truss is cut short so that it won't touch the deck, ensuring that the roof load is borne by the 2x6 plate and not by the plywood deck.



Turning the Second Floor into a Truss Factory

To make sure the assembled trusses were uniform, I nailed stop blocks next to the layout lines and assembled the trusses on the floor. Each gusset was glued with PL 400 construction adhesive (OSI Sealants Inc.; 800-624-7767; www.osipro.com). Additionally, each gusset was nailed to the rafters with 6d nails. After nailing the gussets to one side of each truss, my crew flipped it over and affixed additional gussets and the collar tie to the other side.

We built the gable truss first (this truss needed no collar tie or gussets on the outside because the wall sheathing made the truss rigid). With the gable truss raised and braced plumb, we began assembling and setting trusses one by one (see the top photo at left). The remaining trusses were connected to the gable truss and to each other with 1x3 strapping at the ridge and at each knuckle. We removed the strapping after the roof had been sheathed.

This roof included several shed dormers. These dormers, which we framed conventionally, tie together the gambrel trusses on each side of the dormers with the ridge (see the bottom photo on the facing page). Extending the gambrel's upper slope to the front wall of the dormer creates the dormer roof.



This Roof is Vented above the Sheathing

To leave the maximum space for insulating between the 2x8 rafters, this roof is vented above the sheathing. Here's how.

After completing the sheathing, my crew flashed and covered the roof with #30 tar paper. Then we ran sleepers on 16-in. centers above the trusses and rafters (see the top

left photo below). This particular roof was to be covered with cedar shingles, so the skip sheathing for the shingles was nailed over the sleepers (see the right photo below). In this way, the sleepers provided a vent channel from soffit to ridge. By quickly covering the roof sheathing with tar paper, we could conveniently manage the slow work of cedar roofing without slowing the interior work.

Detailing the Roof



Eave details for this cedar-shingle gambrel are added after sheathing, tar paper, and sleepers.

1. Sleepers atop the deck vent the roof. These sleepers are continuous from soffit to ridge. Skip sheathing



nailed to the sleepers provides nailing for the cedar shingles.

2. A flared roof overhang softens the angles of the gambrel. Curved plywood forms are sandwiched and nailed to the sleepers, tying the overhang to the roof.

3. Treated bottom skip sheathing ensures durability. Following the curve of the plywood forms, skip sheathing provides a nail base for cedar shingles.

Thoughts about Gambrel-Roof Design

I've designed houses with gambrel roofs for a variety of reasons. One use for a gambrel roof is blending a new house into an older neighborhood. Historic examples of gambrels are found in periods ranging from the colonial to the Arts and Crafts.

Roof-height restrictions, often imposed by local zoning, may pre-empt the use of a conventional gable roof over a second floor. The gambrel roof is the most efficient way to create a usable second-floor area when building height is limited. The geometry of a gambrel enables adjustment of the angle of the lower-roof pitch to maximize interior headroom and to flatten the upper roof's pitch to minimize the overall height of the house. Generally, the upper pitch of the roof should not be less than a 3-in-12 to maintain the shingle warranties.

The headroom below the lower roof will be low. Also, the kneewall required to support most gambrels does take away some floor space. The truss I designed for the house in this chapter minimizes this problem because it eliminates the need for a kneewall. But even the space behind a kneewall can be used



From agrarian to elegant. Gambrel roofs are used in barns to provide cheap space and to reduce rafter spans. In houses, gambrels add interest and allow a two-story home to have a relatively low roofline.

efficiently for built-ins and closets, and also for running mechanicals.

While the endwalls for gambrel roofs offer lots of space for windows that can admit an enormous amount of natural light, you'll probably need dormers for light in the center. Dormers also provide an opportunity to create scale, rhythm, and balance (see the photo above).

To some, the gambrel may appear too angular. As I did in the house in this chapter, the lower slope of the roof can be flared to form deep overhangs and to soften the angles.

Gambrel roofs are highly visible, so the roofing material assumes a special importance. Wood shingles are my material of choice, and they create a unified look when the house is sided with wood clapboards.

Finally, many homeowners are attracted to the gambrel roof because of its dramatic interior look. If ceiling lines follow the gambrel and dormer shapes, then the interior spaces can take on a sculptural quality.

Michael McKinley is an architect in Stonington, Connecticut.

One thing that these trusses did not provide was a roof overhang. To provide an overhang and to soften the angles of the roof, the architect had designed a curved, flared overhang. I played with several curves, holding mock-ups in place for the approval of the owner and the architect. Once they were both happy, we built

assemblies of 2x material and plywood that sandwiched around the lower sleepers (see the bottom left photo on the facing page) and provided a form for the skip sheathing.

Joe Stanton is a member of the National Association of Home Builders.

Roof Framing with Engineered Lumber

■ JOHN SPIER

My crew uses engineered-floor systems for most of the custom homes we build. These systems, framed with I-joists and other types of engineered lumber, have many advantages—including uniformity, straight, long lengths of lumber, and no shrinkage—which reduce labor costs and improve customer satisfaction. These same advantages could apply to roof construction as well, especially on jobs where we've had to wrestle truckloads of wet or frozen

24-ft. Douglas-fir 2x12s up to a ridge 35 ft. in the air.

We chose simple structures for our first engineered roofs (see the photo below). One was a small cottage with skylights and shed dormers, and another was a simple gable structure. More complex roofs are possible with engineered lumber, but we figured we'd save those challenges for a later project.

Planning Works Most of the Time

For a dimensional-lumber roof, I usually just figure the pitch and spans to determine the stock size and lengths. With an engineered roof (as with an engineered floor), the first step is to send the plans to the supplier for engineering and specification (see the drawing on the facing page). In some cases, it also turns out to be the second, third, and fourth steps, as the plans go back and forth for revisions. When all the bugs are worked out, we can order the roof-framing material.

One of the big disadvantages of engineered-roof systems is that if you or the suppliers get the order wrong, a trip to the local lumber-



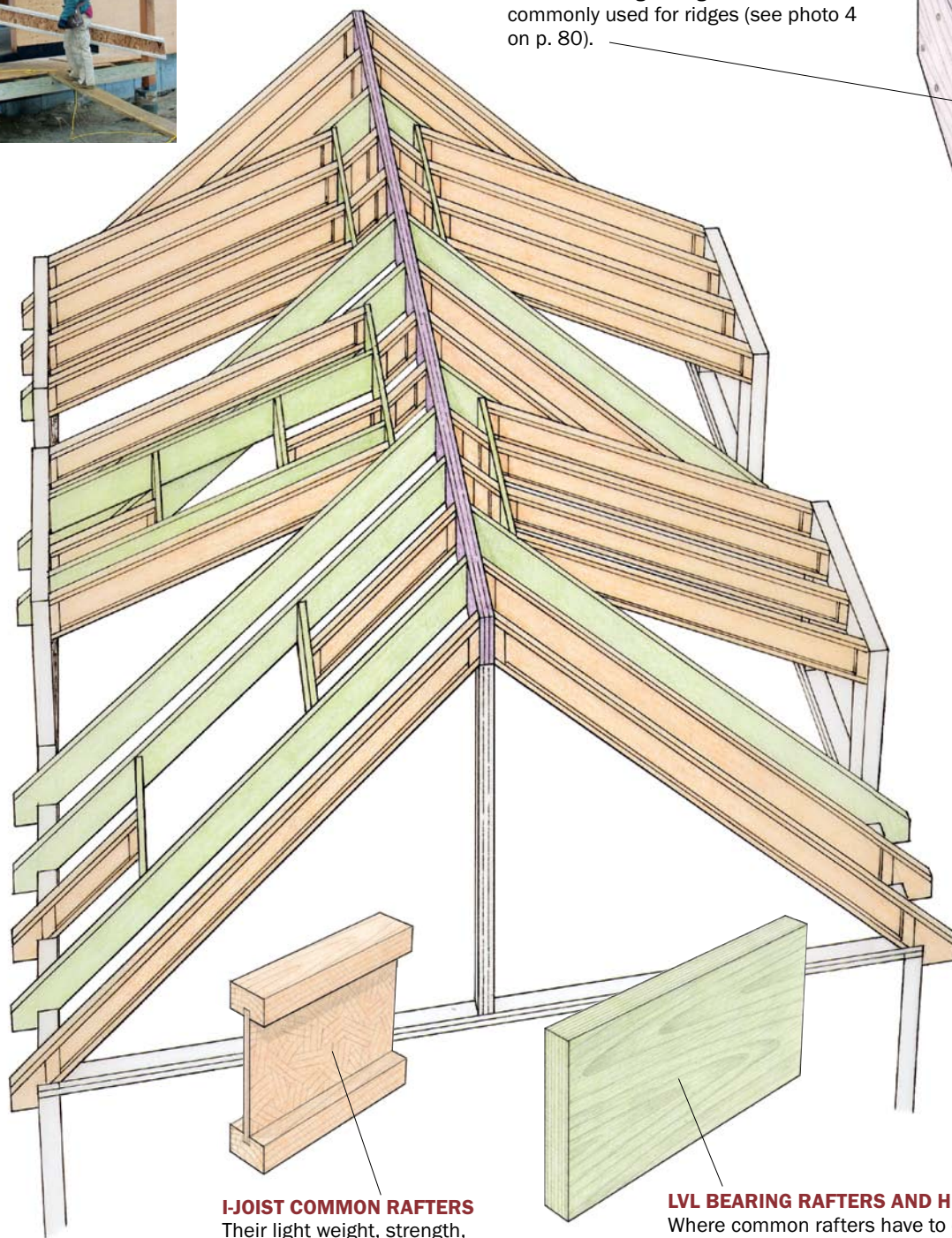
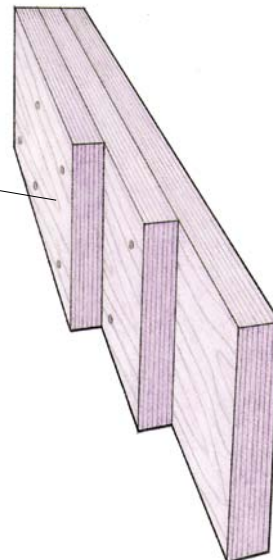
Holding Up a Roof with Engineered Lumber

Engineered lumber makes for flat, straight roofs. Because of its strength, single pieces of engineered lumber often can do a job that would require multiple pieces of dimensional lumber. Plus, lightweight I-joist rafters are easier to handle than 2xs. Metal connectors (not shown in drawing) join all framing members. Although different types of engineered lumber may be specified for some areas, here is where they are typically used.



LVL RIDGE

Multiple members join together to form the ridge. Single LSLs are also commonly used for ridges (see photo 4 on p. 80).



I-JOIST COMMON RAFTERS

Their light weight, strength, and straightness make I-joists perfect for common rafters.

LVL BEARING RAFTERS AND HEADERS

Where common rafters have to carry the extra weight of a dormer or a skylight, single LVL rafters can take the place of multiple 2xs. Similarly, single LVL headers bridge roof openings.

Cutting Time with Production Methods

Gang-cutting I-joist common rafters saves a lot of time. To index the rafters, a saw kerf is made square across the I-joists at the bottom of the plumb cut (photo 1). Next, the rafters' length is measured (photo 2). A second index mark is made at the seat cut (photo 3). One crew member uses a template indexed on a saw kerf to mark the bird's mouth while another cuts the previously marked plumb cut (photo 4).



yard usually won't fix it. All the components are special-order, so you just can't go out back and pull 26-ft. LVLs (laminated veneer lumber) out of the rack. In our case, the local yard is a boat trip away.

The Ridge and Bearing Rafters

Before the roof load arrives, we frame and stand the gable ends, ridge posts, kneewalls, and dormer walls (see "Cutting and Setting Common Rafters," on pp. 4–13). Framing the roof is then simply a matter of assembling the lumber and hardware.

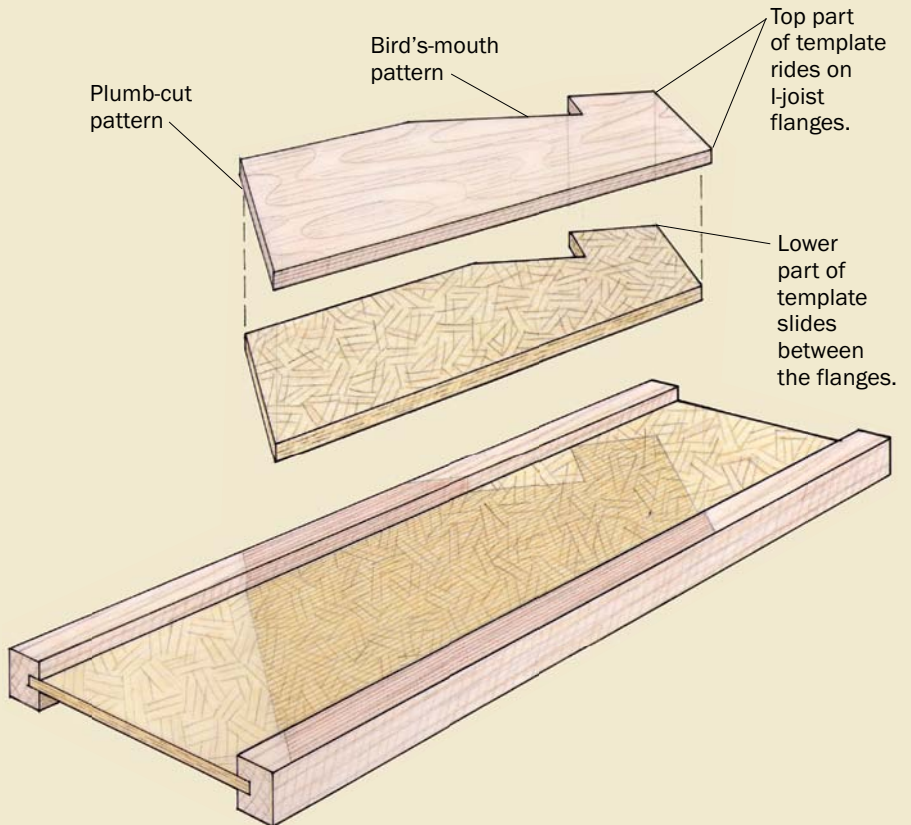
One of the roofs that we built has a single LSL (laminated strand lumber) for the ridge (see photo 4 on p. 80). The other roof has three 26-ft.-long LVLs for the ridge, which were set in place one piece at a time and then spiked together. The engineering specs provide a fastening schedule for assembling multiple structural members (such as an LVL ridge or header), and at least some hand-nailing usually is required to get them tight and to eliminate gaps.

As with any other roof, we transfer the rafter layout from the walls to the ridge, with one crew member taking the measurements along the wall and another marking them on the side of the ridge. For one of



I-JOIST RAFTER TEMPLATE SPEEDS CUTTING

With index marks cut into the I-joists, a two-piece plywood template is used to mark the bird's mouth and plumb cut. The top portion of the template is the same overall width as the I-joist. The bottom portion, cut from web-stiffener stock, fits between the I-joist flanges to align the template and is nailed to the top piece.



the engineered roofs, LVLs were specified for the rafters that have to carry headers, including those on each side of the dormer and skylight openings. In a conventionally framed roof, these rafters would be doubled or tripled 2xs, but because of their added strength, only single LVLs are needed to carry these headers. Some engineers specify doubled or tripled I-joists for these rafters because they are lighter and less expensive, but I've found the advantages are outweighed by increased labor costs for assembly. By the way, you can't just switch materials in the field; you need to ask the engineers to make these changes before you order the roof package.

The bearing rafters that carry the headers are cut the same as the I-joist commons, so we make a pattern rafter, test it, and then cut all the LVL rafters. When these rafters are cut and hung in place, we cut and install LVL headers for the dormer roofs and the skylights. Again, single LVLs can take the place of the multiple 2x members that usually make up a header. I've learned that engineers often miss the extra depth required for a plumb header in a sloped roof, another revision that should be made when reviewing the plan.

I-Joists for the Rest of the Rafters

For the remaining rafters in the roof, we use I-joists of the same depth as the LVLs. These rafters include the gable rafters, commons between the dormers, rafters for the shed-dormer roofs, and jack rafters that fill between the headers and the ridge. In addition to being straight and strong, the I-joists' light weight is a big advantage in roof framing.

Cutting the bird's mouths on the LVLs is as straightforward as cutting those in regular

dimensional lumber. However, I-joists are a bit different. Because they are perfectly straight, they lend themselves to gang-cutting (see the photos on pp. 78–79), so we make a job-site template for marking and cutting the plumb cuts and bird's mouths. We usually leave the I-joist web as the skeleton for the eaves' detail. After tacking the 2x subfascia to the end of the upper flanges, we attach blocking to the webs to give the subfascia solid nailing and to carry the soffits and exterior trim.

Web Stiffeners Let I-Joists Do Their Work



Web stiffeners are blocks of plywood or oriented strand board cut to fit between the flanges of an I-joist. They help to transfer loads and give a nailing base for metal hangers. Blocks for I-joist rafters can be fabricated quickly and easily in the shop (photo 1). The blocks then are nailed onto both ends of the rafter (photo 2), and the hanger is attached, (photo 3) before the rafter is lifted into place (photo 4). The blocks provide extra nailing for the lower ends of the rafters, and additional blocking provides attachment for a structural subfascia (photo 5).



Every I-Joist Gets Web Stiffeners

The plan also specifies web stiffeners in many locations, typically where an I-joist is carried by a sloped hanger or where a bird's mouth is cut into it. Web stiffeners are small pieces of plywood or oriented strand board (OSB) that fill the web of the I-joist to the flanges' thickness. Web stiffeners can be cut on site from scrap plywood or OSB, but mass-producing them in the shop with a tablesaw and chopsaw is more efficient (see photo 1 on the facing page). We glue up

sheet stock ahead of time for the required thickness. For 1-in. flanges, we glue together two sheets of $\frac{7}{16}$ -in. OSB. As with hangers, we've found that nailing the stiffeners on before installing the rafters is more efficient.

Web-stiffener stock also can be used in longer lengths to splice or reinforce I-joists, for example, over a bearing wall or for wide overhangs. In one case, we spliced together two short joists to make a longer one for a nonstructural filler over a dormer cheek wall.

Metal Hangers Make the Critical Connections

Metal hangers or framing connectors are used every place where engineered-framing members meet. To lay out and attach hangers for headers, it's easiest to line up the rafters top to top on sawhorses. Metal-connector nailers, specially designed to shoot nails into the holes in framing connectors, make quick work of attaching hardware (photo 1). Although engineers sometimes specify the minimum number of nails needed to attach a metal connector, putting a nail in every hole is the safest bet (photo 2). Framing connectors such as twist straps strengthen the rafter-to-plate connection (photo 3). Hanger flanges on gable rafters can be bent flat and attached to the ridge end (photo 4).



Lessons Learned about Engineered Lumber

Safety

Some engineered lumber can be slick and dangerous to walk on. Other components, LVLs in particular, have razor-sharp edges; cutting a bevel on an LVL can be an invitation for job-site injury. Also, some engineered materials have a protective wax coating. This stuff gets on your hammer head, which makes it slip, and it gets on your boots, which makes you slip. Last, the sawdust is finer, more irritating, and more noxious than that of most woods, so if you're cutting engineered lumber in areas without good ventilation, use lung protection.

Environmental Concerns

One of the best things about engineered lumber is the environmental benefits: Because of its strength, fewer members are needed, and much of the lumber comes from second-growth, scrap, or recycled wood. But beware: Some of the chemicals used to hold together and treat engineered lumber can be toxic when the scrap is cut or burned, and when the ash is allowed to leach into groundwater.

Product Lists and Ordering

Engineers' material takeoffs are always optimistic and sometimes wrong. For example, they often measure rim stock on the plan in linear

feet, divide by 12 ft. or 16 ft., and give you what they think is enough pieces. They also specify an exact number of joists or rafters, including short pieces, all listed as approximate lengths that are then cut and shipped by the supplier. I suggest combining the short pieces into longer lengths and then ordering one extra of the longest length to allow yourself at least one mistake.

Hardware

The big hangers are expensive and often are special-order items, so check your list and delivery carefully. The smaller hangers are cheap, so order extra. Keep a big box of extras on hand so that you have the right hanger if you need to change something.

Metal Hangers Unite the System

As important as the engineered-lumber schedule is the hanger-and-fastener schedule. Just about every framing connection on an engineered roof involves special hangers and other fasteners. Each hanger as well as its location is keyed on the plan, so we simply sort the fasteners ahead of time and use them where they are called for. Engineers even include a schedule for how many nails are required in each location to meet the load criteria, but it seems that our building official is happiest if every hole is nailed (see the photos on p. 81).

We've learned that it's almost always easier to mount hangers on members before placing them. Common rafters and jack rafters get a hanger on one or both ends; then they are lifted into position and nailed.

Header hangers also can be attached this way, or they can be attached to the bearing rafters. For example, when laying out the rafters that flank the skylight opening, I place the two LVLs edge to edge on sawhorses. After laying out the positions for the headers, it's easiest to nail on the header hangers while the rafters are lying flat. I use a short cutoff of the header material to keep the hanger legs spaced properly (see photo 1 on p. 81).

Another thing we've learned is that many of the hardware components used in engineered-roof systems have flanges that fit between the framing member and its support. The thickness of these flanges needs to be allowed for when determining lengths of rafters. If a framing member is to be hung with one of these hangers, we subtract $\frac{1}{8}$ in. from the overall length ($\frac{1}{4}$ in. if hangers are at both ends). Because these systems are de-

Fastening

A metal-connector nail gun is a necessity unless you have a lot of cheap labor (see photo 3 on p. 81). We have had good luck with Paslode Positive Placement Strip Nailers (800-682-3428; www.paslode.com). Even though these nailers work well, they break down occasionally, so we keep a spare in the shop.

Layout

The better engineers won't put rafters in the way of a plumbing vent. However, figuring out where the pipe goes is not their job. Because you can't just cut in another header, figure out where the systems are going beforehand.

Modular Sizing

Over the years, many products such as fans, ductwork, skylights, and attic stairs have been designed to fit into standard rafter or joist bays. The flanges of engineered lumber are wider than dimensional lumber and can make a mess for you later if you don't plan for those items carefully during framing.

If You Make a Mistake

Of course, we've never, ever made a mistake ourselves, but our plumber did once with his big drill. That's how we found out about the technical support offered by engineered-lumber manufacturers. Most have a toll-free number that puts you in touch with a team of qualified

engineers whose sole job is to recalculate engineered systems and to help you out of your exact framing predicament. Email or fax them a plan (even send a digital photo of your problem), and they'll get right back to you with a fix that works in the field. It's a fantastic service.

signed to be held together by hardware, a bit shorter is better than longer.

A rafter cut to the exact length and then placed in one of these hangers can push a wall out of plumb or bow the ridge or header. I-joist hangers typically require subtracting about $\frac{1}{8}$ in. per hanger, but some specialized hangers have thicker flanges and may require subtracting more. When all the rafters and headers are installed, we double-check that the hangers were nailed properly.

these guides home and reading through it carefully before starting. Most manufacturers specify Simpson Strong-Tie fastening products (800-999-5099; www.strongtie.com), and the Simpson master catalog also offers a wealth of possibilities and information.

John Spier builds and renovates custom homes and is a frequent contributor to Fine Homebuilding magazine. He and his wife, Kerri, own and operate Spier Construction, a general-contracting company on Block Island, Rhode Island.

When in Doubt, Read the Instructions

For engineered floors, and now roofs, we've used engineered-framing systems from several companies over the years. They all provide a pocket reference guide to help with installation details, covering just about any framing situation. It's worth taking one of

Cordless Framing Nailers

■ JOHN SPIER



Adozen or so years ago, I tried out a gas-powered, cordless framing nailer. I wasn't too impressed at the time; the gun was a lot slower than I was. But I thought the idea of unplugging from the compressor had merit, so I've been watching these tools ever since, figuring that the technology had to be improving. When *Fine Homebuilding* offered my crew the chance to put a few of the newest nailers through their paces, I jumped at it. The five of us used them for a couple of months, doing miscellaneous framing and two gut rehabs, and most recently building a new two-car garage.

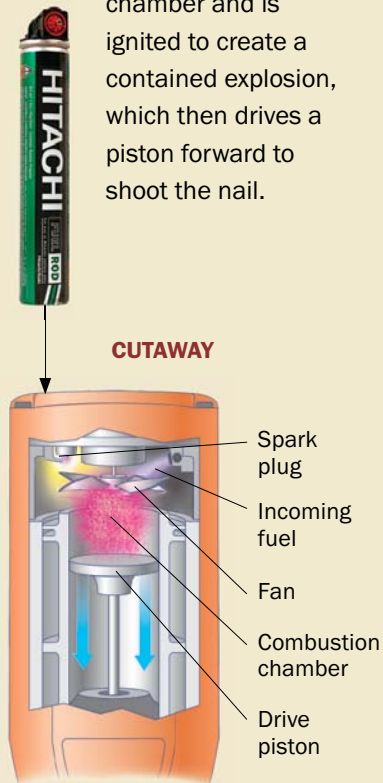
What They're Good for, and What They're Not

By the end of our testing, I was convinced that one of these tools easily would pay for itself on those little projects where I don't want to set up an air compressor and a hose. With a cordless nailer and some battery-powered saws, I can go into a house and build a soffit, change a door or window opening, or frame a closet in less time than it normally would take me to set up power and air for my pneumatic tools. Gas-powered guns are also great for small jobs where I don't want to carry a compressor up three flights of stairs, or listen to it run constantly as I work in a small, cramped room. If you're an electrician or plumber who only occasionally needs a framing nailer, say to put up some blocking, these guns definitely make sense. As long as you remove the battery and gas cartridge between uses, half-charged batteries and half-used fuel cells stay fine over several weeks of inactivity.

To say that these guns are ready for full-time framing would be a stretch, however. Trust me, we tried. To put the guns to the test, my crew and I left our compressor and hoses in the truck and framed an entire

The Ins and Outs of a Gas-Powered Nailer

How it works: Gas-powered nail guns work on the same principle as a combustion engine; gas from a fuel cylinder fills a combustion chamber and is ignited to create a contained explosion, which then drives a piston forward to shoot the nail.



What it shoots: Paslode nailers use proprietary offset-head nails, called Round-Drives® (see the photo above right). Max, Hitachi, and Powers offer two nailers each: one for round-head nails and one for clipped-head nails. The shallow angle (roughly 20°) and widely spaced collation of round-head nails are necessary to fit the fasteners side by side but result in fewer nails per rack. Clipped-head nails are collated more closely together and at a steeper angle (roughly 35°), making them more compact. If nail sizes are equal, a clipped-head rack will have about 10% to 20% more nails than a round-head rack. Some building codes require the use of full round-head nails (Paslode's offset round heads are acceptable), but otherwise, I would choose a



24-ft. by 32-ft. Cape-style garage with three dormers. I really liked climbing around on staging with no hose dragging behind me, but the guns slowed us down by misfiring, by not sinking nails consistently, and by running out of gas or low on battery power in the middle of use.

Still Some Kinks to Work Out

Not one of these guns had the power to drive 12d or 16d (3¼ in. or 3½ in.) nails consistently all the way into framing lumber. They all did OK with 3-in. nails, which is fine for interior framing but not for floors,

exterior walls, and roofs. They also struggled with 8d ring-shank nails, which our local code requires for exterior sheathing and shear walls. Having to drive home half of the protruding nails with a hammer sort of defeats the purpose of using a nail gun.

The nosepiece of all these guns needs to be depressed fully before the trigger is pulled; they can't be bump-fired by holding the trigger and pressing the nosepiece against the work. This safety feature is good, but it definitely slows down the work. To make things worse, all the guns have the same two-stage nosepiece action: The first step turns on the fan, and the second releases the safety. The pressure required to press the

The Paslode nailers are slightly smaller and lighter than the others, and their plastic bodies seem fairly tough. They have a well-protected battery slot, and the reversible combination belt-and-rafter-hook is by far the best. The pinch-and-pull depth of drive works well despite the nailers' being unable to drive some nails all the way. Paslode's nailers are the only ones to require that the nail-feeder slide be pulled back before the gun is loaded; this is hard to get used to only when switching between guns. The Paslode nailer never jammed in two months of hard use, so I never had to follow the manual's disassembly instructions.

Paslode offers two framing nailers, the original model 900420, and the newer CF-325. The CF-325 and the 900420 both shoot full round-head nails collated at an angle of 30°, commonly seen only with clipped-head nails. Paslode achieves this feat by offsetting the nail shanks to the edge of the round heads. The offset heads on these RounDrive nails still meet building codes in areas where full round heads are required, and Paslode claims that the offset heads test comparably with conventional centered heads in terms of pullout strength. Paslode's RounDrive nails also fit into the clipped-head guns made by other manufacturers. The major difference in models with this function is that CF-325's redesigned nosepiece is sturdier and digs in more aggressively for toenailing. It also takes less pressure to depress

the nosepiece and activate the gun, reducing the fatigue factor common to cordless nailers.

The paper collation on the RounDrive nails is an improvement over other round-head racks; it produces less flying plastic. Initially, I was concerned about the durability of paper collation. The racks of nails needed for my old pneumatic Paslode guns used to soften and not feed properly when exposed to moisture. But I've tried soaking these new nails in water, and they seem to be unaffected.

Paslode pioneered the technology that makes gas-powered nailers possible, and the company's 20-year head start is evident. I'd keep these guns in the truck, based on their design, their features, and their trouble-free operation.



Specifications

PASLODE CF-325

Weight: 7.5 lb. with battery
Nail type: Paslode RounDrive Offset Full Head (Brite or GalvGuard)
Nail sizes: 2 in. to 3¼ in.
Collation: 30°, paper tape
Capacity: 48 nails

PASLODE 900420

Weight: 7.4 lb.
Nail type: proprietary RounDrive, or clipped head
Nail sizes: 2 in. to 3¼ in.
Collation: 30°, paper tape
Capacity: 48 nails

Like many other Hitachi tools, the round-head nailer has a comfortable grip, especially for smaller hands. The fuel-cell loading door is designed nicely, with a simple sliding latch that doesn't require finesse to open or close. Hitachi is also the only manufacturer to supply a one-piece, one-hour battery charger (charge time is 2 hours for the Paslode, 2½ hours for the Max and the Powers nailers).

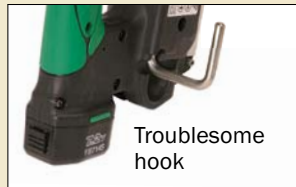
After these few positive points, both of the Hitachi nailers go downhill fast. They have the least power of all the guns, so we had to use a hammer to set a lot of nails. The depth-of-drive setting—which requires an Allen wrench—worked but was often pointless because the nails weren't set to begin with. The nonreversible belt/rafter hook is on the right-hand side of the nailer. That's fine for a left-handed carpenter, but for a righty like me, this placement falls firmly into the "What were they thinking?" department. And to top it all off, the Hitachi nailers misfired more often than all the other guns combined.



HITACHI NR90GC



Easy-open fuel-cell door



Troublesome hook

Although the clipped-head model is slightly lighter and more compact than its round-head sibling, I found it much less comfortable to use. Hours of repetitive plywood nailing opened a sore on my thumb from pressing the clipped-head nailer against the sheathing. This gun was the one that finally drove me to switch back to my pneumatic nailers.



HITACHI NR90GR

Specifications

HITACHI NR90GR

Full round head

Weight: 7.9 lb.

Nail sizes: up to 3½ in.

Collation: 20°, plastic

Capacity: 42 nails

HITACHI NR90GC

Clipped head

Weight: 7.7 lb.

Nail sizes: up to 3½ in.

Collation: 33°, paper

Capacity: 47 nails

nosepiece fully can be awkward, especially when reaching at arm's length.

All the cordless nailers use straight collated nails, presumably because the fuel-cell technology needed to advance coil nails hasn't been developed yet. I gave up my pneumatic stick nailers long ago in favor of coil nailers because coil nailers hold five times as many nails (200 8ds in a coil vs. about 40 in a stick). When I'm nailing off plywood, stick guns need to be reloaded two or three times per sheet. Also, all stick nailers

—pneumatics included—tend to misfire a lot more than coil nailers, and they blow plastic shrapnel all over the place. The occasional misfire is no big deal, but when you're straining every muscle to hold something on layout with one hand, it's not something you want to worry about.

These nailers all are lightweight plastic-bodied tools. You can't use them to thump things into place the way I've been doing with my alloy-bodied pneumatic nailers all these years. Also, I suspect they won't do as

The Max nailers have some redeeming features. The depth-of-drive adjustment was fast and easy and required no tools; it worked well within each model's power limitations. The reversible rafter/belt hook is effective. The spurred nosepiece is heavier duty than that on the Hitachi and Paslode models; after a few months of use, it was still sharp, where the others were rounded over and dull. The Max round-head gun was the only one that jammed during testing, and it wasn't much fun to fix. I had to remove the three hex-head screws holding the magazine in place and juggle several small parts that can fall off in the process before accessing the jammed nails that still had to be pried out. This happened twice, and I couldn't figure out why. I checked the nails carefully to make sure I hadn't misloaded the gun, and I hadn't hit anything very hard.

Like Hitachi and Powers, Max makes one gun for round-head nails and one gun for clipped-head nails. Unlike the Hitachi, though,

the Max clipped-head nailer was comfortable to use. The differences in the handling configuration were subtle but significant. Also, I initially had trouble getting the round-head nailer to fire. I finally figured out that the battery was defective and would not take a charge. Fortunately, I was able to test both nailers using one battery.



MAX
GS683CH



MAX
GS683RH

Specifications

MAX GS683RH

Full round head

Weight: 7.8 lb.

Nail sizes: up to 3¼ in.

Collation: 21°, plastic or paper

Capacity: 32 nails

MAX GS683CH

Clipped head

Weight: 7.8 lb.

Nail sizes: up to 3¼ in.

Collation: 34°, paper

Capacity: 40 nails

well when they inevitably fall from a high place, especially because they don't have a hose to break their fall.

Battery Power and Cost of Use

All these guns came supplied with only one battery. I initially thought that this was a liability because any other cordless tool is just about worthless for professional use if it

doesn't have a backup battery to use while the first recharges. Manufacturers say that you can drive approximately 4,000 nails on one battery charge. We didn't count, but I can say that a fully charged battery lasted all day most of the time, no matter how hard the gun was working. The only time that I had trouble was when I forgot to put a battery in the charger overnight.

Battery cycle life shouldn't be a problem, either. These batteries are low voltage (6v for the Max, Powers, and Paslode mod-

Close inspection of the Powers round-head nailer didn't reveal any differences from the Max models. Even the carrying cases came out of the same mold; the only differences in appearance that I could find were the color scheme and stickers. But several of my crew members thought that the Powers gun had more power, so to speak.

Because Powers makes a few different gas-powered fastening tools, they have a few different sizes of fuel cells. The wood-framing nailers shown here typically are powered by red-capped fuel cells, but if you run out, you can use blue-capped (concrete nailer) cells and keep working. Company reps claim there is no difference in performance between the two cells. We also discovered that the Powers nailer could use Paslode fuel cells and Hitachi nails. A Powers sales rep confirmed this, a refreshing change from all those tool manuals that threaten you if



**POWERS
W3-34CDH**

Fuel-cell choices



you don't use the manufacturer's own proprietary accessories.

The Powers round-head nailer was the only one that got an inadvertent drop test, from the top of an 8-ft.-tall stepladder. Nothing broke, and it still worked fine afterward. Powers also makes a clipped-head nailer, but it was not available for this review.



**POWERS
W3-21FRH**

Specifications

POWERS TRAK-IT W3-21FRH

Full round head

Weight: 7.8 lb.

Nail sizes: up to 3¼ in.

Collation: 20° to 22°, plastic

Capacity: 32 nails

POWERS TRAK-IT W3-34CDH

Clipped head

Weight: 7.8 lb.

Nail sizes: up to 3¼ in.

Collation: 34°, paper tape

Capacity: 40 nails

els; 7.2v for the Hitachi models). My experience with other tools has been that this type of battery recharges many hundreds of times, as opposed to higher-voltage batteries, which need more frequent replacement.

Every nailer except the Hitachi came with a battery charger consisting of a transformer connected to a battery holder with a length of 22-ga. wire. They use this type of charger because they can offer a 12v vehicle plug-in option. I didn't get to try that out, but it sounds like it might be a handy option.

Fuel-cell life wasn't a big issue. A carpenter might use two or three \$10 fuel cells in

a long day; in an area where labor costs are between \$20 and \$50 per hour, this is not a significant part of the financial picture. Manufacturers claim that fuel cells fire about 1,200 nails before needing replacement. We tried to quantify the actual number of nails driven, but decided that there were too many variables to control and that the results wouldn't be that crucial.

John Spier builds and renovates custom homes and is a frequent contributor to Fine Homebuilding magazine. He and his wife, Kerri, own and operate Spier Construction, a general-contracting company on Block Island, Rhode Island.

Doghouse Dormers

■ RICK ARNOLD





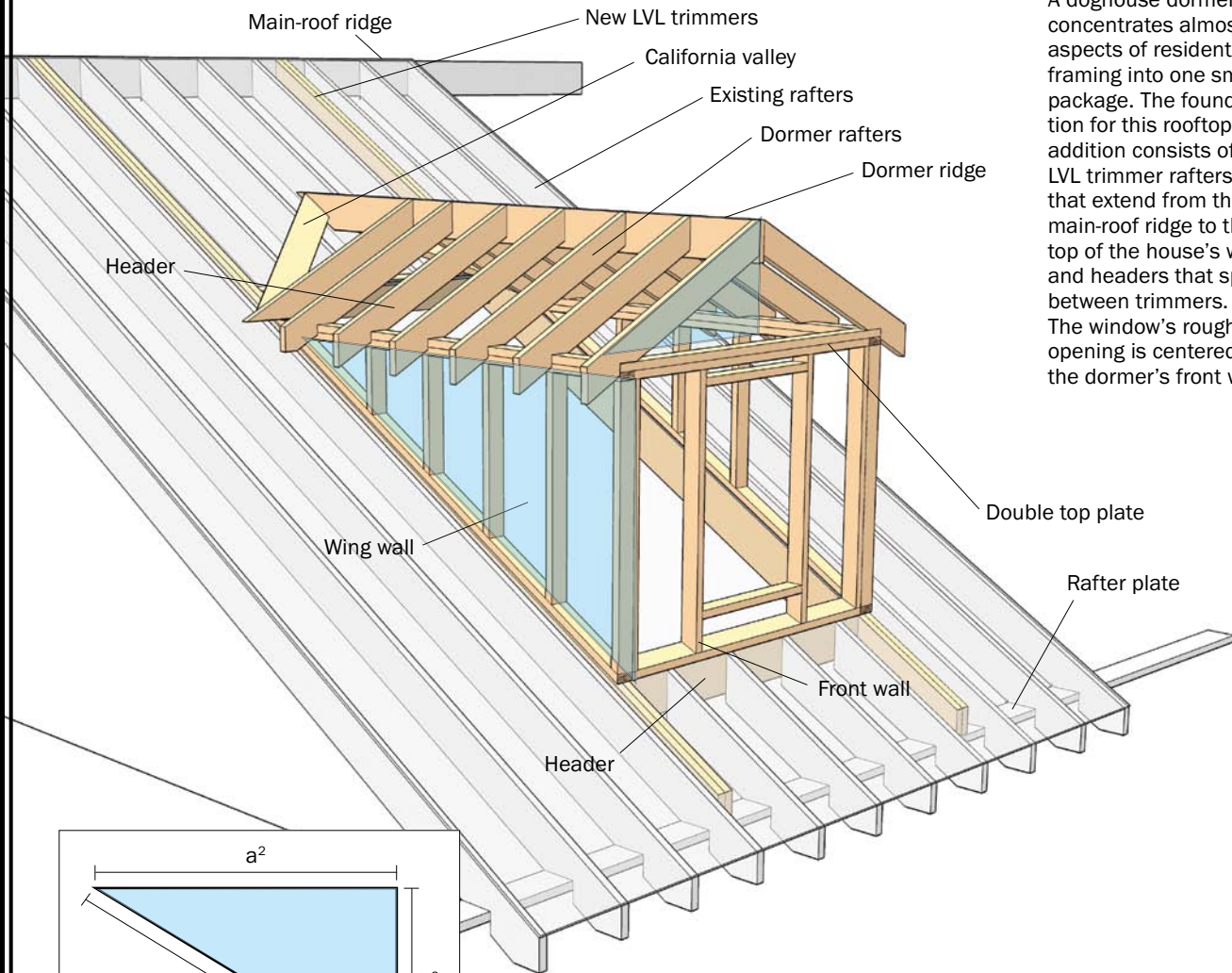
Assembling components on the ground and cutting the roof at the last minute provide a low-stress route to a high-value remodeling project.

One of the most popular ways to open the dark, cramped upper level of a house is to build one or more dormers. From a homeowner's point of view, these small additions can increase curb appeal and create more-hospitable living space in the top level of a house. From a builder's point of view, dormers concentrate almost all aspects of residential framing into one small package (see the drawing on p. 92). If the dormer is too big, it will look out of scale with the rest of the house. The front wall of the dormer should be just large enough to fit the window (ideally, smaller than the windows on the lower levels of the house) and should leave just enough room for proper flashing where it joins the main roof. Also, a well-proportioned dormer sits beneath the line of the main-roof ridge and is set back from the facade of the house.

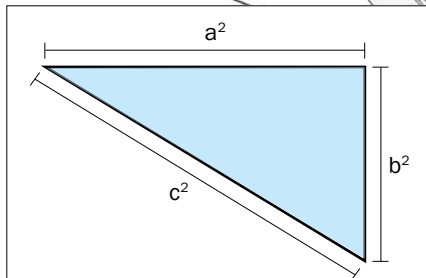
Like any building project, the success of constructing dormers depends on precise calculations, careful planning, and some smart assembly work. Trust me, the last thing you want is to be on the roof trying to figure out why the wing wall won't fit while a rain cloud hovers overhead, waiting to take advantage of that big hole in the roof.

Over the years, I've built a number of dormers, improving the process each time. I've finally settled on a system that enables me to figure all the dormer measurements precisely, cut and assemble most of the pieces on the ground (or in the attic), and put off

It's Like Building a Small House with Angled Walls



A doghouse dormer concentrates almost all aspects of residential framing into one small package. The foundation for this rooftop addition consists of LVL trimmer rafters that extend from the main-roof ridge to the top of the house's wall and headers that span between trimmers. The window's rough opening is centered in the dormer's front wall.



Dormers look difficult to frame because of the angled sidewalls and all the beveled cuts they require. But you're actually dealing with a series of triangles, so most of the calculations can be made by getting measurements for two sides of a triangle and solving for the third (the Pythagorean theorem: $a^2 + b^2 = c^2$).

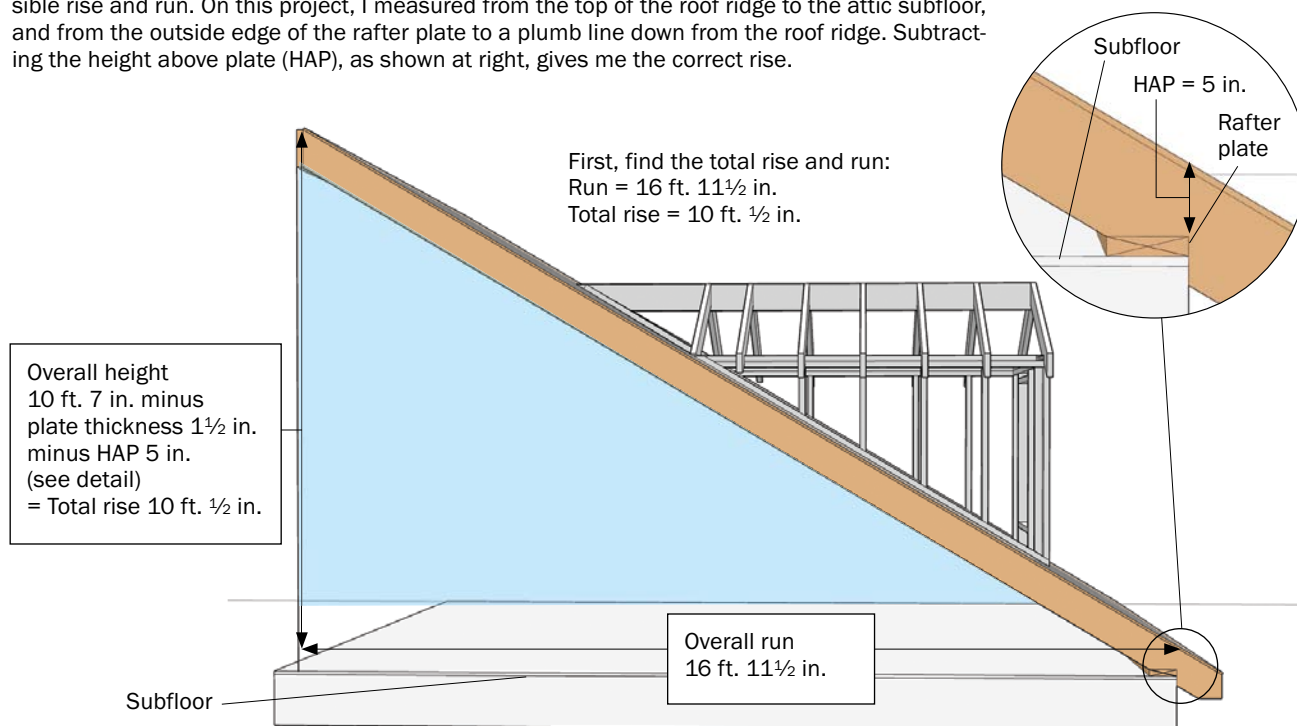


A CONSTRUCTION CALCULATOR HELPS TO MINIMIZE THE MATH

To make things easier, construction calculators allow you to work with quantities and components that you encounter on the job site. Measurements are entered in feet and inches; labeled keys enable you to input and calculate rise, run, pitch, and other useful dimensions. It's much faster than relying on longhand equations. Construction calculators are available at most hardware stores and lumberyards, or through online sources like www.calculated.com.

Measure the Biggest Triangle to Find the Precise Pitch

You can use a Speed Square or framing square to find the roof pitch, but measurements from such a small area can be misleading. To get the most accurate pitch, I measure the largest possible rise and run. On this project, I measured from the top of the roof ridge to the attic subfloor, and from the outside edge of the rafter plate to a plumb line down from the roof ridge. Subtracting the height above plate (HAP), as shown at right, gives me the correct rise.



ON THE CALCULATOR

Enter 10 ft. ½ in.; Press **RISE**. Enter 16 ft. 11½ in.; Press **RUN**. Press **PITCH**, and get 7¼ pitch, or 7¼ in. of rise for every 12 in. of run.

cutting a hole in the roof until the last minute—no blue tarp needed.

This system is safer because it reduces the amount of time I'm measuring and building on the roof, and it also minimizes the number of trips to the ground to make cuts. My system also lowers the level of stress that comes with having a roof that's open to the elements for an extended period of time. The trade-off is that all the measurements have to be as accurate as possible. Many of the calculations build off one another, and a sloppy measurement in one step throws off the math in the many steps that follow. It sounds daunting, but most of the components of a doghouse dormer can be found by dividing the framing components into a

series of triangles, and then calculating the missing dimensions.

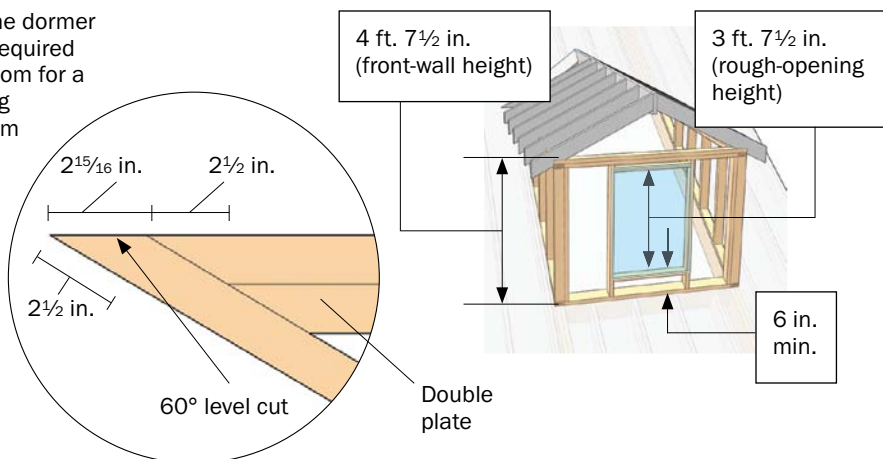
Check the Existing Pitch On Site

I always start a dormer project by verifying the pitch of the existing roof. I don't want to assume that I know the pitch, then cut and build all the dormer components only to discover that the dormer doesn't fit correctly. Trusting the plans is tempting, but you might end up missing an abnormality like the 7¼-in-12-pitch roof on this project.

The most accurate process is to measure the total rise and total run from inside the attic. This project took place in an attic that

Decide on Window Size, Then Calculate Wing-Wall Details

On this project, the homeowner wanted the dormer window to be about 3 ft. 6 in. tall, which required a rough opening of 3 ft. 7½ in. to allow room for a window. I always keep the window opening at least 6 in. up from the roof to leave room for flashing, and in this case, about 6 in. down from the top plate of the front wall so that the top of the window lines up near the bottom of the dormer's soffit. I ended up with a front-wall height of 4 ft. 7½ in. As shown below, once you know the front-wall height and the roof pitch, it's not difficult to calculate exact dimensions for all wing-wall framing members.



ON THE CALCULATOR

Top and bottom plates

Knowing the height of the front wall, I also have the height of the adjoining wing wall. This height, combined with the roof pitch, gives me the length of the wing-wall top plates and bottom plate.

Enter 4 ft. 7½ in. front-wall height; Press **RISE**.

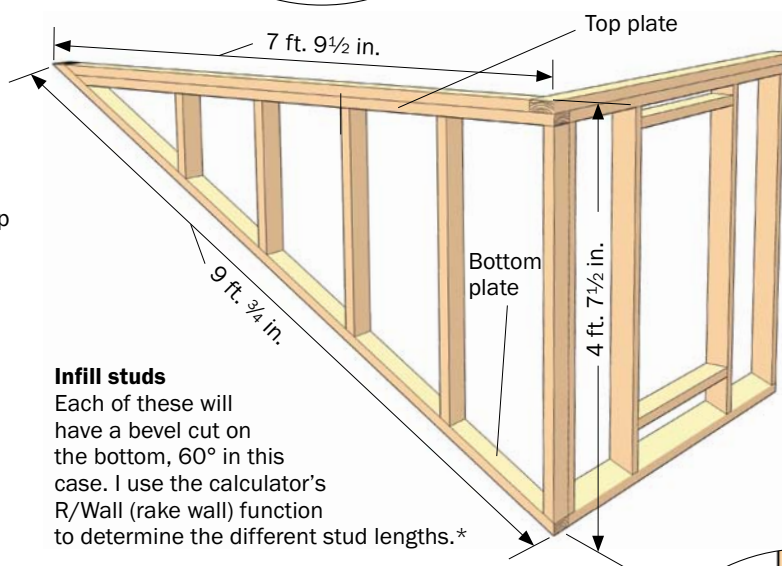
Enter 7⅛ in. pitch; Press **RUN**, and get 7-ft. 9½-in. **wing-wall length**.

Press **DIAG**, and you get 9-ft. ¾-in. **bottom-plate length**.

Press **DIAG**, and you get a 30.7° plumb cut. Round this to an even 30°.

Press **DIAG** again, and get a 59.3° level cut. Round this to an even 60°.

Refer to the detail drawing to see how the wing-wall top plate and the wing-wall double plate need to be shortened because of corner overlaps and bevel cuts.



Infill studs

Each of these will have a bevel cut on the bottom, 60° in this case. I use the calculator's R/Wall (rake wall) function to determine the different stud lengths.*

Enter 4-ft. 2¾-in. **front-wall stud length**; Press **RISE**.

Enter 7⅛ in. pitch; Press **PITCH**.

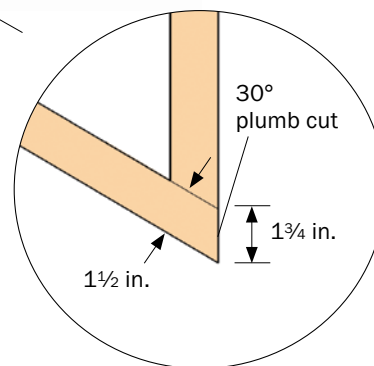
Press **R/WALL**. (Screen displays selected stud spacing, 16 in. on center in this case.)

Press **R/WALL** repeatedly to display descending stud lengths.

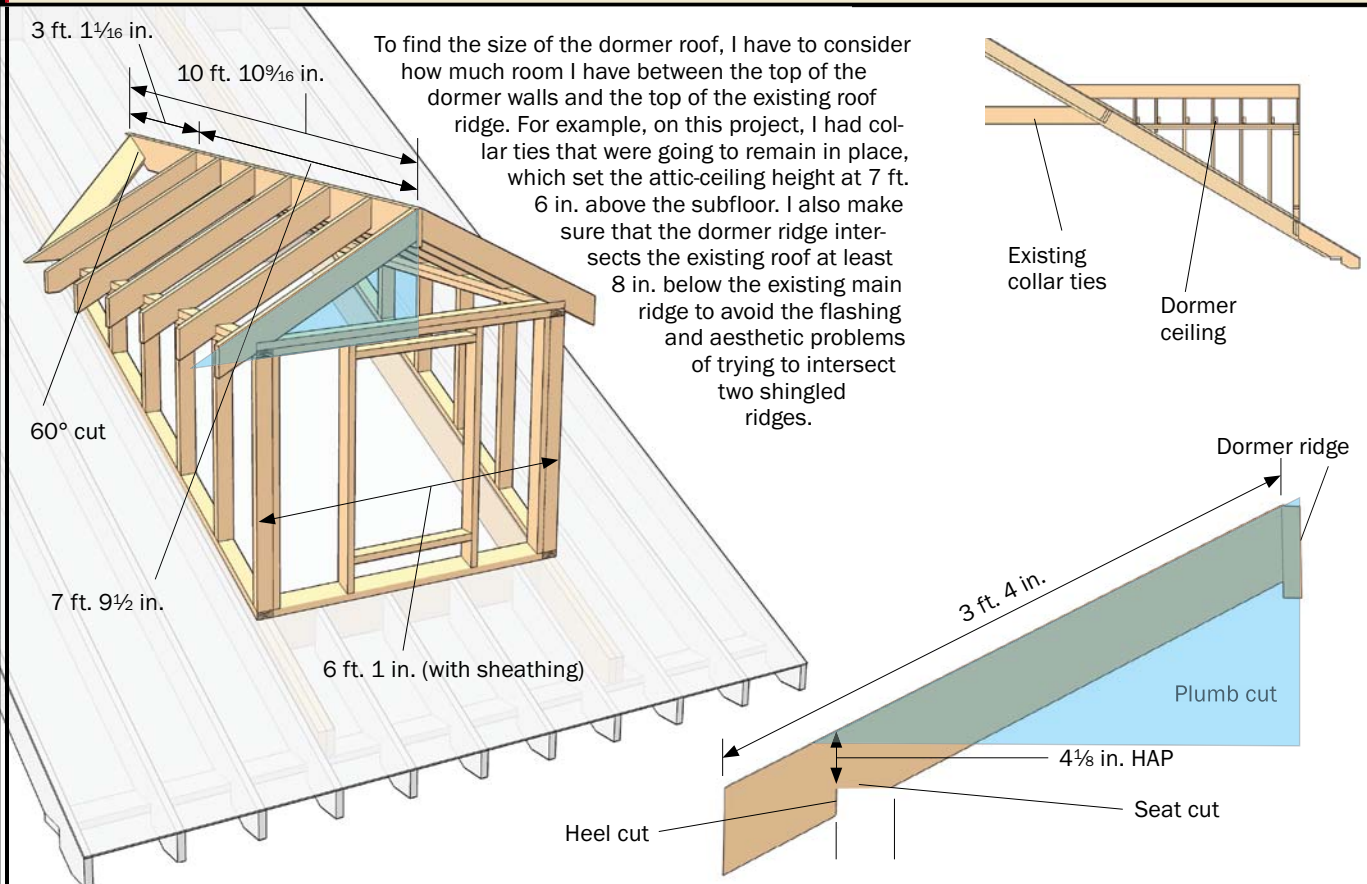
*You might have to Press **CONV** first to use the **R/WALL** function.

Front-wall studs

From the finished height of the front wall (4 ft. 7½ in.), subtract 3 in. for the double plate and the top plate, and 1¼ in. for the thickness of the angled bottom plate (detail below). This yields a front-wall stud length of 4 ft. 2¾ in.



Base Size of Dormer Roof on Available Space



ON THE CALCULATOR

1. Find the location of the dormer ridge

Before I can lay out the dormer rafters, I need to find the distance between the sheathed wing walls. The easiest way to do this is to take the length of the front-wall top plate (6 ft.) and add in the thickness of the wing-wall sheathing ($\frac{1}{2}$ in. on each side). This gives a finished width of 6 ft. 1 in.

Enter 6 ft. 1 in. $\div$ 2, Press **=**, and you get 3 ft. $\frac{1}{2}$ in.; this is the **total run of dormer rafters**, but this number needs to be adjusted by subtracting half the thickness of the dormer-roof ridge: 3 ft. $\frac{1}{2}$ in. - $\frac{3}{4}$ in. = 2 ft. $11\frac{3}{4}$ in.

2. Calculate dormer-ridge height

I wanted a 6-in-12 roof pitch on the dormers, so I used that combined with the run I found above to determine the adjusted length of the dormer rafters and the height of the dormer ridge:

Enter 2 ft. $11\frac{3}{4}$ in.; Press **RUN**.

Enter 6 in.; Press **PITCH**.

Press **DIAG**, and get 3 ft. 4 in. (**length of the dormer rafter**).

Press **RISE**, and get 1 ft. $5\frac{5}{8}$ in. (**unadjusted dormer-ridge height**).

3. Lay out the dormer rafter

I start by making a plumb cut that reflects the 6-in-12 pitch of the dormer roof. Next, I measure 3 ft. 4 in. from the long point of that cut and mark a line plumb with the wing wall to indicate the heel cut of the rafter bird's mouth. The seat cut is perpendicular to the heel cut and is equal to the width of the top plate and sheathing—in this case, 4 in. ($3\frac{1}{2}$ -in. top plate + $\frac{1}{2}$ -in. sheathing).

With the bird's mouth marked, I find the HAP of $4\frac{1}{8}$ in. I add this number to the rise I found in the calculations above (1 ft. $5\frac{5}{8}$ in.) and get a top-of-ridge height of 1 ft. 10 in. above the dormer walls—still falling well below the main ridge.

4. Find dormer-ridge length

I already know that the wing walls are 7 ft. $9\frac{1}{2}$ in. long, so I just need to find the length that the ridge extends past the wing walls before meeting the existing roof. I do this by using another small triangle:

Enter 1 ft. 10 in.; Press **RISE**.

Enter $7\frac{1}{2}$ in.; Press **PITCH**.

Press **RUN**, and get 3 ft. $1\frac{1}{16}$ in.

Add 7 ft. $9\frac{1}{2}$ in.; Press **=**; you get 10 ft. $10\frac{9}{16}$ in., which is the **total length of dormer ridge**, straight cut to long point, with a 60° cut.

Install Trimmers and Headers, and Then Cut the Hole



I can perform all the work up to this point, including cutting all the components for the dormer and assembling the walls, without opening the existing roof. This way, unless I have to strip off the entire roof to be reshingled, the rest of the procedure, including dry-in, takes only about four hours from start to finish. This procedure minimizes risk of exposure to the elements.

Measure for the new dormer headers. I first draw a level line across the rafter at the desired height (photo 1). In this case, I'm matching the underside of the collar ties. Then, starting from the inside end of that mark, I square up to the underside of the sheathing. Then I move the square toward the ridge, marking the 1½-in. thickness of each header piece (photo 2). The last line I draw is the inside edge of the first top header, which is also the cutline. To mark for the bottom header, I first put a nail into the sheathing at the last line I just drew, hook my tape to the nail, and measure along the underside of the sheathing the length of the wing-wall bottom plate. Next, I plumb down that line along the face of the rafter (photo 3). The inside edge of the dormer wall is 3½ in. in (toward the ridge) from this plumb line. Then I measure back (toward the eave) the thickness of the doubled-up 3-in. header and draw a plumb line to indicate the cutline for the lower header. I transfer these cutlines to all the rafters to be cut.



Install the trimmers. We removed or bent back any protruding nails that might get in the way before sliding the LVL trimmer into place through the exposed eaves. Slightly beveling the leading edge of the trimmer made it easier to rotate into place.

was being remodeled, so the rafters, the sub-floor, and the main ridge all were exposed. This made it easy to get precise rise and run measurements. If the framing had not been exposed, I would have cut back the drywall at the proposed dormer opening and measured the roof pitch there. That said, I prefer to have the rafters exposed so that I can take the largest set of measurements possible. The

longer the two sides of the triangle (rise and run) that you are measuring, the more accurate the numbers will be.



Double 2x headers complete the rough framing. Once the rafters are removed, I install two-piece headers at the top and bottom of the opening. A couple of temporary cleats support the newly cut rafters and keep the LVL trimmers spaced evenly until the double headers are put in place.



The safest way. Standing inside on the subfloor and cutting through the roof is easier and safer than standing on the roof and cutting down into the attic.



True up the opening. I run a stringline along the inside edge of the trimmers and make any necessary adjustments to get them straight and plumb. Then I nail through the existing roof sheathing and into the new framing to keep everything lined up.

Roof Pitch and Window Height Determine the Wing-Wall Dimensions

Once I know the pitch of the existing roof, I need to calculate one of the two sides that make up the dormer's triangular wing wall.

I begin with the height of the front wall, which often is driven by the window height.

On this project, the homeowner wanted the dormer window to be about 3 ft. 6 in. tall. That would require a rough opening of 3 ft. 7½ in. to allow for window installation. As a rule, I keep dormer-window openings at least 6 in. above the main roof, leaving

The Payoff: Parts Go Together Quickly

If the calculations were accurate, the front wall and the two wing walls should fit each other and the existing roof without any major hitches. The dormer rafters and ridge should be carried up in pieces and assembled in place.

The wing walls go up first. It takes two workers to lift the assembled walls into place (photo 1). Make sure to keep the inside face of the wing wall flush with the edge of the new trimmers (photo 2). Drop the front wall between the wing walls (photo 3).



room for proper flashing, and about 6 in. below the top plate of the front wall so that the top of the window lines up near the bottom of the dormer's soffit (see the photos on p. 97). Adding the numbers, I end up with a front-wall height of 4 ft. 7½ in. Now I can combine the height of the wing wall with the pitch of the roof and simply solve for the missing pieces.

Dormer Roof Is Based on the Available Space

To figure the size of the dormer roof, I have to determine how much room I have between the top of the dormer walls and the top of the existing roof ridge. A dormer-roof ridge that comes too close to the existing main-roof ridge not only will look out of



Flash the top corners. I apply a large square of roofing membrane (approximately 18 in. sq.) to a difficult area that is almost impossible to flash after the dormer roof has been assembled. I leave the lower and outer edges of the release sheet intact so that later I can tuck the rest of the flashing and felt paper under this flap to seal the dormer-flashing system together.



Four rafters hold the ridge. Nail opposing rafters to the plates at the front and back of the dormer, then install the ridge board and the remaining rafters.

proportion but also will be much harder to flash and shingle properly.

For this project, the ceiling height was limited in the attic by a series of collar ties, which were 7 ft. 6 in. off the subfloor; so I installed the dormer wing walls so that the top of the top plate would be level with the bottom of the existing collar ties. I also added about an inch of wiggle room to the height of the dormer ceiling; experience has

taught me that it's unusual to find old collar ties that are perfectly level and in line with each other.

Knowing that the distance from the top of the main-roof ridge to the surface of the subfloor was 10 ft. 7 in., I subtracted the existing ceiling height of 7 ft. 6 in. and was left with just over 3 ft. from the wing-wall top plates to the existing main-roof ridge.

Measuring, Cutting, and Installing the California Valley

A California valley is calculated and cut to sit on top of the sheathing of a roof rather than connecting directly to the underlying framing. The length of the California valley is the hypotenuse (**A**) of an imaginary triangle that lies flat on the existing roof (**shown in blue**). Just like in the previous parts of the dormer, my goal is to find this missing hypotenuse by plugging in the lengths of the other two sides (**B and C**) that make up the completed triangle.

- **Side B:** Based on the measurements I used to find the adjusted run of the dormer rafters, I know that the distance from the outer edge of the sheathed wing wall to a line that's plumb with the near face of the dormer ridge is 2 ft. 11 $\frac{3}{4}$ in. I also have to add in the distance to the point that the rafter intersects the roof plane (**shown in green**).

Enter 4 $\frac{1}{4}$ in.; Press **RISE**.

Enter 6 in.; Press **PITCH**.

Press **RUN**, and get 8 $\frac{1}{4}$ in.

Add 2 ft. 11 $\frac{3}{4}$ in. + 8 $\frac{1}{4}$ in.; Press **=**, and get 3 ft. 8 in.

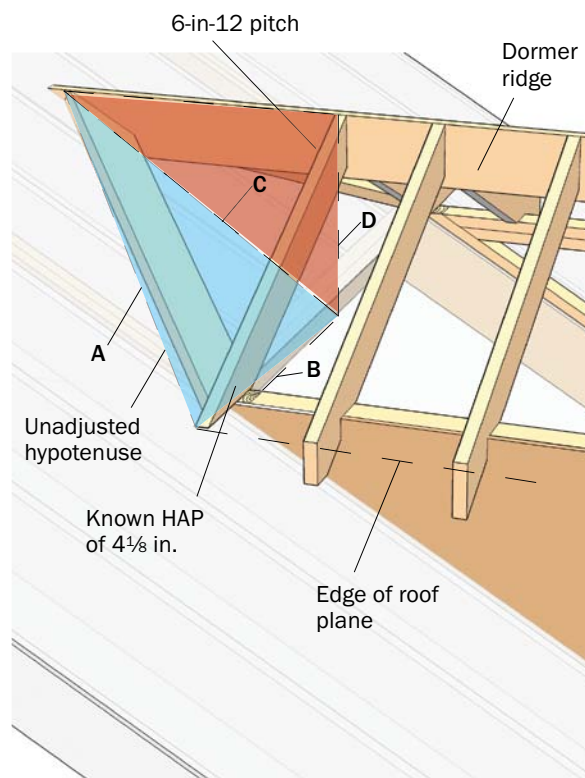
- **Side C:** I still need to find one of the legs of this triangle, so I have to create a second triangle (**shown in orange**) in which side C is a shared dimension. I know the height of the dormer ridge (**D**) is 1 ft. 10 in., and I know the pitch of the existing roof is 7 $\frac{1}{2}$ -in-12, so I use my calculator to find (**C**).

Enter 1 ft. 10 in.; Press **RISE**.

Enter 7 $\frac{1}{2}$ in.; Press **PITCH**.

Press **DIAG**, and you get 3 ft. 7 $\frac{1}{16}$ in.

Adjust for a flush fit. I now have the two legs of the triangle (**B and C**) that I need to solve for the missing hypotenuse (**A**), but first I have to adjust their lengths so that when the California valley is installed, the edge of the 2x stock won't stick up past the top edges of the dormer ridge and the rafter tail.



The plans for this project called for a dormer-roof pitch of 6-in-12. I always make sure that the dormer ridge intersects the existing roof at least 8 in. below the existing main ridge to avoid the flashing and aesthetic problems of trying to intersect two shingled ridges.

I knew from previous calculations that the overall width of the dormer (including the $\frac{1}{2}$ -in. sheathing on each side) would be 6 ft. 1 in. I divided that number in half, then used it to find the dimensions of the dormer rafters and the dormer-ridge height.

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Reduce top (ridge) end of valley

Enter 1½ in.; Press **RISE**.

Enter 7⅞ in.; Press **PITCH**.

Press **RUN**, and get 2½ in.

Reduce lower (rafter tail) end of valley

Enter 1½ in.; Press **RUN**.

Enter 7⅞ in.; Press **PITCH**.

Press **DIAG**, and get 1¼ in.

Enter 1¾ in.; Press **RISE**.

Enter 6 in.; Press **PITCH**.

Press **RUN**, and get 3½ in.

Adjusted length of side B:

3 ft. 8 in. – 3½ in.; Press **=**,
and get 3 ft. 4½ in.

Adjusted length of side C:

3 ft. 7⅞ in. – 2½ in.;
Press **=**, and get 3 ft. 4⅞ in.

Side B = Enter 3 ft. 4½ in.;
Press **RUN**.

Side C = Enter 3 ft. 4⅞ in.;
Press **RISE**.

Side A = Press **DIAG**:
4 ft. 9⅞ in.

Press **DIAG** 45.04 plumb cut

Press **DIAG** 44.96 level cut

A quick bevel for a snug fit.

Last, the bottom of the valley needs to be beveled to sit snug against the dormer rafter. To find this plumb bevel angle, use the known main roof pitch:

Enter 7⅞ in.; press **PITCH**.

Then Press **PITCH** again,
and get a **30° bevel angle**.



Framing a Classic Shed Dormer

■ JOHN SPIER

Of all the ways to bump out a roof, I think shed dormers offer the most bang for the buck. They're easy to build, are simple to finish, and provide lots of usable interior space. So why aren't all dormers sheds? Compared to doghouse, eyebrow, or A-frame dormers, shed dormers aren't always the prettiest option. On the back side of a house, though, beauty sometimes needs to take a backseat to utility. Besides, with some attention to size, shape, and proportion, a shed dormer can actually look pretty good.

Unfortunately, many builders don't take the time to think about the details before they get started working on a shed-dormer project. Many years of building have taught me that if I spend a little extra time planning a shed dormer, then I spend a lot less time trying to make a bunch of mistakes look good later.

The Subfloor Becomes a Big Set of Blueprints

There are as many ways to frame shed dormers as there are ways to design them. The dormer featured here doesn't peak at the ridge the way that many shed dormers do, but the lessons here can be applied to shed

dormers of all kinds, new construction or remodel.

Whenever possible, I take details from the framing plans and recreate them full size on the subfloor. I start by snapping chalklines on the subfloor to represent the gable end. After building and standing these walls, I snap more chalklines to complete the full-scale section drawing of the rest of the roof.

Next, I draw the ridge, and if there will be a header for the dormer, I draw that, too. At this point, I can lay out the dormer rafters and then snap the lines for them. This part of the drawing can be worked in either direction: If I have a specified or desired pitch, I get out my calculator and then figure out where to draw the rafter. Otherwise, I follow some rules of thumb for shed-dormer rafters and then use the calculator to figure out what the roof pitch really is (see "Dormer Design," on pp. 104–105). Either way, this method allows me to tweak the dormer design before any of the nails are driven.

At this point, I also go as far as to sketch in the thicknesses of the sheathing, the roofing, and the flashing. I draw all the trim details full scale so that I know they will fit and look right. Sometimes I play around with the drawing until I'm satisfied, then draw a clean version on the other end of the



Although John feels comfortable working on the scaffolding shown above, in this situation OSHA guidelines call for the use of guardrails, a safety net, or a personal fall-arrest system.

floor for reference. The process might sound time-consuming, but it pays off later.

Building Is the Easy Part

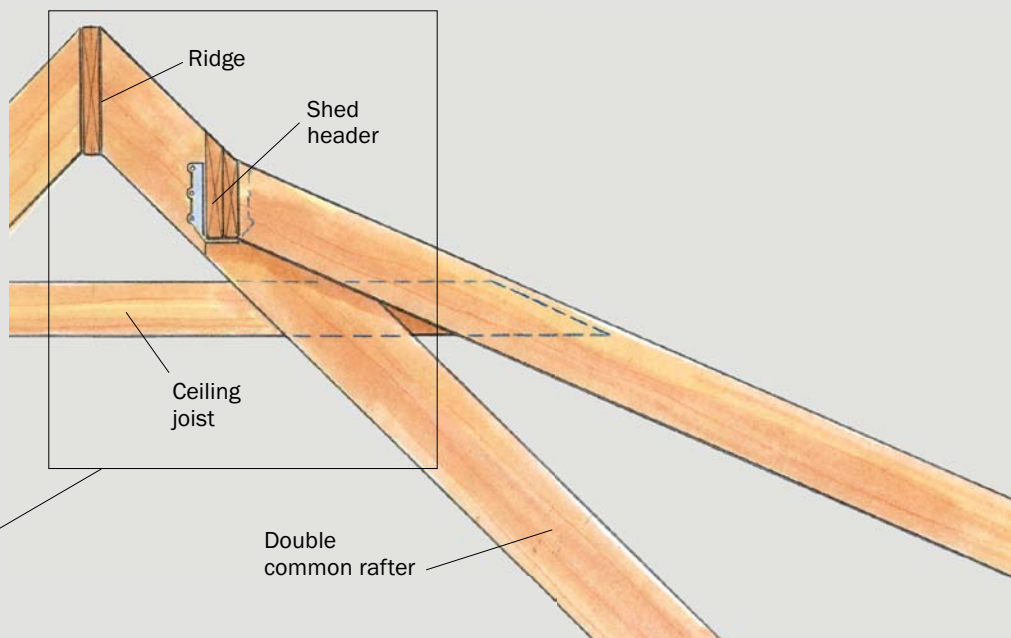
Once all the thinking and figuring are done, building a shed dormer is easy. I start with the front wall of the dormer. I build it flat on the subfloor, sheathe it, apply house-

wrap, and stand it like any other wall. When the front wall is stood, I brace the ends, run a stringline, and straighten it with some intermediate braces. Next, I build the short roof in front of the dormer, though this step can just as easily be done later if you prefer. The layout for the dormer rafters can be taken from the drawing on the subfloor, but I often cheat by making the plumb cut at the top and holding the rafter in place to

If you start with a full-scale layout on the subfloor and plan for the finished details, the framing is relatively painless.

Dormer Design

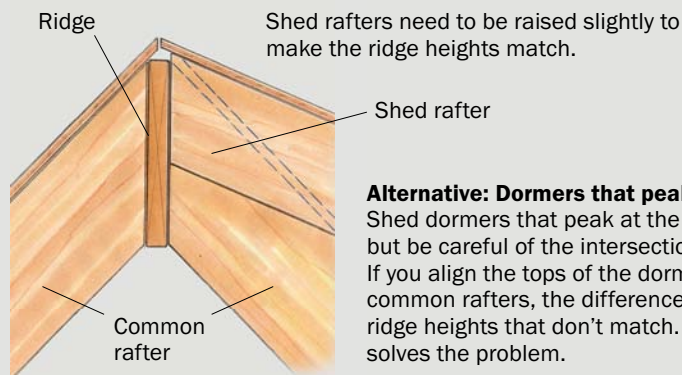
It's hard to make a poorly planned dormer look good, so it's crucial to consider the relationship between design and construction at every step of the project. Beginning with chalklines that represent the gable ends, I like to create a full-size section of the dormer right on the subfloor so that I can work out all the important details before I begin framing.



1. ROOF PITCH

First and foremost, it's important—both functionally and visually—to maintain adequate roof pitch on a shed dormer. Steeper almost always looks better, and the steeper the main roof, the steeper the dormer should be. I regard a pitch of 4-in-12 as a minimum, not least because this is the practical minimum for installing conventional roofing materials such as asphalt or cedar shingles. Keep in mind, though, that a 4-in-12 dormer might look good on an 8-in-12 roof, but a 10-in-12 or 12-in-12 roof needs a steeper shed to look right.

When it comes time to build, you can meet a specific pitch by using a calculator, or you can use the full-size sub-floor drawing to decide on the appropriate pitch. Either way you work it, the pitch could need some tweaking to look right. The two most important things to consider are the height of the front wall and the location where the tops of the rafters meet the main roof. Shed dormers that share the ridge with the main roof (see the drawing below) are the easiest to build, but smaller dormers look better with their roofs intersecting lower. Keep in mind that close to the ridge but not connected isn't good. If the dormer doesn't peak at the ridge, you need to leave adequate room for roof vents and flashing.



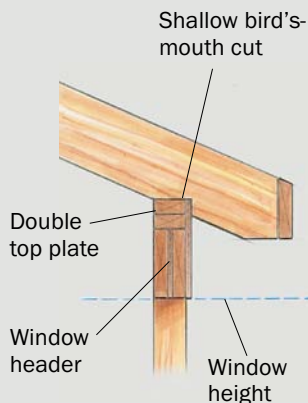
Alternative: Dormers that peak at the ridge

Shed dormers that peak at the ridge are easier to frame, but be careful of the intersection of the two differing roof pitches. If you align the tops of the dormer rafters with the tops of the common rafters, the difference in roof pitches will lead to finished ridge heights that don't match. Raising the shed rafter slightly solves the problem.

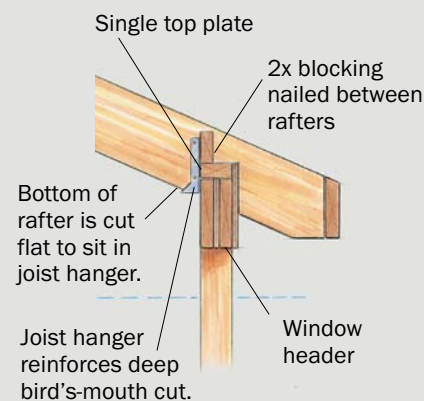
2. OVERHANGS AND HEADER HEIGHT

Dormer-roof trim and eave overhangs typically mimic the main roof, though scaling down the sizes is usually appropriate. Whatever the desired look, the details should be worked out at the framing stage. I draw in the window headers, figure the overhang, and draw out every layer from subfascia to finished trim. In conventional 8-ft.-high walls, window heads are typically between 80 in. and 84 in. from the floor. This height provides comfortable viewing for most people in a standing position and also aligns window tops with door tops. In a shed dormer, though, ceiling heights are often reduced, so it's acceptable to lower the window heights as well. Whenever possible, I raise the window headers a bit (see the drawing at right). This gives me the option of increasing the size of the windows if the design dictates.

Conventional approach



Better approach

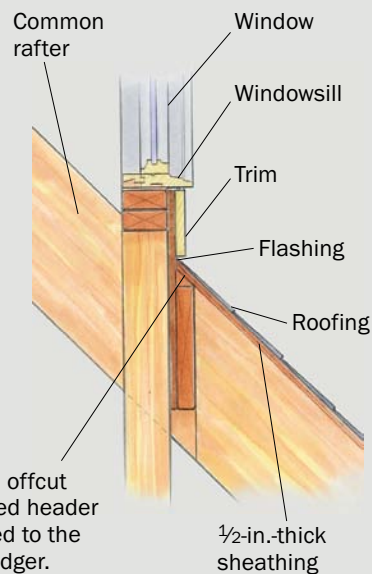


A better look: Raise the height of windows

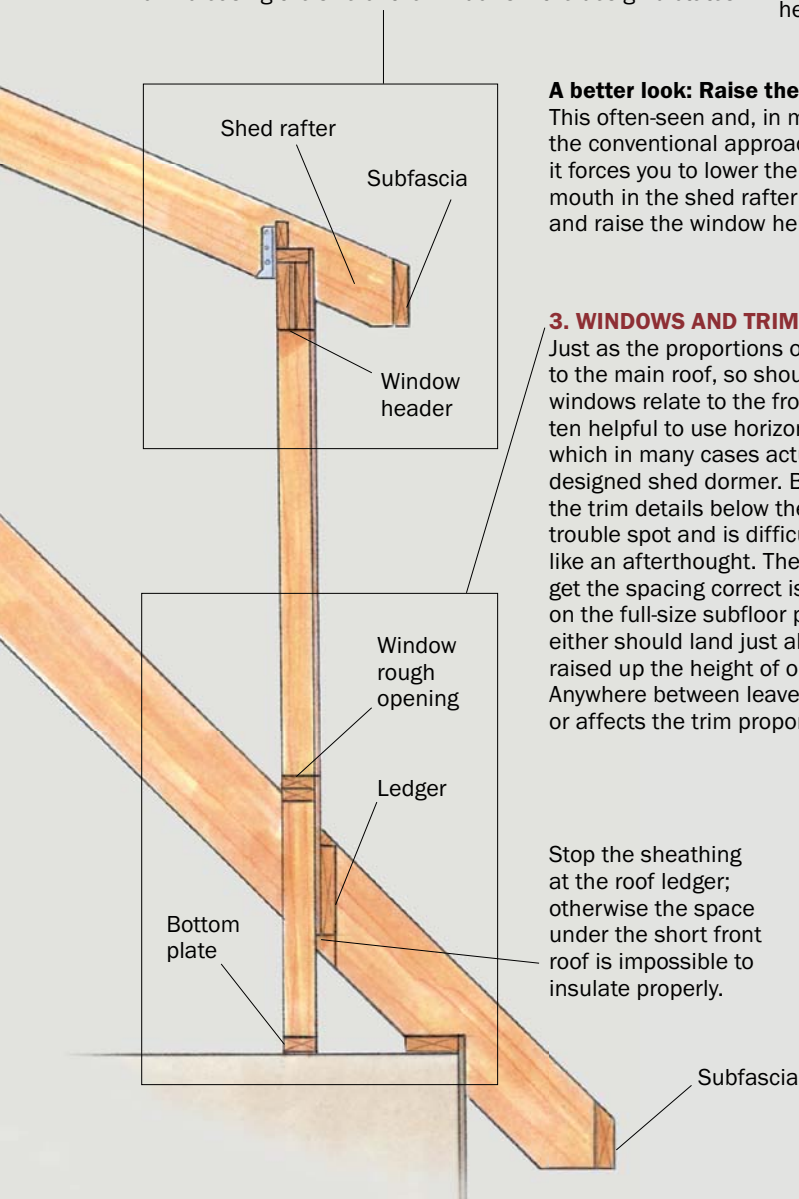
This often-seen and, in my opinion, always ugly detail (see the drawing above left) has become the conventional approach to building the front edge of the dormer roof. It's easy to frame, but it forces you to lower the windows to accommodate the header. But by cutting a deep bird's mouth in the shed rafter and capping the wall with a single top plate, I can move up the header and raise the window height (see the drawing above right).

3. WINDOWS AND TRIM

Just as the proportions of the dormer should relate to the main roof, so should the proportions of the windows relate to the front wall of the dormer. It's often helpful to use horizontally proportioned windows, which in many cases actually complement a well-designed shed dormer. But take extra time planning the trim details below the windows; this is a notorious trouble spot and is difficult to correct without seeming like an afterthought. The only sure way I've found to get the spacing correct is to draw the trim components on the full-size subfloor plans. Ideally, the windowsills either should land just above the roofing or should be raised up the height of one course of siding or trim. Anywhere between leaves an awkward course of siding or affects the trim proportions.



Stop the sheathing at the roof ledger; otherwise the space under the short front roof is impossible to insulate properly.



Raise the wall but not quite plumb. Unless ceiling joists will bear directly on the top plate of the front wall, lean the wall in about $\frac{1}{8}$ in. before bracing it; the rafter loads will push the wall out as the building settles and the rafter crowns flatten.

Solid Planning Pays Off at the Building Stage



With a little extra planning, all the dormer components fit together nicely on the first try. For instance, the full-size drawing made it obvious that to ensure a smooth transition between the two different planes of roof sheathing, the dormer rafters (see the inset photo above) should be cut so that they sit just below the beveled dormer header (photo 1).

Always sheathe the cheek walls before you sheathe the roof; it's a lot

easier to trace these oddly shaped pieces than it is to measure and fit them. Just remember to cut the wall sheathing $\frac{1}{4}$ in. short. If scribed to the top and cut exactly, the wall sheathing will push up on the roof sheathing as the rafters dry and shrink (photo 2).

The short rafters that make up the small piece of roof in front of the shed dormer can be traced from the same template used to make the common rafters; you just

need to adjust the location of the plumb cut. Don't forget to subtract the thickness of the beveled ledger from the rafter length before making the cuts. Toenail these rafters to the bottom plate running along the outside edge of the subfloor, then nail them to the ledger on the face of the wall (photo 3).

If the ceiling will flatten at the peak, it's crucial to keep the joists in plane with each other so that the joint between the ceiling and the

mark the bird's mouth and tail cuts. Which-ever way you do it, make a pattern rafter, and test it at both ends of the front wall and in the middle before you cut and hang the rafters.

Cheek walls on each end of the shed dormer can be done three ways: framed in place and extending all the way up, framed flat to

the ceiling and crippled in above, or framed only from the common rafter to the dormer roof for an open plan. Always sheathe these walls before the roof, though; it's easier to trace these oddly shaped pieces than it is to measure and fit them. Just remember to cut the sheathing $\frac{1}{4}$ in. shy to allow for rafter shrinkage. I finish by building the rake over-



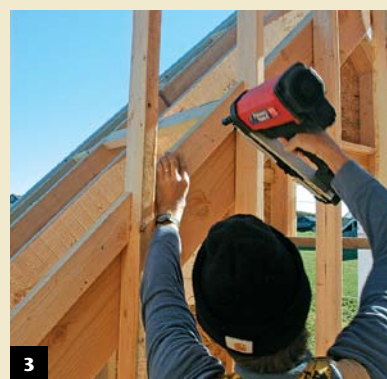
dormer roof is straight, and so that the ceiling remains flat. I start by measuring the ceiling height up from the subfloor at all four corners of the room; then I snap a chalkline between the points and install the joists with their bottom edge on the chalkline (photo 4).

hangs and adding the subfascia, the blocking, the hardware, and the sheathing.

John Spier builds and renovates custom homes and is a frequent contributor to Fine Homebuilding magazine. He and his wife, Kerri, own and operate Spier Construction, a general-contracting company on Block Island, Rhode Island.

Cheek Walls Are Framed in Place

Start the cheek walls by nailing a top plate along the underside of the outermost shed rafter. Next, cut the bottom plate to the desired length, slide it against a previously framed wall to lay out the stud spacing quickly (photo 1), and nail the plate to the subfloor. Use a level to plumb up from each stud mark on the bottom plate, then measure the length, cut the studs with the appropriate top angle, and toenail in place (photo 2). Finish the cheek walls by nailing angled blocking to the doubled rafters at each stud bay (photo 3). The blocking should extend past the top of the rafter to provide solid nailing for the cheek-wall sheathing.



Framing a Dramatic Dormer

■ JOHN SPIER

A lot of houses built on New England's coast use dormers to tuck light, airy living spaces under their roofs. Steep-roofed A-dormers are an attractive approach to this style. A house my crew and I recently built on Block Island, Rhode Island, incorporated three A-dormers on the front of a conventional colonial-style roof.

What is an A-Dormer?

An A-dormer differs from most other dormers in that its gable wall is built in the same plane as the exterior wall of the house below it (see the photo on the facing page). It's just about the only dormer that looks good when not recessed into the roof. With steeply pitched roofs (these were 24-in-12), A-dormers provide minimal floor area, but they can accommodate tall windows and interesting cathedral-ceiling details. The exterior trim is usually simple with a uniform soffit width and long rakes connected by minimal lengths of horizontal fascia.

Because the entire A-dormer roof extends down to form a valley with the main roof of the house, none of the usual dormer details,

such as cheeks, corner boards, or siding-to-roof flashings, is an issue. Absence of these details makes A-dormers easy to finish and weatherproof.

First Building Steps Are the Same as for a Doghouse Dormer

As is the case with most other dormers, the main roof of the house is framed first: The gables are raised, the ridge beam is set, and the common rafters are installed with double or triple rafters framing the openings left for the dormers ("Cutting and Setting Common Rafters," on pp. 4–13). The dormers for this project were supported by 5-ft.-high kneewalls that extend inward from the outside wall; in turn, beams in the ceiling below carry the kneewalls. We framed these kneewalls first and set all the common rafters for the main roof outside of them.

Because A-dormer gable walls are flush with the wall below, the adjacent common rafters must have their tails cut off flush with the exterior-wall plate (see the photos



on p. 111). A triangulation using the dormer pitch and the kneewall height showed which common rafters needed to be cut flush and which needed full tails to carry the fascia between the dormers.

Next, we framed the gable faces of the dormers. Lines snapped on the subfloor represent the top and bottom plates and the king studs, and the walls are framed to the snapped lines and lifted into place in a miniature version of raising the main gable.

The 24-in-12 pitch of these dormers required bevel cuts of 64° for the tops of the studs, which is beyond the reach of any saw I own. Because each of these narrow dormers had about only eight of these cuts, I mass-produced the cuts by stacking the studs on edge and gang-cutting them. An 8¼-in. circular saw helped, but a regular saw with

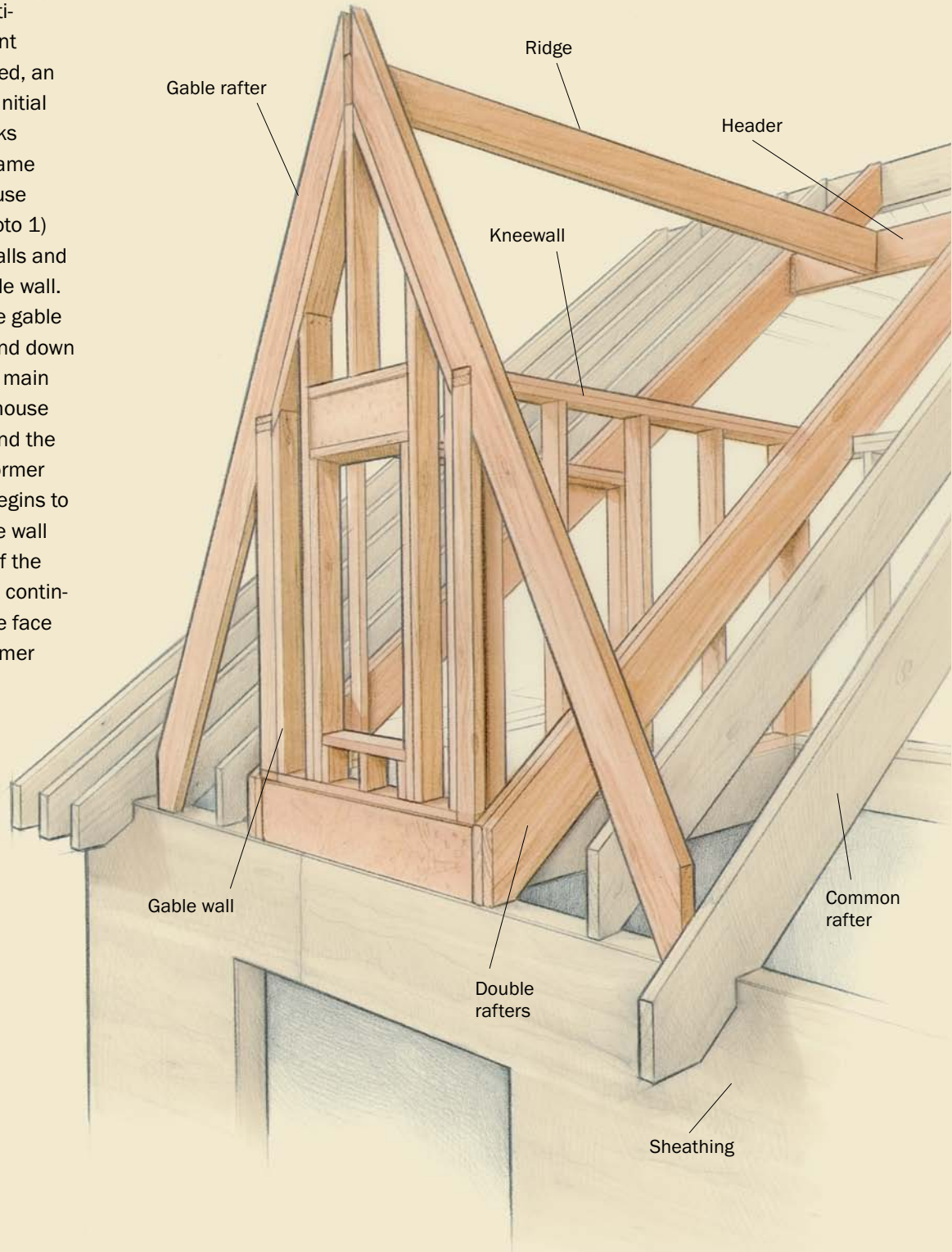
a reciprocating saw to finish the cuts also would work.

Next, we took the height of the dormer ridges from the plans and installed headers between the doubled common rafters on each side of the dormers. We nailed in hangers to support the ends of the headers. After the gables were made plumb, the ridge boards were cut, laid out, and nailed in place. Next, we made and tested a pattern rafter (without a tail), and we set a pair of rafters on each dormer gable. We cut and installed short studs under these gable rafters outside the kneewalls as nailers for the sheathing and as a way to tie the common-rafter ends to the gable rafter of the dormer. After the rafters were in place, we extended the sheathing from the main house onto the dormer gable.

If doghouse dormers or shed dormers aren't dressy enough, A-dormers can add an exciting design note, and they're easier to seal against the elements.

Not Your Basic Doghouse

Although dramatically different when finished, an A-dormer's initial framing looks much the same as a doghouse dormer (photo 1) with kneewalls and a small gable wall. But then the gable rafters extend down to meet the main roof of the house (photo 2), and the unique A-dormer character begins to emerge. The wall sheathing of the main house continues onto the face of the A-dormer (photo 3).





Two Types of Valleys in Each Dormer

Roof valleys can be framed two ways, and each dormer valley in this project is a hybrid of both. The first method uses a valley rafter, which carries jack rafters on each side. This approach was used for the valleys above and inside the plane of the kneewalls where the interior was to be finished as cathedral space.

The second approach, sometimes known as a California valley, was used for the valleys below and outside the plane of the kneewalls where the interior space was unimportant. A California valley is made by framing (and in this case, sheathing) the roof on one side of the valley, then building the roof for the other side of the valley on top of it.

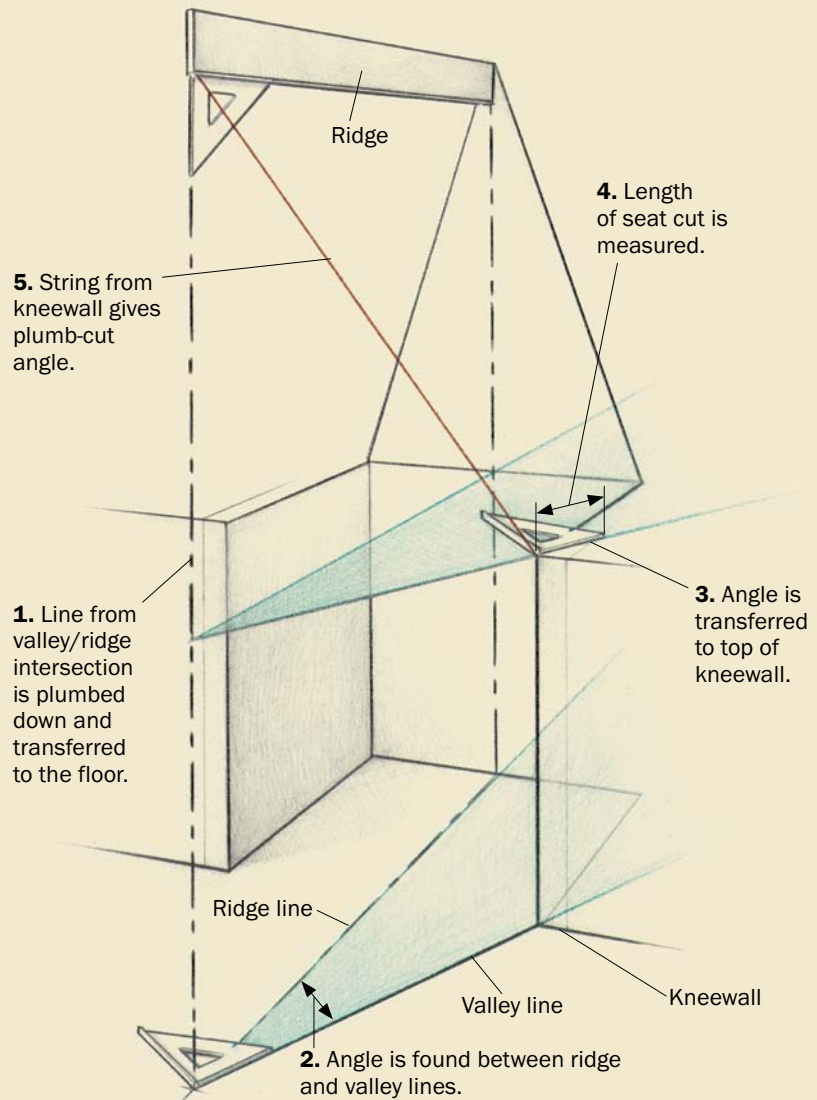
Valley Rafters for Tops of Dormers

Any regular valley between roofs of equal pitch is fairly straightforward; the compound cuts are all beveled at 45°, and standard tool settings and references are used to calculate the valley-rafter angles. An irregular valley, which joins roofs of different pitch, introduces several complications. These A-dormers with their 24-in-12 pitch intersected a roof with a 10-in-12 pitch, creating an extremely irregular valley.

The first step is finding the angles and location for the valley rafter (see the photos and drawing on pp. 112–113), which is possible through advanced mathematics. But every carpenter I know does it by snapping lines and taking measurements. I start by transferring the location of the valley/ridge intersection to the floor with a plumb bob or a tall level. With a straightedge, I draw a line from that point to the corner of the kneewall, which supports the lower end of the valley rafter. Using a rafter square, I then measure the bevel angle directly from the floor.

Gathering Valley-Rafter Information

To find the bevel angle for the valley rafters, the author plumbs down from the ridge (1). Lines drawn from the corner of the kneewall represent the valley, and a rafter square finds the angle (2). That angle then is transferred to the top of the kneewall (3), and the length of the seat cut is measured for the valley-rafter layout (4). A string from the kneewall to the ridge is used to find the plumb cut (5).



Next, I stretch a string from the corner of the kneewall to the ridge and record the angle of the plumb cut with a rafter square. The length of the valley rafter then is measured between those points (along the bottom edge of the rafter). I transfer the bevel angle of the valley to the top of the kneewall, and then I can measure the length

of the seat cut to complete the valley-rafter layout.

Another complication when dealing with irregular valleys is the different depths of the rafters for the different roof pitches. In some cases, the width of the stock can be adjusted. In this more extreme case, I framed everything to the planes of the interior ceiling,



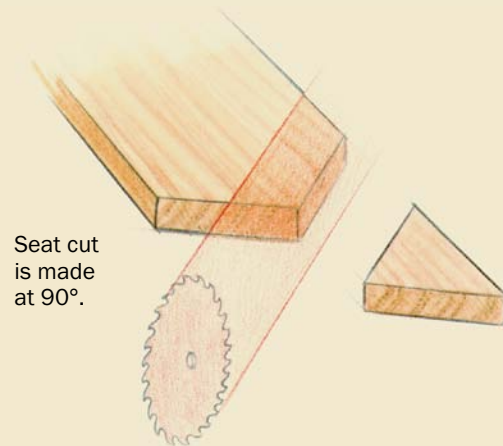
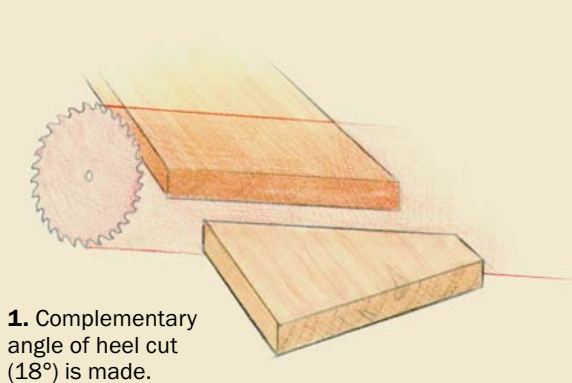
then allowed the plane of the deeper dormer roof to land beyond the valley rafter on the roof sheathing of the main house.

One of the greatest challenges to framing these dormers is cutting the extreme compound bevels on the ends of the valley and jack rafters (see the photos on pp. 114–115), in this case at 72°. After laying out the cut-

lines, I cut the complementary angle (90° minus 72° , or 18°) along the heel of the rafter. Then I stood the rafter on edge and made a 90° cut, letting the saw ride along the bevel cut I just made, and I finished the cut with a reciprocating saw.

Cutting the Valley Rafter

After the ends of the valley rafters are laid out, the first step to cutting the steep bevel angle is making the heel cut or plumb cut at the complementary angle, in this case 18° (1). With the board on edge, a saw set at 90° rides on the first cut to create the bevel angle of 72° (2). A reciprocating saw finishes the cut (3).



California Valleys Simplify Framing the Lower Dormer Roof

After the valley rafters and jack rafters are installed, we lay out and finish the rest of the roof. First, we make a set of fly rafters with blocks to establish the overhang. These rafters are installed with the lower ends left long, and they then are cut in place to the level of the common-rafter tails from the main roof. Next, we install short sections of

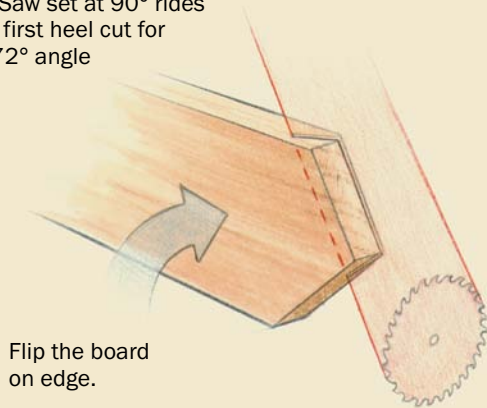
subfascia to join the fly rafters of adjacent dormers.

As I mentioned, we sheathe the common roof with plywood before installing the plate for the California valley (see the photos on pp. 116–117). For strength and simplicity, the sheathing runs to the sides of the dormer kneewalls.

We locate the plate for each California valley by snapping a chalkline from the valley rafter to the outside edge of the gable rafter. After measuring the length, we cut a 2x10 plate (wide enough to catch the tails of



2. Saw set at 90° rides on first heel cut for a 72° angle

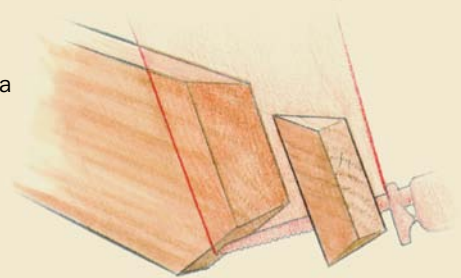


Flip the board on edge.



Just as if it grew here. When the valley is in place, the 72° heel cut lies flat against the doubled common rafters. The rafter bottoms are kept flush, and the dormer roof sheathing hides the height difference in the rafters.

3. Finish the heel cut with a reciprocating saw.



the rafters) that forms the base for the California valley. We bevel one edge of the plate to the angle of the dormer roof and cut the angles for the ends, which we figure using a rafter square along our snapped line. We nail the plate to the snapped line. The rafters for the California valley are identical from the bird's mouth at the kneewall up, so it's just a matter of cutting the tails to length.

Top-Down Sheathing Removes the Guesswork

The last step is sheathing the dormer roof. As with most dormers, and especially with roofs this steep, I find it easiest to work from the top to the bottom. Not only do I usually have safer, more comfortable footing with this method, but measuring the remaining angled pieces is also easier.

After snapping the course lines, I start with a full sheet of plywood at the upper



Challenging but dramatic. The steep pitches and sharp angles of A-dormers are an extra challenge for the roofing, plastering, and painting subcontractors, but the dramatic results are worth the extra effort.

and outermost corner of the dormer roof. The trapezoidal shape of succeeding pieces of plywood then can be given to the person doing the cutting simply by measuring the short and long points or by using overall lengths and the common difference.

***John Spier** builds and renovates custom homes and is a frequent contributor to Fine Homebuilding magazine. He and his wife, Kerri, own and operate Spier Construction, a general-contracting company on Block Island, Rhode Island.*

Building a California Valley

With a standard valley above and the main roof sheathed (photo 1), the crew snaps a chalkline for the edge of the California valley (photo 2) and measures the length. A 2x plate with a beveled edge forms the base of the valley (photo 3), and the rafters cut to length land on the plate (photo 4). Sheathing is installed from the top down (photo 5).



1



A Gable-Dormer Retrofit

■ SCOTT MCBRIDE

Carol and Scott Little's home draws its inspiration from the cottages of colonial Williamsburg and the one-and-a-half story homes of Cape Cod. Both styles typically feature a pair of front-facing gable dormers. But for some reason, the builder of the Littles's house put only one dormer on the front, leaving the facade looking unbalanced. I was hired to add a new dormer on the front of the house to match the existing one and, for more light, added a scaled-down version of the same dormer on the back of the single-story wing.

As the crew set up the scaffolding and rigged the tarps against the possibility of rain (see the sidebar on p. 120), I crawled under the eaves to study the existing roof. I soon realized that framing the sidewalls of the two dormers and directing their load paths would require different strategies, as would the way the dormer ridges would be tied to the main roof.

The first consideration in a retrofit is the location of the dormers, and the second is their framing. The existing front dormer fit neatly into three bays of the 16-in. o.c. main-roof rafters. These main-roof rafters (or commons) were doubled up on each side of the dormer, creating the trimmer rafters that carry the roof load for the dormers.

Full-height dormer sidewalls stood just inside these trimmers, extending into the house as far as the bedroom kneewalls. Additional in-fill framing completed the dormer walls that were above the sloped bedroom ceiling.

Fortunately, three rafter bays at the other end of the roof landed within a few inches of balancing with the location of the existing dormer. Consequently, I had only to sister new rafters to the insides of the existing ones to form the new trimmers, and I could match the framing of the existing front dormer, leaving a uniform roof placement, appearance, and size.

Cut the Opening and Shore Up the Main-Roof Framing First

After laying out the plan of the front dormer on the subfloor, I used a plumb bob to project its two front corners up to the underside of the roof sheathing. Drilling through the roof at this location established the reference points for removing the shingles and cutting the openings.

The tricky part was establishing how far up the slope to cut the opening. To play it



Protecting the Roof

To protect the exposed roof against rain, we rolled up new poly tarps around 2x4s and mounted them on the roof ridge above each dormer. The tarps were rolled down like window shades each evening,

with some additional lumber laid on top as ballast. The ballast boards were tacked together as a crude framework so that they would not blow away individually in high winds.



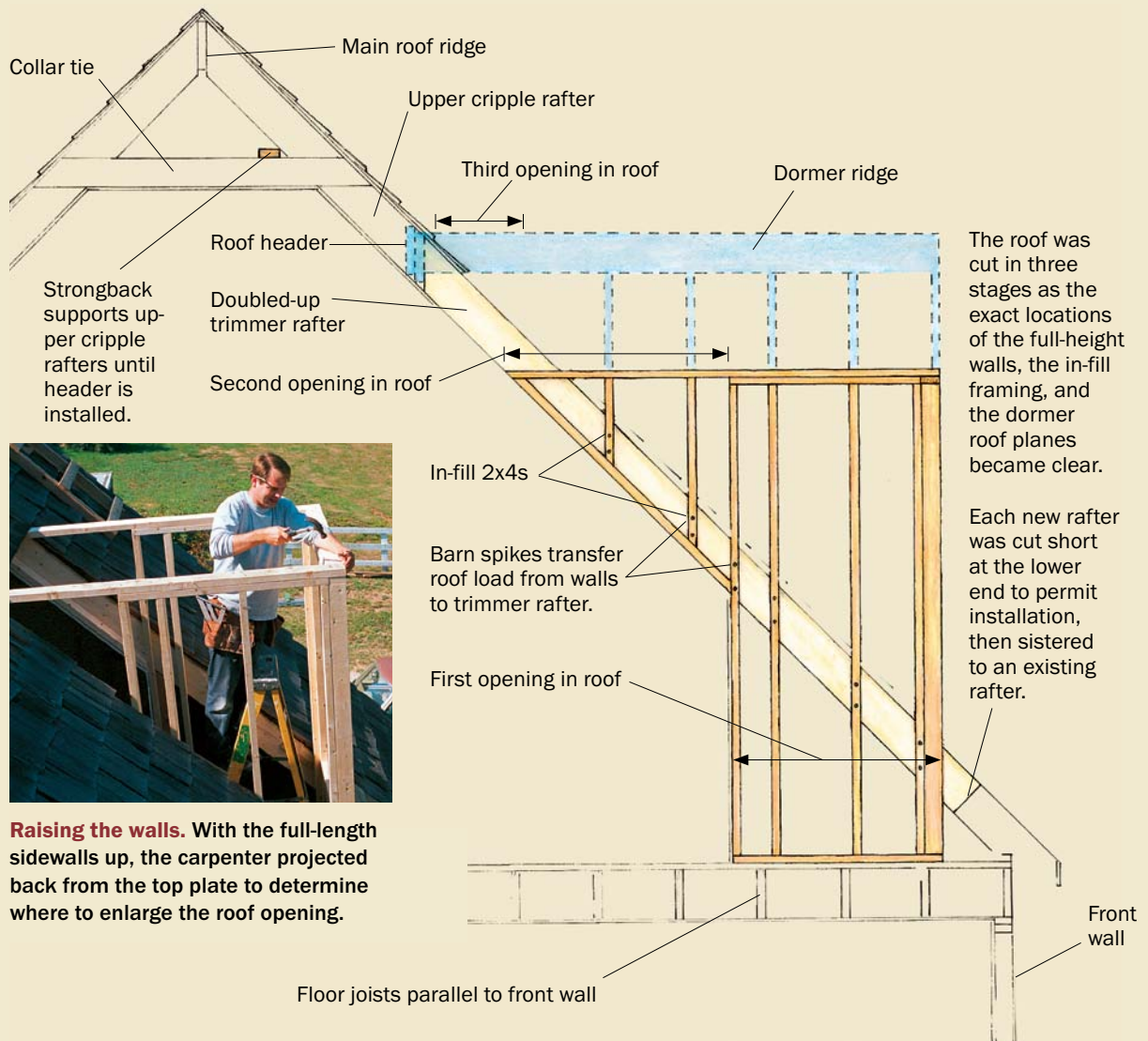
safe, I first opened just enough room to raise the full-height portion of the sidewalls (see the drawing on the facing page). With those walls up and later with some dormer rafters in place, I could project back to the roof to define the valley and then enlarge the opening accordingly.

Inserting new rafters into an already-sheathed roof can be problematic because of the shape of the rafters. They are much longer along the top edge than along the bottom, so there's no way to slip them up from below. A standard 16-in. bay doesn't afford nearly enough room to angle them

Supporting the Dormer

After doubling the rafters flanking each dormer, the author cut out the existing rafters where they crossed through the dormer. He installed a strongback across the collar ties to support the upper cripple rafters until the roof header was in

place. Because the floor joists ran parallel to the front wall instead of sitting on it, the author transferred the weight from the sidewalls to the trimmer rafters with 6-in. spikes.



Raising the walls. With the full-length sidewalls up, the carpenter projected back from the top plate to determine where to enlarge the roof opening.

in, either. To form the new trimmer rafters, we cut the new members about 6 in. short of the wall plate before we secured them to the existing rafters.

When faced with this situation, I normally use posts to transfer the load from the trimmer rafters to an above-floor header. In

fact, I did follow this step with the smaller rear dormer (see the sidebar on pp. 122–123), but that would not work in this case. Here, the floor joists ran parallel to the front wall, instead of perpendicular to it, and so could not transfer the load to the wall.

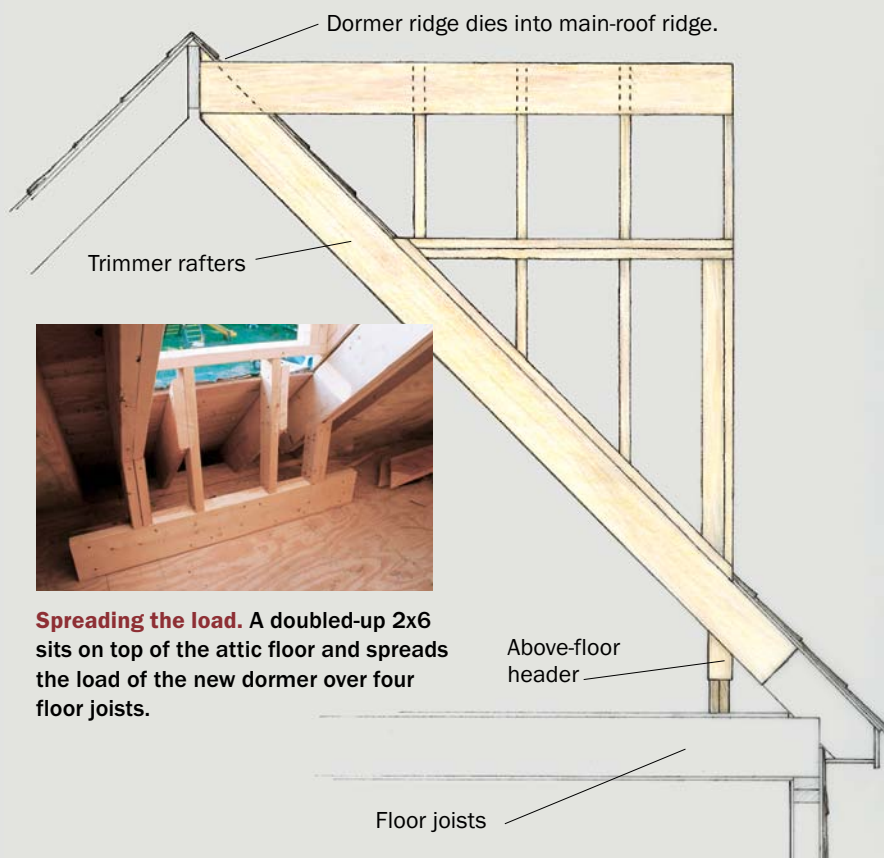
Back Dormer Demands Different Strategies

Unfortunately, when it came to the smaller dormer in back, the existing rafter layout did not match where the dormer needed to be, as was the case in front. Here, I had to build new trimmer rafters in the middle of the existing rafter bays.

The attic space differed, too. Whereas the front dormer served a bedroom, the back dormer was in a storage room. Because the owner wanted to

maximize floor space in this storage area, I built the sidewalls on top of the rafters, which pushed the kneewall back and allowed the ceiling slope to extend all the way to the dormer's gable wall (see the drawing below).

As in the front dormer, we cut the new trimmer rafters short. This time, however, the floor joists ran perpendicular to the front and back walls, which



ABOVE-FLOOR HEADER DISTRIBUTES WEIGHT OF THE DORMER

There wasn't enough room in the existing roof structure to install full-length trimmer rafters that would bear on the exterior wall. Instead, the trimmers were cut short, and an above-floor header was used to transfer their loads to the floor joists and to the exterior wall.

Spreading the load. A doubled-up 2x6 sits on top of the attic floor and spreads the load of the new dormer over four floor joists.

I decided simply to let the existing single rafter carry the load for the last 6 in. to the front wall plate. This situation is not the ideal solution, but the weight of the dormer is not great enough to overtax the rafters over such a short span, and doubling up the new trimmer rafters would at least stiffen the existing rafters considerably.

With the new trimmer rafters in, the existing main-roof rafters falling between them were cut and partially torn out to make room for the dormers. The portions above and below the dormer would remain as cripple rafters. The lower cripple rafters were plumb-cut in line with the dormer front wall where they would be spiked to cripple studs.



In the doghouse. Narrow dormers are prone to racking. To stiffen this one, the author sheathed the front wall with a single sheet of plywood.

meant that I could use posts to transfer the load from the trimmer rafters to an above-floor header (see the photo on the facing page). The header distributes the weight over several floor joists, and the joists carry the weight back to the wall. The additional strain imposed on the floor joists is minimal because the header is so close to the wall.

The location of the back dormer's roof ridge altered another aspect of the framing. Because this dormer's roof ridge was at the same elevation as



Finding the bottom of the valley. A straightedge is laid across the dormer rafters to project the roof surface to the inside of the trimmer rafter.

the main-roof ridge, I tied the dormer ridge and the main-roof ridge directly together instead of building a separate dormer header.

Measuring and cutting the valley rafters was the same for the back as for the front with the exception that at the bottom of the back dormer's valley rafters, the compound miters did not need a level seat cut because the valley rafters would not sit on top of 2x4 wall plates. Instead, the valley rafters were simply nailed to the face of the trimmer rafters.

Rough cuts were then made at the top, leaving the upper cripple rafters long. These rafters would be trimmed back further only later, after we established the precise location of the dormer-roof header.

To support the upper cripple rafters temporarily, I climbed up into the little attic above the bedroom. There I laid a 2x4

strongback across four collar ties, including the collar ties connected to the recently doubled trimmers. This strongback would support both the collar ties and the upper cripple rafters until we could install the dormer-roof header.

Dormer Sidewalls Can Be Framed Two Ways

With trimmer rafters installed and cripple rafters secured, I could proceed with the walls. I know two common ways to frame dormer sidewalls: You can stand a full-height wall next to a trimmer rafter, or you can build a triangular sidewall on top of a trimmer rafter, which is how I framed the rear dormer. To match the new front dormer to the existing one, I used full-height studs 16 in. o.c. only as far in as the kneewall.

This type of dormer sidewall normally delivers the weight of a dormer to the floor. In new construction, this weight is taken up by doubling the floor joists under these walls. I didn't want to tear out the finished floor, however, so I joined the full-length sidewalls to the trimmer rafters by predrilling and pounding two 6-in. barn spikes through each stud. This transferred the load to the trimmer rafters rather than placing it on the floor framing. I've seen barn spikes withstand tremendous shear loads in agricultural buildings, so I felt confident they could carry this little dormer.

Plan the Cornice Details before Framing the Roof

With the walls up, the roof framing, which is the most complicated, came next. Before cutting any dormer rafters, though, I drew a full-scale cornice section, using the existing dormer as a model. Worrying about trim before there is even a roof may seem like the tail wagging the dog; but it makes sense, especially in a retrofit. The existing dormer featured a pediment above the window. The eaves had neither soffit nor fascia, just a crown molding making the transition from the frieze board to the roof (see the photo on the facing page). That detail reduced the dormer rafter tail to a mere horn that would

catch the top of the crown molding. The eaves section drawing helped to establish the cuts for the rafter tails and trim details.

Along the rakes, the crown molding was picked up by the roof sheathing, which was beveled and extended out past the gable wall. Using a short piece of molding as a template, I worked out the amount of the overhang and the correct bevel for the edge of the sheathing in the rake-section drawing. Juxtaposing the drawings ensured that the rake crown, the eave crown, and the level-return crown would all converge crisply at a single point.

Framing the Roof Defines the Valleys

Ready to proceed with the roof framing, we set up two pairs of common rafters with a temporary ridge board between them. Then we used a straightedge to project the outline of the dormer roof planes onto the main roof and cut back the main-roof sheathing accordingly (see the drawing on p. 126). Having established the elevation of the dormer ridge, we trimmed back the upper cripple rafters and then installed the roof header to carry the permanent dormer ridge board. The roof header spans between the trimmer rafters, carrying the dormer ridge and the valley rafters. (On the rear dormer, the ridge was level with the main-roof ridge, so no header was necessary there.)

When the dormer common rafters and ridge were installed permanently, we used the straightedge again to find the intersection of the dormer roof planes and the inside face of each trimmer rafter (see the photo on p. 123). This point is where the centers of the valley rafters would meet the trimmer rafters. At their tops, the valley rafters would nuzzle into the right angle formed between the dormer ridge and the main-roof header.

I like to “back” my valley rafters, a process of beveling them so that they accept the sheathing of each adjoining roof on its

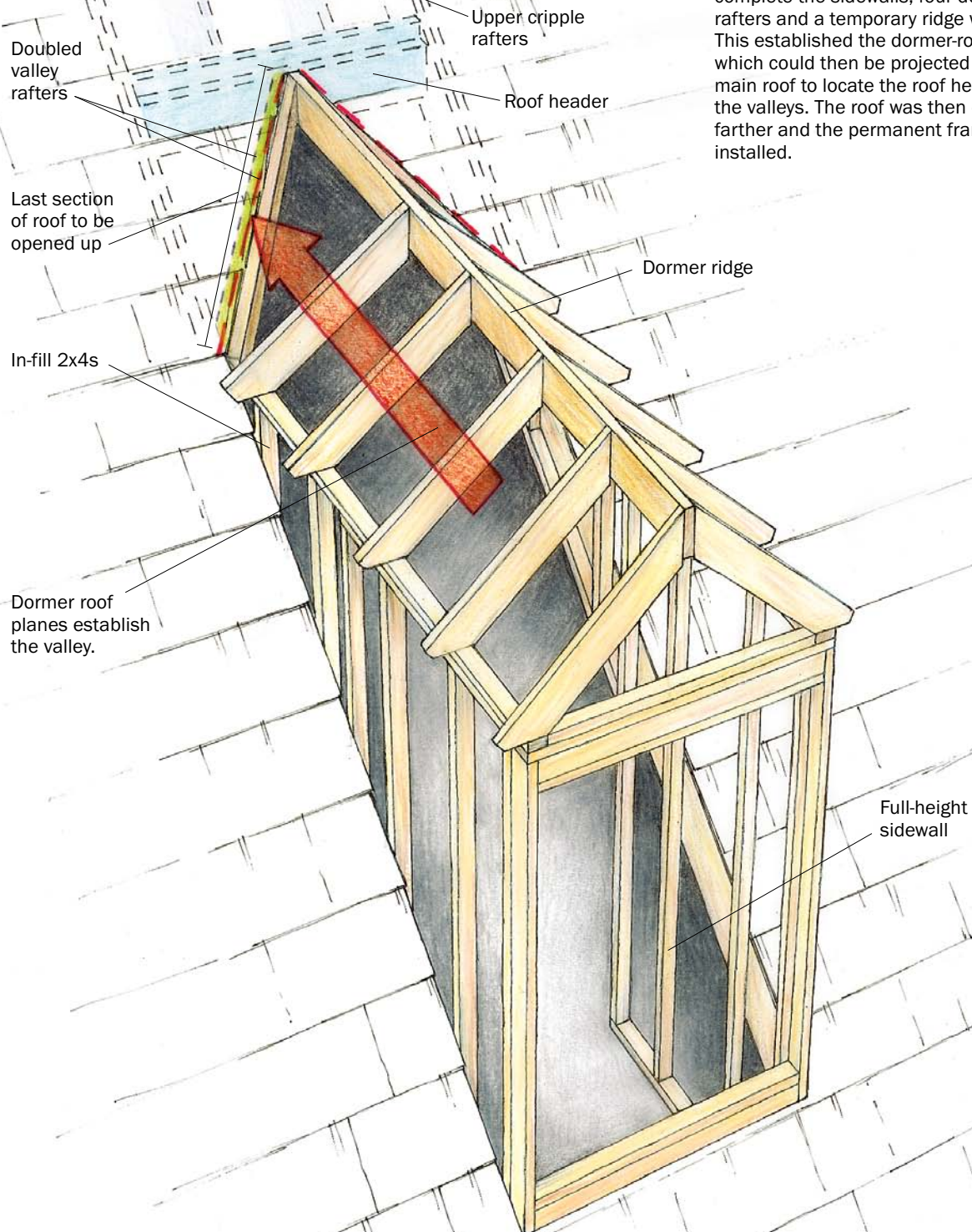


A crowning moment.

Three pieces of crown converge at the bottom corners of the pediment. Trim, casings, and sills, primed on every side, resist rot.

Dormer Rafters Help to Locate Valleys

Once the in-fill 2x4s were added to complete the sidewalls, four dormer rafters and a temporary ridge were raised. This established the dormer-roof planes, which could then be projected onto the main roof to locate the roof header and the valleys. The roof was then cut back farther and the permanent framing installed.



respective plane. Because a cathedral ceiling was to wrap under the valley, I backed the lower edge of the valley as well, giving a nice surface for attaching drywall. In addition to backing, I double valleys, even when not structurally necessary, because it gives ample bearing for plywood above and drywall below. Doubling valley rafters also simplifies the cheek-cut layout at the top and bottom of the valley because a single compound miter is made on each piece instead of a double compound miter on a single piece.

Because of the dormer's diminutive size, valley jack rafters weren't required. Consequently, with the valleys in place, the framing was complete, and we could dry it in.

Careful Sheathing and Flashing Combat Wind and Water

We sheathed the front of each dormer with a single piece of plywood for maximum shear strength (see the left photo on p. 123). With so little wall area next to the windows, I was concerned that the dormer might rack in high winds. The small back dormer was especially worrisome because it had no full-length sidewalls to combat racking, but the single piece of plywood on its front stiffened the whole structure. We extended the roof sheathing past the gable wall and beveled it to receive the rake crown molding.

Flashing work began with an aluminum apron flashing at the bottom of the dormer front wall (see the top photo at right). The downhill fin of this flashing extends a few inches beyond both sides of the dormer, and its vertical fin was notched and folded back along the sidewall. Then the first piece of step flashing had its vertical fin folded back along the front wall to protect the corners where the apron flashing had been notched (see the bottom photo at right). Step flashings march up along both sides of the dormer, with the uppermost pieces trimmed to fit tightly beneath the dormer roof sheathing. It was tough work weaving step flash-



Keep the water moving down. An apron flashing seals the front wall with its ends bent around the corners (top photo). Then the lowest step flashings have their vertical fins bent over to cover the notches in the apron (bottom photo).



Water-table flashing protects window and trim. The crown that forms the bottom of the pediment will go below the flashed water table and miter with an eave crown (seen poking out past the corner).

ings into the existing cedar-shake roof. Hidden nails had to be extracted with a shingle ripper, a tool with a flat, hooked blade. If I had it to do over, I would sever these nails with a reciprocating saw before the dormer sidewalls were framed.

The valley flashing was trimmed flush with the dormer ridge on one side of the roof, and the opposing valley flashing was notched so that it could be bent over the ridge. We protected the point where the valleys converge at the dormer ridge with a small flap of aluminum with its corners bent into the valley. This approach is more reliable than caulk.

The last piece of flashing to go on was the gable water-table flashing (see the photo on the facing page). Its front edge turns down over the return crown molding, and its rear corners fold up under the extended roof sheathing to repel wind-driven rain.

Finish Trim Improves on Weather Performance of Existing Dormer

The house is just a few years old, but the existing front dormer had suffered extensive decay. In the worst shape were the finger-jointed casings and sill extensions that the original builder had used. To avoid a repeat of this calamity, I used only solid moldings and bought cedar for the trim boards. Everything was primed, especially the ends. To promote air circulation, the ends of corner boards and rake boards were elevated an inch or so above nearby flashings.

We wanted the new cedar shakes on the dormer to blend in with the existing weathered roof. I asked around for a stain recipe, but the only response I got was from an old farmer standing at the lumberyard counter. He insisted that horse manure was

the ticket. To my great relief, we hit upon a more savory alternative. We brushed on an undercoat of Minwax Jacobean, followed by a top coat of oil-based exterior stain in a driftwood-type shade. The undercoat added a nice depth to the gray top coat.

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To promote air circulation, the ends of the corner boards and rake boards were elevated an inch or so above nearby flashings.

Framing an Elegant Dormer

■ JOHN SPIER

Some years ago, my wife, Kerri, and I built a small Cape-style house for ourselves on Block Island, Rhode Island, where we live and work. Most small Capes have essentially the same upstairs plan: a central stairwell and a bathroom at the head of the stairs with bedrooms on each side. Dormers provide the headroom to make these upstairs spaces usable.

The most common arrangement is probably a doghouse, or gable, dormer in each of the bedrooms, with a larger dormer on the other side for the bathroom. Another alternative is a shed dormer over all three spaces, but we weren't too keen on that look. Then at some point, one of us found a picture of a dormer that was essentially two doghouse dormers connected by a shed dormer.

This design would give us as much interior space as a shed dormer, and it was a lot nicer-looking. Of course, we argued over the choice at great length. Kerri, the artist, insisted on the beauty and complication of this hybrid dormer (see the photo on p. 132), while I, the practical carpenter, thought about how much easier and faster a basic shed dormer would be. I never had a chance of winning that argument.

As our dormer took shape, an old-timer on the island told us that what we were building was called a Nantucket dormer. The name stuck, and we use it to describe the several different variations that we've built since, including the project here. Ironically, the history experts on Nantucket island disavow any connection to the name, claiming that the design has no historical precedent.

Two Different Strategies for Two Different Interiors

Even though its design seems to be two dormers connected by a third, the Nantucket dormer is actually built as a single structure. The front wall can be a single plane, or its center section can be recessed. The project here has the center section stepped back, a look that I've come to prefer. As with most dormers, I think Nantucket dormers look better if the walls are set back from the ends and edges of the main roof and from the plane of the walls below.

The doghouse-dormer wall is plumbed and braced in place.





Hybrid dormer. Doghouse dormers create more room and larger egress for the bedrooms at the ends of this house, while the shed room in between creates a space for a full bath.

The key element in supporting a Nantucket-dormer design is that it is point-loaded, either at the bases of the valleys or at the bottoms of the carrying rafters.

I frame Nantucket dormers two different ways to produce two distinctively different interiors. The difference, roughly speaking, is that one method uses structural rafters and the other uses structural valleys.

Framing the dormers with structural valleys allows the interior partitions to be eliminated, creating one big open room with interesting angular ceiling planes. For the project here, however, we used the structural-rafter method to create the more common floor plan with two bedrooms and a bath.

The key element in supporting a Nantucket-dormer design is that it is point-loaded, either at the bases of the valleys or at the bottoms of the carrying rafters. Those loads need to be carried by appropriate floor or wall structures below. The same frame that supports the uniform load of a shed dormer might not carry the point loads of a Nantucket dormer. If you have any doubts at all, it's a good idea to have a structural engineer evaluate the support structure.

Doghouse Walls Go Up First

After the main gables of the house are raised and braced, we lay out the locations of the main roof rafters on the top of the main wall plates. We also locate and snap lines for the outside walls of the doghouses and the shed on the second-floor deck.

The first things that we build are the two doghouse gables. The walls are framed, sheathed, housewrapped, and trimmed before they are lifted and braced plumb (see the photo on p. 131).

Next, we turn our attention to the main ridge of the house. Temporary scaffolding or pipe staging is set up down the middle of the house to work from while the ridge is set. We place the ridge boards (in this case, 2x12s) on top of the plates and transfer the rafter layout directly from plate to ridge (see the photo below).

The ridge boards are set in their pockets and held up with temporary posts and a few common rafters, which help to keep them straight and level.



Laying out the ridge. To get the rafter layout to match precisely, the layout on the plates is transferred directly to the ridge stock.

Structural Rafters and Headers Form the Backbone of the Dormer Roof

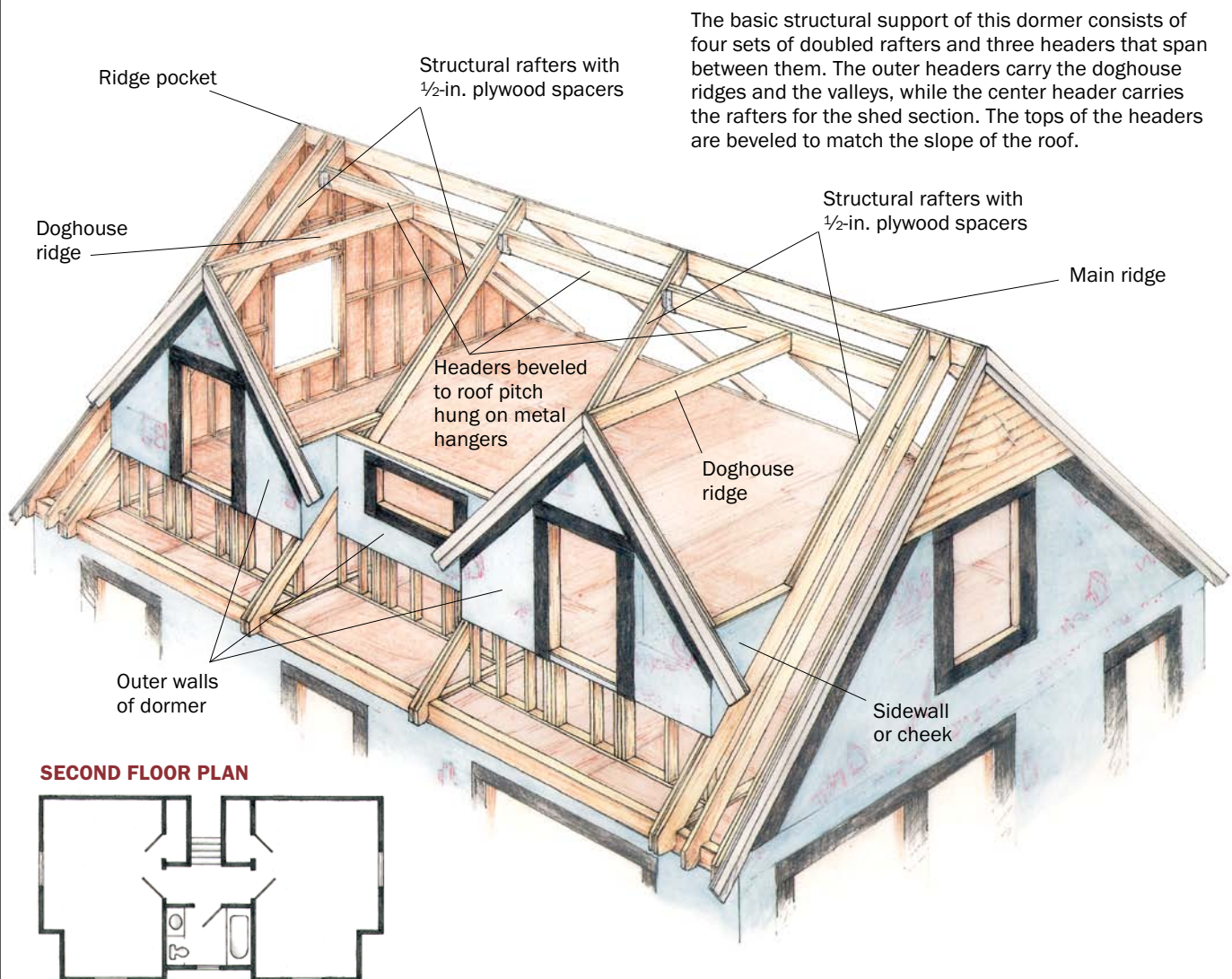
With the ridge in place, the structural rafters adjacent to the doghouse walls are installed. We doubled these rafters using ½-in. plywood spacers in between to create a total thickness of 3½ in., which matches the width of wall plates for interior partitions

below the doubled rafters. If you're building larger dormers, a triple rafter or a double LVL can be used.

The four sets of structural rafters split the main roof into three bays. Our next step is to hang doubled 2x12 headers in each of these bays. The tops of the headers are beveled to match the pitch of the rafters they hang from, and steel hangers hold the headers in place.

The two outside headers carry the valley rafters and the ridges of the doghouses. The

Backbone of an Elegant Dormer





center header holds the rafters of the shed section. Along with the structural rafters and the dormer walls, these headers form the backbone support for the dormer-roof structure (see the drawing on the facing page).

While the headers are being built and installed, other crew members build and raise the front wall of the shed section. Next, we build and sheathe the triangular sidewalls, or cheeks, on the doghouses that support the common rafters for the two end sections. The doghouse ridges are dropped in next (see the photo above), and their common rafters are cut and installed.

Lining Up the Roof Planes and Soffits

Until this point, all the framing has been fairly routine. But now we bump into the chief complication in framing the Nantucket dormer, the fact that the shed roof in the middle is at a different pitch from the gable roofs of the doghouse dormers on each side. In this case, the pitch of the main house roof and the doghouse roofs was 12-in-12, and the shed roof worked out to be 7-in-12.

Different roof pitches mean that the valleys where the roof pitches intersect are irregular (they don't run at a 45° angle in plan). It also means that the roof planes have to align and that the rafter tails have to

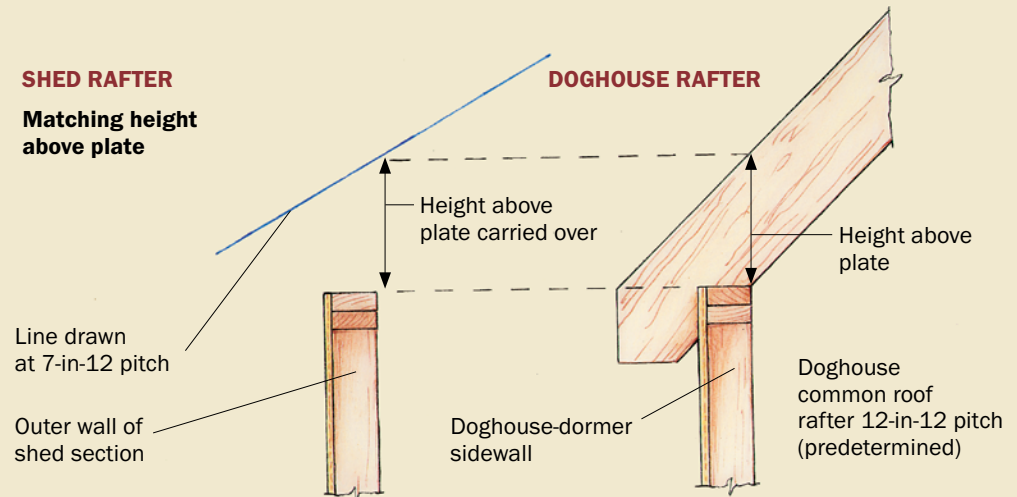
Doghouse ridge drops in.
The doghouse ridge connects the outer wall of the doghouse dormer to the header.

Working out the Details of the Shed Rafter

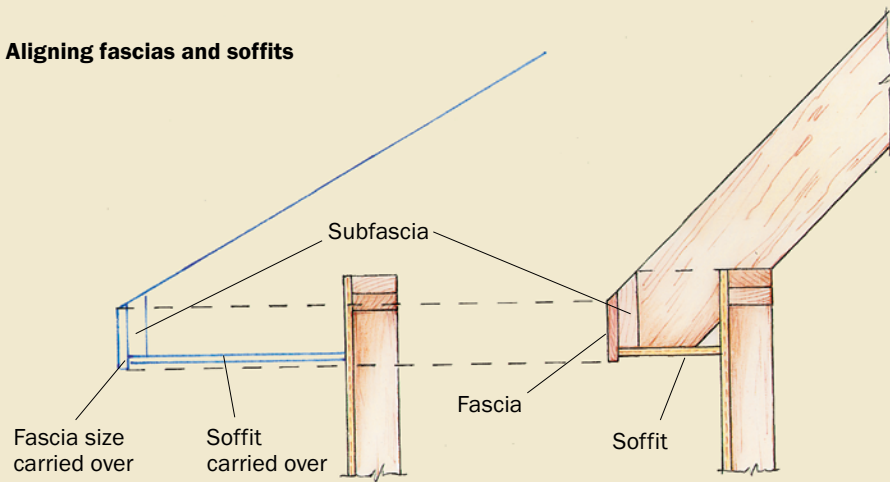
The rafters on the doghouse sections are 12-in-12 pitch, and the shed rafters are 7-in-12 pitch. A three-step drawing gets the fascias and soffits to line up, along with the roof and ceiling planes.

SHED RAFTER

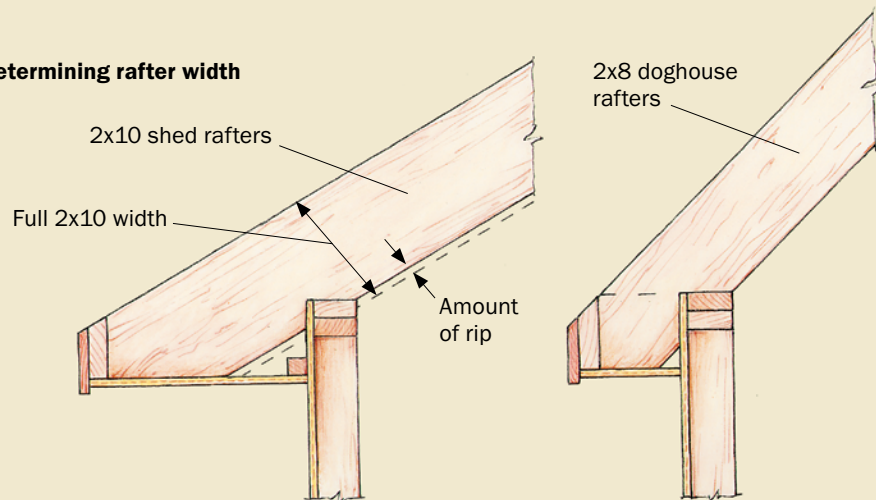
Matching height above plate



Aligning fascias and soffits

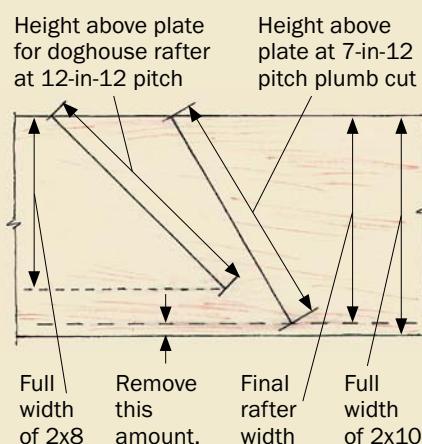


Determining rafter width



Finding the Exact Rip

Once the stock size of the shed rafters has been determined (in this case, 2x10), a simple procedure determines the final rafter width. First, the height-above-plate distance is measured for the 2x8 doghouse-dormer rafters. Next, that distance is transferred to a plumb-cut line at the shed-rafter pitch. That point marks the final width of the rafter.



be adjusted to get consistent fascia heights and soffit levels. So early on in the process, I work out the rafter details (see the drawings on the facing page). These elements can be worked out on the drawing board, but most often, I make a full-scale drawing of the trim details on either rafter stock or on a sheet of plywood. With this on-site drawing, I can design the rafter tails before I pick up a saw.

Another complication caused by the differing roof pitches is getting the planes of the cathedral ceiling inside to line up. Obviously, a 2x10 rafter meeting a valley at a 12-in-12 pitch will do so at a much different depth than one meeting it at a 7-in-12 pitch. The simplest approach to this problem is to increase the size of the framing material for the shed-roof section. With dormer gables at the same pitch as the main roof, the vertical depth of the rafters at the plate can be measured. The central shed portion of the dormer has a shallower pitch, so it requires a larger rafter size to achieve the same vertical dimension. For this project, the doghouse rafters were made of 2x8s, but the shed-roof rafters had to be 2x10s. But for the roof planes outside and the ceiling planes inside to match up, the 2x10s had to be ripped down to around 9 in. (see the drawing and photo at left).

Valleys Are Strung and Measured

Four years of architecture and engineering school taught me that it is possible to work out the framing details of an irregular valley using math and geometry. They even gave me the tools and education to do it. But 20 years as a carpenter have taught me that figuring out irregular valleys is faster and easier with a taut string.

After cutting and installing the common rafters and subfascia for both the doghouses and shed, I stretch a string from the corner where the subfascias meet up to the intersection of the header and the doghouse ridge. From this string, I measure the length of



Measuring an irregular valley. The quickest way to figure out the irregular valley is to stretch a line from corner to corner. Here, a measurement is taken along that line.



Finding the plumb cut. A rafter square held in the corner against the string determines the angle of the valley plumb cuts.



Corner of the valley. Angles that are taken on each side of the string determine the corner cuts that are needed for the ends of the valley rafter.



the valley rafters (see the top photo on the facing page) as well as the angles of the top and bottom plumb cuts (see the bottom left photo on the facing page), the seat-cut angle, and the bevel angles I need to cut into the rafter ends (see the bottom right photo on the facing page). Armed with all this information, I cut a valley rafter and drop it into place. Then, using a straightedge from the commons on each side, I mark the bevel cuts on the bottom edge.

After cutting the bevels, I install the valley rafters permanently (see the photo above) and then lay out and measure the jack rafters. The jack rafters in the center section usually have a compound cut where the miter is beyond the 45° or even 60° that most saws can cut.

If I have a lot of those cuts to make or if the framing is going to be left exposed, I make my cuts with a jig using either a hand-saw or a reciprocating saw to make a clean, accurate cut. However, the typical dormer has only three or four jack rafters per side, so I mark the angles on the rafter stock and cut them with a circular saw as close as the saw allows. I carve out the remainder of the wood by slowly and carefully dragging the circular saw blade across the face of the cut. This operation is potentially dangerous, so if you're not comfortable with it, you can use one of the methods mentioned above.

Valley rafter slips into place.

After all the angles have been cut into the valley rafters, including a bevel on the bottom edge where the ceiling planes intersect, the valleys are nailed in permanently.



Jack rafters complete the framing. With the valleys in place, jacks are cut and installed to finish the framing of the roof planes.

The Rest Is Plywood

While jacks are being cut and fit (see the photo above), other crew members fill in the cripple rafters that complete the main roof framing below the three dormer sections. The subfascia is applied to the main eaves, and we can start running the sheathing. Other than the fact that the various plywood shapes are somewhat irregular, sheathing proceeds in the usual fashion, working from the eaves up (see the photo on the facing page).

With the outside framed, sheathed, and ready for roofing, we can turn our attention to the inside. The interior of a Nantucket dormer is usually finished with a cathedral ceiling, which helps the small second-story spaces to feel more spacious and airy.

Instead of applying the cathedral-ceiling finishes directly to the bottoms of the rafters,

here in New England, we nail 1x3 strapping to the rafters, usually 12 in. or 16 in. o.c.

Strapping the ceilings of the Nantucket dormer not only simplifies board hanging, providing an extra measure of resistance to deflection and nail popping, but the strapping also helps to provide a smooth, easy transition between the various ceiling planes. To this end, I usually supplement the strapping by running 1x6 or 1x4 on the undersides of the valley rafters where the roof planes intersect.

***John Spier** builds and renovates custom homes and is a frequent contributor to Fine Homebuilding magazine. He and his wife, Kerri, own and operate Spier Construction, a general-contracting company on Block Island, Rhode Island.*



Skinning the dormer. When the framing is complete, the sheathing is applied, bringing out the final dramatic shape of the Nantucket dormer.

Framing a Bay-Window Roof

■ SCOTT MCBRIDE

For as long as architects have been drawing bay windows, carpenters have been scratching their heads about framing the roofs. Victorian builders sometimes got around the problem by letting two-story bays die into a projection of the main roof above. Tract builders in the 1950s did likewise by tucking bay windows under overhanging second floors or wide eaves.

When a bay bumps out on its own, however, it needs a miniature hip roof to keep out the elements. Because the corners of bay windows aren't square, neither is the roof above, and figuring the rafter cuts isn't straightforward. I've built many of these roofs and have worked out a system that does the job without guesswork.

Roofs on Site-Built or Manufactured Bays are Much the Same

The skeleton of a bay roof breaks down into two parts (see the drawing on p. 144). The first part is the cornice, an assembly of horizontal lookouts tied together by subfascias. (A subfascia will receive a finished material, in this case aluminum coil stock. If you're planning to install a painted wood fascia, you can substitute the finished fascia material for the subfascia.) A horizontal ledger carries the lookouts where they attach to the building.

The common rafters for the middle roof, hip rafters, and jack rafters comprise the second part of the skeleton. The side roofs also require sloped ledgers to support the sheathing where it meets the building.

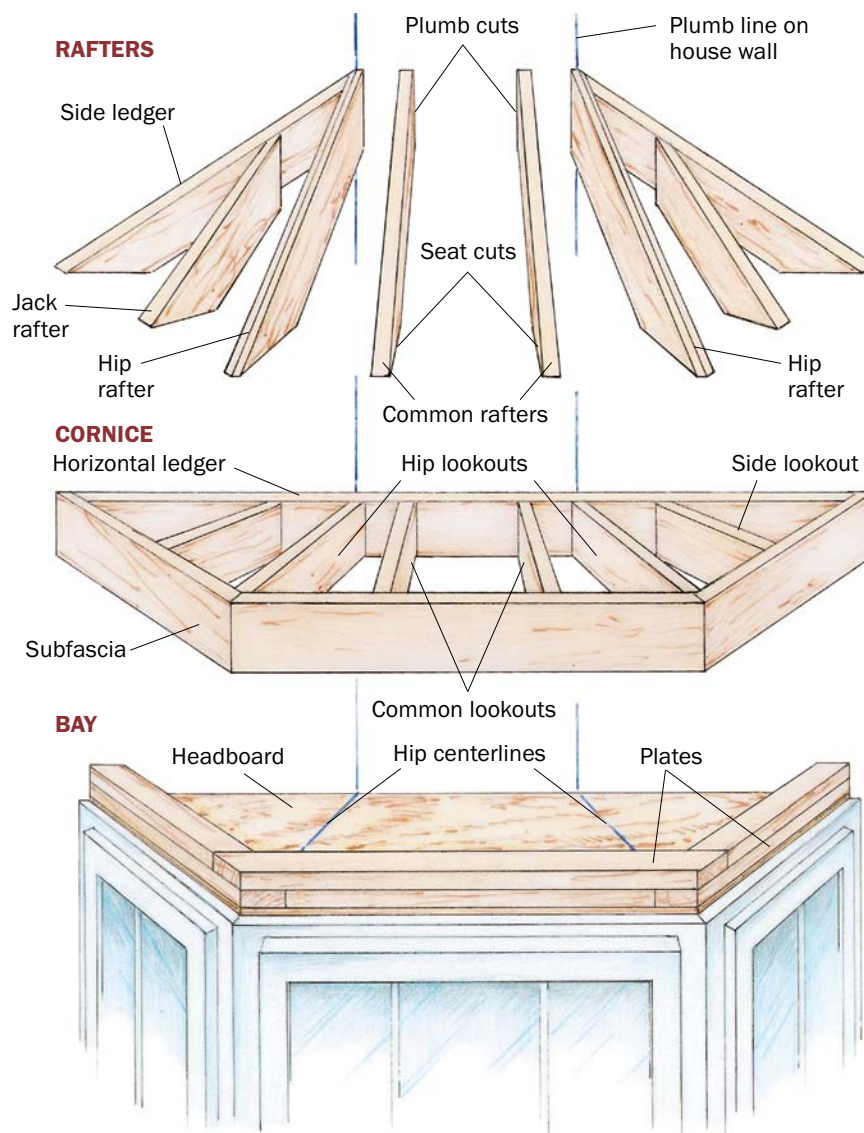
Bays can be site-framed or manufactured units. When the walls of a bay are framed on site, the horizontal lookouts double as ceiling joists. In that case, the lookouts bear directly on the wall's top plates.



A sturdy scaffold makes for efficient bay-roof construction. The walk-board height allows work to be done at waist level. The boards behind serve as a workbench, saving a lot of climbing up and down.

Two Distinct Assemblies Comprise a Bay Roof

The lower portion, or cornice, rests on the bay's walls, or on 2x4 plates fastened to the headboard if it's a manufactured unit. The rafters that form the roof's upper portion fasten to the cornice members and to the house wall.

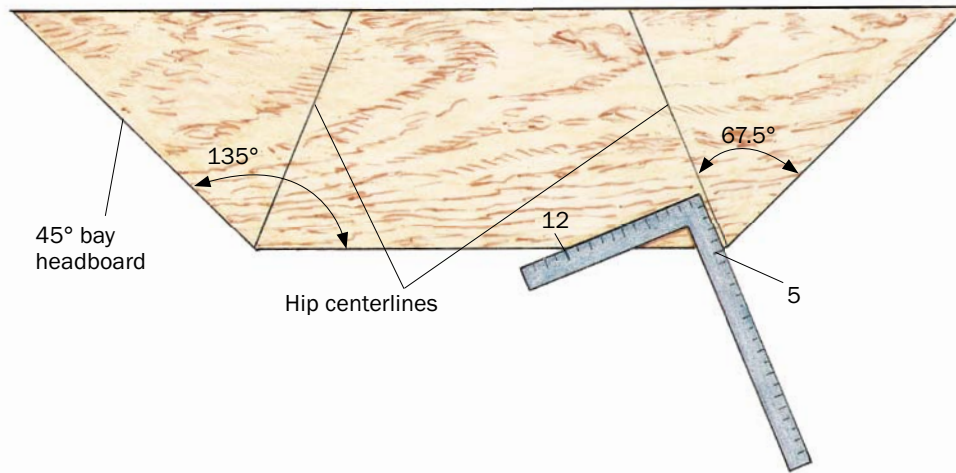


When I'm installing a manufactured bay, as I did for this project, the bay's plywood headboard provides the ceiling. With the bay installed, I screw through the headboard to affix 2x4 plates above, parallel with the bay's outside edges. I nail a second plate atop the first. This step makes room for a 3-in. frieze above the windows, which I think looks better than having the fascia directly above the glass. Raising the overhang

lets in more light and provides room for insulation, which must usually be installed before the roof is sheathed. As a final plus, adding plates to the headboard provides a meatier surface for nailing the lookouts.

Lay Out the Hips with a Framing Square

The hip's centerlines bisect the bay's 135° outside corners, so their angle is 67.5° . A 5-in-12 pitch on a framing square also yields 67.5° .



There Are No Rectangles in a Hipped Bay Roof

A frequent mistake is framing the middle roof as a rectangle, using common rafters as hips. This error makes the side roofs steeper than the middle roof. The result looks clunky, and the disparity in pitch complicates the cornice details.

Bisecting the bay angle with the hip shapes the middle roof as a trapezoid and also ensures that the middle roof and the side roofs will be equally pitched.

Before attaching the plates, I draw the centerline of each hip on the headboard, extending the line all the way to the house. To find the centerlines, it helps to realize that the angle encompassed by a bay window is not its nominal angle, in this case 45° , but rather its supplement. (An angle plus its supplement equals 180° .) So the outer corners of a 45° bay each encompass an angle of 135° (see the drawing above). The hips bisect these angles, so the hip centerline angle for a 45° bay is half of 135° , or 67.5° . The other common bay angle is 30° . The techniques

in this project work on 30° bays, or bays of any angle for that matter, but you'll have to adjust the angles accordingly.

To lay out the hip centerline accurately, I use a framing square. Conveniently, a 5:12 angle on a framing square is equal to 67.5° , the hip angle of a 45° bay. I place 5 on the apex of the bay's angle, 12 on either the front or side edge of the bay, and mark on the 5 side. Doubling 5:12 to 10:24 provides even greater accuracy.

I pencil plumb lines on the house wall where the hip centerlines intersect it. These plumb lines serve as references for locating the hip lookouts and hip rafters.

Lookouts Form a Map for the Rafters to Follow

After plating, I install the 2x6 horizontal ledger. Its ends function as lookouts, supporting the subfascias where they die into the building. I cut the ledger's ends to match the bay's angle and its length to support the subfascia at the proper overhang.

Drawing bay roofs out full scale is the key to fast and accurate framing.

Next come the common lookouts. I usually start the layout in the bay's middle and work outward. By centering either a lookout or the space between two lookouts, I can lay out the cornice so that a common lookout ends up close to each hip. In this way, I can usually avoid having to place a jack lookout between the last common and the hip. Because I position a rafter over each lookout, this consideration also eliminates a jack rafter.

Common lookouts are cut square on both ends, but I miter the side lookouts at 45° where they hit the ledger. In both cases, I find their length by measuring the distance from the ledger to the outside of the plate, then adding the overhang less the subfascia. I nail the common and side lookouts to the ledger before cutting the hip lookouts.

To find the length of the hip lookouts, I cut a $22\frac{1}{2}^\circ$ miter on the inboard end of an oversize piece of lookout stock. I tack this stock in position above the hip centerline and use a straightedge to project lines from the ends of the common and side lookouts. These lines should cross the end of the hip to form a $22\frac{1}{2}^\circ$ miter. I trim and permanently install the hip lookouts. Hanging the subfascias completes the cornice frame.

Drawing the Roof First Takes the Guesswork from the Rafter Angles

The rafters of a bay roof contain a surprising variety of angles. To understand these angles and make a more accurate job, I sometimes draw them on a sheet of plywood. This process is called graphic development. Bay roofs are generally small enough to draw full scale, but the same process can be used to develop angles for larger roofs by drawing at a reduced scale.

Geometric drawings may seem beyond the call of duty for the average carpenter, but the alternative was described to me suc-

cinctly by one of my backwoods buddies: "We just cut on 'er till she fits."

I start the graphic development by drawing a half-plan that shows the outside of the bay's cornice (see the top drawing on the facing page). The first line to be added to the half-plan is the run of the hip, AB, drawn as it was on the headboard. Next, I draw the run of a common rafter, BC, perpendicular to the house wall.

The next move is establishing the slope of the common rafters. Sometimes I know the pitch, such as the 8-in-12 pitch shown on the facing page. In that case, I lay out the common-rafter slope with a framing square (see line CD in the center drawing on the facing page).

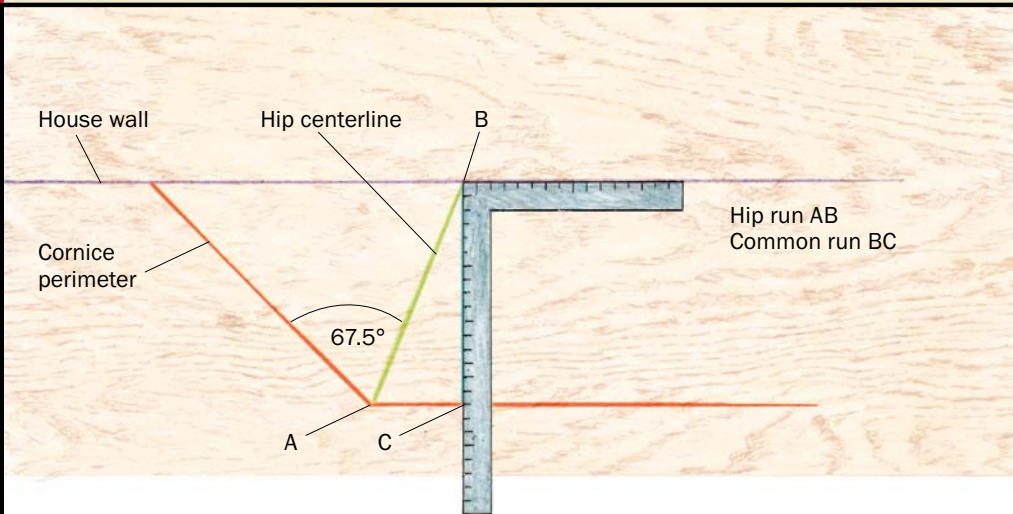
Other times, I want the roof of the bay to top out at a particular elevation, such as the bottom of a window or the bottom of a clapboard. To find the slope of the common rafters in these cases, I measure the rise from the top of the lookouts to the desired elevation. On the drawing, I place D this distance from B.

To find the slope of the hip, I swing an arc from D and centered on B until it crosses a line raised perpendicular to AB. The point of intersection is E, and BE represents the rise of the hip. The idea behind swinging an arc is to transfer the rise of the common, BD, to the rise of the hip, BE, because the common and the hip rise the same distance.

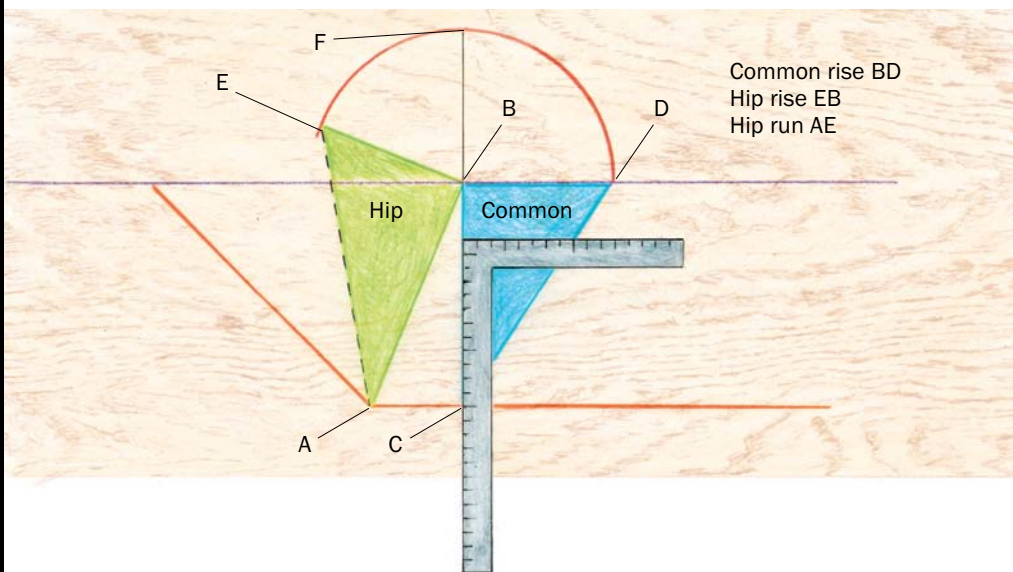
The side ledger also rises the same distance as the common and the hip. To find it, extend line BC until it intersects the arc at F. BF is the rise of the ledger, and it corresponds to the plumb line drawn on the house's wall. FG is the ledger's slope (see the bottom drawing on the facing page).

Full-scale graphic development provides all the information you need to make the plumb and seat cuts as well as lengths of the rafters. Bird's mouths aren't required for any of the seat cuts; the rafters simply sit on top of the lookouts and are nailed in place.

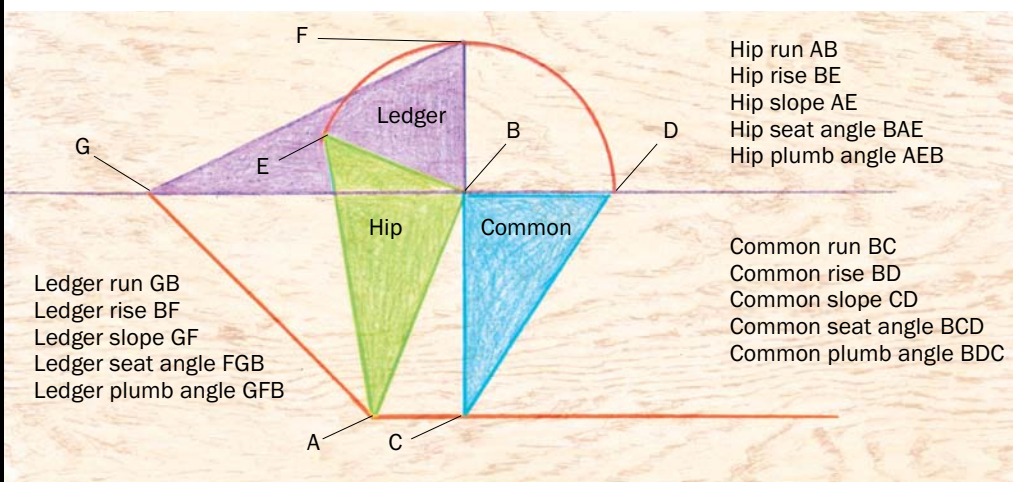
Full-Scale Graphic Development Creates Templates for All the Rafter Cuts



Draw a half-plan of the house wall and the cornice perimeter. Next, the hip centerline, AB, which bisects the bay's corner, is drawn. The outside corners of a 45° bay encompass 135°, so the hip centerline angle is half that, or 67.5°. Line BC, which represents the common rafter run, is drawn next.



The common rise, BD, is marked on the house-wall line. D can be found by using a framing square to plot a desired slope, such as 8-in-12, or by positioning D the desired rise of the roof from B. An arc whose radius is the rise of the roof is centered on B and swung from D to E. BE is the hip rise and is perpendicular to AB. CB is extended to F, and BF represents the plumb line drawn on the actual house wall.

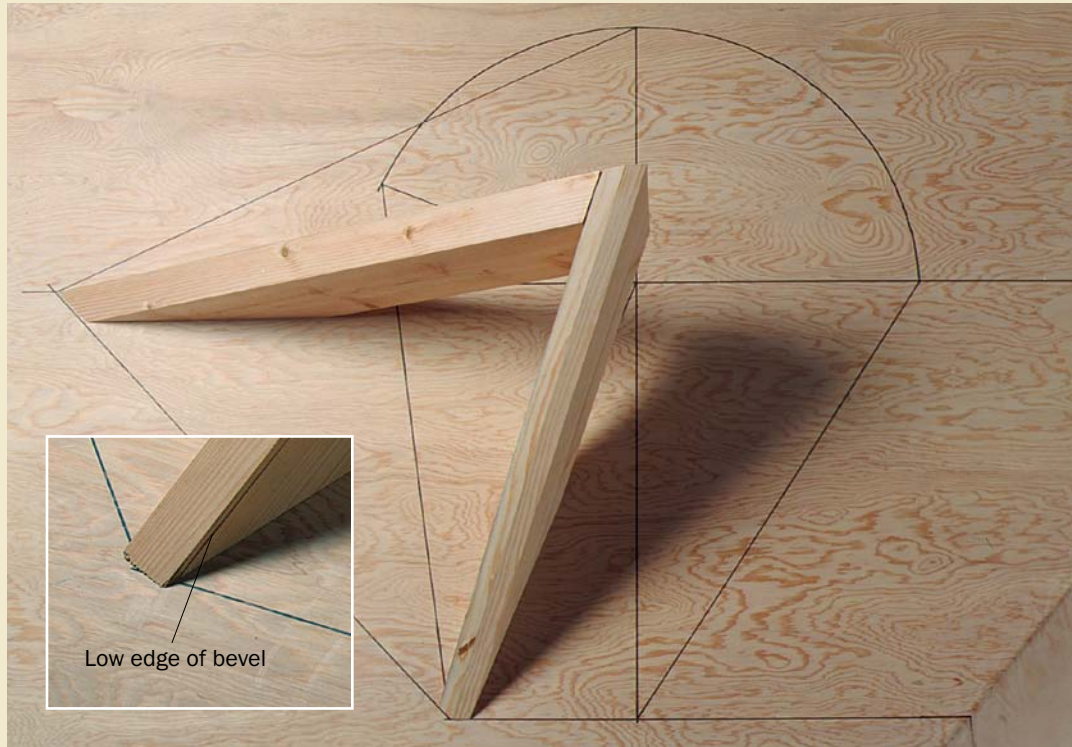


Connecting A and E develops the hip slope. FG is the ledge slope, and all the rafter angles are now there for the taking. To visualize the roof, try this mental origami. Imagine folding the drawing along the house-wall line so that BF, the ledge rise, is plumb. Now imagine raising BD, the common rise, and BE, the hip rise, to plumb.

Aligning the Hips and Ledgers with the Roof Plane

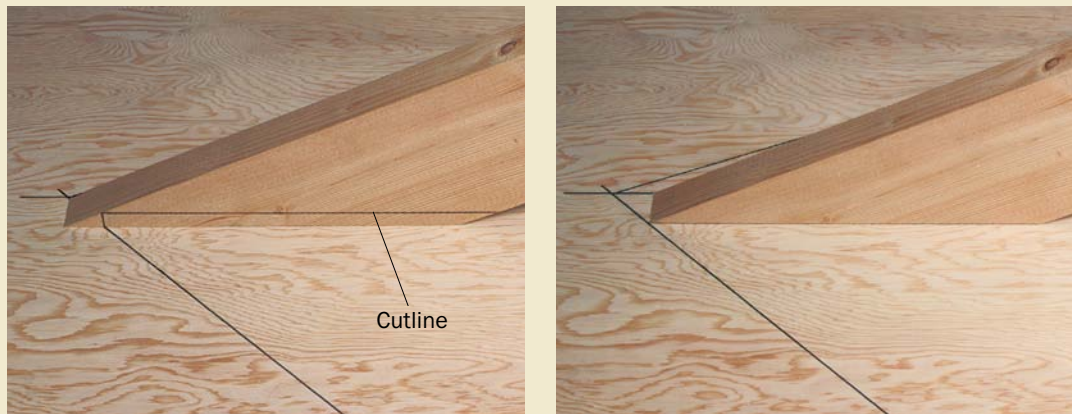
Full-scale graphic development generates two-dimensional templates for all the rafters of a bay roof. When cut, however, edges of the three-dimensional hips and ledgers will protrude above the roof plane unless the rafters are dropped or beveled.

BEVELING



With the rafter stock held in place on the graphic development, the low edge of the bevel is easily marked (inset). The high point of the hip's bevel is the center of the rafter. The ledger's high point is the upper edge that contacts the house.

DROPPING



Cutting a bit extra from the seat of a hip or ledger will align it with the roof plane. A plumb line raised where the held-in-place rafter intersects the bay's perimeter (above left) shows how much to cut off the rafter (above right). Unlike beveled rafters, sheathing contacts only the dropped rafters' edge.

Dropping or Beveling the Hip and Side Ledgers

Graphic development outlines the entire top surface of the common rafters, but the hips and side ledgers are more complex. The slope lines from the graphic development are one-dimensional representations of the centerline at the top of the hip and of the top edge of the side ledger that hits the house. The actual rafters are, of course, three-dimensional. The corners of a hip rafter or side ledger will protrude above the adjoining roof planes unless some adjustment is made (see the photos on the facing page).

One way to make the adjustment is to drop the hip or ledger so that just the corners align with the roof plane. Cutting a little extra from the seat cut does this alignment. An alternative is to bevel, or back, the top edge of the rafter so that the edge is in plane with the roof. Backing is nice if you've got a table saw handy, but dropping works just as well.

To find the drops, I cut scrap blocks with the same seat cut as the hip and the ledger. I place the blocks in position on the developed drawing, straddling the hip centerline or, for the side ledger, on the wall line. The hip line on the drawing represents the rafter's center, so the center of the scrap block must align with the apex of the cornice angle. For the ledger, the line represents its inward edge, so the inner corner of the scrap must land on the intersection of the house and the cornice. I then draw plumb lines on the scraps, starting from where the blocks intersect the cornice's edges. The height of these lines is the drop to be deducted from the seat cut of the hip or of the side ledger.

If you want to bevel the rafters, you need to go one step farther. From where the block touches the edge of the bay, draw a line on the block parallel to its top edge. This line is the low side of the backing bevel. The center of the hip or the opposing corner of the ledger represents the high side.

Raising the Roof

If a band or rim joist backs up the sheathing where the commons top out, as is often the case, the common rafters can be nailed directly to the sheathing. If not, it's a good idea to shorten the hips and commons by a horizontal distance of 1½ in., and hang them on a 2x ledger. The ledger ends line up on the plumb lines I raised earlier from the hip centerlines drawn atop the bay. The ledger's top will have to be dropped or beveled so that it's in plane with the rafters.

If there is to be a horizontal ledger for the common rafters, I install it and the side ledgers now. If there is no horizontal ledger, I install the hip first, centering it on the plumb line I raised earlier from the bay. In either event, the hip's plumb cut is compound, with a 22½° bevel for a 45° bay.

Once the ledgers are installed, I plumb up from the lookouts below to locate any jack rafters. The jacks can then be measured directly. They have the same seat and plumb cut as the commons, except that the plumb cut is made with a 45° bevel.

Laying out the sheathing cuts is a matter of transferring measurements from the rafters. I usually add overhang to the sheathing to pick up the top edge of a crown molding.

Scott McBride has been a carpenter for more than 34 years and is a contributing editor to *Fine Homebuilding* magazine. He lives in Sperryville, Virginia.

Raising Roof Trusses

■ RICK ARNOLD AND MIKE GUERTIN

We learned truss raising the hard way. Fingers trapped between sliding trusses were broken, and backs were strained muscling 32-ft.-wide trusses up two stories for steep-pitched colonial roofs. The process involved six or seven guys and usually lasted a whole frustrating, tiring day. The process was tough on the trusses as well. Lifting them flat would cause the truss plates to bend or pop, ruining the truss. If we were lucky enough to get all of the trusses installed in a day, we then faced the arduous task of lugging up all of the sheathing and roofing materials. After all of that hauling and lifting, there wasn't much enthusiasm or energy for swinging a hammer. Our lives got much simpler after we opened the phone book to the listing for "Cranes."

We have come to depend on a crane to lift the trusses for all but the smallest single-story roofs. Here, we'll discuss how we use a crane to assemble simple gable roofs. We cover hip and valley roofs on pp. 172–183.

Before the roofing materials and trusses are dropped at the site, we anticipate where the crane will be positioned so that all materials are out of the way but still easily within reach. Before the trusses are lifted to the roof, the crane hoists the sheathing, the shingles, and the interior-framing materials for the second floor (see the sidebar on pp. 154–155). The crane we hire can usually reach an entire house and garage from one position near the outside middle of the building. We also keep the job site as clean as possible. Scrap lumber and debris can be accidents waiting to happen on raising day. Our scrap pile is always located out of the way but still within tossing distance of the house.

When the trusses arrive, we land them on top of 2x blocks as they come off the truck to keep them as flat and as much out of the dirt as possible. Sometimes trusses arrive as much as a week before they can be installed. If the trusses are not kept flat, they can warp, and after they've warped, they're much harder to install.

Instant, ready-made gable. With the sheathing, shingles, and trim boards already attached, the only thing this gable needs is the vent. The crew will leave the peak of this gable just tacked in place until the overall length of the house is checked at the eaves and the peak.



Stacked for easy layout. With the trusses stacked neatly on the ground, layout lines are drawn on all of them at once. The line closest to the tail will be used to position the truss on top of the wall plates. The other lines are for ceiling strapping. The top chords are laid out for roof sheathing.



We have come to depend on a crane to lift the trusses for all but the smallest single-story roofs.

Layouts Are Done with the Trusses on the Ground

We mark three different sets of layout lines on the trusses before they ever get off the ground (see the photo above). The first set is for positioning the trusses on the walls. The second is for the strapping or furring strips to which we'll screw the drywall or plasterboard ceilings, and the last set of lines is for the roof sheathing. We also mark the front of the trusses near the tail of the top chord to avoid getting them spun in reverse when they're lifted. Before we mark these lines, the trusses need to be aligned on top of one another as closely as possible. We arrange them in a stack by tapping them back and forth with a sledgehammer until all of the bottom chords and ridges are in line. When the trusses are in a straight stack, we can make our layout lines.

In the past, we aligned the trusses after they were raised. We would run a string from one gable peak to the other and bang the trusses back and forth with a sledgehammer until they lined up with the string. But all of that banging knocked the walls out of plumb, and the whole process took a lot of time. We also tried measuring in from the tail cuts to position the trusses but soon

discovered that those distances varied significantly and that the peaks of the trusses didn't line up. Now we mark the wall position on the bottom chord of the trusses before we lift them; it's the quickest, most accurate way of ensuring that the trusses are installed in a straight line.

First we measure the overall width of the house where the trusses will sit. Then we locate the exact center of the bottom chord on the top truss of our pile and measure back half of the width of the building minus the thickness of the wall from that point. For example, if the house is 30 ft. wide with 2x4 walls, we would measure back 14 ft. 8 $\frac{3}{4}$ in. from the center point (figuring the walls at 3 $\frac{5}{8}$ in.). We mark each end of the top truss and then repeat the whole process on the lowest truss in the pile. We either snap a chalkline or scribe a line along a straightedge between the top and bottom marks to transfer the layout to the other trusses. We extend our position lines slightly onto the face of the bottom chord to make it easier to see the lines when the trusses are being dropped into place.

Ceilings in our region are typically strapped with 1x3 furring strips before the interior walls and wallboard are installed. Furring strips serve several functions, one of which is adding a structural element to the trusses. If we didn't use strapping, the truss

TIP

Keep the job site as clean as possible. Scrap lumber and debris can be accidents waiting to happen on raising day. Locate your scrap pile out of the way but still within tossing distance of the house.

engineer would require us to run three or four 2x braces the length of the building to tie the trusses together and also to keep the gable walls straight.

We mark the lines for the furring strips 16 in. o. c. from the positioning marks at one end of the truss. Again, the same marks are made on the top and bottom trusses, and lines are drawn or snapped between them. We run a lumber crayon up one side of each line to indicate which side of the line our furring gets nailed to once the trusses are set.

The last set of layout lines is for the roof sheathing. We usually fill in any ripped sheets at the bottom of the roof rather than at the top, so we begin our layout from the ridge. First we measure down along the top chord of the upper truss from the peak to the 4-ft. increment nearest the tail of the truss. We add $\frac{1}{8}$ in. per sheet for the H-clips plus an extra $\frac{1}{4}$ in. to our overall measurement to be safe. For example, if the top chord of the truss is 17 ft. 6 in., we would measure 16 ft. $\frac{3}{4}$ in. ($4 \text{ sheets} \times \frac{1}{8} \text{ in.} = \frac{1}{2} \text{ in.}; \frac{1}{2} \text{ in.} + \frac{1}{4} \text{ in.} = \frac{3}{4} \text{ in.}$). If a ridge vent is being installed, we increase our extra amount to a full 1 in., and our layout line is at 16 ft. $1\frac{1}{2}$ in. The top chords of the lowest truss in the pile are marked at the same points, and lines are drawn or snapped between the marks.

Gable Trusses Are Sheathed and Sided Before They Go Up

Another big time-saver that we've found is sheathing, siding, and trimming the gable-end trusses while they are still on the ground (see the photo at right). It saves us the hassle of setting up tall staging to work up high and requires just a little planning. Because the gable trusses sit on top of walls, we make sure that there are no humps in the wall or dips in the bottom chord of the truss. We check the walls by eye and string the bottom chord of the gable trusses. If



Nails for attaching the gable truss are started on the ground. To facilitate setting the gable truss, nails are started along the bottom chord. When the truss is in position, a crew member on a ladder will drive the nails into the top plate of the gable-end wall.

Let a Crane Do the Heavy Lifting

No matter what your physical condition, reducing the amount of bull work on the job is always welcome. A crane is one great way of saving muscles as well as man-hours and money. Before the trusses are raised, the crane lifts the roof sheathing, second-floor interior-wall studs, furring strips, and roof shingles to the second floor.

Materials Are Prepped for Lifting ahead of Time

With a rough count of all of the second-floor interior studs we'll need, we crown, cut, and stack all of the framing stock on 3-ft. to 4-ft. scraps of 2x4 (see the photo below). The roof

shingles are usually delivered the day before the truss raising, along with several extra pallets to stack them on. We generally stack 21 to 24 bundles per pallet and use a long hook that the crane operator made to feed the lifting strap through the pallet. We use 3-ft. 2x4s as strap spreaders to keep the lifting straps from crunching the top bundles of shingles (see the top photo on the facing page). Roofing subcontractors love having the shingles on the second floor. Passing the bundles out a window, onto the staging, and up to the roof is much easier and safer than hauling them up two stories on a ladder.



Interior wall framing on the rise. Lumber is stacked ahead of time for an easy crane hoist; crew members land the framing lumber inside the house where it will be out of the way until it's needed.

The roof sheathing is sent out at the same time as the shingles. Our lumberyard will band sheets of plywood in any quantity that we ask. Bundles of 15 to 20 sheets for $\frac{5}{8}$ -in. plywood or bundles of 20 to 25 sheets for $\frac{1}{2}$ -in. plywood seem to work best for us (see the bottom photo at right). When the sheathing is slid off the delivery truck, we ask the driver to put heavy-duty nylon load straps around the entire stack to keep the steel bands from snapping. Occasionally, we get lucky and are able to coordinate delivery of the sheathing and shingles with the actual lift. In those rare instances the crane plucks the sheathing and shingles right off the delivery truck and lifts them up to the second floor.

Placement of the Materials on the Second-Floor Deck Takes a Bit of Planning

Roof sheathing and the furring will be used up before the interior walls are built so that material can go almost anywhere. The studs and the roof shingles, however, need to be positioned so that they won't interfere with framing the interior walls. We try to land the stacks near windows for easy handling, and because of the concentrated weight, we keep them away from the middle of the floor joists to avoid overloading them.

When rigging the bundles and stacks with the lifting straps, we try to keep the straps as far apart on the load as possible. The crane operator takes the strain slowly so that we can make sure the load is going to stay flat and even while it's in the air. It's not uncommon to have a load put back down on the ground to get the straps positioned just right. This minor hassle is infinitely preferable to a load coming apart or straps shifting and sliding while a load is in midair.



Roof shingles are dropped near a window. The crew member on the left signals the crane operator while the other crew member guides the pallet of shingles to its temporary home.



Prepackaged loads of sheathing are easier to handle. The lumber company bundles the sheathing in stacks of 15 to 20 sheets for easy strapping and lifting.

TIP

If rake overhangs are called for, take extra care to keep the top chord of the truss perfectly straight while you're sheathing the truss.

necessary, we rip a little off the bottom of the bottom chord of the truss.

We always plan to extend our gable-truss sheathing down beyond the bottom chord of the truss a couple of inches. To set this overhang, we run a string between the seat positions of the truss and measure from the string to set our sheathing. We always leave the sheathing $\frac{1}{4}$ in. short to avoid any binding between the gable-wall sheathing and the truss sheathing when we're setting the truss. The gable truss must be lying absolutely flat when the sheathing is applied, or it may be impossible to straighten the truss when it's installed. Any sheathing that extends above the top chord gets trimmed off flush.

If no rake overhangs are called for, siding the gable goes quickly. We start by figuring out the approximate height of the top of the second-floor windows (they don't get installed until after the trusses) and determine the siding courses from there. It's best to start one or two courses up from the bottom of the truss sheathing so that the siding doesn't interfere with the truss installation. Wood siding allows us to adjust our course exposure slightly to blend the siding on the walls with the truss siding. We've never tried this technique with vinyl siding and suspect that it would be difficult to match the courses exactly. We're careful to nail the bottom course of the truss siding up high so that the course coming up from below can be slipped in later.

With no rake overhangs, we run the siding over the top chord of the truss but keep the nails 3 in. back from the top of the chord. The gable-vent hole can be cut out at this point, and the vent tacked in for installing the siding. The vent is then removed to give us a hole for our lifting straps, and it is reinstalled later (see the photo on p. 151). When there are no gable vents, we leave off the last couple of siding courses at the top of the truss and cut a hole for the straps. We precut the missing siding pieces and tack them to the gable end to be nailed on later from a ladder.

After the siding is nailed on, we snap a chalkline $2\frac{1}{2}$ in. down from the top edge of the top chord and cut the siding off to that line. We nail on a piece of 1x3 above the cut siding as a spacer. The rake boards and band moldings are nailed over the 1x3, and the height of the rake boards is adjusted to match the thickness of the roof sheathing. We leave the tails of the rake boards long and cut them off after the gable truss is set in place.

If rake overhangs are called for, we take extra care to keep the top chord of the truss perfectly straight while we're sheathing the truss. We make our overhangs out of a 2x4 ladder with waste sheathing nailed to the topside of it to keep it stable. The overhang assembly is nailed to the sheathed gable truss, keeping the top of the assembly flush with the top of the truss. We install $\frac{1}{2}$ -in. AC plywood on the underside of the overhangs for our soffits and nail the rake boards and band moldings to the outside of the ladder, again adjusting for the thickness of the roof sheathing. We side the gable the same as before except that now the siding butts to the plywood soffit and a 1x2 frieze board is added.

We often have a chimney or chimney chase on the gable ends of our houses. Before siding the truss, we meet with the mason and determine the location of the chimney so that we can break back the siding and rake trim to his dimensions. After the gable truss is installed, we drop a plumb bob from the gable siding to the fireplace footing and snap a chalkline for the mason to go by. The final step in prepping the gable truss is starting nails in the bottom of the truss that will attach the bottom chord of the truss to the end-wall plate (see the photo on p. 153).

Using a Nailer Saves a Truss

After the trusses are ready, there are other preparations that make the raising go more smoothly. First we set up all of the staging front and rear. All of the walls that will receive the trusses are laid out, and strings are set up along the inside of the top plates for straightening the walls. We install adjustable diagonal braces to help straighten and tune the walls. We double-check the plans to see where the second-floor walls will be built in order to locate the best out-of-the-way places to drop materials (see the sidebar on pp. 154–155). We build a lot of two-story colonials with single-story attached garages. We save the cost of one truss by using a nailer in place of the truss that ordinarily would go against the wall of house (see the photo at right). We slide one truss up before the crane arrives and use it as a template to mark the nailer location. After installing the nailer on the house wall, we set the truss in place and wait for the crane to do the rest.

We also lay out ten 16-ft. pieces of 1x3 with 2-ft. centers for truss spacing and have another ten ready for diagonal bracing. We round up a bunch of clubs, 3-ft. to 4-ft. pieces of 2x4, to put under and between the piles of materials when the crane drops them off on the second floor.

Crew Members Have Assigned Tasks for the Lift

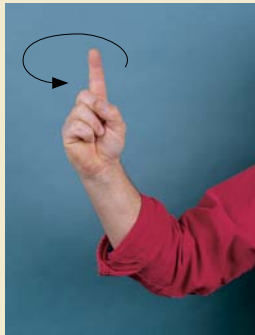
As truss-raising day approaches, we watch the weather carefully. The best weather for raising trusses is calm and overcast. Wind is our worst enemy, and bright sun can make it difficult to see hand signals as well as trusses in midair. We always shoot for an early start when the sun's angle is low and when the winds are usually calmest. Before the actual lifting begins, we round up all of the tools we'll need for the raising, including the truss



The first gable truss is sent up with two regular trusses. By sending the first three trusses up together, the crane will be able to hold the gable truss steady while the other trusses are set and while braces are attached to the gable truss.

Getting the Signals Straight

Communication between the crane operator and crew is essential for safe and smooth lifting. A designated signal person has the responsibility of directing the lifting operation through hand signals. Here are the four basic hand signals we use with all of our crane operators.



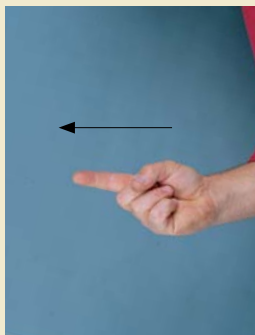
Cable Up/Cable Down

To move a load straight up or down, the crane operator must take up or let out the cable holding the load. To signal this procedure to the operator, point one finger either straight up or straight down and spin your hand in a circle.



Boom Up/Boom Down

Raising the boom on the crane moves the load toward the crane, and lowering the boom sends the load away. The signal for this procedure is a thumb pointed either up or down with the hand moving in an up or down motion.



Boom Right/Boom Left

Moving a load side to side is accomplished by pivoting the crane and boom. Pointing a forefinger to one side or the other in the direction you want the load to move is the proper signal for this procedure.



Stop and Hold

To hold a load still momentarily, for example, while positioning blocks on the deck for materials to land on, a fist held stationary in the air stops the crane operation until the next signal is given.

spacers, a level and a straightedge for plumbing the first gable, and braces for holding and adjusting the first gable-end truss. We also get the tag line ready, fill our pouches with nails, and recheck the walls to make sure they are straight. We also set up a ladder on the end of the house to make it easier to nail the bottom of the gable truss.

We always prefer to be a little overstaffed on raising day. Everyone has assigned duties, and the most important task is signaling the crane operator. We have used the same operator for six years, and we try to have the same crew member do the signaling for every raising (see the sidebar on the facing page). For safety's sake we always review the hand signals with the crane operator and the crew member who will be signaling. A thumb pointed in the wrong direction could get someone knocked off the staging in an instant. The signal person should never leave the crane operator's sight unless he signals "stop and hold."

For lifting materials, two crew members on the ground strap and launch loads, and two or three other crew members inside the house land and unstrap loads. The signal person usually sits in a second-floor window where he can watch materials coming in and see the crane operator clearly. After materials are secured on the second floor, we reposition the crew for the trusses.

The signal person is now stationed on the staging at the front of the house to set truss ends and to signal the crane operator. A second crew member is on the rear staging to orient the positioning marks on the trusses to the inside of the wall and to nail the trusses to the rear-wall plates. Two other crew members work in the middle of the trusses, tying them together at the peak when the crane drops them in. A crew member on the ground puts the trusses on the hook or strap and handles the tag line that steadies the trusses en route from the ground to the house. A sixth person is useful but not absolutely necessary to act as a gofer and to help when needed.

Lifting the First Three Trusses at Once Is Safe and Easy

Setting the first gable truss can be tricky. The best way we've found is sending that truss aloft with two other trusses, but with the gable truss in a separate strap (see the photo on p. 157). If we sent up the gable truss by itself, we would have to depend on a brace with a steep angle to hold the gable until other trusses could be set. Our method lets the crane hold the gable truss steady until two other trusses are set and safer braces can be attached. Here's how it works.

After landing the first three trusses at the end of the house, the bottoms of the two regular trusses are kicked away from the gable about a foot so that they don't interfere with setting the gable truss. We adjust the gable truss to its positioning mark at the rear wall, then drive all of the nails we'd started earlier to fasten the bottom chord of the truss to the top plate of the end wall.

The strap holding the two regular trusses is then released, but the one holding the gable remains. We use a short length of 1x3 with the same 2-ft. layout as the wall plate to anchor the first two regular trusses to the gable. Then the bases are nailed to the wall plates on the rear wall.

Next, we brace the gable end with a couple of long diagonals running down to the subfloor. The extra crew member then slides two 2x braces through the webs of the regular trusses, and the top ends of the braces are nailed as high as possible to the gable-end truss. We make sure that the braces won't interfere with the bottom chord of the next truss we lift into place. We plumb the gable truss with a level and a straightedge, and when it's ready, the extra crew member fastens the braces to 2x blocks that have been nailed through the subfloor and into joists. Only after the braces have been nailed at both ends do we release the strap from the gable truss.

For safety's sake, always review hand signals with the crane operator and crew before starting a job.



Spacers lock the peaks in position. One crew member holds the trusses in place while another attaches truss spacers (made by Truslock, Inc.) along the peaks of the trusses. Strapping replaces the spacers so that only a couple of 16-ft. lengths of spacers are needed. The crew member at the rear of the house taps the truss into position on the wall plate and nails it home.

After the first trusses are set, we usually lift two trusses at a time using a hook that the crane operator had made. The rest of the trusses go up rather quickly. One of the two crew members working the center of the trusses holds the trusses while the other fastens the Truslock truss spacers (see the photo on the facing page) (Truslock, Inc., www.truslock.com; 800-334-9689). These spacers unfold, gripping the next truss and holding it at the proper spacing in one simple motion.

The two crew members working the middle of the trusses set the pace of installation and direct the others. The crew member at the rear of the house continues to align the positioning mark on each truss with the inside of the rear wall and nails his end of the truss securely with three 16d nails. The crew member at the front of the house just traps his end of the truss with a couple of nails (see the photo at right). After all of the trusses are up, we restraighten the walls and nail the front ends of the trusses with three 16d nails. To meet wind uplift and seismic requirements, we go back and install metal hold-down hardware as required by the truss company and/or building official or engineer.

The extra crew member follows the action, strapping the ridge of the trusses with the 16-ft. 1x3s and tacking diagonal braces to secure the trusses until sheathing goes on. After the ridge is strapped, the truss spacers can be removed and used further down the roof. The top of the other gable end is tacked until we can set the distance between gables to the same measurement as the overall length of the house.

The garage trusses are a breeze by comparison. The first truss has been braced to the house wall. We just set the trusses the same as before and plumb the garage gable after the crane leaves.

Lifting the materials and setting the trusses for a 2,600-sq. ft. to 3,200-sq. ft. house with an attached garage generally takes us three to four hours. By the end of the day, we usually have the entire roof



The front of the truss is left loose. With the trusses secured at the rear of the house and the peaks locked together, the front of each truss is allowed to float until after all of the trusses are in place. The walls can then be restrung and straightened if necessary before the fronts are nailed permanently.

sheathed and our subfascias set with a crew of five or six. If for some reason we can't sheathe at least one side of the roof before we have to leave for the day, we put on plenty of diagonal bracing to secure the trusses in case the wind decides to kick up during the night.

Mike Guertin is a custom home builder and remodeler and contributing editor to *Fine Homebuilding* magazine from East Greenwich, Rhode Island.

Rick Arnold is a veteran contractor and contributing editor to *Fine Homebuilding* magazine. He is the author of numerous articles and books on home construction and remodel. He is a well-known and sought-after speaker and presenter at home shows and building seminars around the country.

Rolling Roof Trusses

■ LARRY HAUN

Roof trusses offer many advantages. They are lightweight (generally made from kiln-dried 2x4s), so they are fairly easy to handle. Because trusses are engineered, they can span longer distances without having to rest on interior bearing walls, allowing for more flexibility in room size and layout. Finally, installing trusses on most houses is pretty simple. If you want to get a house weatherized quickly, roof trusses are the way to go. Ceiling joists and rafters are installed in one shot, and no tricky cuts or calculations are required.

Lay Out Braces as well as Plates

Laying out the top plates for trusses is the same as for roof rafters. Whenever possible, I mark truss locations on the top plates before the framed walls are raised, which keeps me from having to do the layout from a ladder or scaffolding. For most roofs, the trusses are spaced 2 ft. o.c. I simply hook a measuring tape on one end of the plate and mark the truss positions every 2 ft., putting an “X” on the far side of each mark. I also mark the layout on several 16-ft. 1x4s, which serve as top-chord braces during installation.

A Straight Fascia is Just a Snap Away

Remember to order trusses well in advance of when you’ll need them. In Oregon, where I work, a three-week lead time is common. Before I ask for truss delivery, I make sure all the exterior and interior walls are upright, nailed off, and braced properly. Interior walls help to keep the exterior walls straight and plumb. In addition, with all walls in position, I have more support for the bundles of trusses when they’re delivered.

Even when the walls are straight, it’s worth taking some trouble to ensure that when the trusses are installed, the rafter ends line up perfectly. There’s an easy way to do this.

I measure in 1 in. from the outside edge at each end of the top plate. Then I snap a chalkline the full length of the wall as a straight reference line (see the sidebar on p. 164). As I set each truss, I measure from the tail of the rafter chord the distance of the eave overhang plus 1 in. I mark this point on the bottom chord of each truss and align the mark to the snapped reference line, keeping the ends of the trusses straight.



It's Easy to Keep a Straight Fascia

Even if the walls aren't perfectly straight, the trusses can be. To keep the eaves aligned and the fascias straight, you can take advantage of truss uniformity. Snap a chalkline along an outside top plate (photo 1). Align a mark on the truss with the chalkline when you set the truss (photos 2, 3).



I also snap a chalkline along the gable end-wall plates to locate and align the gable truss. Unless it's required by code, I usually don't sheathe gable trusses. The gable truss is set flush with the outside face of the wall sheathing below. I snap the chalkline along the gable end-wall plates 1 in. from the outside. When the gable truss is set on this line, it overhangs the right amount.

Cutting blocks to nail between trusses is another important step to complete before you start setting trusses. In seismic and high-wind areas, code requires blocking between trusses at the plates and often at the ridge as well. I cut 22½-in. blocks to maintain the 24-in.-o.c. truss spacing and to help keep the trusses stable as they go up.

Lifting Trusses onto the Plates

To help with setting the trusses, I build a catwalk scaffold down the center of the house. Framed with 2x lumber, the catwalk gives the crew a safe, temporary platform to work from as we raise trusses into position and nail them to the wall plates.

The next step is getting the trusses onto the plates. Around here, trusses are delivered in bundles held together with steel strapping. The number of trusses per bundle depends on the size of the roof and usually the types of trusses. For this project, there were three bundles: the porch trusses, the scissor trusses, and the trusses for the rest of the roof. With the help of a job-site forklift or the boom attached to the delivery truck, the bundles are positioned on top of the framed walls. If the house is too tall for the forklift or boom, or if the trusses are heavy or wide, a crane is the best way to lift the trusses into place.

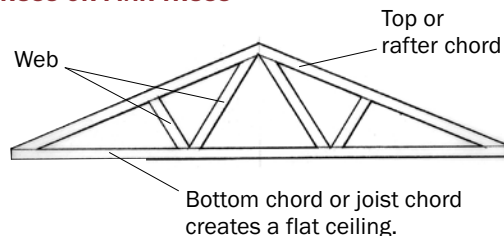
To be safe, I lay the bundles of trusses flat across the walls at the opposite end of the house from where I'll begin installation. Avoid the temptation to set the bundle of trusses upright on the plates. If the trusses

are standing up when you cut the bands holding the bundle, they can fall and hurt someone. Lay the bundles down with the peaks pointing in the direction you'll be spreading the trusses.

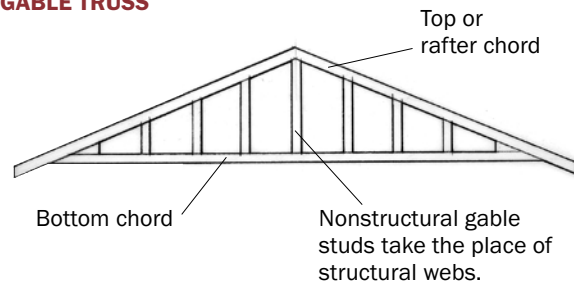
Truss Terms

Trusses gain their strength from lightweight components assembled in triangular shapes. In most cases, they can span the width of a house with no support from interior walls. Here are three common trusses.

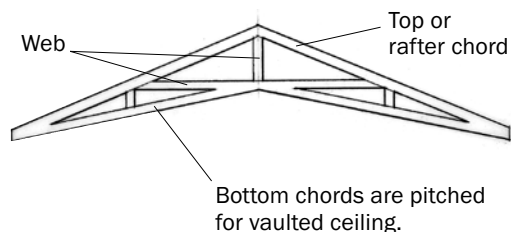
W TRUSS OR FINK TRUSS



GABLE TRUSS



SCISSOR TRUSS



Unloading and Spreading Trusses Set the Stage

Erected to ease installation, a temporary catwalk is completed before the trusses arrive in bundles (see the photo at right). Lay down the bundle with the peak pointing in the direction the trusses will be dragged. Spread out the trusses near their layout marks, overlapping each truss like fallen dominoes (see the photo below).



Start at One End with a Gable Truss

When the bundles are resting safely on the wall plates, I use tin snips to cut the metal bands holding the bundles together, taking care to avoid getting sliced. The first truss is for the gable end of the building and usually has vertical studs instead of angled webbing.

Most trusses are lightweight, so one person walking on the catwalk should be able to grab a truss by the peak and pull it into position.

The gable truss is dragged to the end of the house first. Then, before any trusses are raised, the rest of the trusses are dragged over to their approximate locations, with each truss overlapping the one below, like fallen dominoes (see the bottom photo above). With the trusses spread out in this

Brace the Gable Truss Plumb and in Plane with the Outside Wall

If the first gable truss is plumb, the rest will follow. On this house, the gable doesn't require sheathing, so the author aligns the outside face of the truss flush with the wall sheathing below (photo 1). Holding a long level against a tall truss web is a good way to plumb the truss (photo 2). A temporary diagonal brace is installed to hold the gable truss plumb (photo 3).



fashion, the raising process goes quickly and efficiently. On this house, the front gable was the first to go up. While the truss is held upright, I line it up with the exterior wall sheathing and toenail it every 16 in. with 16d nails. I also brace the truss temporarily until it can be tied to the rest of the roof.

Roll the Trusses into Place

When the gable truss is set, I roll the next truss into place, which in this case was a scissor truss (see the drawing on p. 165). The truss company sent an extra scissor truss, so I nailed it to the gable truss to provide nailing for the end of the vaulted-ceiling

A Team of Three Can Make Quick Work of Rolling Trusses

The middle man “rolls” each truss upright while his two partners toenail truss ends to top plates (photo 5). Accurate spacing is ensured because the author marked the 2-ft.-o.c. layout with the plates and top-chord braces ganged together on the subfloor before the trusses were delivered (photo 1).

The 1x4 top-chord brace helps to keep trusses properly spaced until roof sheathing is installed (photo 2). Cut to a uniform length of 22½ in., 2x8 blocking is nailed to adjacent trusses and to the top plate, bracing the lower part of the roof (photo 3). It’s also important to install a permanent gable brace, extending it diagonally from the tallest gable stud (photo 4).



drywall. A 2x4 nailed to the gable truss could have done the trick as well.

With the first gable resolved, I turn to raising the rest of the trusses. A team of three framers is ideal for “rolling” trusses (see the photos above). You need to have one framer who is located in the middle and one who is placed at each exterior wall. Each truss is nailed to the top plate with one 16d toenail on one side and two on the other side. After the truss is set, I install the block-

ing. As shown in the center photo 3, above, these 2x members maintain a uniform distance (22½ in.) between the trusses and help the roof assembly to resist lateral loads.

When the first couple of trusses have been put in place, I nail one of the 16-ft. 1x4s that I had laid out earlier to the rafter chords near the ridge. An 8d nail in each chord holds the truss at the proper spacing to keep the trusses stable until the roof has been sheathed.

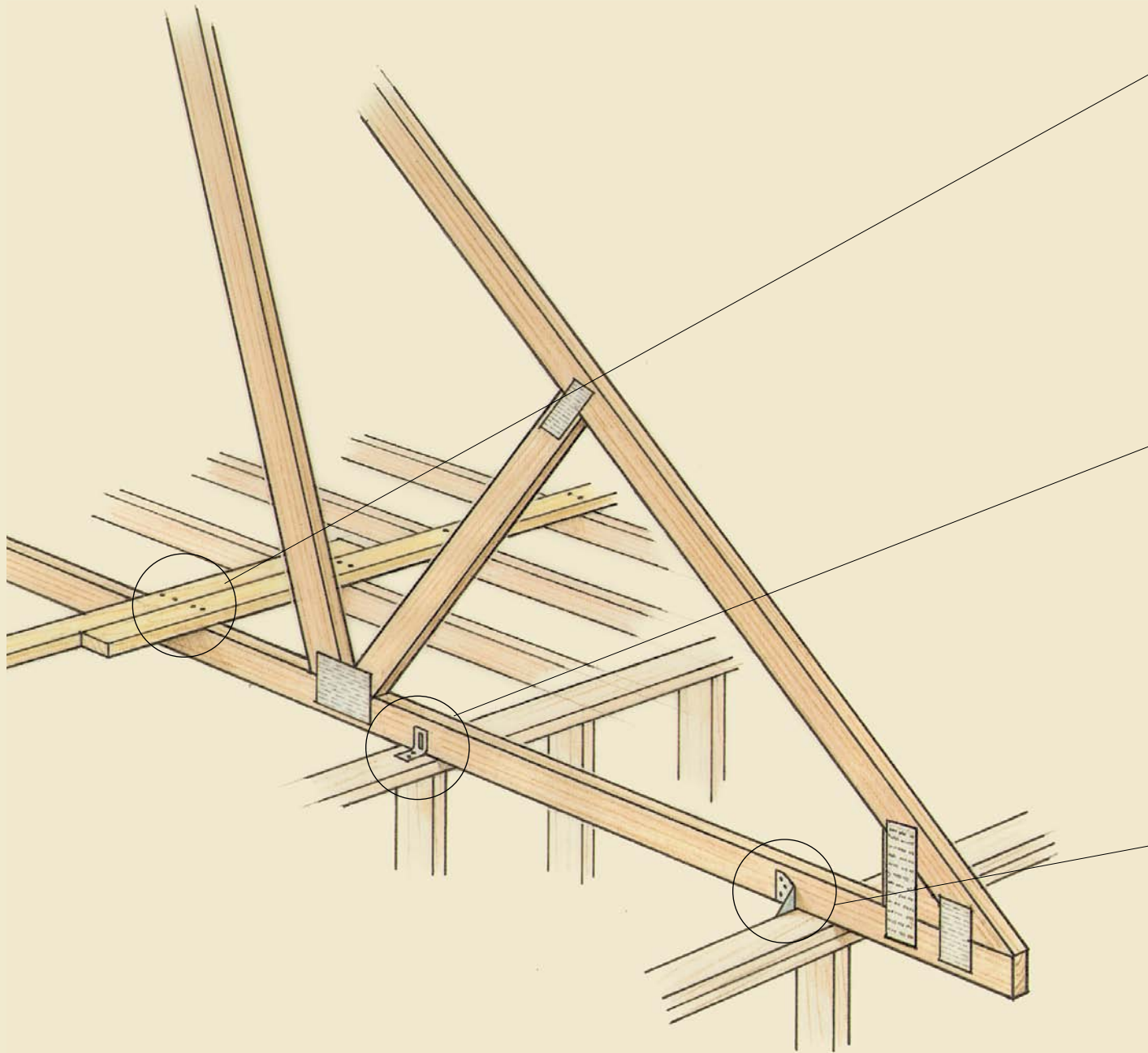


Once four or five of the trusses have been put in place, I put in a permanent sway brace, which adds lateral stability in the event of an earthquake or high wind. A sway brace has 45° angle cuts at both ends and extends from the top plate of an exterior wall up to the top chord of an inboard truss. Building code requires the use of sway braces at each end of the building and every 25 ft. between. But I like to install sway braces more often for added insurance.

Now the rest of the trusses can be brought into position and nailed into place on the layout. For this project, we used scissor trusses over the kitchen, dining room, and living room to create a large open area with a vaulted ceiling. The scissor trusses have a 5-in-12 roof pitch with a 3-in-12 ceiling pitch for the interior. Scissor trusses are set just like regular ones, but because they tend to be top heavy, they should be handled carefully until they're secured.

Hardware and Bracing Get the Roof Ready for Sheathing

The trusses are up, but the framing job isn't done until the final bracing is installed. A combination of steel framing connectors and wood braces strengthens the roof assembly and ties it to the walls of the building.





BOTTOM CHORD BRACES

Running the full length of the house, 16-ft.-long 2x4 braces are nailed across truss bottom chords to strengthen the roof structure.



ROOF TRUSS CLIPS

Installed where the bottom chord crosses an interior wall, these clips can help to prevent drywall cracks by allowing the truss to move slightly in response to temperature and humidity changes.



HURRICANE CLIPS

Install these metal connectors wherever a truss crosses an exterior wall. By securing the truss to the top plate, hurricane clips keep the roof in place during high winds.

Tying Up Loose Ends

When all the trusses are in place, I nail 16-ft. 2x4s to the tops of the joist chords in the attic space, near the center of the span. Overlapping each other and running the full length of the house, these permanent braces stabilize the joist chords and hold them at the correct spacing.

If diagonal web braces are called for in the engineered specs, I nail them on at this point, along with any other braces. Metal hurricane clips keep the roof attached to the house frame in a heavy wind. The metal clips nail to each joist chord and then to the top plates of the exterior walls (Simpson Strong-Tie Co.; 800-999-5099; www.strongtie.com). They can be nailed on the inside or outside of a wall. Be sure to use the “hanger” nails made specifically for nailing these clips.

Larry Haun, author of *The Very Efficient Carpenter* and *Habitat for Humanity: How to Build a House* (The Taunton Press), lives and works in Coos Bay, Oregon.

Factory-made trusses save time and give you a roof engineered for strength and stability.

Building Hip and Valley Roofs with Trusses

■ RICK ARNOLD AND MIKE GUERTIN

A few years and many roofs ago, a builder approached us about framing a two-story colonial-style house. He said that he wanted to try a truss system for the hip roof. We had used trusses for a lot of gable roofs, but we had never seen a hip done that way. When the trusses for the job were delivered, we just stood back and scratched our heads. It looked as if bunches of unrelated pieces had been strapped together in no particular order. The engineering plan looked like a map of some unfamiliar suburb.

Too smug to admit that we needed help, we muddled our way through, lifting each weird-looking truss up to the roof by hand and then moving each piece three or four times until we found the right spot to nail it. That roof is still in good shape after two hurricanes, and whenever we drive by the house, we chuckle at how much time and effort it took to put that roof together.

Our methods for assembling hip-and-valley truss systems have evolved a great deal since that first puzzled attempt. The biggest advance in our technique came when we described the process to our crane operator. He suggested assembling some of the trusses on the ground and lifting whole hip sections onto the house in one shot (see the photo on the facing page). It worked like a charm. Now we even sheathe the assemblies before they go up.

Building Hip Systems on the Ground Is Quicker and Safer

Before anything is assembled, we prep the hip-and-valley trusses much as we do standard trusses (See “Raising Roof Trusses” on pp. 150–161). We line them up in a stack on the ground and mark layout lines for the



The hip goes up in one piece. Like a giant box kite on a string, an entire hip section is lifted to its home atop a two-story house.

sheathing and strapping and for alignment on the walls. If necessary, we also restack the trusses that will be lifted individually by the crane to be sure they're in the proper order. We lay out the wall plates according to the truss plan (see the sidebar on p. 174) and write the number and designation for each truss at its layout point.

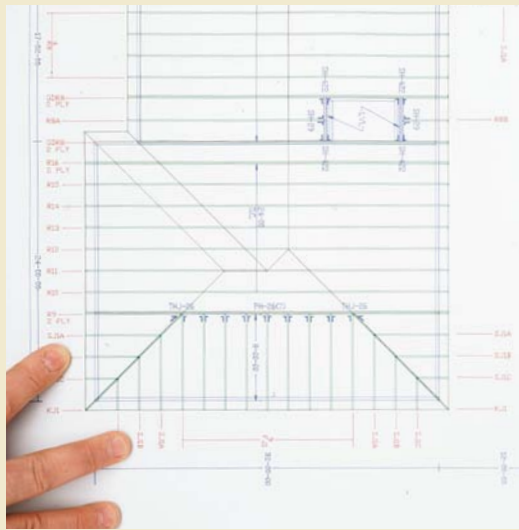
When framing hip roofs with trusses, we most often use a step-down hip truss system (see the top drawing on p. 175). Trusses in

this system have the same span as common trusses, but they're flat on top. The flat parts of the hip trusses become progressively wider and lower as the trusses step away from the last common truss to begin forming the hip. The lowest and widest hip truss, the hip-girder truss, supports a series of monotrusses, called jack trusses, that complete the roof. The hip-girder truss usually has a heavier bottom chord than the other hip trusses to accommodate the extra weight

When framing hip roofs with trusses, we most often use a step-down hip truss system.

Truss Fabricators Engineer the Roof for You

Truss systems can be designed for almost any complicated roof design (see the photo below). Although the cost for the truss package may be more than the cost for conventional framing materials, the labor savings are phenomenal. As an added benefit, the interior bearing walls necessary for conventionally framed roofs can be eliminated, which allows greater design flexibility. Some of the truss packages we have ordered even include



The map of a complicated roof system. Engineered-truss plans like this one, which is for the roof pictured on p. 183, are provided by the truss manufacturer. The plan identifies each type of truss and its exact location. This roof features a dozen different types of trusses.

complicated details such as vaulted ceilings and roofs with hips and valleys of different pitches, roofs that would have been a real challenge to frame conventionally.

We've found that the best way to explore the possibilities is to go over the house plans with the engineer for the truss fabricator. At that meeting, we often make arrangements for minor structural changes in the house to accommodate the roof trusses. Sometimes by moving a couple of bearing points or inserting a carrying beam, we can change a roof from conventional framing to a truss system. The benefits we gain by using trusses have always outweighed any changes we need to make.

After the meeting, our fabricator usually gets back to us within a few days with a rendering of the truss plan and a price. We are occasionally astonished when a truss system ends up costing less than the lumber for a conventionally framed roof because trusses are made of less expensive, smaller dimension lumber.

We study the truss plan before the trusses arrive. If we're having trouble understanding a plan view of the system, the truss fabricator will provide an isometric drawing, usually at no extra cost. An isometric drawing shows the roof in 3-D and helps clarify the more difficult details.

of the jack trusses and the metal hangers that hold the jacks. Generally, two girder trusses are nailed together and work in tandem for each hip system.

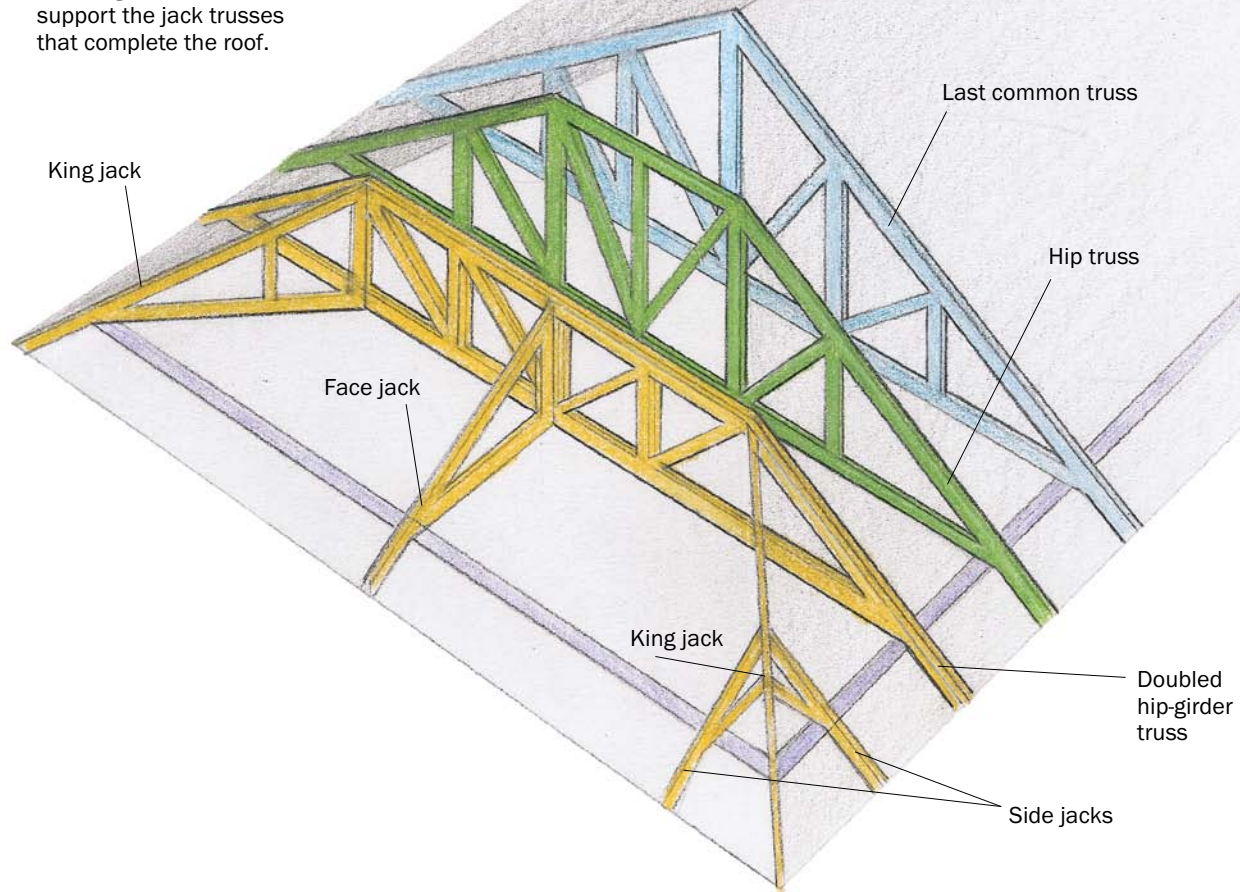
After the wall plates are laid out, we lay out a hip-girder truss while it is still lying flat on top of the pile. We begin our layout by locating the exact vertical center of the truss, top chord to bottom (see the bottom drawing on the facing page). First we locate the middle of the top flat chord of the truss. Then from the ends of the flat chord, we

measure equal distances diagonally to the bottom chord. Halfway between our diagonal marks is the midpoint of the bottom chord. The line between the midpoints is the vertical centerline.

From this centerline we can locate the position of the outermost jack trusses on both the top and bottom chords as indicated on our truss plans. A jack truss is a monotruss with a single top chord. There are three different types of jack trusses in a hip system: face jacks that are attached to the face of the

A Step-Down Hip Truss Roof System

The hip is formed by a series of flat-top trusses with progressively wider top chords. The lowest truss in the sequence, the hip-girder truss, is doubled to support the jack trusses that complete the roof.



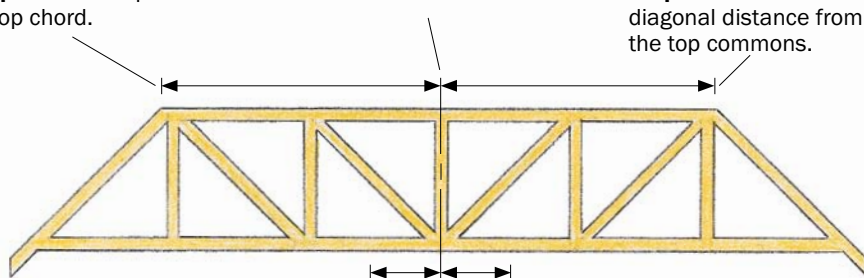
Finding the Centerline of the Hip-Girder Truss

The layout of the girder truss is based on the centerline. Here's how to locate it.

Step 1. Find midpoint of top chord.

Centerline

Step 2. Measure the same diagonal distance from the top commons.



Step 3. Find midpoint between diagonal lines and connect to top midpoint.



A jack truss holds the girder truss upright. The center face jack truss is tacked to the girder truss to keep it vertical while the rest of the face jacks are installed.

Straightening the girder trusses. A temporary brace keeps the girder trusses straight while they are being nailed together.



hip-girder truss and that run perpendicular to it; king jacks that run diagonally from the girder truss and form the outside corners of the roof; and side jacks that are attached to both sides of king jack trusses.

The layout for the rest of the face jacks is taken from the wall-plate alignment mark on the girder truss. However, the center jack truss is always at the exact center of the girder, regardless of the spacing. We tack metal hangers for the face jack trusses onto the bottom chord of the girder truss with just a couple of nails in each hanger. They will be nailed in permanently with spikes after the second girder truss is mated to the first.

Jack Trusses Are Nailed to a Pair of Hip-Girder Trusses

Next we move the prepared hip-girder truss to a relatively flat area of the job site and prop it upright on blocks. The center face jack truss is set into its hanger and tacked to the girder truss at the top to hold them both upright (see the top photo on the facing page). The tails of all of the jack trusses need to be supported, so we make a continuous block out of long lengths of 2x material. The blocking for the jacks is raised until the hip-girder truss is sitting fairly plumb, and the rest of the face jacks are then slipped into their hangers and tacked at the top. When they're all in place, we nail them off through the chords and webs of the girder truss.

Now we tack the second hip-girder truss to the first with just a few nails so that the girder trusses can be straightened before they are joined permanently. We run a stringline on the top and bottom chords of the girder trusses to get them straight. If need be, we temporarily brace the bottom chord against the ground to keep it straight (see the bottom photo on the facing page). The tails of the face jacks are kept at the correct spacing with furring strips, marked to match the jack-truss layout and tacked on top of the bottom chords (see the photo below). When the girder trusses are straight and the face jack trusses are spaced properly, we nail the two girder trusses together through all of the chords and webs, and we nail off the hangers for the face jacks.



A furring-strip spacer keeps the tails in place. Before the system can be squared, the tails of the face jack trusses are spaced according to the layout and held in position with a piece of 1x3.



Diagonal measurements square the system. Measurements are taken between the two outermost jack trusses, and the tails of the trusses are moved in unison until the measurements are equal.

We are now ready to square the assembly. First we recheck our strings on the girder trusses and then measure diagonally between the top chords of the two outermost face jack trusses (see the photo above). The tail ends of the face jacks are moved in unison until our measurements are equal and the face jacks are square with the girder truss. We check our strings one last time and nail a furring strip diagonally onto the underside of the top chords of the face jacks and on top of their bottom chords to keep the whole system square and uniform.

A 2x4 subfascia is now nailed to the tails of the face jack trusses and extended

far enough to catch the tails of the king jack trusses when they're installed. We will straighten the subfascias after the hip systems are installed on the house walls. If the hip roof is going on a single-story house, we ordinarily stop here. Because the staging is simpler for a single-story house and because materials can be passed to the roof directly from the ground, it's quicker for us to complete the assembly in place.

Special Hangers Hold the Jack Trusses for the Hip Corners

For multistory houses we finish building the hip section on the ground. The next step is tacking the king jack trusses in place (see the photo below). The king jack truss is built with the top chord at the same pitch as a hip rafter and functions in much the same way. The king jack trusses are installed between the hip-girder truss and the last face jack truss on both ends of the assembly. They fit into a specially designed hanger, provided by the truss manufacturer, that eliminates the need for the 45° angles normally cut on the top end of a hip rafter. We position the king jacks at exactly the same

distance from the girder truss and the adjacent face jack truss, and we temporarily hold them in place with a furring-strip brace.

The tails of the hip trusses are usually left long by the manufacturer and cut to length on site. We run a string along the tails of the face jacks to determine where the tails of the king jacks need to be cut. We usually make this cut with a reciprocating saw because the subfascia tends to get in the way of a circular saw.

Next we cut the return angle on the tail of the first king jack. We find this cut by measuring along the bottom chord of the hip-girder truss from the first face jack truss to the end of the overhang. Then we measure that distance from the tail of the face jack to the tail of the king jack and make our cut there. The subfascia is cut to the

For multistory houses we finish building the hip section on the ground.



The king jack truss forms the corner. The top chord of the king jack is cut to the pitch of a hip rafter and functions similarly. It is held in place with a special hanger, and the tail is positioned equidistant from the girder truss and the outermost face jack.

same length and then nailed to the king-jack tail. On the other end of the assembly, we cut the king-jack tail and subfascia so that the length of the subfascia is the same as the overall length of the girder truss. The returning subfascias can now be nailed on. If possible, we extend the returning subfascias back beyond the girder trusses to tie into the other step-down hip trusses when they are installed.

The side jack trusses are attached directly to the king jacks (see the photo below). A side jack truss is a simple monotruss with just a top and a bottom chord joined to-

gether with truss plates at the splice point. We locate the attaching points for side jacks by pulling 24-in. centers off adjacent girders and face jack trusses. The subfascias are laid out the same way.

Usually the manufacturer cuts the side jack trusses to the proper length but without the 45° angles on the ends of the chords. We cut these angles on site. For each hip system, there are four of each size side jack trusses, two with right-hand 45° cuts and two with left. Having one person organize and cut the side jacks minimizes the chances of cutting them wrong. Once the side jacks are

Side jacks fill in the framing beside the king jack. Side jack trusses consisting of just a top and bottom chord are nailed to the king jack and the subfascia.



cut with the proper angle, they can be positioned and nailed to the king jack truss and the subfascia.

We sheathe the trusses by snapping lines across all of the jack trusses and filling in as many sheets as we can. We don't sheathe return facets of the hips until the system is in place on the house so that our sheathing will tie back into the other trusses. Lower sheets are tacked in place temporarily so that we can lift them out of the way when we nail trusses to top plates.

Assembled Hip Sections Are Lifted Level

When we lift the hip sections, we run heavy-duty straps through the top corners of the hip-girder trusses where the king jack trusses are attached for the strongest lifting points (see the photo on p. 173). We attach an adjustable strap around the tails of the three middle face jack trusses to balance the load. The crane operator lifts the assembly just a little so that we can adjust the middle strap and get the assembly as level as possible before it's lifted into place. The more level the assembly is, the easier it is to position on the walls.

When the assembled hip system is airborne, a crew member stationed on the ground keeps it steady with a tag line until it is within reach of the crew on the staging. First we land the assembly at the layout marks on the plates for the hip-girder trusses. Then we have the crane tug the whole assembly toward the front or back until the lines on the bottom chord of the girders align with the inside edge of the walls. When the system is properly positioned, we release the straps and nail the trusses to the top plates of the end wall and along one side. The process is repeated for the opposite hip assembly.

The step-down hip trusses are now lifted into position one at a time. We tack on short pieces of furring just below each of the flat

sections to connect one truss to the next at the correct spacing. The process is repeated until we set the first full-height common truss. Then we pause the crane and tack a long piece of furring onto the flat tops of the trusses, measuring and spacing them properly as we go.

The common trusses are sent up two at a time and locked in place temporarily with Truslock truss spacers (Truslock, Inc., www.truslock.com; 800-334-9689). The layout for the last common truss is usually irregular to accommodate the step-down hip or valley system. We space that truss with a piece of furring marked to reflect the difference in the layout. The step-down hip trusses for the other end of the house can now be sent up one at a time and braced with furring as we did with the first end.

Building Valleys Out of Trusses Is a Snap

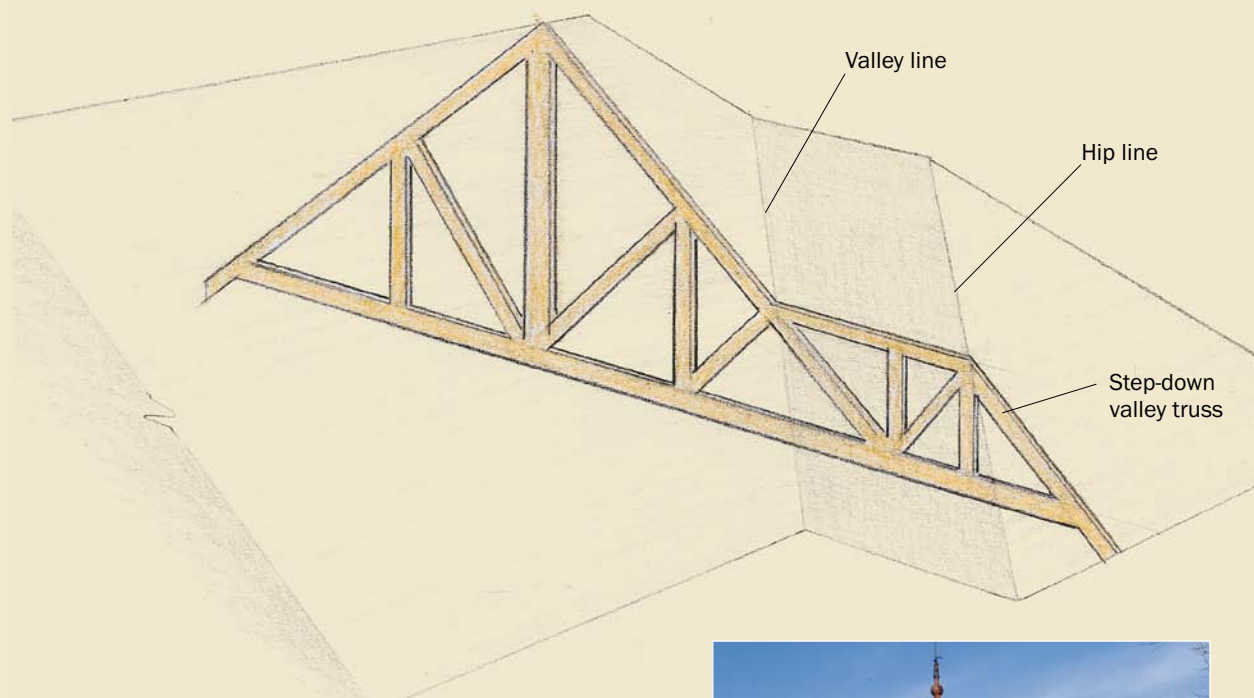
There are two basic ways of framing valleys with trusses. The one we encounter most frequently, and the easiest to frame, is the intersection of two simple roofs. We begin by setting all of the trusses for the main roof. If there are no interior bearing walls to support the trusses of the main roof where the two roofs meet, we hang the ends of the unsupported trusses on hangers nailed to a girder truss, which is part of the other intersecting roof.

Once the main roof has been sheathed, we set the trusses for the intersecting roof as far as the main roof. The valleys are created with a valley kit, which is a set of progressively smaller common trusses nailed directly onto the sheathing (see the bottom photo on p. 182). We usually rip the pitch angle of the intersecting roof onto the bottom chord of each truss in the valley kit. Although cutting trusses is not a practice that is generally accepted, our truss manufacturer has assured us that ripping valley-kit trusses for this type of application is permissible.

Having one person organize and cut the side jacks minimizes the chances of cutting them wrong.

Hips and Valleys Next to Each Other Require Special Trusses

When a hip and a valley are too close together to be framed with conventional trusses, as in the drawing below, special step-down valley trusses have to be used.



Step-down valley trusses create the roof plane. When step-down valley trusses (photo right) are installed, the flat portion of the top chord gets higher with each successive truss (photo below), forming the roof plane between the hip and the valley.





If a valley is so close to a hip that a girder truss can't be used to hold the main roof trusses, a second method using special step-down valley trusses may be the answer (see the sidebar on the facing page). These valley trusses are similar to common roof trusses except that the top chord is interrupted by a flat extension. The length of the flat extension is the same for every step-down valley truss and reflects the distance between the hip and valley lines. However, the height of the flat extension increases with each successive truss, creating both the valley and the hip as they go. Again, because each truss in the series is different, we take extra care to stack the trusses in the order that they will be lifted by the crane. Following the truss plan to the letter helps a great deal.

All of the Hip and Valley Lines Are Reinforced with Blocking

After all of the trusses are set and the crane leaves, we complete the truss installation with a few extra details. First, we beef up the hips and valleys with 2x blocks cut with compound angles. These reinforcing blocks are not specified on the engineer's plan, but nailed between the step-down trusses at

the hip and valley lines, they're helpful as spacers for the trusses and as nailers for the sheathing.

As with a simple truss roof, we nail the trusses only along one side of the house during the raising. After the crane leaves, we restraigten the walls in case they've been knocked out of line while the trusses were set. When the walls are straight, we nail off the other end of the trusses. Then we go back and install metal hold-down hardware as required by the truss company and/or the building official or engineer. This is done to meet wind uplift and seismic requirements. Now the rest of the subfascias can be installed and shimmed straight. After our lunch break, we finish sheathing the roof.

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A valley kit is nailed directly to the sheathing. A series of progressively smaller trusses, called a valley kit, forms the valleys between two intersecting roofs.

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INDEX

A

A-dormers, 108–17
 about: overview of, 108
 California valleys, 114–15, 116–17
 compared to doghouse dormers, 108–10
 components, illustrated, 110
 features and benefits, 108
 first building steps, 108–11
 gable wall, 108–09, 110
 kneewalls, 108–09, 110, 111, 112
 pitch, 109, 111
 rafters, 108–09, 110, 111–15, 116–17
 sheathing, 115–17
 types of valleys, 111
 valley rafters, 112–15

B

Barge rafters, 24, 25
 Battery-powered nailers, 88–89
 Bay-window roofs, 142–49
 about: overview of, 142
 angles, 145, 146
 assembling, 144
 beveling hips, 148, 149
 components, described and illustrated, 142–44
 cornices, 144, 145, 146, 147, 149
 drawing first, 146–48
 laying out hips, 145
 ledgers, 142, 144, 145, 146, 147–48, 149
 lookouts, 144, 145–46
 map for rafters to follow, 145–46
 rafters, 142, 144, 145–49
 raising, 149
 scaffolding for, 143
 site-built vs. manufactured, 142–44
 templates for rafters, 147–48
 Bird's mouth
 common rafters, 7, 13
 cutting on I-joists, 79, 80
 gang-cutting, 18, 19
 hip roof, 53, 55–56, 57, 58
 laying out, 16–17, 31
 nailing first, 13
 valley rafters, 29, 31
 Blocking
 frieze, 20, 23, 59
 gable roofs, 21–22, 23

hip roofs, 59
 trusses, 168, 183
 See also Web stiffeners
 Braces. See Hangers and braces

C

Calculations
 calculators for, 5, 26, 35, 92
 functions of rafter squares, 37
 key to, 36
 rafter squares for, 16, 36–37, 43
 rafter tables and, 54–55, 61
 specific. See *specific applications*
 California valleys, 92, 100, 114–15, 116–17
 Collar ties, 22, 70, 73, 95, 99, 123
 Common rafters, 4–13
 aligning with studs, 8–9
 bird's mouths, 7, 13
 bracing ridge, 11
 calculations/math, 4–5
 cutting to length, 25
 determining number needed, 22
 elements, illustrated, 5
 first rafter, 6–7
 installing, 12, 13
 length of, 5, 6–7, 37
 metal ties, 13
 nailing, 13
 pattern, 6–7
 plumb cuts, 5, 6–7
 production cutting, 10–13
 rafter horse for, 14, 15
 rise and run, 5
 saws for cutting, 14–17
 seat cuts, 5, 6–7
 staging/laying out, 8, 9
 starting with straight, plumb walls, 4
 testing, 11

D

Doghouse dormers, 90–101
 about: overview of, 91
 A-dormers compared to, 108–10
 anatomy of, 92
 assembling components on ground, 91
 assembling on roof, 98–99
 California valleys, 92, 100
 components, illustrated, 92
 cutting hole for, 97
 figuring size of, 95, 98–100
 finding pitch, 93–96

hybrid of shed and. See Nantucket dormers
 laying out rafters, 95
 preparing to cut hole for, 96–97
 rafters, 92, 93, 95, 96–97, 98, 99, 100
 ridges, 92, 93, 95, 98–100
 subfloors, 93, 99
 trimmers and headers for, 96–97
 window specifications, 92, 94, 97–98
 wing-wall dimensions, 94, 97–98
 Dormers, framing
 as series of triangles, 92
 See also A-dormers; Doghouse dormers; Nantucket dormers; Shed dormers

E

Engineered lumber, framing with
 about: overview of, 76
 bearing rafters, 78–79
 correcting mistakes, 83
 environmental concerns, 82
 fastening, 83
 layout lesson, 83
 lessons about, 82–83
 metal hangers, 81, 82–83
 modular sizing, 83
 planning, ordering material, 76–78, 82
 production cutting methods, 78–79
 reading instructions, 83
 ridges, 77, 78–79
 safety considerations, 82
 supply disadvantage, 76–78
 web stiffeners, 80–81
 See also I-joist rafters; LVL (laminated veneer lumber)

F

Face jacks, 174–76, 177–78, 179
 Fink trusses, 165
 Flashing, 127–29
 Frieze blocking, 23, 59

G

Gable-dormer retrofit, 118–29
 about: overview of, 118
 above-floor header, 121, 122–23
 components, illustrated, 121
 cornice details/finish trim, 124, 125, 129

- cutting opening for, 118–20
- flashing, 127–29
- inserting new rafters into sheathed roof, 120–23
- preparation, 118
- protecting roof during (rain protection), 120
- sheathing, 127
- sidewalls, 121, 122, 124, 126
- supporting dormer, 121
- transferring load for, 121–23
- trimmer rafters, 121, 122–23, 124
- valley rafters, 123, 124–27
- Gable rafter layout (nontraditional approach), 38–49
 - about: overview of, 38
 - altitude of measuring triangle, 43
 - base of measuring triangle, 43
 - building jig for, 42
 - hypotenuse of measuring triangle, 43
 - laying out main part of rafter, 44–47
 - laying out rafter tail, 47
 - marking/cutting rafters, 48–49
 - measuring triangle and, 41–42, 43–44
 - preserving layout, 47
 - rise, run, and pitch, 41–42
 - setting ridge, 44, 45
 - step-by-step, 43–49
 - technique overview, 40–41
 - traditional methods vs., 38–40
 - using jig for, 44–49
- Gable roofs, 14–25
 - barge rafters, 24, 25
 - blocking, 21–22, 23
 - calculations/math, 23
 - collar ties/purlins, 22–23
 - compensating for ridge thickness, 22
 - cutting rafters, 14–17 (see also production cutting)
 - finishing overhangs, 25
 - framing ends, 23
 - framing tips, 22
 - laying out (see also Gable rafter layout (nontraditional approach))
 - layout tee for, 16–17, 25
 - length of rafters, 22
 - lookouts, 24, 25
 - nailing, 20–21
 - production cutting, 15, 18–19
 - staging/laying out, 19–20
- Gable roofs, framing, 14–25
- Gable trusses, 150–51, 153–56, 157, 165, 167–68
- Gambrel roofs, 68–75
 - about: overview of, 68
 - anatomy of roof, 70
 - angles, 71
 - collar ties, 70, 73

- components, illustrated, 70
- design considerations, 75
- full-scale layout, 68–71
- gable truss, 73
- kneewall, space availability and, 68, 75
- knuckles, 68, 70, 73
- laying out trusses on floor, 68–71
- plumbing and bracing, 72
- plywood gussets, 68–69, 70, 71, 73
- pros and cons, 75
- raising/installing, 72–73
- sleepers, 74–75
- truss production assembly, 73
- venting above sheathing, 74–75
- Gas-powered nailers, 85. *See also* Nailers, cordless

H

- Hangers and braces
 - for common rafters, 4, 9
 - for engineered lumber roofs, 81, 82–83
 - for gable roofs, 20
 - for gambrel roofs, 72
 - for jack trusses/hip corners, 179–81
 - for ridges, 11
 - Simpson Strong-Tie, 83
 - for trusses, 157, 159, 161, 162, 167, 168, 169, 170–71
- Heel cuts
 - illustrated, 5, 31, 53
 - marking/cutting, 16, 18–19, 29, 30–31, 47, 95, 115
- Hip roofs, 50–59, 60–67
 - about: overview of, 50, 60–61
 - anatomy of, 52, 61
 - assembling, 58–59
 - backing the hip, 54
 - bird's mouths, 53, 55–56, 57, 58
 - bringing end of to a point, 56–57
 - components, illustrated, 52, 54, 61
 - cutting rafters, 57–58, 66–67
 - dropping the hip, 54
 - finding rafter drop, 55
 - finding run of common rafters, 62
 - frieze blocks, 59
 - jack rafters, 50–51, 52, 57–58, 59, 61, 65, 66–67
 - king commons, 50–52, 54, 56, 57, 58–59, 61, 62, 64
 - laying out rafters, 56
 - laying out hip rafters, 65
 - length of rafters, 37, 54–55, 63–65
 - lowering rafters at seat cut, 54
 - Metric vs. English measuring systems, 66
 - rafter tables, 54–55, 61

- rafter templates, 52–53
- ridge cut, 55
- ridge/hip intersection, 56, 61
- rise, run, and pitch, 61, 63–65, 66–67
- stabilizing, 59
- story stick, 61, 62, 63, 65, 66
- streamlining measurement and layout, 52–53
- 2-D vs. 3-D images of, 65
- See also* Bay-window roofs
- Hitachi nailers, 87

I

- I-joint rafters
 - common rafters, 77, 78–79
 - cutting bird's mouths on, 79, 80
 - metal hangers for, 81, 82–83
 - for other rafters, 80
 - production cutting methods, 78–79
 - production cutting methods (gang cutting), 78–79
 - template for cutting, 79
 - web stiffeners for, 80–81
 - See also* Engineered lumber, framing with

J

- Jack rafters
 - beveling, 32
 - cutting, 32–33
 - finding length of, 33, 37
 - hip roof, 50–51, 52, 57–58, 65, 66–67
 - laying out, 35
 - Nantucket dormer, 139, 140
 - valley framing, 28, 29, 32–35
- Jack trusses, 173–76, 177–81
 - defined, 174
 - face jacks, 174–76, 177–78, 179
 - king jacks, 175, 176, 179–80, 181
 - nailing to hip-girder trusses, 177–78
 - side jacks, 175, 176, 180–81
 - types of, 174–76
- Jigs, rafter
 - for hip-roof framing, 66–67
 - for nontraditional layout approach, 39–40, 41, 44–49

K

- King commons, 50–52, 54, 56, 57, 58–59, 61, 62, 64
- King jacks, 175, 176, 179–80, 181

L

Layout tees, 16–17, 25
 Lookouts
 bay window, 144, 145–46
 gable roof, 24, 25
 LSL (laminated strand lumber),
 77, 78
 LVL (laminated veneer lumber)
 cutting bevel on, 82
 headers, 77, 79
 metal hangers for, 81, 82–83
 mounting header hangers on, 82
 rafters, 77, 79
 ridges, 5, 28, 77, 78–79
 safety considerations, 82
 trimmers, 92, 96, 97
 See also Engineered lumber,
 framing with

M

Max nailers, 88
 Metric vs. English measuring
 systems, 66

N

Nailers, cordless, 84–89
 about: overview of, 84
 advantages of, 84
 battery-powered, and cost of use,
 88–89
 gas-powered nailers, 85
 Hitachi nailers, 87
 limitations of, 84–88
 Max nailers, 88
 Paslode nailers, 86
 Powers nailers, 89
 Nailers, for engineered lumber, 83
 Nantucket dormers, 130–41
 about: overview of, 130
 components, illustrated, 134
 description of, 130
 doghouse walls, 130–31, 133
 headers and structural rafters,
 134–35
 jack rafters, 139, 140
 lining up roof planes and soffits,
 135–37
 pitch of rafters, 135, 136, 137
 rafters, 132–40
 ridges, 133, 134, 135
 sheathing, 140, 141
 shed-rafter details, 136–37
 strapping ceilings of, 140
 structural backbone, 132,
 134–35
 supporting, 132
 two distinct interiors, 132
 types of, 130–32
 valleys, 137–39

P

Paslode nailers, 83, 86
 Pitch
 A-dormers, 109, 111
 doghouse dormers, 93–96
 gable roofs, 41–42
 hip roofs, 61, 63–65, 66–67
 measuring triangle and, 41–42,
 43–44
 Nantucket dormers, 135, 136,
 137
 shed dormers, 104
 valley rafters, 26, 28–29
 See also Rise and run
 Plumb
 checking walls for, 4, 6
 cut angle, 5, 6–7, 16, 30, 31, 44
 double-bevel cut, 31–32
 measuring, cutting angles, 16
 Powers nailers, 89
 Purlins, 22–23

R

Rafter horse, 14, 15
 Rafters. See Common rafters;
 specific types of roofs
 Rafter squares, 16, 36–37, 43
 Rafter tails
 cutting, 15, 25
 illustrated, 5
 laying out, 7, 31, 47
 maintaining strength, 17, 19
 valley rafters, 29, 31
 Ridges
 bracing, 11
 compensating for thickness of,
 22
 doghouse dormers, 92, 93, 95,
 98–100
 gable roofs, 44, 45
 gang-cutting, 17, 19
 hip roof, 56, 61
 illustrated, 5
 LSL (laminated strand lumber),
 77, 78
 LVL (laminated veneer lumber),
 5, 28, 77, 78–79
 Nantucket dormers, 133, 134,
 135
 production cutting, 19
 shed dormers, 104
 staging/laying out, 19–20
 thickness of, 5
 Rise and run
 calculating, 5, 29
 common rafters, 5
 hip roofs, 61, 63–65, 66–67
 illustrated, 5
 rafter squares for, 37
 valley rafters, 26, 28–29

S

Saws
 beam, 17, 19
 circular, 13, 14–16, 17, 19, 25,
 42, 49
 worm-drive, 14, 17, 18, 19
 Scaffolding, 103, 120, 143, 165
 Scissor trusses, 165, 169
 Seat cuts
 common rafters, 5, 6–7, 31
 dormers and bays, 95, 112, 144,
 146, 149
 gambrel trusses, 72
 hip roof, 53, 54, 63, 64, 65, 66
 illustrated, 5, 31
 lowering rafters at, 54
 marking/cutting, 7, 16, 17, 19,
 29, 30–31
 production cutting, 19
 valley rafters, 31
 Shed dormers, 102–07
 about: overview of, 102
 building, 103–07
 cheek walls, 106–07
 components, illustrated, 104–05
 designing and drawing, 102–03,
 104–05, 106
 hybrid of doghouse and. See
 Nantucket dormers
 minimizing mistakes, 102
 overhangs and headers, 105
 pitch of roof, 104
 rafters, 102, 103–07
 ridges, 104
 scaffolding and guardrails, 103
 sheathing, 106
 subfloors, 102, 103, 104
 window height, 105
 Side jacks, 175, 176, 180–81
 Sleepers, 74–75
 Spacers, truss, 160, 161, 181
 Squares, rafter, 16, 36–37, 43
 Step-down hip system, 173–74,
 175, 181
 Step-down valley trusses, 181–83

T

Tables (rafter), hip roofs and,
 54–55, 61
 Templates/patterns
 bay-window rafters, 147–48
 common rafters, 6–7
 hip roof, 52–53, 61
 I-joist rafters, 79
 layout tee, 25
 Triangle, measuring, 41–42,
 43–49. See also Rafter
 squares
 Trimmer rafters, 92, 96–97, 121,
 122–23, 124
 Trusses
 advantages of, 162
 bracing, 157, 159, 161, 162,

- 167, 168, 169, 170–71
- building valleys from, 181–83
- ensuring straight fascia, 162–64
- gable, 150–51, 153–56, 157, 165, 167–68
- laying out, 162
- lifting onto plates, 165–66 (see also Truss raising)
- lining up rafter ends, 162–64
- nailing, 159–61
- ordering, 162
- raising with cranes. See Truss raising
- rolling into place, 167–69
- scissor, 165, 169
- spacers for, 160, 161, 181
- types of, illustrated, 165
- unloading and spreading, 166
- W or Fink, 165

Trusses, hip, 172–83

- building on ground, 172–76
- fabricators engineering, 174
- hangers for holding jack trusses/hip corners, 179–81
- lifting assembled sections, 181
- nailing jack trusses to hip-girders, 177–78
- squaring assembly, 178
- step-down system, 173–74, 175
- step-down valley trusses, 181–83
- See also Jack trusses

Truss raising, 150–61

- about: overview of, 150
- ceiling furring strips and, 152–53
- cranes for, 150, 154, 155, 157, 159–61
- crew assignments for, 157–59
- first trusses, 157, 159–60, 166–67
- gable-end trusses, 150–51, 153–56, 157, 167–68
- hand signals for, 158
- layout for, 152–53
- lifting building materials and, 154–55
- nailer aiding, 157
- preparation for, 150, 154–55, 157
- rake overhangs and, 156
- rolling into place, 167–69
- sheathing/siding before, 153–56
- time required for, 161
- two at a time, 161

V

Valley framing, 26–35

- about: overview of, 26
- A-dormers, 111–15, 116–17
- bird's mouth and tail, 29, 31

- calculations, 26, 29, 30–31
- flashing, 127–29
- gable dormer, 123, 124–27
- getting started, 26
- jack rafters, 28, 29, 32–35
- laying out rafters, 30–31
- length of overhang, 31
- length of rafters, 30–31, 33, 37
- pitch of rafters, 26, 28–29
- rise and run, 26, 28–29
- See also specific types of roofs

Valleys, building from trusses, 181–83

Venting roofs

- frieze blocks and, 59
- gable vents, 156
- gambrel roofs, 74–75
- ridge vents, 6, 153
- sleepers for, 74–75

W

W (Fink) trusses, 165

Walls

- A-dormers, 108–09, 110, 111, 112
- checking for square, straight, plumb, 4, 6
- doghouse dormers, 94, 97–98
- gable-dormer, 121, 122, 124, 126
- Nantucket dormers, 130–31, 133
- rafters aligning with studs, 8–9
- shed dormers, 106–07

Web stiffeners, 80–81

Windows

- bay, roof for. See Bay-window roofs
- for doghouse dormers, 92, 94, 97–98
- for shed dormers, 105

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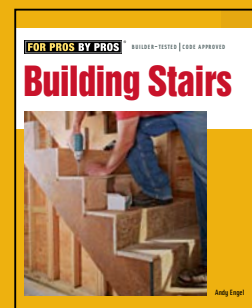
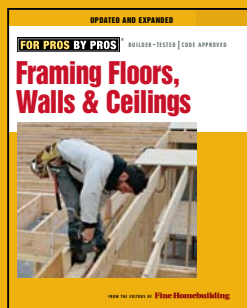
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