CHAPTER 19

Roof Assembly & Sheathing

Chapter Objectives

After completing this chapter, you will be able to:

- **Identify** the two basic types of ridges.
- **Calculate** ridge length.
- **Create** the ridge layout for gable roofs, hip roofs, addition roofs, and dormers.
- **Identify** different types of cornice construction and name the parts.
- **Assemble** a simple box cornice.
- **List** the basic requirements for the placement and nailing of panel roof sheathing.

Discuss the Photo

Roofing Safety must always be a concern when working on a roof. *What is the biggest danger?*

Writing Activity: Quick Write

Roof assembly includes laying out the rafters, erecting the ridge board, and erecting the rafters. Each step is usually done by two or more carpenters. Write a paragraph describing why you think most steps in roof assembly would require more than one person.

Chapter 19 Reading Guide

Before You Read Preview

Scan the section headings, subheadings, and illustrations in this chapter. Write a question that you expect to be answered within the chapter. When you find the answer to that question, write it down.

Content Vocabulary

- ridge
- ridge beam
- collar tie
- purlin
- brace
- common difference
- eaves
- cornice
- fascia
- soffit
- lookout
- rake

Academic Vocabulary

You will find these words in your reading and on your tests. Use the academic vocabulary glossary to look up their definitions if necessary.

- intermediate
- suspended
- version

Graphic Organizer

As you read, use a chart like the one shown to organize the steps in roof assembly and details about each step, adding rows as needed.

Steps in Roof Assembly	Details
Step 1:	
Step 2:	
Step 3:	
Step 4:	

Go to **glencoe.com** for this book's OLC for a downloadable version of this graphic organizer.

Academic Standards

Mathematics

Number and Operations: Understand numbers, ways of representing numbers, relationships among numbers, and number systems (NCTM)

Geometry: Use visualization, spatial reasoning, and geometric modeling to solve problems (NCTM)

English Language Arts

Use information resources to gather information and create and communicate knowledge (NCTE 8)

Conduct research and gather, evaluate, and synthesize data to communicate discoveries (NCTE 7)

Science

Science and Technology: Understandings about science and technology (NSES)

Science as Inquiry: Abilities necessary to do scientific inquiry (NSES)

Industry Standards

Roof Framing

Roofing Applications

Truss Installation

NCTE National Council of Teachers of English

NCTM National Council of Teachers of Mathematics

NSES National Science Education Standards

Section 19.1

Ridges

Types of Ridges

How would a roof's strength change if it had no ridge?

A **ridge** is a roof framing member placed at the intersection of two upward-sloping surfaces. Carpenters may install a ridge in various ways. In most cases they will cut the rafters first. Laying out and cutting common rafters is discussed in Chapter 17.

There are two basic types of ridges: nonstructural and structural. The type of ridge is indicated on the building plans. A *nonstructural ridge* does not support the weight of the rafters or the roof. In fact, it is the rafter system that holds a non-structural ridge in place. This ridge serves as a bearing surface for the top ends of the rafters and helps to tie them into a rigid structure. In contrast, a *structural ridge* actually supports some of the weight of the roof system. The loads it carries must be transferred to the foundation, either by structural posts or by bearing walls.

The framing member that forms a nonstructural ridge is called a *ridge board.* This type of ridge is the most common. It is usually made of nominal 2" lumber that is slightly wider than the rafter stock. For example, the ridge board for a roof framed with 2×8 rafters would be a 2×10. The extra width ensures that angled cuts at the ends of the rafters will bear fully on the ridge board, as shown in **Figure 19-1**. However, code also allows nominal 1" lumber to be used as a ridge board. A ridge board can also be made from a continuous length of LVL stock. In any case, the thickness of the ridge stock must be accounted for when calculating the actual length of the rafters.

The framing member that forms a structural ridge is called a **ridge beam**. A ridge beam is made from LVL, glue-laminated lumber, or nominal 4" lumber. The rafters rest on top of the ridge beam or are supported by metal brackets or hangers nailed to its side, as shown in **Figure 19-2**. The ends of the ridge beam are supported by posts or bearing walls. **Intermediate** support posts may also be needed. A structural ridge is commonly used when framing low-pitched or shed roofs or when the house is framed using posts and beams (see Chapter 14).

Whether installing a structural or non-structural ridge, the stock should be as long and straight as possible. If the ridge is bowed, twisted, or warped, this will create a lot of extra work for the roof framing crew. When a lumber ridge board is used, it can

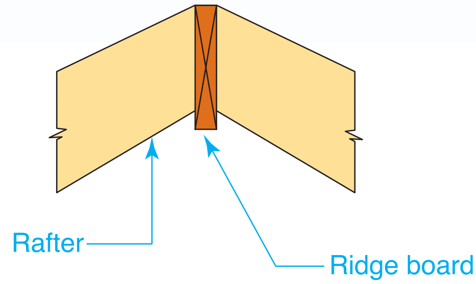


Figure 19-1 Ridge Board
One Size Up A ridge board must be wider than the rafters that support it.

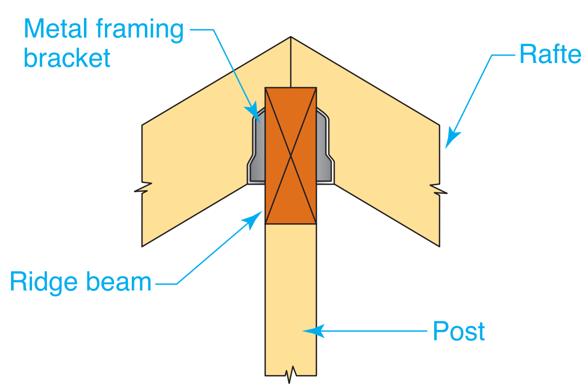


Figure 19-2 Ridge Beam
Two Options A ridge beam supports rafters. They rest on top of the ridge or are notched to fit over it.

be the same grade of lumber as the rafters. An LVL ridge board is used when the roof is framed with engineered lumber. Seams between lengths of ridge board should occur only between opposing pairs of rafters. Seams between lengths of ridge beam should occur only over support posts.

Reading Check

Contrast *What is the difference between a nonstructural ridge and a structural ridge?*

Calculating Ridge Length

How do you determine ridge length?

The following text refers to solid-lumber ridge boards. However, the information also applies to engineered-lumber ridge boards and ridge beams.

Gable Roofs

Calculating the length of the ridge board for a gable main roof is easy. The theoretical length of the ridge board (or ridge beam) is equal to the length of the building, measured to the outside edge of the wall framing. The actual length of the ridge board includes any overhang.

Hip Roofs

For a main hip roof, the ridge board layout requires calculations. In an equal-pitch hip roof, the theoretical length of the ridge board amounts to the length of the building minus twice the total run of a main roof common rafter. The actual length depends on the way in which the hip rafters are framed to the ridge.

The theoretical ends of the ridge board are at the points where the ridge centerline and the hip rafter centerline cross. If the hip rafter is framed against the ridge board, the actual length of the ridge board exceeds the theoretical length, at each end, by one-half the thickness of the ridge board plus one-half the 45° thickness of the hip rafter, as in **Figure 19-3**. If the hip rafter is framed between the common rafters, the actual length of the ridge board exceeds the theoretical length, at each end, by one-half the thickness of a common rafter.

Builder's Tip

ADVANCED CARPENTRY SKILLS Framing a complex roof is the most challenging task in rough carpentry. Learning the skills required to do this work calls for determination and patience. Even master framers do not get every cut perfect every time. Pieces sometimes have to be trimmed to fit, or even recut.

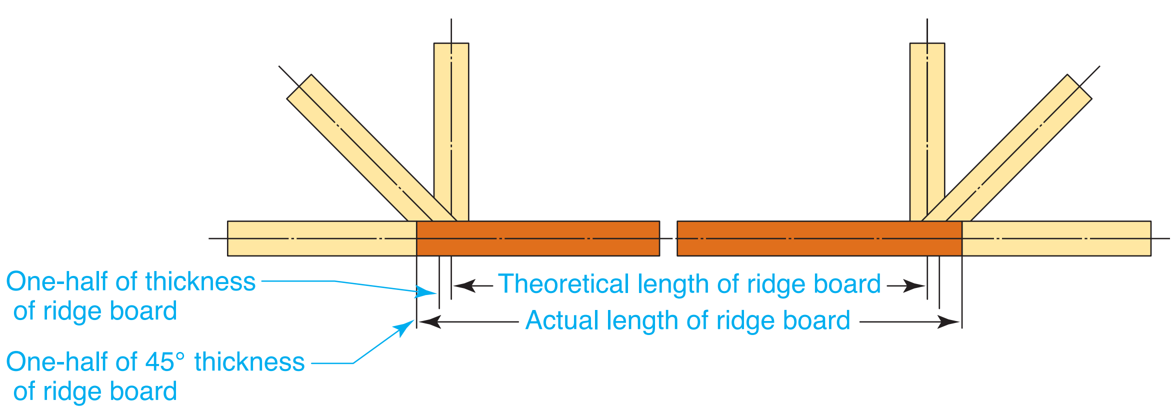


Figure 19-3 Ridge Board Length

Against the Ridge Theoretical and actual lengths of a hip roof ridge board. In this case the hip rafter is framed against the ridge.

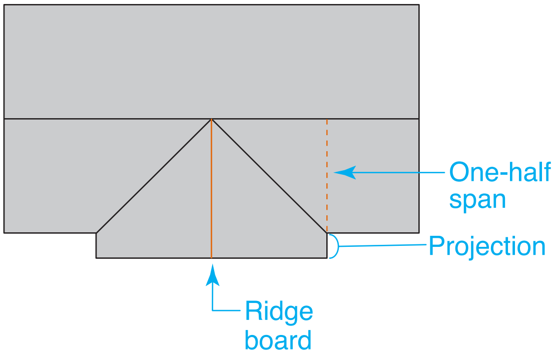


Figure 19-4 Equal Span
Note Shortening Allowance Determining the length of a ridge board for an equal-span addition.

Builder's Tip

VERIFYING DIMENSIONS The length of the ridge board or ridge beam can be taken from the building plans. However, a carpenter should always confirm this dimension by measuring the actual framing. This will account for any minor differences between the house as planned and the house as built.

Equal-Span Additions

For an equal-span addition, the length of the ridge board is equal to the distance that the addition projects beyond the building, plus one-half the span of the building, minus the shortening allowance at the main-roof ridge. This is shown in **Figure 19-4**. The *shortening allowance* accounts for the thickness of the main-roof ridge board when determining the length of an intersecting ridge. It is different for different framing situations. For an equal-span addition, it equals one-half the thickness of the main-roof ridge board.

Reading Check

Explain *How is the length of the ridge board for a gable main roof calculated?*

Unequal-Span Additions

When the width of an addition is less than the width of the main portion of the house, their roof spans are unequal. The length of the ridge board for an unequal-span addition varies with the method of framing the ridge board. If the addition ridge board is **suspended** from the main roof ridge board, the length is equal to the distance the addition projects beyond the building, plus one-half the span of the main roof.

If the addition ridge board is framed by the long-and-short-valley-rafter method (see Addition Roofs on page 536), its length is equal to the distance the addition projects beyond the building, plus one-half the span of the addition, minus a shortening allowance. This is shown in **Figure 19-5**. In this case, the shortening allowance is one-half the 45° thickness of the long valley rafter.

If the addition ridge board is framed to a double header set between a pair of doubled main-roof common rafters, the length of the ridge board is equal to the distance the addition projects beyond the building, plus one-half the span of the addition, minus a shortening allowance. This shortening allowance is one-half the thickness of the inner member of the double header.

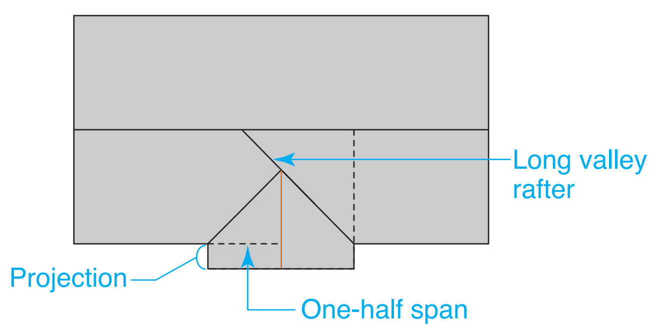


Figure 19-5 Unequal Span
Long Valley Determining the length of a ridge board for an unequal-span addition.

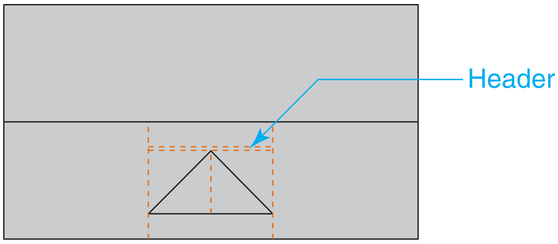


Figure 19-6 Dormer Without Side Walls
Header Determining the length of a ridge board on a dormer without side walls.

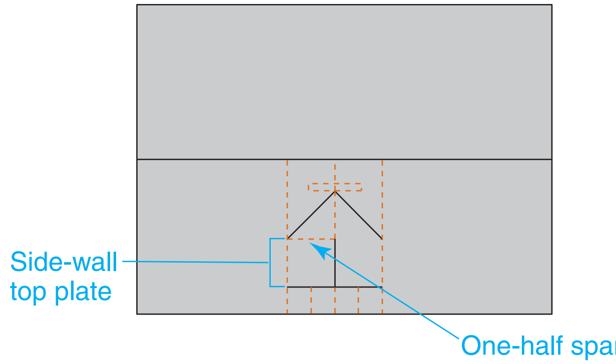


Figure 19-7 Dormer With Side Walls
Top Plate Determining the length of the ridge board on a dormer with side walls.

Dormers

The length of the ridge board on a dormer without side walls is equal to one-half the span of the dormer, minus a shortening allowance. The shortening allowance is one-half the thickness of the inner member of the upper double header, as shown in **Figure 19-6**.

The length of the ridge board on a dormer with side walls is equal to the length of the dormer side-wall top plate, plus one-half the span of the dormer, minus a shortening allowance. The shortening allowance is one-half the thickness of the inner member of the upper double header, as shown in **Figure 19-7**.

Mathematics: Measurement

Ridge Board Length What is the length of a ridge board on a 12' dormer without sidewalls and a 2" shortening allowance?

Starting Hint Draw a diagram as in Figure 19-6 to help you visualize the measurements.

Section 19.1 Assessment

After You Read: Self-Check

1. What is the difference between a ridge board and a ridge beam?
2. Why must a ridge board be wider than the rafters?
3. Based on what you have read, why is the ridge board for a hip roof shorter in length than the ridge board for a gable roof?
4. How do you calculate the length of the ridge board for an equal-span addition?

Academic Integration: English Language Arts

5. **Length of a Ridge Board** The length of the ridge board on a dormer without a sidewall is different than the length of the ridge board on a similar dormer with sidewalls. Write a paragraph explaining why there is a difference in length.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 19.2

Roof Assembly

Roof Assembly Steps

Who does roof assembly?

Roof assembly includes laying out the rafters, erecting the ridge board, and erecting the rafters. This is generally a job for two or more carpenters and at least one helper. The order of steps may vary, depending on the type and complexity of the roof. However, work generally proceeds in this order:

1. Install the common rafters and ridge boards.
2. Install hip and valley rafters, if any.
3. Install jack rafters, if any.
4. Frame special items such as gable ends and roof openings.
5. Install roof sheathing.

Laying Out Rafter Locations

Where can rafter spacing be found?

Laying out the locations of common rafters is much like laying out the locations of floor joists. However, other roof members may make the layout more complex.

The rafter spacing on the wall plates and ridge board is found on either the building plans or the roof framing plan (see Chapter 17). Rafter locations are laid out on plates, the ridge board, and other rafters with the same lines and *X*s used to lay out stud and joist locations (see Chapter 16).

In some cases all the rafters are located next to the ceiling joists. The rafters can then be fastened to the side of the joists as well as to the plate in order to tie the building together. In most cases, however, some rafters will be next to joists and others will rest between the joists. This is because the on-center spacing of the joists is often different from the on-center spacing of the rafters.

Gable Roofs

For a gable roof, lay out the rafter locations on the top plates first. Transfer the locations to the ridge board by laying the ridge board on edge against a top plate and matching the marks, as shown in **Figure 19-8**.

The first rafters on each end are usually set even with the outside wall to provide a smooth, unbroken surface for the wall sheathing. Because the first ceiling joist is along the inside edge of the exterior wall, place a spacer block between the first rafter and the first ceiling joist as shown in **Figure 19-9**. Fasten the other rafters to the side of the joists along the length of the building.

If the rafters are on 24" centers and the ceiling joists are on 16" centers, place the first rafter as shown in Figure 19-9. The second rafter will rest on the plate between the second and third joists. Nail the third rafter to the side of the fourth joist. The rafters will continue to alternate in this fashion along the length of the building as shown in **Figure 19-10**.

Sometimes the rafters and the ceiling joists will have the same on-center spacing.

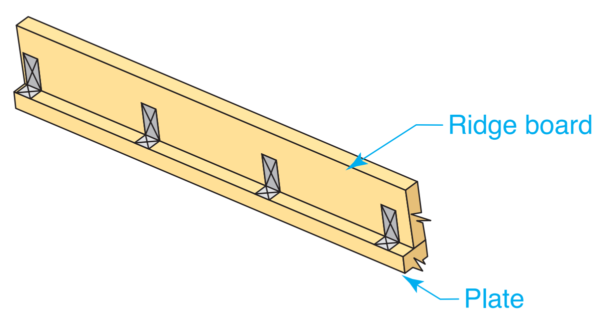


Figure 19-8 Ridge Board Layout

Transfer the Layout Lay the ridge board on edge on the top plate and extend the layout lines from the plate onto the ridge board.

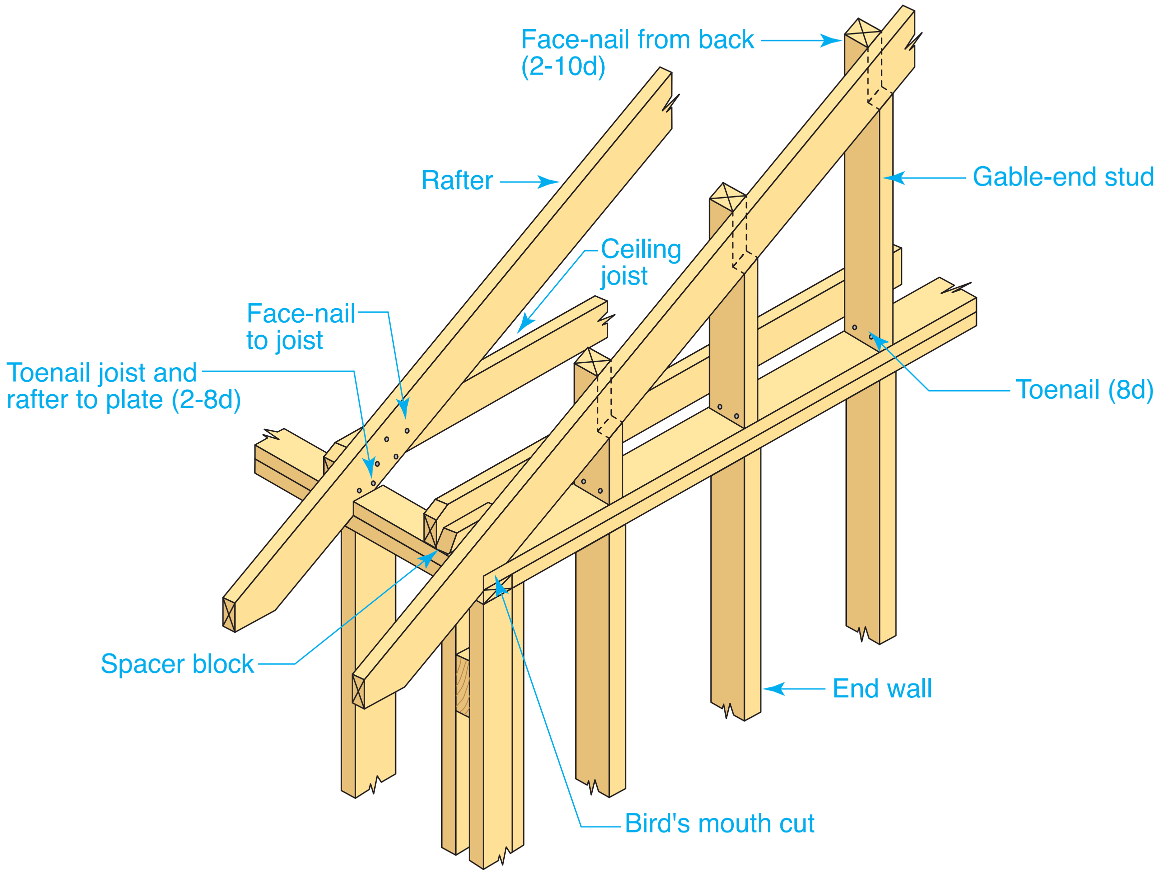


Figure 19-9 Rafter Positions

Gable End Details Note the spacer block. Sometimes the gable-end studs are cut all the way across, rather than notched. The gable-end studs are then toenailed to the rafter.

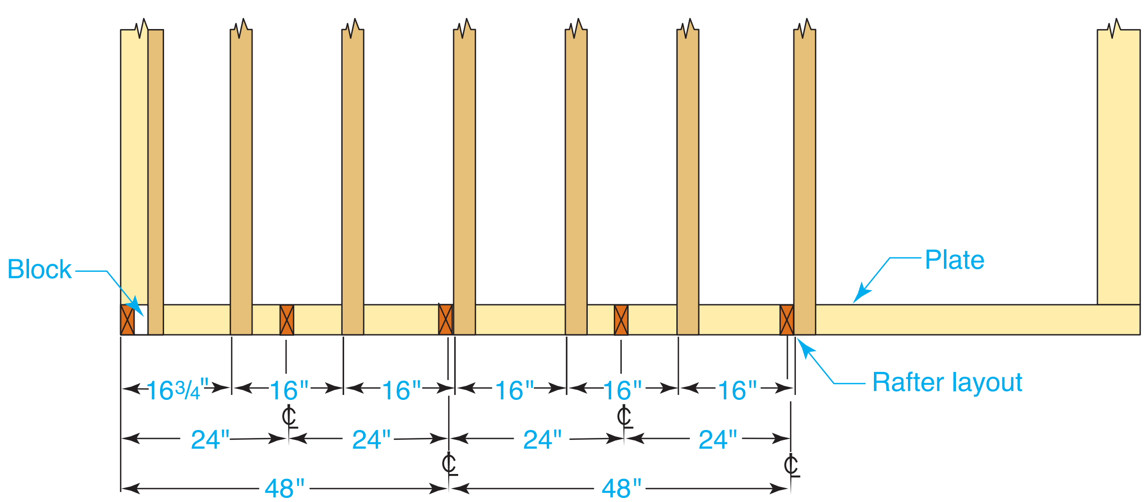


Figure 19-10 Alternating Spacing

Rafters and Joists Layout of a building with the rafters on 24" centers and the ceiling joists on 16" centers.

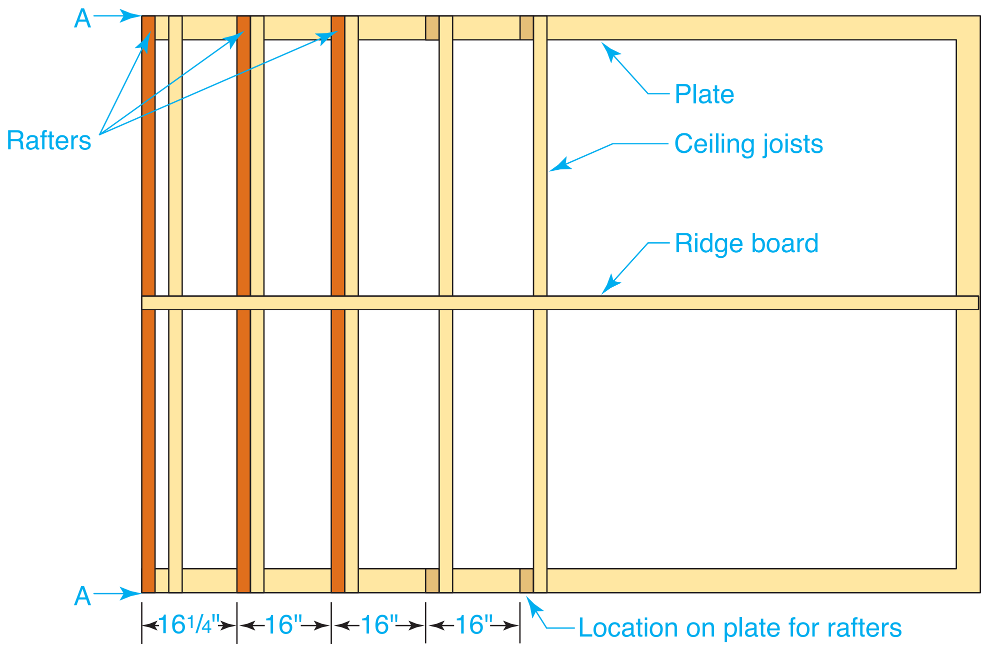


Figure 19-11 Matching Spacing

Accuracy Improves Always begin the layout of opposing rafters from the same end of the building. In this drawing, the layout for each phase began at arrow A on the same side wall.

In that case, the layout would be as shown in **Figure 19-11**. In any case, always begin the rafter layout for opposing plates from the same end of the building. This will ensure that the rafters butt against the ridge board directly opposite each other.

Hip Roofs

The ridge-end common rafters in an equal-pitch hip roof are located inward from the building corners at a distance equal to one-half the span (or the run of a main-roof common rafter). See **Figure 19-12**. The locations of these ridge-end rafters and the common rafters lying between them can be transferred to the ridge board by matching the ridge board against the top plates.

Addition Roofs

An addition complicates the process of laying out the locations of the rafters and ridges. Study the following drawings carefully.

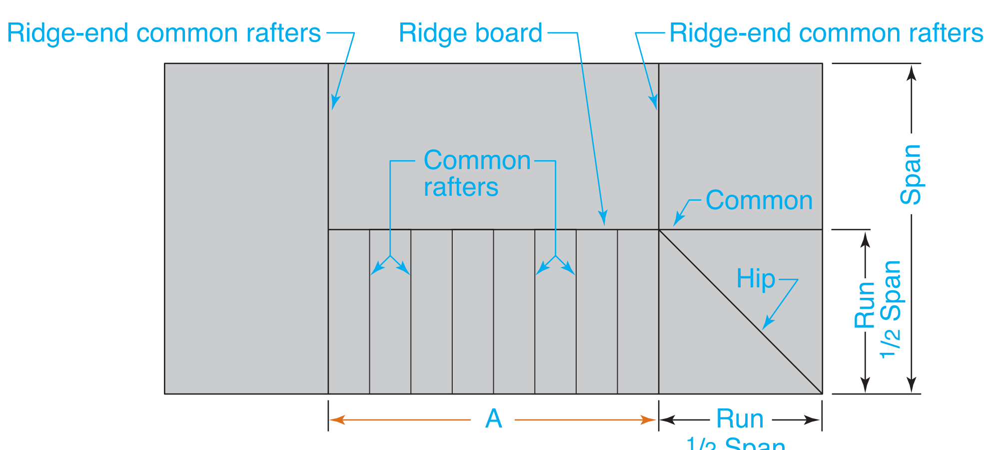


Figure 19-12 Ridge-End Rafters

Transfer the Layout The locations of the rafters in area A are transferred to the ridge board from the top plate.

Equal Spans For an equal-span addition, mark the main ridge board to indicate where it will be intersected by the addition ridge board. The top ends of the addition's valley rafters will rest on either side of this location. In **Figure 19-13**, the distance between the end of the main-roof ridge board and the point where it intersects the addition ridge board is equal to distance A plus distance B (distance B equals one-half the span of the addition). In **Figure 19-14**, the distance between the theoretical end of the main-roof ridge board and the point where it intersects the addition ridge board is the same as distance A.

Unequal Spans If framing is by the long-and-short-valley-rafter method, the distance from the end of the main-roof ridge board to the upper end of the longer valley rafter is equal to distance A plus distance B (distance B is one-half the span of the main roof). See **Figure 19-15**.

The intersection of the shorter valley rafter and the longer valley rafter can be located in the following way. Obtain the unit length of the longer valley rafter from the rafter table on the framing square shown in **Figure 19-16**. For example, suppose that the common rafter unit rise is 8". In that case, the unit length of a valley rafter is 18.76".

The total run of the longer valley rafter is the hypotenuse of a right triangle. The shorter sides of this triangle are each equal to the total run of a common rafter in the addition. The total run of a common rafter in the addition is one-half the span. If the addition is 20' wide, the run of a common rafter would be 10'. Refer to distance C in Figure 19-15.

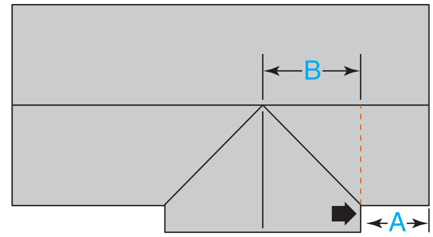


Figure 19-13 Gable Roof Addition
Mark the Intersection Ridge board location for an equal-span addition on a gable roof.

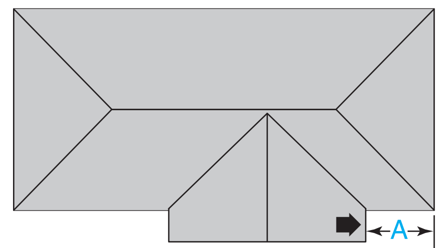


Figure 19-14 Hip Roof Addition
Check the Distance Ridge board location for an equal-span addition on a hip roof.

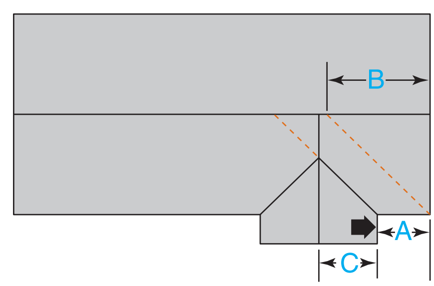


Figure 19-15 Unequal Span Addition
Long and Short Valleys Ridge board and valley rafter locations for an unequal-span addition.

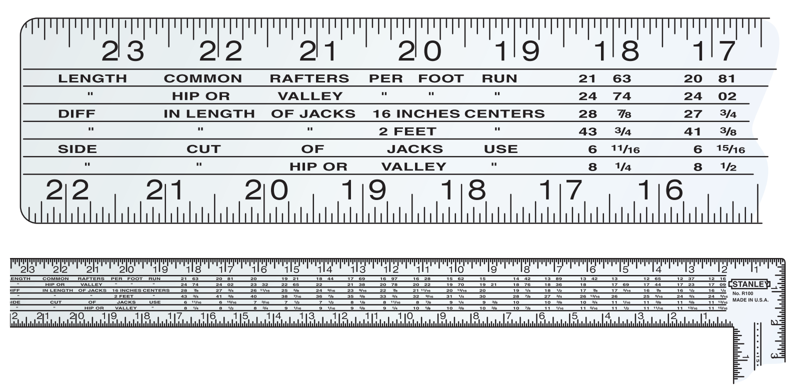


Figure 19-16 Framing Square
Useful Table To find the unit length of the longer valley rafter, check the rafter table on the face of the framing square.

The valley rafter in our example is 18.76" long for every foot of common rafter run. The point where the inboard end of the shorter valley rafter intersects the longer valley rafter can be calculated as follows: 18.76 (in. per ft. of run) $\times$ 10 (ft. of run) = 187.6" 187.6" = 15.63' (15' 7 9/16"). This is the distance from the heel plumb cut line of the longer valley rafter to the intersecting point.

Assembling the Ridge

Why must the ridge be straight and level?

Many carpenters raise the ridge board and the gable-end rafters all at one time because the members support one another. Other carpenters prefer to put the ridge board in place before raising any rafters. To do this they support it with temporary framing, as shown in **Figure 19-17**. The framing rests on any partition top plates that are handy. The ridge board should also be braced along its length to prevent it from swaying.

Reading Check

Recall *Name two strategies used by carpenters for placing the ridge board.*

Raising the Rafters

What weather would make rafter installation hazardous?

Depending on the type and height of the roof, you may have to install the rafters while working from scaffolding. The scaffold planking should not be less than 4' below the level of the ridge board. In some cases, it may be possible to work from ladders instead. (See Chapter 7 for ladder safety guidelines.)

If the building has an addition, frame as much of the main roof as possible before starting the addition roof framing. All types of jack rafters are usually left until after the headers, hip rafters, valley rafters, and related ridge boards have been installed.

The following text describes standard assembly techniques. Other techniques may be required in areas of the country exposed to unusually high winds and seismic activity. In these areas, local building codes often require the addition of special metal anchors, straps and hold-downs to connect the roof framing to the wall framing. These anchors must be installed with care. Follow all code requirements regarding the type, spacing, and number of nails used to secure these devices.

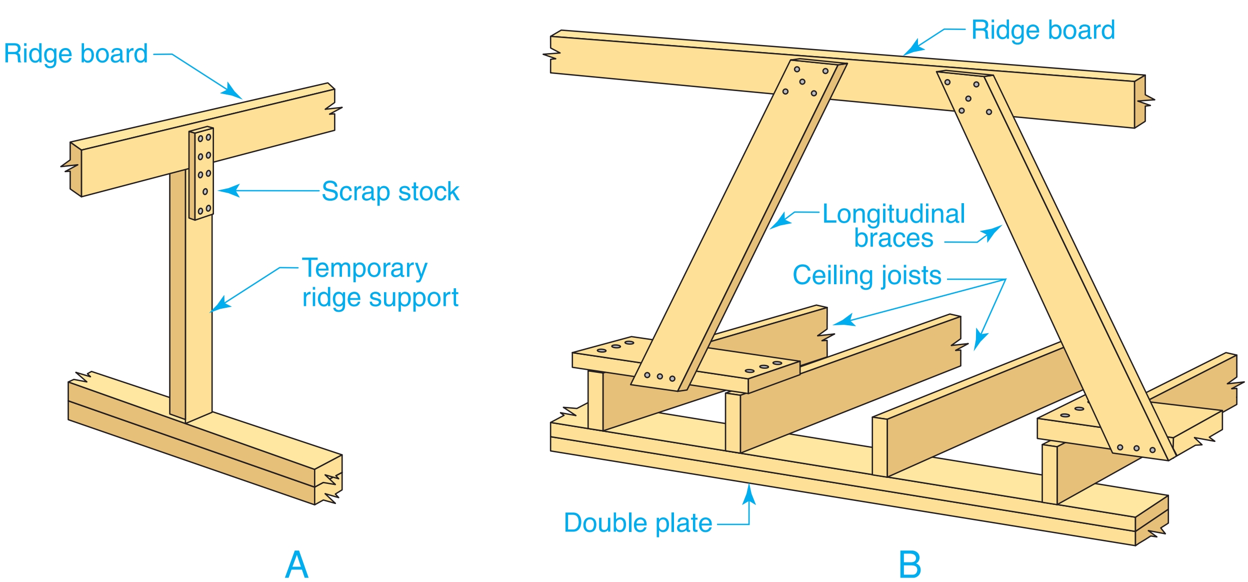


Figure 19-17 Ridge Supports

Temporary Support A. An upright (leg) supports the ridge board in position for erecting the rafters. **B.** Brace the ridge board as needed along its length.

Gable Roofs

For a gable roof, the two pairs of gable-end rafters and the ridge board are usually erected first. Two people, one at each end of the building, hold the ridge board in position. Meanwhile, a third person sets the gable-end rafters in place and toenails them at the top plate with 8d nails, two on one side and one on the other side. Nailing at the plate first prevents the rafter from slipping out of position as the ridge is being installed. Make certain the heel (plumb) cut of the bird's mouth is tight against the side of the building when the rafter is nailed at the plate. Otherwise, the ridge will not be set at the correct height.

The ridge board is then secured to one of the rafters with three 16d nails driven through the ridge board and into the end of the rafter, as shown in **Figure 19-18**. The opposing rafter is toe-nailed to the ridge board with four 16d nails, two on each side of the rafter. If the ridge board has not been previously erected and braced, temporary braces like those for a wall should be installed at the ridge ends. These will prevent the rafters from tipping from side to side. Ceiling-joist ends are nailed to adjacent rafters with three 10d nails, two to each side. Nailing continues in this fashion until all the rafters are in place.

Hip Roofs

On a hip roof, first install the ridge board and the common rafters extending from the ridge ends to the side walls. This is done in about the same manner as for a gable roof. Then fill in the intermediate common rafters.

Next, install each common rafter that extends from the ridge end to the midpoint on the end wall. Do this for both end walls. These rafters are sometimes referred to as end rafters. Finally, install the hip rafters and hip jacks.

The common rafters in a hip roof do not have to be plumbed. If the hip rafters are correctly cut, installing the hip rafters and the common rafter that projects from the end of the ridge board to the end wall will make the common rafters plumb.

Toenail hip rafters to the plate with 10d nails, two to each side. At the ridge board, toenail hip rafters with four 8d nails. After the hip rafters are fastened in place, drive a nail partway into the top edge of the hip rafter at the ridge end and at the plate end. Pull a string taut between the nails as the hip jacks are nailed to the hip rafter. Keep it centered on the top edge of the hip rafter. This allows you to see if the hip rafter is being pushed out of alignment by the jacks and ensures a straight hip line.

The hip jacks should be nailed in pairs, one opposite the other. Do not nail all the jacks on one side of the hip first. This would push the hip out of alignment and cause it to bow. Toenail hip jacks to hip rafters with l0d nails, three to each jack, and to the plate with 10d nails, two to each side.

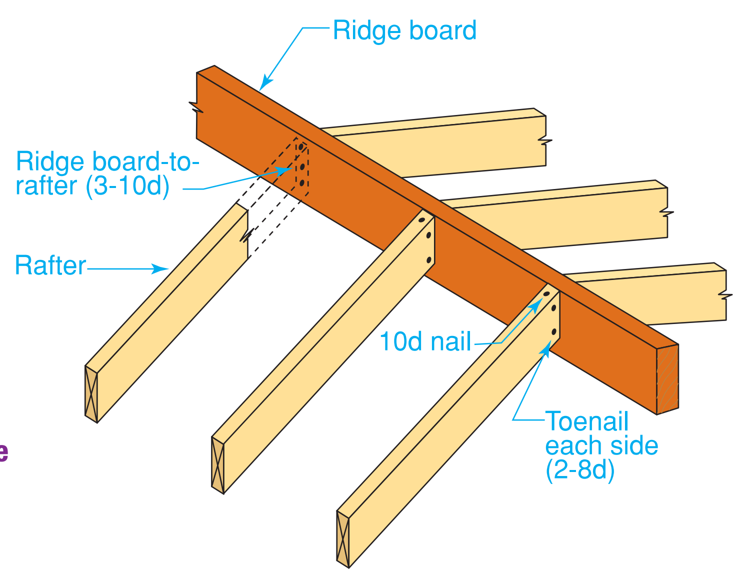


Figure 19-18 Nailing Rafters to the Ridge

The First Rafters Help Once the first pairs of rafters are nailed to the ridge board, the remaining rafters will be easier to position.

Estimating and Planning

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Roofing Framing Materials

Estimating Materials

Estimating lumber and nails for a roof can be done in several ways.

Method 1

The number of rafters needed may be counted directly from the roof framing plan. For a gable roof, the number may also be estimated as follows:

Step 1 For rafters on 16" centers, take three-fourths of the building's length in feet, add one for the end rafter, and then double this figure. For example, if a rectangular building is 40' long, 31 rafters will be required for each of the longer sides:

$$\tfrac{3}{4} \times 40 = 30$$
$$30 + 1 = 31$$
$$31 \times 2 = 62$$

A total of 62 rafters would be needed.

Step 2 Add to this amount extra rafters for the required trimmers and any other special framing. An accurate cost estimate can then be figured by multiplying the number of rafters required by the cost per rafter.

Method 2

Sometimes a builder does not make up a complete bill of materials and needs only a rough cost estimate. This method will give an approximate cost for materials.

Step 1 Find the area of the roof. The area is the length times the width of each roof plane. Add the areas of each roof plane to find the total area of the roof.

Step 2 Refer to the table to determine the number of board feet needed for rafters, ridge board, and collar ties. For example, if the rafters are 2×6 spaced 16" OC, 102 bd. ft. of lumber are needed for each 100 sq. ft. of roof surface area.

Step 3 Divide the total roof area by 100 and multiply by the factor in the table. For our example:

$$867 \div 100 = 8.67$$
$$8.67 \times 102 = 884.3 \text{ bd. ft.}$$

Step 4 Multiply this figure by the cost of the lumber per board foot to find the total cost of lumber for the roof.

Step 5 The table can also be used to determine the number of nails needed. For the roof in the example, 12 lbs. of nails are needed for each 1,000 bd. ft. Since the roof in the example has only about 884 bd. ft., it will require about 10½ lbs. of nails:

$$884 \div 1{,}000 = 0.884$$
$$0.884 \times 12 = 10.6 \text{ or } 10\tfrac{1}{2} \text{ lbs. of nails}$$

Step 6 The cost of nails for roof framing is determined by multiplying the number of pounds needed by the cost per pound.

Estimating on the Job

Using Method 2, estimate the board feet and pounds of nails needed for a roof that measures 22' wide and 37' long and has a rise of 6". There is no overhang, and 2×8 rafters will be placed 16" OC.

Estimating Materials and Labor for Roof Framing

	MATERIALS				LABOR
	Board Feet Required for 100 Square Feet of Surface Area			Nails per 1,000 Board Feet	Board Feet per Hour
Rafters	12" OC	16" OC	24" OC		
2×4	89	71	53	17	Common-35
2×6	129	102	75	12	Hip-35
2×8	171	134	112	9	Jack-25
2×10	212	197	121	7	Valley-35
2×12	252	197	143	6	Ridge-35
					Collar-65

Note: Includes common rafters, hip and valley rafters, ridge boards, and collar ties.

Additions and Dormers

When there is an addition or dormer, the valley rafters are usually erected first. Toenail them to ridge boards and headers with three 10d nails. Install the ridge boards and ridge-end common rafters next. Then install the other addition common rafters and, last, the valley and cripple jacks. As with hip rafters, pull a string along the top edge of the valley rafter and nail the jacks in pairs. A valley jack calls for special attention as it is being nailed. When the jack has been properly positioned, the end of a straightedge laid along its top edge should contact the centerline of the valley rafter, as shown in **Figure 19-19**.

Using Roof Framing Brackets

Metal brackets such as the ones in **Figure 19-20** may be used to attach common rafters to the plate. In parts of the country that are regularly exposed to high winds, the lower rafter brackets should extend from the rafter and connect to a wall stud wherever possible. This strengthens the connection between the roof system and the walls.

When using certain types of roof framing brackets, it is sometimes helpful to install them on the ridge board before it is lifted into place. This technique is also suitable when a ridge beam is being used. Brackets may be attached to the wall plates as well before the rafters are lifted into place. However, care must be taken not to bend or otherwise damage the brackets. Also, protect your hands. The edges of metal brackets can be sharp.

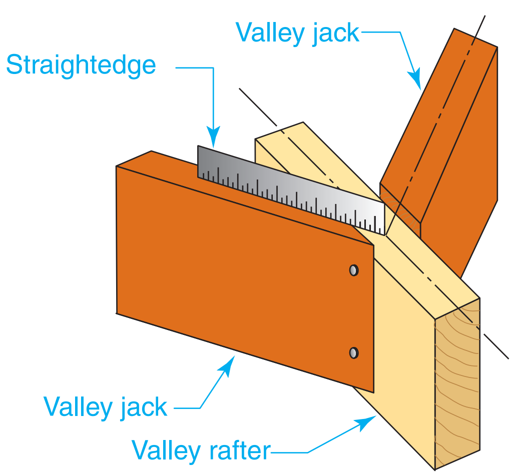


Figure 19-19 Aligning the Jacks

Align to the Centerline Correct position for nailing a valley jack rafter.

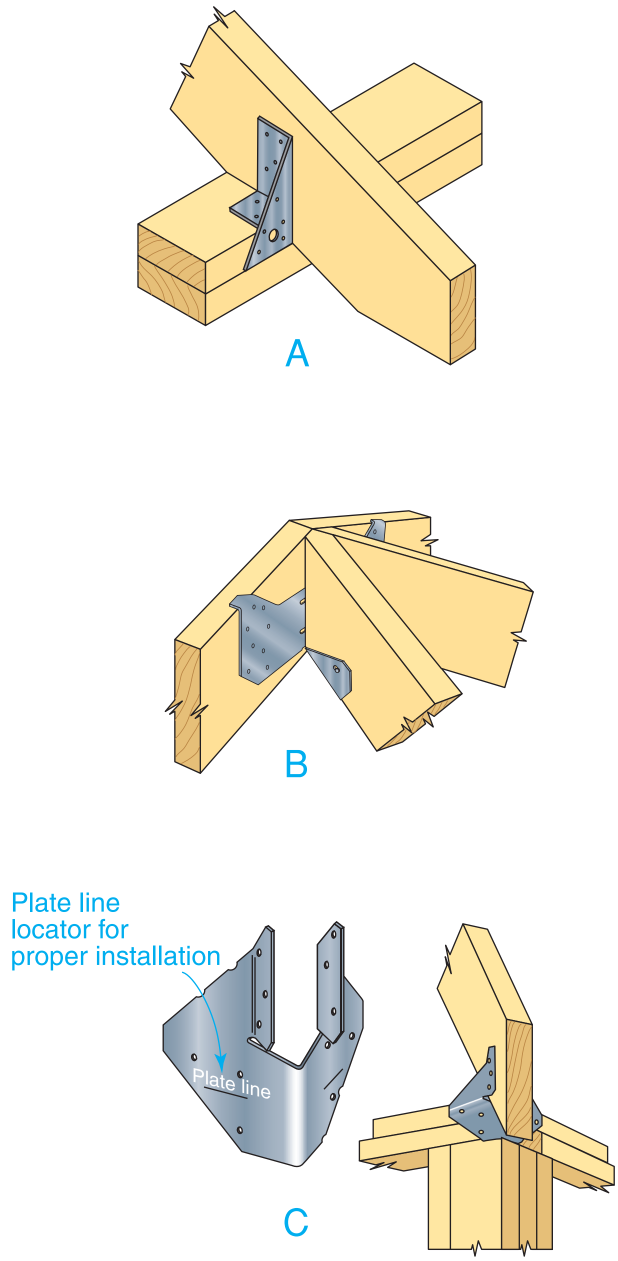


Figure 19-20 Roof Framing Brackets

Strong Connections Metal brackets are often used to secure the rafters and are available in many shapes. **A.** A simple rafter bracket. **B.** An adjustable-pitch bracket. **C.** A bracket to anchor the end of a hip rafter.

Section 19.2 Assessment

After You Read: Self-Check

1. Describe the procedure for laying out rafter locations for a gable roof.
2. When nailing common rafters in place in a gable roof, why must the rafter be nailed at the plate first?
3. How should the ends of the ceiling joists be connected to the rafters in a gable roof?
4. Why must hip jack rafters be installed in pairs?

Academic Integration: Mathematics

5. **Converting Fractions to Decimals** Estimate the number of rafters on 16" centers needed for a gable roof on a rectangular building measuring 48' long.

   Math Concept It is often easier to perform mathematical operations if you convert fractions to decimals. Memorize the decimal equivalents of common fractions, such as ¾ = 0.75.

   Step 1: Figure ¾ the building's length in feet.

   Step 2: Add one for the end rafter.

   Step 3: Multiply by two to get the total number of rafters that will be needed.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 19.3 Special Framing Details

Collar Ties

What is a collar tie used for?

Rafters in a gable roof are sometimes reinforced by collar ties. A **collar tie** is a horizontal framing member that prevents opposing rafter pairs from spreading apart. It also prevents the rafters from bowing inward when weight is placed upon them. In a finished attic, collar ties may also support the ceiling surfaces where the ceiling joists have been omitted, or where ceiling joists run perpendicular to the rafters. When ceiling joists tie opposite walls together, collar ties may not be required.

If the collar ties will support a ceiling, they should be installed at every rafter pair. Otherwise, attach a collar tie to every fourth rafter pair if the spacing is 16" OC and every third rafter pair if the spacing is 24" OC. Local codes may require a closer spacing.

Collar-Tie Length

A collar tie may be made of nominal 1" or 2" thick lumber. Check the building plans for the specified dimensions. The length of a collar tie can be found either by calculation or by measurement.

Calculation Method This method is used when collar tie framing must be done at a precise

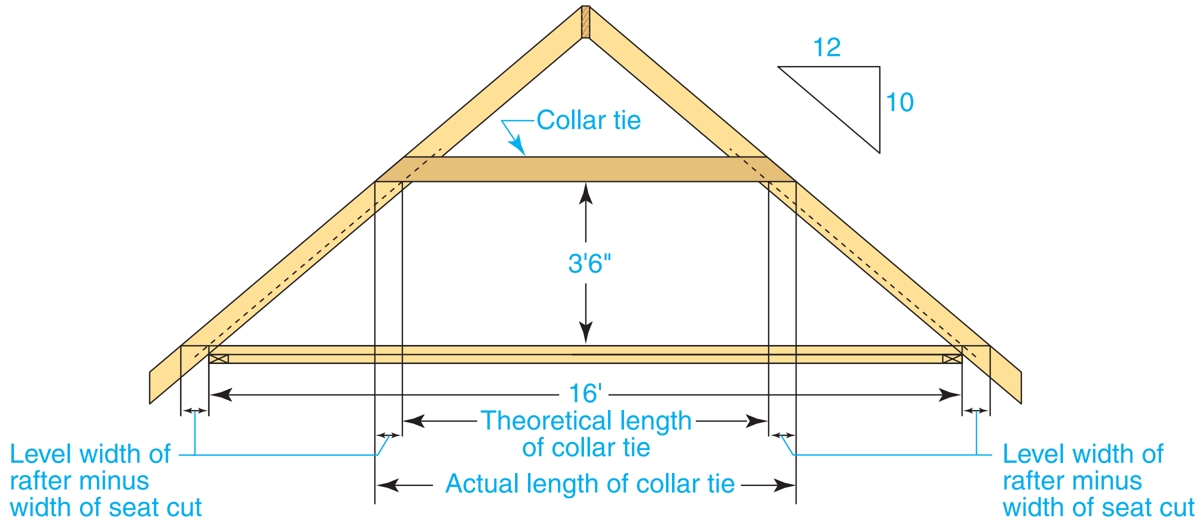


Figure 19-21 Calculating Rafter Tie Length
Find the Height Laying out a collar tie based on calculations.

height. This is often the case when the collar ties will form the base for a finished ceiling surface. The length of a collar tie can be calculated based on its distance above the level of the side-wall top plates. The theoretical length of a tie in feet is found by dividing this distance in inches by the unit rise of a common rafter and subtracting twice the result from the span of the building.

In the roof shown in **Figure 19-21**, the collar tie is 3'6" (42") above the top plate. The unit rise of a common rafter in the roof is 10". Forty-two divided by 10 is 4.2, and twice 4.2 is 8.4. This number is subtracted from the span of the building: 16 − 8.4 = 7.6', or about 7'–7³⁄₁₆". This is the theoretical length of the tie.

To bring the ends of the collar tie flush with the upper edges of the common rafters, you must add to the theoretical length of the tie, at each end, an amount equal to the level width of a rafter minus the width of the rafter seat cut. One way to obtain the level width is to hold a framing square on the rafter set to the pitch of the roof. You then draw a level line from edge to edge and measure the line's length.

Measurement Method Collar ties are sometimes used only for structural purposes. In such cases, the length of the collar tie can be easily determined by measuring. Simply measure between the rafters on a level line, starting from the height noted in the building plans. Cut one collar tie and check its fit before cutting all the collar ties to length.

After the overall length of a collar tie is determined, the ends must be cut to the pitch of the roof to prevent the tie from getting in the way of roof sheathing. Lay out the end cuts with a framing square set to the pitch of the roof, as shown in **Figure 19-22**. These cuts can be made with a circular saw, radial-arm saw, or slide-compound miter saw.

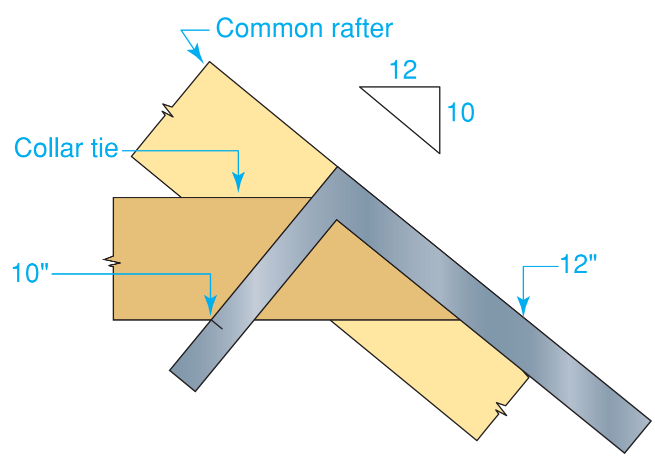


Figure 19-22 Cutting Rafter Tie Ends
Determine the Angle Laying out the end cut on a collar tie for a roof with a unit rise of 10".

Installing Collar Ties

Collar ties must be aligned during installation to ensure that their lower edges are in the same plane. First, snap a chalk line across the rafters on one side of the house, indicating the desired height of the top or bottom edge of the collar tie. Then install one tie at each end of the house by aligning one end to the chalk line and using a level to align the other end. Nail the ties into place. Now stretch a string tightly between the ties. Align the remaining ties to the chalked line and to the string. Nail nominal 1" collar ties to the common rafters with four 8d nails in each end. Nail nominal 2" collar ties with three 16d nails at each end.

Purlins, Braces, & Gable Ends

What does a purlin do?

Carpenters may have to install various types of framing to provide extra support for rafters. At each end of a gable roof, framing must be installed to close in the gable end and provide a nailing surface for sheathing.

Purlins and Braces

To span a greater distance, a rafter must have a greater depth. However, deeper rafters are not always desirable or available. A system of purlins and braces can be used instead, as shown in **Figure 19-23**. A **purlin** is a horizontal structural member that supports roof loads and transfers them to structural supports. A **brace** is a member used to stiffen or support a structure.

Purlins should be no smaller than the rafters they support. They must be continuous between braces. Braces should be at least 2×4 stock. They should connect to bearing walls at no less than a 45° angle. They should be no longer than 8" and be spaced not more than 4' OC. Braces should not be connected to non-bearing walls.

Gable Ends

Wall studs must be installed at each end of a gable to support sheathing. These studs rest on the top plate and extend to the rafter line. There are various ways to install them. In the case of a gable end with no overhang, as shown in **Figure 19-24**, the gable end studs are not load bearing framing members. The gable end rafters are self supporting and would carry the roof loads whether or not the studs were in place. When the gable end will have an overhang, as in **Figure 19-25**, the gable end must support roof loads. The studs must be capped with a wall plate.
In either case, gable-end studs should be installed like standard wall studs: one edge should be flush with the outside wall.

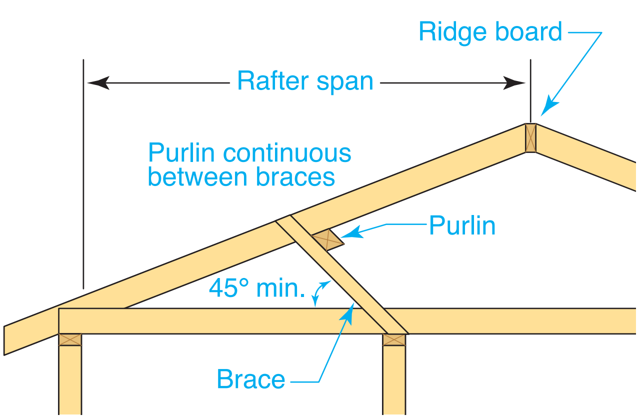


Figure 19-23 Purlin and Brace
Increasing Strength A system of purlins and braces can be used to provide additional support for rafters.

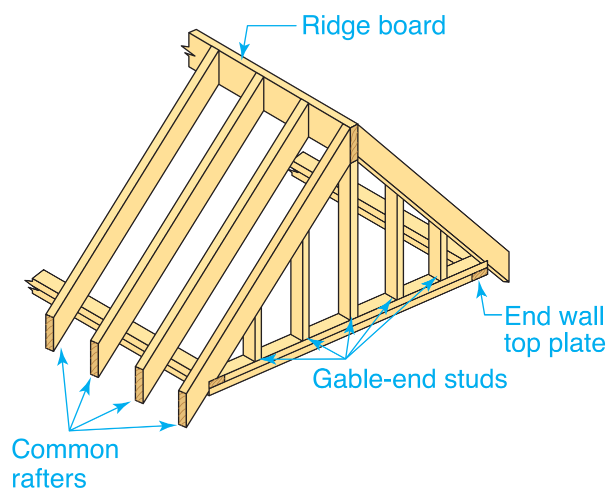


Figure 19-24 Non-Structural Gable End
Filler Studs The only purpose for these studs is to provide support for roof sheathing, so this is not a bearing wall.

Carpenters have different preferences for how the tops of non-structural gable-end studs connect to the gable-end rafters. Some notch the studs to fit around the rafters, as shown in **Figure 19-26A**. This allows the studs to be toenailed as well as face nailed to the rafter. Another approach is to bevel the top ends of the studs to fit the slope of the rafters, as in **Figure 19-26B**.

Layout and Installation To install studs of the type shown in Figure 19-26A, proceed as follows. Similar techniques, without the notch, can be used to lay out gable-end studs with a beveled end.

Locate the first gable-end stud by making a mark on the double plate directly above the wall stud nearest the ridge line (see arrow A in **Figure 19-27**). Plumb the gable-end stud on this mark. Mark the pitch of the roof across the edge of the stud (see arrow B).

Now determine the length of the stud. (It must not extend above the top edge of the rafter.) Cut the stud to length and notch it to a depth matching the thickness of the rafter (see arrow C). Toenail it into place with three 8d or two 16d nails at each end. As you nail the studs into place, take care not to force a crown into the rafter.

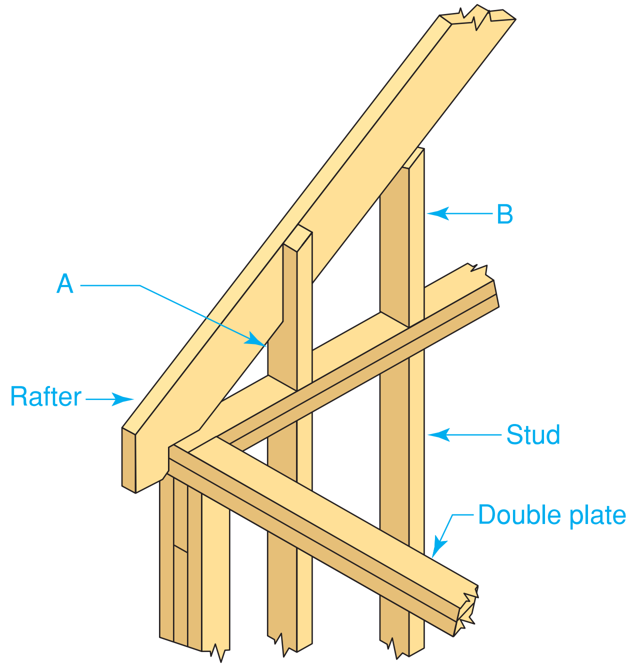


Figure 19-26 Gable-End Studs
Two Methods A. Some carpenters notch the studs to fit over the rafter. **B.** Others prefer to bevel the ends.

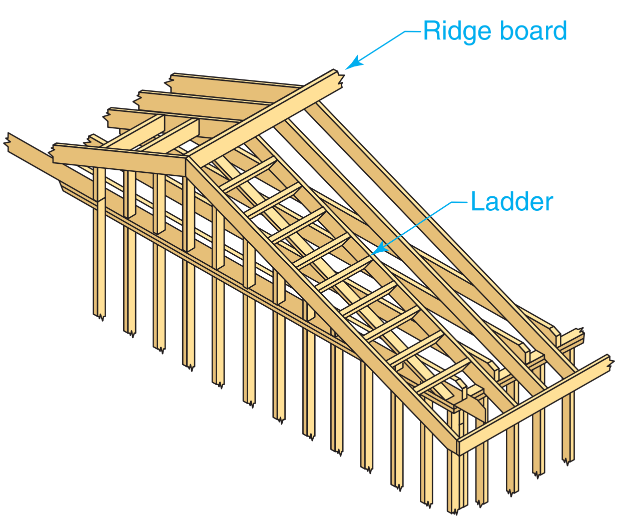


Figure 19-25 Structural Gable End
Bearing Studs These studs support roof loads, so the gable end is a bearing wall. They have the same spacing as studs in the wall below.

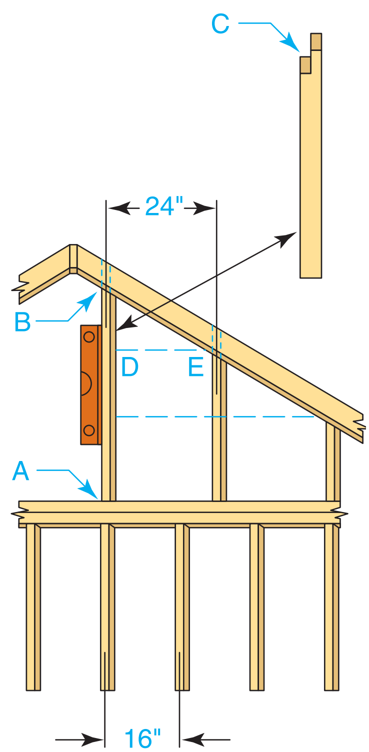


Figure 19-27 Gable-End Stud Layout
Making Them Fit Locating the gable-end studs and determining the common difference in length.

All remaining studs can be sized using this method. However, it is much easier to calculate stud lengths by using the common difference method. The basic calculation technique is the same, whether the studs are notched or just bevel cut.

Calculating the Common Difference

Gable-end studs have the same on-center spacing as standard wall studs. However, each stud is a different length than the studs on either side. Their differences in length are based on a single figure that depends on the pitch of the roof. This figure is called the **common difference**. After you have determined the length of the tallest gable-end stud, you can subtract the common difference to find the length of all the shorter gable-end studs. This is faster than making individual measurements for each stud.

The common difference is calculated using the unit run and unit rise. For example, to find the common difference in the length of gable-end studs placed 24" OC:

$$24" \div 12" \text{ (unit run)} = 2$$
$$2 \times 6" \text{ (unit rise)} = 12"$$

A common difference of 12" means that the second stud will be 12" shorter than the first (tallest) stud. The third stud will be 12" shorter than the second stud, and so on. If the studs are spaced 16" OC for the same roof, the common difference is 8":

$$16" \div 12" \text{ (unit run)} = 1.333$$
$$1.333 \times 6" \text{ (unit rise)} = 8"$$

Steps for finding the common difference using a framing square are given below.

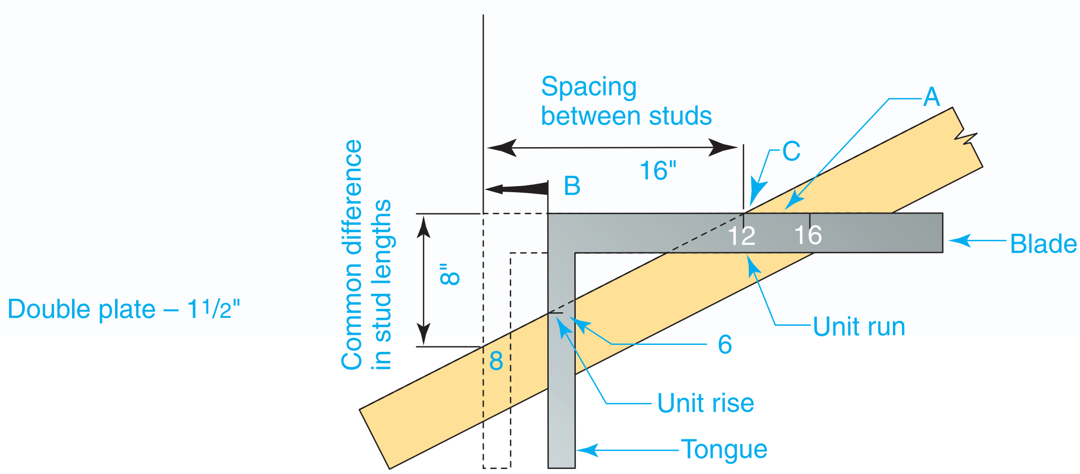
Step-by-Step Application

Figuring the Common Difference Using a Framing Square The common difference in the length of the gable-end studs may also be figured directly with the framing square.

Step 1 Place the framing square on the stud and set it to the unit rise and unit run of the roof (6 and 12 for this example). Draw a line along the blade at A, as shown in the figure below.

Step 2 Slide the blade along this line in the direction of the arrow at B until the spacing between the studs (16 for this example) is at the intersection (C) of the line drawn at A and the edge of the stud.

Step 3 Read the dimension on the tongue where it meets the same edge of the stud. This is the common difference (8" for this example) for the gable-end studs.



Go to **glencoe.com** for this book's OLC for additional step-by-step procedures, applications, and certification practice.

Roof Openings

What common features require roof openings?

Roof openings often interrupt the normal spacing or run of rafters. Openings may be required for a dormer, a chimney, or skylights. Roof openings, like floor openings, are framed by headers and trimmers as shown in **Figure 19-28**. Single or double headers are used at right angles to the rafters. The rafters are set into the headers in the same manner as joists around a floor opening. Just as trimmers are double joists in floor construction, they are double rafters in roof openings.

There are two ways to frame roof openings, as shown in **Figure 19-29** on page 548. The headers may be plumb, as shown in part A. This method is used to accommodate vertical objects that must pass through the framing, such as chimneys. In this method, the end of an intersecting rafter must be cut at an angle to fit against the header.

A second method is to keep the headers in the same plane as the surrounding roof framing, as shown in part B of Figure 19-29 on page 548. Such an opening is easier to install and is sometimes used for skylights. In this case, the end of an intersecting rafter must be cut square to fit against the header.

Reading Check

Contrast *What are the two methods for framing roof openings? How are they different?*

Shed Dormers

How does a shed dormer differ from a gable dormer?

Dormers are framed after all of the common rafters are in place and a roof opening has been created. The framing of a gable dormer was discussed in Chapter 18. Shed dormers (**Figure 19-30** on page 548) will be discussed here.

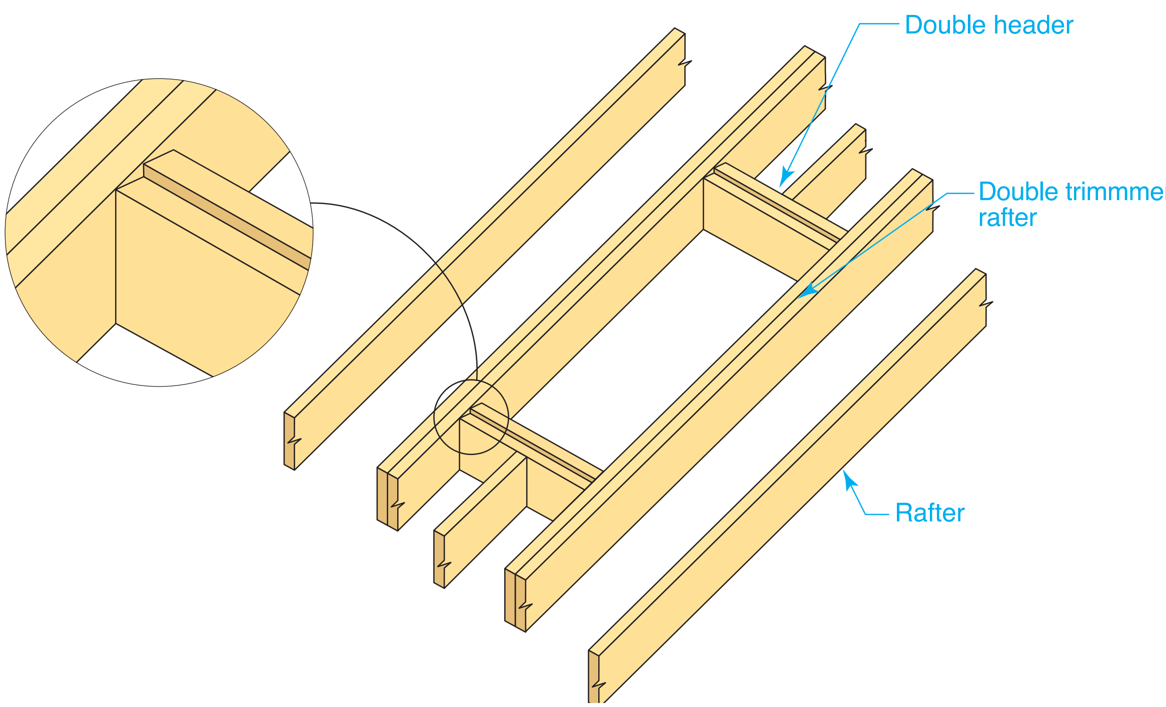


Figure 19-28 Roof Framing Around a Chimney

Details Are Important The top edges of the headers are kept below the top edge of the rafter. The lower edges of the headers are kept even with the top edge of the rafter.

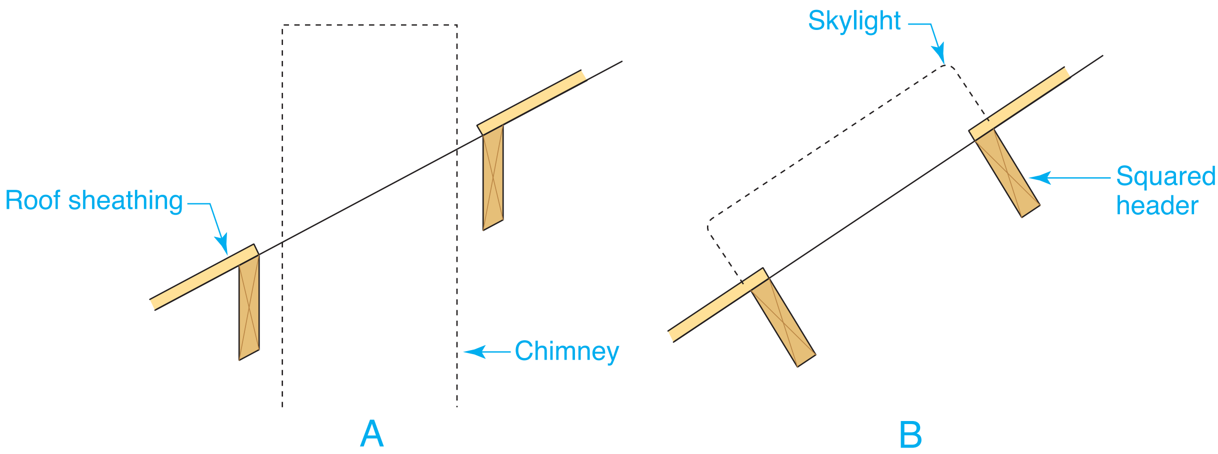


Figure 19-29 Types of Roof Openings
Two Methods The two basic methods for framing roof openings. The headers may be single or double, as needed.

Laying Out the Rafters

To determine the total run of a shed-dormer rafter, divide the height of the dormer end wall by the difference in inches between the unit rise of the dormer roof and the unit rise of the main roof. See **Figure 19-31**. Suppose the height of the dormer end wall is 9', or 108", as in Figure 19-31A. The unit rise of the main roof is 8". The unit rise of the dormer roof is 2½". The difference between them is 5½". The total run of a dormer rafter is therefore 108" divided by 5½", which is 19.64". Knowing the total run and the unit rise, you can figure the length of a dormer rafter by any of the methods already described.

The inboard ends of dormer rafters must be cut to fit the slope of the main roof, as in Figure 19-31B. To get the angle of this cut, set a framing square on the rafter to the pitch of the main roof, as in Figure 19-31C. Measure off the unit rise of the dormer roof along the tongue, starting at the heel. Make a mark at this point and draw the cut-off line through this mark starting at the 12" mark on the blade.

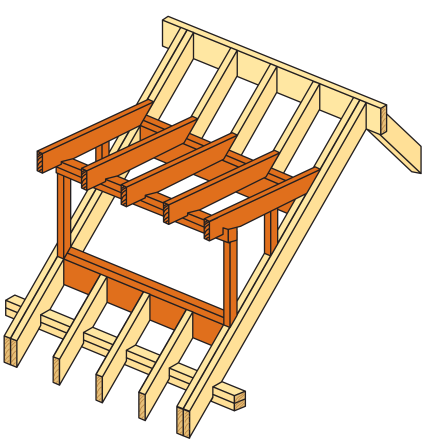


Figure 19-30 Framing a Shed Dormer
Basic Elements This shows the framing for a small shed dormer. The dormer roof appears flat but is actually pitched to encourage drainage.

Finding the Length of Side-Wall Studs

To frame a shed dormer, you must also find the lengths of the side-wall studs. Suppose a dormer rafter rises 2½" for every 12" of run, and a main-roof common rafter rises 8" for every 12" of run, as in Figure 19-31A. If the studs are spaced 12" OC, the length of the shortest stud is the difference between 8" and 2½", which is 5½". (This is also the common difference.) If the stud spacing is 16", the length of the shortest stud is the value of x in the proportional equation 12:5½ :: 16:x. Thus x = 7⁵⁄₁₆. The shortest stud will be 7⁵⁄₁₆" long. The next stud will be 2 × 7⁵⁄₁₆" long, or 14⅝", and so on.

A second method of determining the length of the shortest stud (the common difference) is to make the layout directly on a stud with the framing square, as shown in **Figure 19-32**. The

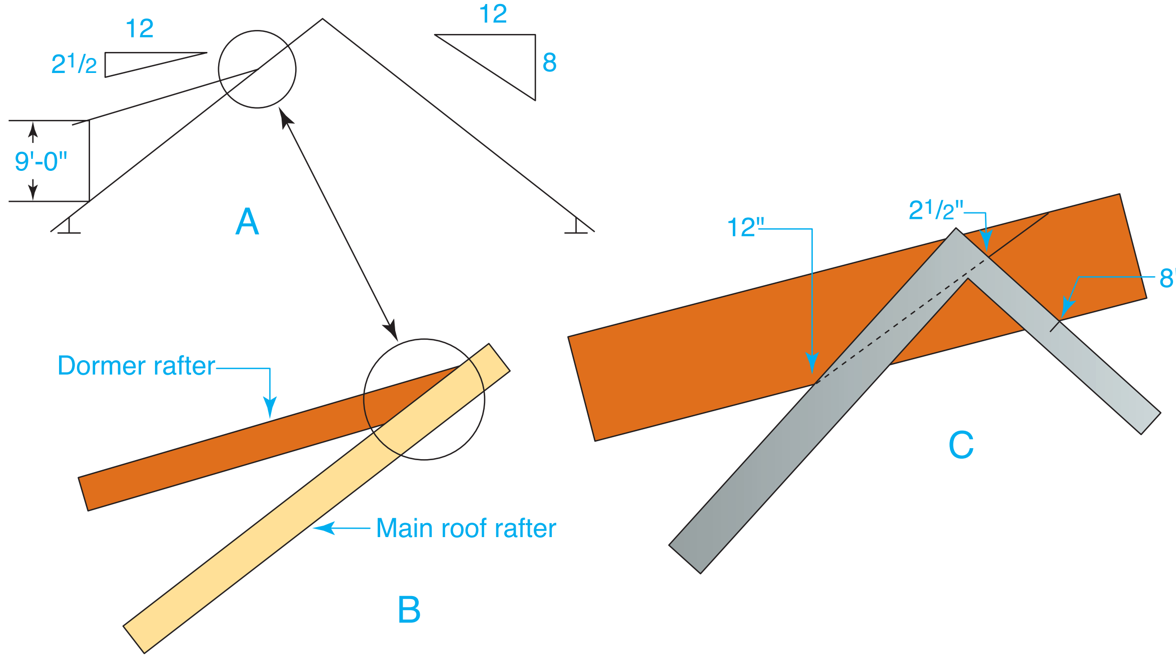


Figure 19-31 Rafter Top Cut

Laying Out the Top Cut This diagram shows how to determine the top cut of the dormer rafters where they meet the main roof rafters.

difference in the rise of the two roofs is 5½". Find the 5½" mark on the tongue of the square and place it on the edge of a stud. Place the blade's 12" mark on the same edge of the stud. Draw a line on the stud along the blade. Slide the square along this line until the blade's 16" mark (the on-center spacing between the studs) is over where the 12" mark had been.

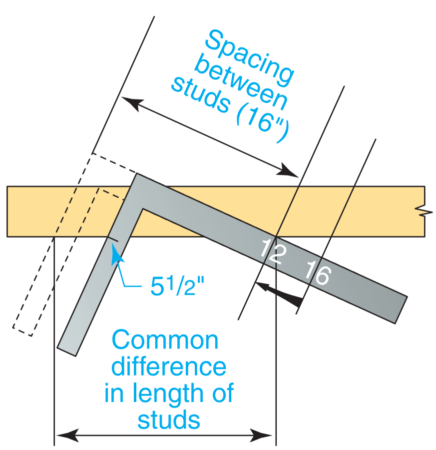


Figure 19-32 Direct Layout Method

Using the Square Determining the common difference in the length of dormer side-wall studs by direct layout.

Draw a line along the tongue of the square. This completes the layout for the shortest stud. The second stud will be longer by this measure (the common difference), and so on.

To get the lower-end cut-off angle for studs, set the square on the stud to the pitch of the main roof. To get the upper-end cut-off angle, set the square to the pitch of the dormer roof.

Reading Check

Recall *How are the lower-end cut-off angle and the upper-end cut-off angle for studs found?*

Mathematics: Calculation

Calculate Dormer Side Walls A dormer has a sidewall height of 8' 7" (103") and a unit rise of 2½' on the dormer roof. If the main structure's roof has a unit rise of 10', what is the total run of the dormer rafter?

Starting Hint Find the difference between the unit rise of the main roof and the unit rise of the dormer roof.

Chimney Saddles

Where is the chimney saddle constructed?

A *chimney saddle*, or *cricket*, diverts water around a chimney and prevents ice from building up on the roof behind it. It is a fairly small piece of framing but it can be challenging to build.

The saddle may be constructed while carpenters are on the roof. However, if the chimney span and roof pitch are known, it can also be fabricated on the ground. The completed assembly can then be lifted into position and nailed to the roof framing. There are various methods for building chimney saddles. One method is shown here.

Valley strips for the saddle are 1×4 or 1×6 stock, as shown in **Figure 19-33**. The distance across the widest part of the valley strips must be slightly less than the width of the chimney. This accounts for the distance that the saddle sheathing will project beyond the strips (see B in Figure 19-33). This distance should be estimated by the carpenter. It varies, depending on the slope of the saddle. The length is determined in the same way as for a valley rafter. Use the framing square. Lay out the top and bottom cuts along the tongue of the square. For the length of the strip, use the unit length of a common rafter from the roof on which the saddle is to be framed.

Suppose a roof with a unit rise of 5" has a unit length of 13". To lay out the valley strip, position the square with the tongue's 13" mark and the blade's 12" mark on the edge of the strip. Draw a line along the tongue for the top cut. Measure and lay out the length of the valley strip. With the square set the same as for the top cut, place the edge of the blade on the length mark and draw a line along the blade for the bottom cut.

The end of the saddle's ridge board rests on the valley strips (see A in Figure 19-33). This cut is the same as the seat cut for a common rafter in the main roof. Place the square on the ridge board for the pitch of the roof (in our example, 5" on the tongue and 12" on the blade) and draw a line along the blade. The length of the ridge is equal to the run of the common rafter in the saddle's span minus the allowance for the drop of the ridge, which is approximately ¾".

To determine the theoretical length of the longest rafter, multiply the saddle's run (half the saddle's span) by the unit length of a common rafter. Deduct the ridge shortening allowance to obtain the actual length. The top and bottom cuts are the same as for a common rafter in the main roof. However, there is a side cut on the bottom where the rafter rests on the valley strip. This cut is the same as for regular valley jacks (see Section 18.3).

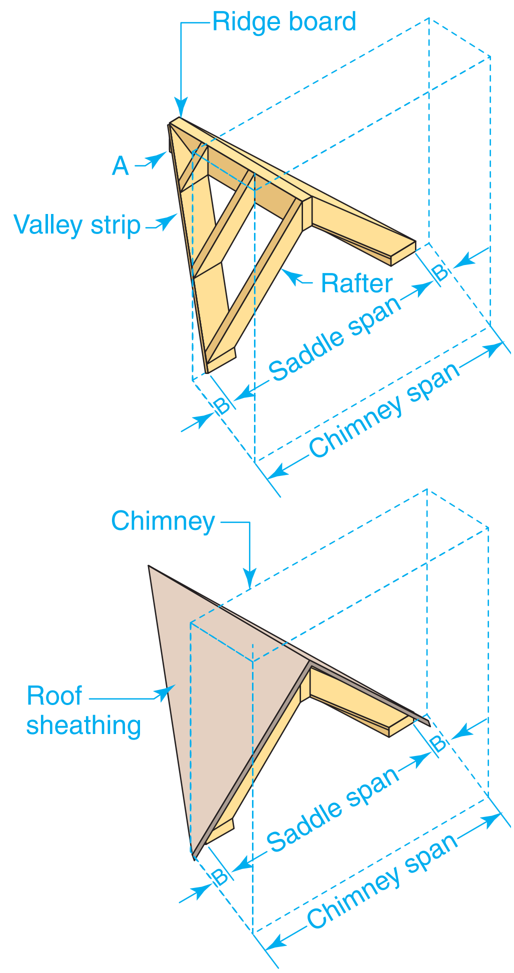


Figure 19-33 Chimney Saddle

Sheathing Projection When sheathing is attached to the framing, the saddle should be the same width as the chimney.

The cuts are the same for all the rafters in the chimney saddle. However, the rafter lengths differ. The difference in the length of the rafters can be found on the framing square's rafter table under Difference in Length of Jacks. For rafters 16" on center in a roof with a unit rise of 5", the second rafter will be 17 5⁄16" shorter than the first rafter. The third rafter will be 34 5⁄8" (2 × 17 5⁄16) shorter than the first rafter, and so on. When the saddle framing is complete, nail the roof sheathing to it.

Section 19.3 Assessment

After You Read: Self-Check

1. What is a collar tie and what is its purpose?
2. What is the purpose of purlins and braces?
3. In gable-end framing, what is meant by "common difference"?
4. At what point in roof construction are dormers framed?

Academic Integration: Mathematics

5. **Calculate Common Difference** What is the common difference in length of gable-end studs placed 16" OC for a roof with a 5⁄12 pitch?

Math Concept The common difference is calculated using the unit run and the unit rise.

Step 1: Divide the OC distance by the unit run.

Step 2: Multiply by the unit rise.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 19.4 Rakes & Cornices

Roof Edge Details

Does every style of roof have eaves?

The **eaves** are those portions of a roof that project beyond the walls. On a house with a hip roof, the eaves are the same width and height around the entire house. On a house with a gable roof, the eaves at the ends of the house follow the slope of the roof. They may be a different width than eaves at the sides of the house or may be omitted entirely. The upward slope of the eaves at a gable end is called the *rake angle.*

The roof-edge details can take many forms, depending on tradition and local preferences. They can include molding and decorative cuts in exposed rafter tails. Ventilation of the attic is another important factor to consider when planning and constructing roof-edge details.

The eaves themselves are formed by the rafter overhangs. For more on that topic see Chapters 17 and 18. The material in this section relates to details that are installed after the rafters are in place.

Cornices

What materials would not be good to use in cornice construction?

A **cornice** consists of a fascia, a soffit, and various types of molding, as shown in **Figure 19-34**. The **fascia** is a board that is nailed to the ends of the rafter tails. It protects the end grain of the rafters and serves as a mounting surface for gutters. Sometimes a sub-fascia made of 2× lumber will be nailed to the ends of the rafters to provide extra strength in this area. It is sometimes called a structural fascia. The sub-fascia is always covered later by a finished fascia, which is high-quality 1× stock. In some cases a finished fascia can be nailed directly

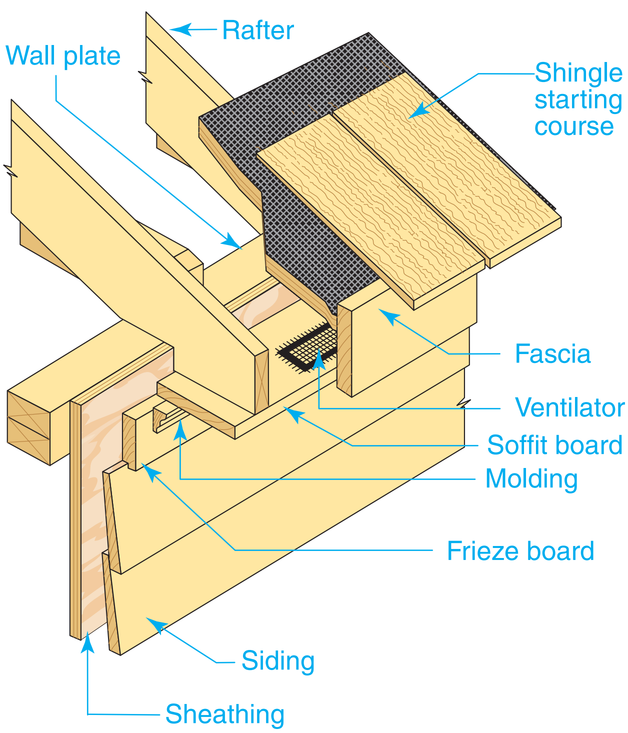


Figure 19-34 Basic Cornice Construction
Parts of a Cornice A cornice can take various forms. This illustration shows one common way to build a cornice.

to the rafter ends. The **soffit** is the underside of the eaves. It is sometimes enclosed with plywood, prefabricated vinyl panels, or aluminum sheets. It can also be left open, exposing the rafter tails.

Some cornice work may be done as soon as the roof has been framed. However, the cornice can also be built after the roof covering is in place. Cornice construction details are shown on the wall sections of the house plans. Detail drawings are usually included as well.

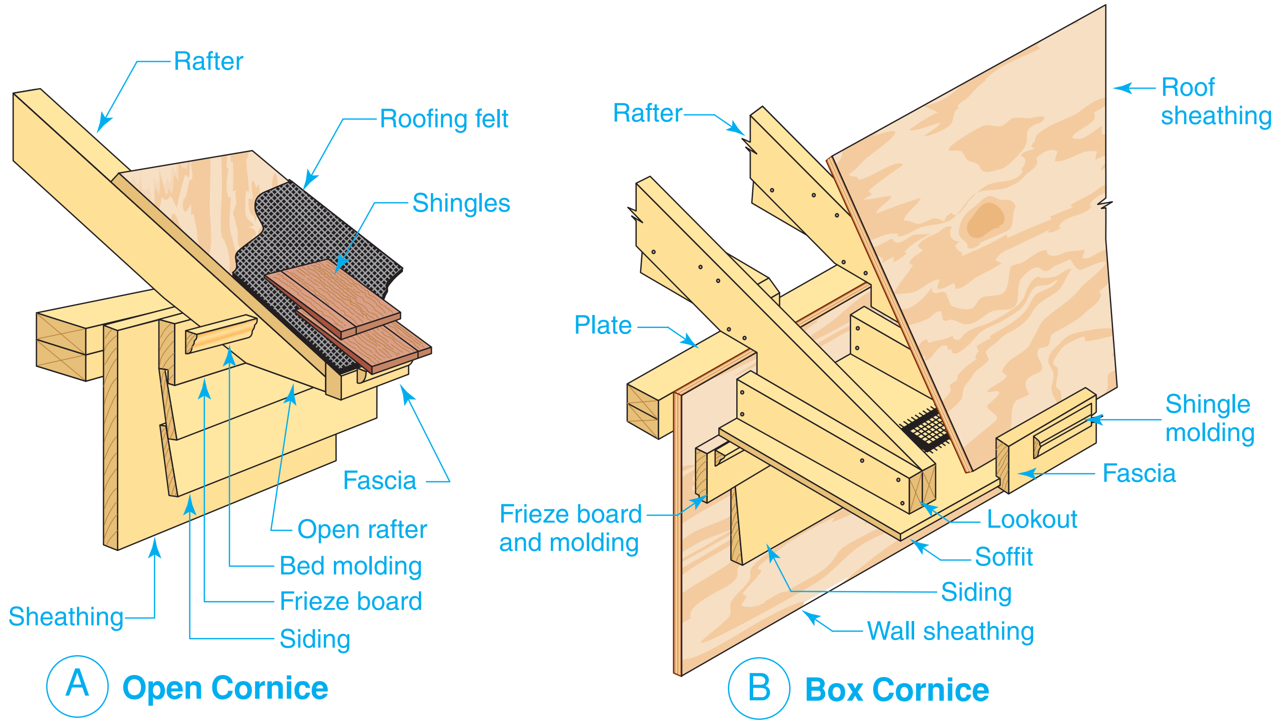
Types of Cornices

There are three basic types of cornices: open, box, and closed, as shown in **Figure 19-35**. An *open cornice* consists of frieze blocks, molding, and a fascia. The underside of the roof sheathing and the rafters are exposed. It is simple to construct. One variation includes a continuous *frieze board*, which runs above the top course of siding, as shown in Figure 19-35A. Unlike a frieze board, a frieze block is strictly functional. It is a short piece of 2× framing lumber nailed between the roof rafters to seal off the attic space.

A *box cornice* entirely encloses the rafter tails. It is built of roof sheathing, fascia, and a soffit. There are several ways of building a box cornice. The soffit can be nailed directly to the underside of the rafters. However, it is more often nailed to lookouts as in Figure 19-35B. A **lookout** is a horizontal member that extends from a rafter end to a nailer or the face of the wall sheathing. Lookouts form a horizontal surface to which the soffit material is attached.

A *closed cornice* (Figure 19-35C) appears on a house that has no rafter overhang. One **version** consists of a frieze board and one or more pieces of molding. This type of cornice is common on older houses in some parts of the United States. However, it is seldom used on newer houses because of the difficulty in providing attic ventilation.

Solid Wood Solid wood is the traditional material used for cornices. Because portions are exposed to the weather, rot-resistant



woods are preferred. The cornice is very visible, so top grades of lumber should be used. Avoid any board that contains sapwood, surface cracks, or loose knots. The fascia may be nominal 1× or 2× stock.

Other Materials The use of synthetic, composite, and engineered materials for cornice construction is now common. These materials come in many varieties, but some of the most common consist of rigid boards made from high-density polyurethane or from recycled wood fibers. Builders like using these materials because they are more uniform than solid lumber and free of defects. They are also available in long lengths. Many are pre-primed at the factory on all surfaces and edges. This saves labor at the job site and improves durability. Some of these products are composite blends of wood fiber and plastic. Others are made of high-grade PVC (polyvinyl chloride) resins and other polymers. Still others are made from finger-jointed lumber or laminated-veneer lumber with MDO (medium-density overlay) surfaces. With any of these materials, always follow the manufacturer's guidelines for installation. If the manufacturer's guidelines are not followed, any warranty on the product is void.

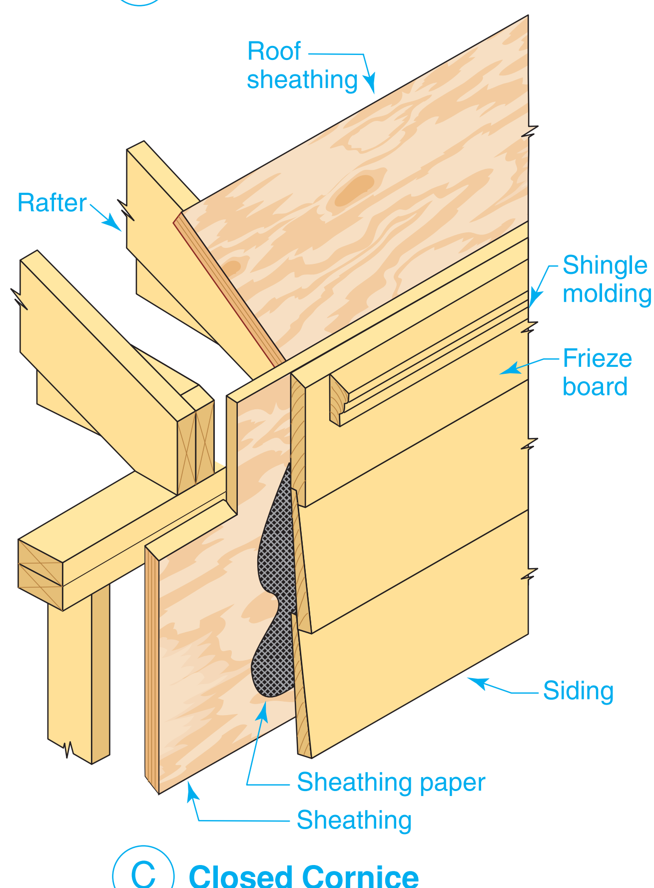


Figure 19-35 Types of Cornices

Three Types A. An open cornice with a fascia board and frieze board. **B.** A box cornice with a flat soffit enclosure and lookouts. **C.** A closed cornice.

Building an Open Cornice

One method of constructing an open cornice is to install 2× frieze blocks between the rafters, as shown in **Figure 19-36**. The blocks are drilled for ventilation holes and circular, screened metal vents are fit into the holes. To install the blocks, nails are driven through the side of the rafter into the end of a block on one side. Nails have to be toenailed on the other side.

The frieze block is sometimes positioned at an angle to the walls, as in Figure 19-36. However, some carpenters prefer to install the block so that it is parallel to the walls and at an angle to the rafters. In this case, the block must be a size larger than the nominal dimension of the rafters. It may have to be cut to a width that will fit the space and beveled to the slope of the roof.

A disadvantage of an open cornice is that the underside of the roof sheathing is exposed. The material used for roof sheathing may have surface imperfections that are unattractive. To counter this problem, carpenters sometimes install a higher grade of plywood sheathing above an open cornice. Another solution is to install tongue-and-groove boards as sheathing in this area (see Section 19.5). Cornice workmanship is readily visible from the ground. For this reason, all joints in the construction of an open cornice should fit together tightly. Moldings should be mitered at outside corners and mitered or coped on inside corners.

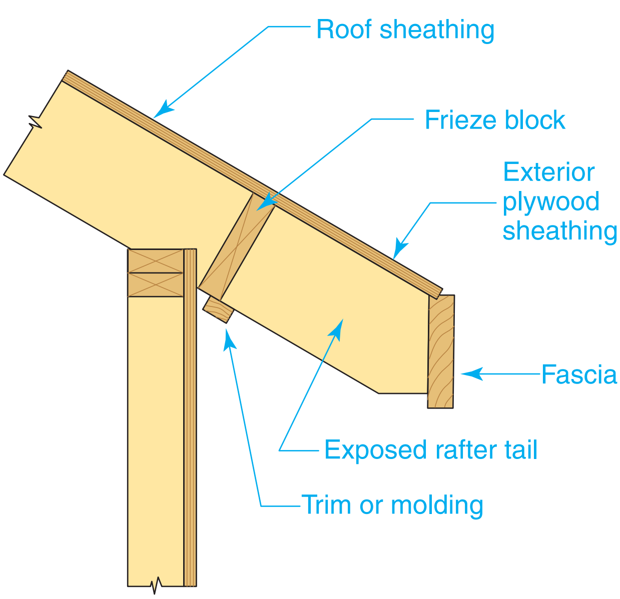


Figure 19-36 Frieze Blocks

Quick and Inexpensive This is a very simple type of open cornice.

Reading Check

Recall *What are the two ways freeze blocks might be installed?*

Building a Box Cornice

Before adding a box cornice, check the plumb cuts on the rafter tails to make certain they are all in line with one another. This check can be done by stretching a line along the top ends of the rafters from one corner of the building to the other. However, many carpenters do not make the plumb cut on the rafter tails when the rafter is cut. Instead, they install the rafters with the tails running longer than necessary. Then they snap a chalk line across the top of the tails to indicate the top of the cut. After drawing a plumb line downward from the chalk line on every rafter, they cut it to length. See pages 556–557 for steps in building and installing a box cornice.

Installing Sectional Soffits Several materials may be used for the soffit of a box cornice. Because wide overhangs are popular, materials available in large sheets are often used.

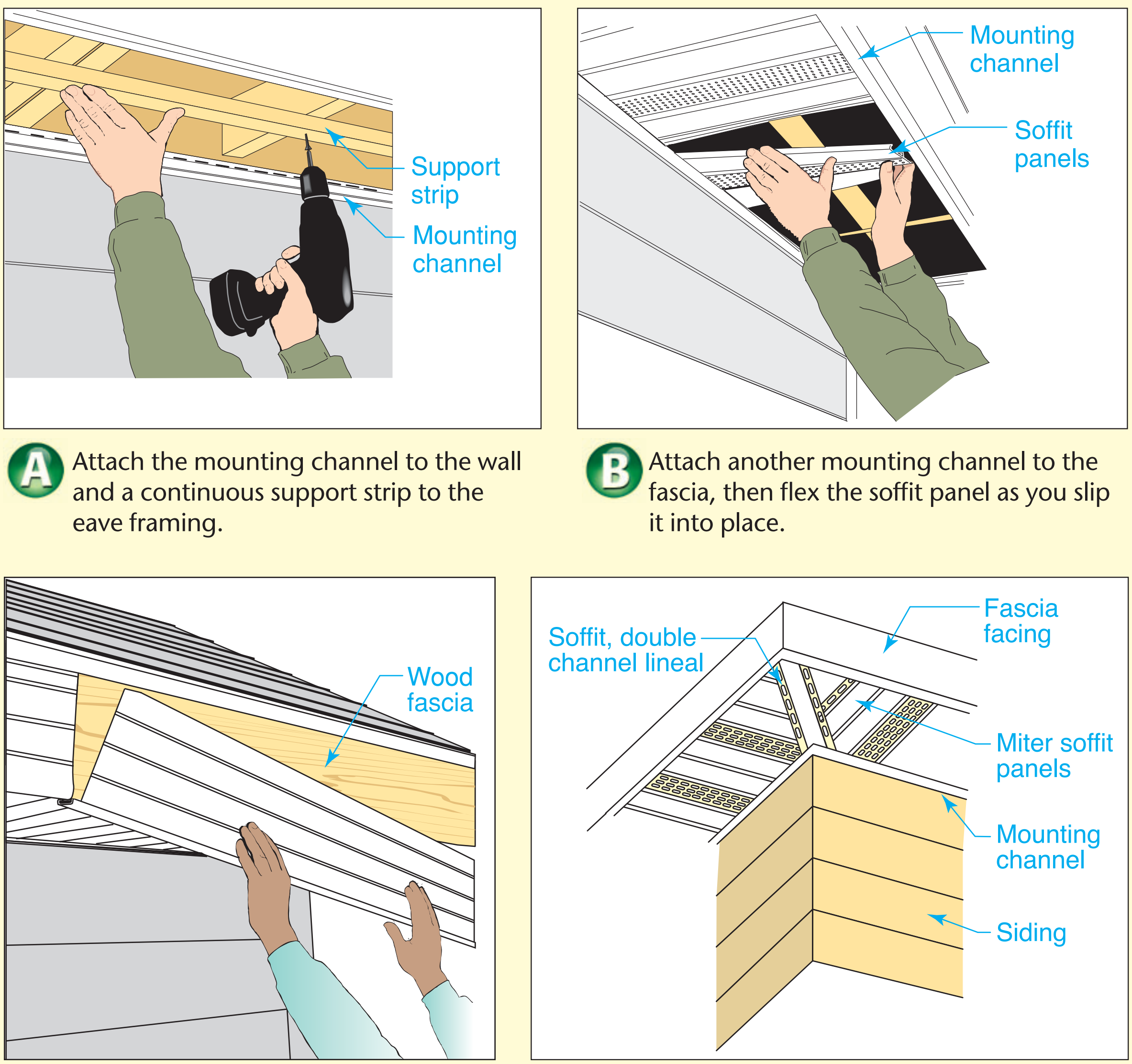
Builder's Tip

WHO INSTALLS SOFFITS? All contractors should review the plans and specifications regarding soffit finish materials. If a house is sided with wood, wood soffits might be installed by carpenters. However, if the house is sided with vinyl, vinyl siding contractors might install soffit panels along with the siding.

The installation of exterior-grade plywood is described in the Step-by-Step Application on page 556. However, the use of vinyl soffit material is very popular, even on houses that do not have vinyl siding. This is because vinyl soffits require little maintenance. The material is light in weight and easy to install. It is entirely prefinished and available solid or perforated for ventilation. Aluminum soffit material can be used for many of the same reasons. When using either material, always follow the manufacturer's installation instructions. **Figure 19-37** shows one installation method.

Figure 19-37 Installing Sectional Soffit Material

Piece by Piece Installing soffit material.



A Attach the mounting channel to the wall and a continuous support strip to the eave framing.

B Attach another mounting channel to the fascia, then flex the soffit panel as you slip it into place.

C Add fascia facing if called for.

D Where corners occur, miter the soffit material and support it with suitable trim.

Step-by-Step Application

Building a Box Cornice The general procedure is to install lookouts first. The fascia and soffit can then be installed. See **Figure 19-38, A–E**.

Step 1 Use a piece of 1×4 material as a ledger. Temporarily nail it tight against the wall and against the rafters, and align it with the inside edge of the first rafter (Figure 19-38A). The bottom edge of the ledger should be even with the bottom of the rafter tail. (A ledger is a horizontal length of lumber used to support other structural elements.) With a straightedge against the side of the rafter, draw a line on the ledger. Place an X on the side of the line away from the underside of the rafter to indicate the location of the lookout. Do this along the entire length of the building.

Step 2 Determine the length of the lookouts. Measure on a level line from the plumb cut on the rafter tail to the wall. Subtract 3/4" from this measurement to allow for the thickness of the ledger. Subtract another 3/4" to make sure that the lookouts do not project beyond the end of the rafters. Otherwise, any deviation in the wall would cause the lookout to extend beyond the end of the rafter tail. This would interfere later with installation and alignment of the fascia.

Step 3 Lookouts are generally made from 2×4 lumber. After they have been cut to length, remove the ledger from its temporary position. Nail the lookouts to the ledger over the *X*s. Nail through the back of the ledger into the end of each lookout with two 16d coated nails (Figure 19-38B). Some carpenters toenail the ends of the lookouts to the ledger instead. Note that the end lookout is nailed into the end of the ledger strip. This means that the end lookout has to be of the same thickness as the rafter and longer than the rest of the lookouts. It will have to be cut to fit under the rafter tail.

Step 4 Locate the ledger on the wall by leveling from the rafter tail in toward the wall and placing a mark on the sheathing (point B in Figure 19-38C). Do this at each end of the building. Snap a chalk line along the length of the building on the sheathing.

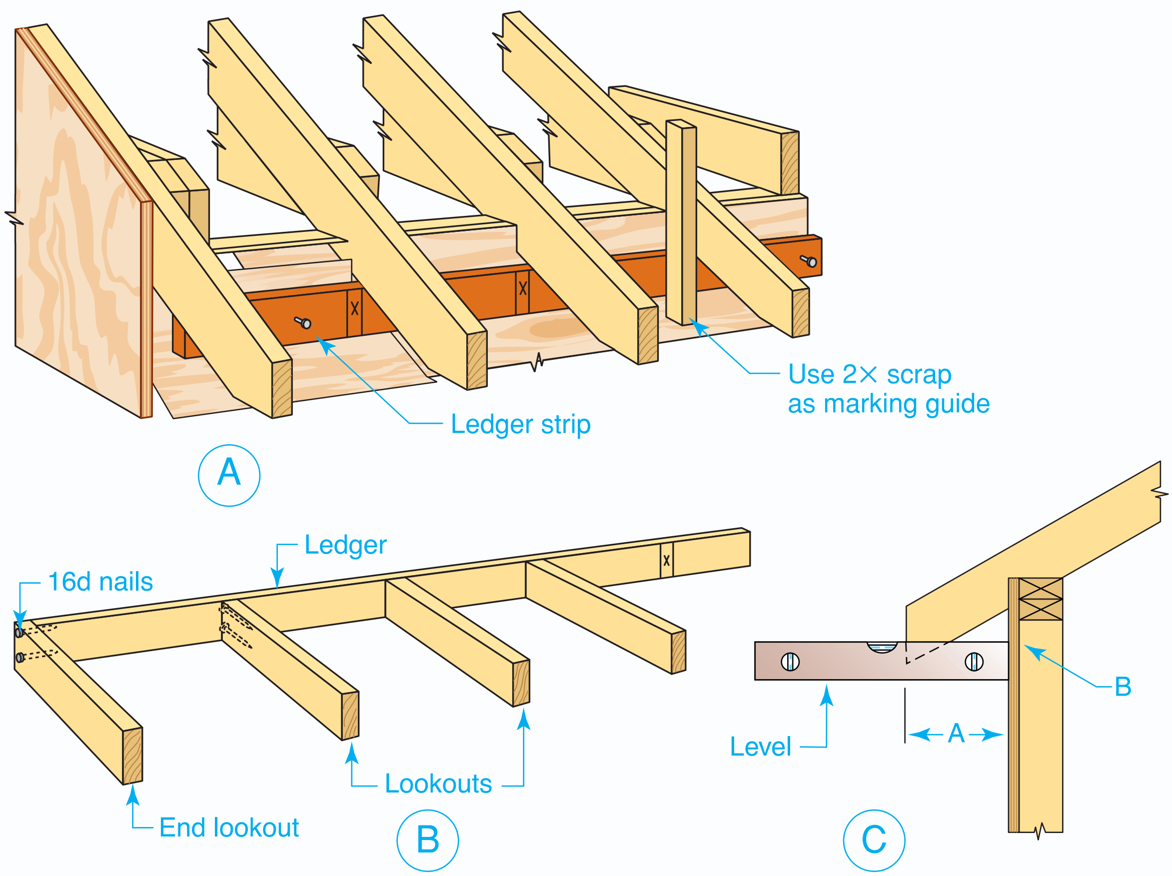


Figure 19-38 Box Cornice Details

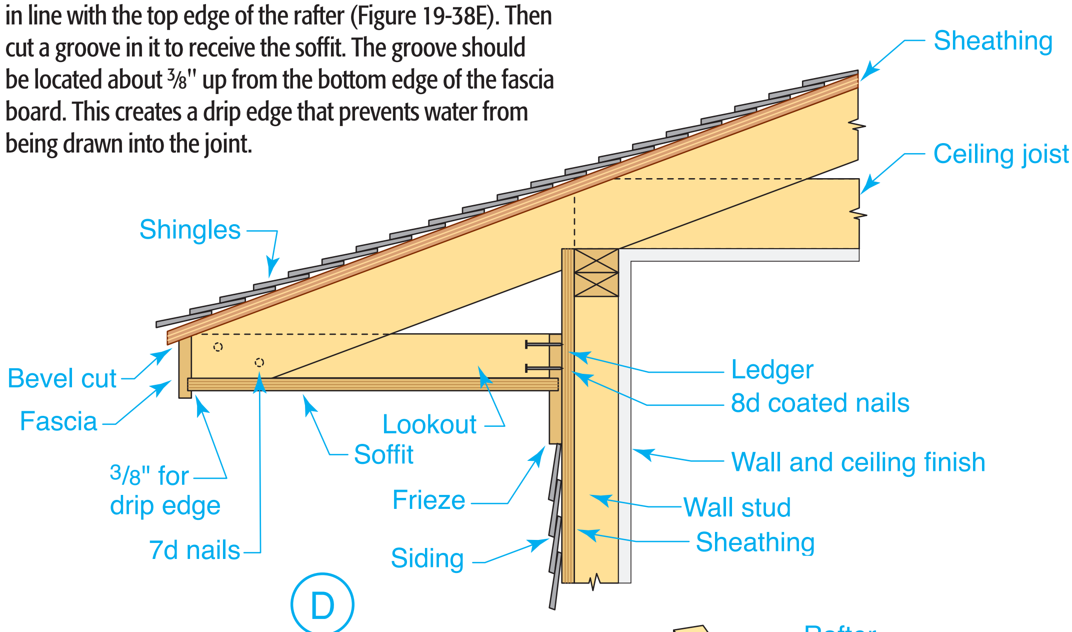
Step 5 Place the bottom edge of the ledger on this line. Nail it through the sheathing and into the studs. Nail each lookout to the side of a rafter tail, except the end lookout. The end lookout should be cut to fit against the underside of the rafter. Level each lookout as it is nailed.

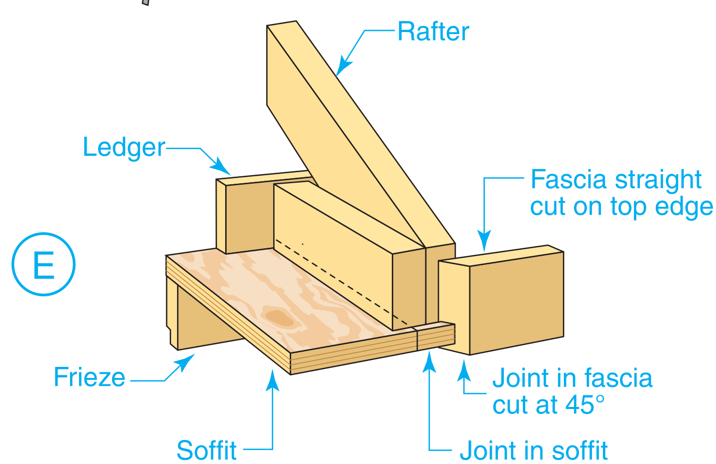
Step 6 If the soffit is narrow, as in Figure 19-34 on page 552, the connection between the fascia and the soffit may be a butt joint. If the soffit is wide, as in Figure 19-38D, one edge of the soffit material can fit into a groove cut in the back of the fascia. That method is described in the following steps.

Step 7 Rip the fascia stock to width if necessary. The top edge of the fascia may be beveled to the same angle as the pitch of the roof. If it is not, its outside top corner must be in line with the top edge of the rafter (Figure 19-38E). Then cut a groove in it to receive the soffit. The groove should be located about ⅜" up from the bottom edge of the fascia board. This creates a drip edge that prevents water from being drawn into the joint.

Step 8 Nail the fascia to the ends of the rafter tails so that the top of the groove is even with the bottom edge of the lookouts (Figure 19-38D). Make certain that the fascia is straight along its length. If it is not, the soffit material will not fit properly. If the fascia must be spliced, the joint should be mitered and fall on the end of a rafter tail.

Step 9 Cut exterior-grade plywood soffit material to fit and slip it into place so that one edge fits into the groove in the fascia. Nail the soffit to each lookout and to the ledger strip with 4d galvanized nails spaced about 6" apart. As with the fascia, any joints in the soffit material must occur over solid backing (Figure 19-38E). This joint is not mitered.





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Estimating Cornice Materials

The materials for cornice framing, such as ledger strips, are estimated based on lineal foot measurements. This information is easily obtained from the building plans. Estimates for moldings and most other materials that are attached to the walls can be figured based on the perimeter of the house. The amount of material required for the fascia board and any molding attached to the fascia is figured by determining the perimeter of the roof at the rafter ends (not the perimeter of the walls).

Soffits The amount of soffit material required is based on the length and width of the soffit. These dimensions can be obtained from the house plans.

The method for determining the quantity of material needed depends on the material being used. With plywood, the estimate is based on the lineal footage of strips that can be ripped from a 4×8 panel. Aluminum and vinyl soffit material may be estimated by the square footage of soffit to be covered, or by referring to coverage charts provided by the manufacturer. Vinyl and aluminum soffit material comes in small sectional panels or in sheets that are 12' long.

Gable Rakes

What joint would you use where two fly rafters meet?

The part of a gable roof that extends beyond the end walls is called the **rake**. It is like a cornice in some respects so it is sometimes called a rake cornice. However, it has different installation requirements. A rake may be either closed or extended.

Closed Rake

A *closed rake* consists primarily of the frieze board and moldings. Some additional protection and overhang can be provided by using a 2×3 or 2×4 fascia block over the sheathing, as shown in **Figure 19-39**. This member acts as a frieze board. The siding can be butted against it. The fascia, often 1×6 stock, then serves as trim. Metal roof edging is used along the rake to seal out water. Rakes with little or no overhang are inexpensive and simple to build. However, extending the rake helps to protect side walls from weathering, which reduces maintenance costs.

Extended Rake

An *extended rake* may be as narrow as 6" or as wide as 2'. An extended rake is shown in **Figure 19-40**. If the underside of the roof sheathing is exposed, it is called an *open rake*. If it is not exposed, it is called a *boxed rake*.

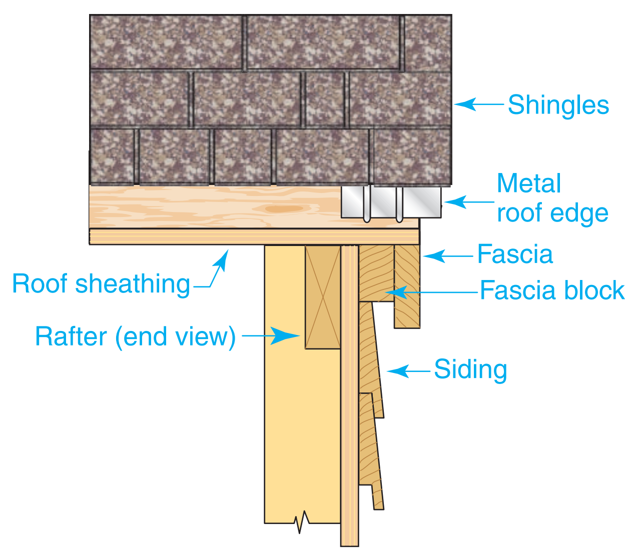

Figure 19-39 Closed Rake

Some Protection A closed rake consists of various materials applied directly to the gable end of the house.

REGIONAL CONCERNS

Rakes and the Weather A wide rake can help to shade walls and protect them from rain and snow. However, in climates where severe winds are common, a wide rake may not be recommended. If it is part of a home's design, be sure to consult local codes regarding resistance to wind uplift. Likewise, follow local codes when installing wide rakes in areas that receive heavy snowfall.

Go to **glencoe.com** for this book's OLC for more information about regional concerns.

When the rake extension is only 6" to 8", the fascia and soffit can be nailed to a series of short lookout block (Figure 19-40A). The fascia is further secured by nailing through the projecting roof sheathing. A frieze board and appropriate moldings complete the construction.

In a moderate overhang, both the sheathing and a fly rafter aid in supporting the rake section (Figure 19-40B). A *fly rafter* extends from the ridge board to a structural fascia and is made of nominal 2" stock. The roof sheathing should extend from inner rafters to the end of the gable projection to provide rigidity and strength. It is nailed to the fly rafter and to the lookouts. The lookouts also serve as nailing surfaces for the soffit material. The assembly of lookouts, blocks, and fly rafter is sometimes called a *ladder*.

Wide rake extensions require rigid framing to prevent deflection. This is usually done by installing a series of lookout rafters that cantilever over the end walls, as shown in **Figure 19-41** on page 560. It may be constructed in place or built on the ground and hoisted into place. The lookouts are usually spaced 16" or 24" OC.

When the framing is preassembled, it is usually made with a header rafter on the inside and a fly rafter on the outside. Each is nailed to the ends of the lookouts that bear on the gable-end wall (rake wall). Lookouts are a type of purlin. In this use they are sometimes called an *overhanging purlin*.

JOB SAFETY

LIFTING LADDER FRAMING Preassembled ladder framing can be heavy and unwieldy. Be sure to install it with plenty of help. Do not rely on stepladders for lifting the ladder framing into place because they can tip easily. Use scaffolding or properly anchored extension ladders instead.

Go to **glencoe.com** for this book's OLC for more on job safety.

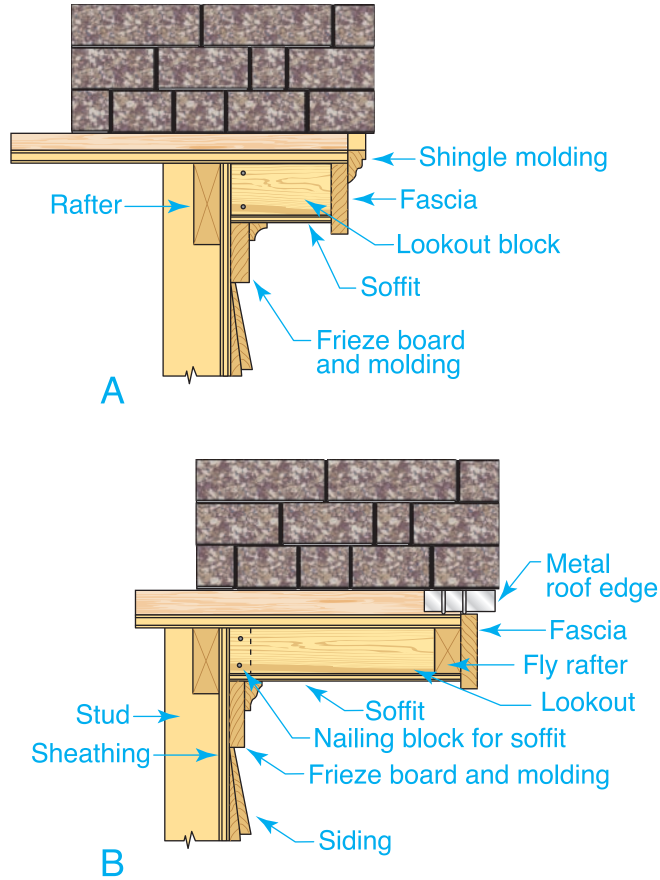

Figure 19-40 Extended Rakes

More Protection An extended rake with **A.** a narrow overhang and **B.** a moderate overhang.

When the header is the same size as the rafter, it should be cut just as a standard rafter, including the bird's mouth. The header rafter is face-nailed directly to the standard rafters with pairs of 12d nails spaced 16" to 20" apart. Each lookout should be toenailed to the rake wall plate.

The lineal footage for rake moldings is figured in the same way as the length of the gable-end rafter. The amount of material needed for the lookouts is obtained by multiplying the projection times the number of rafters.

Reading Check

Describe *What is the difference between an open rake and a boxed rake?*

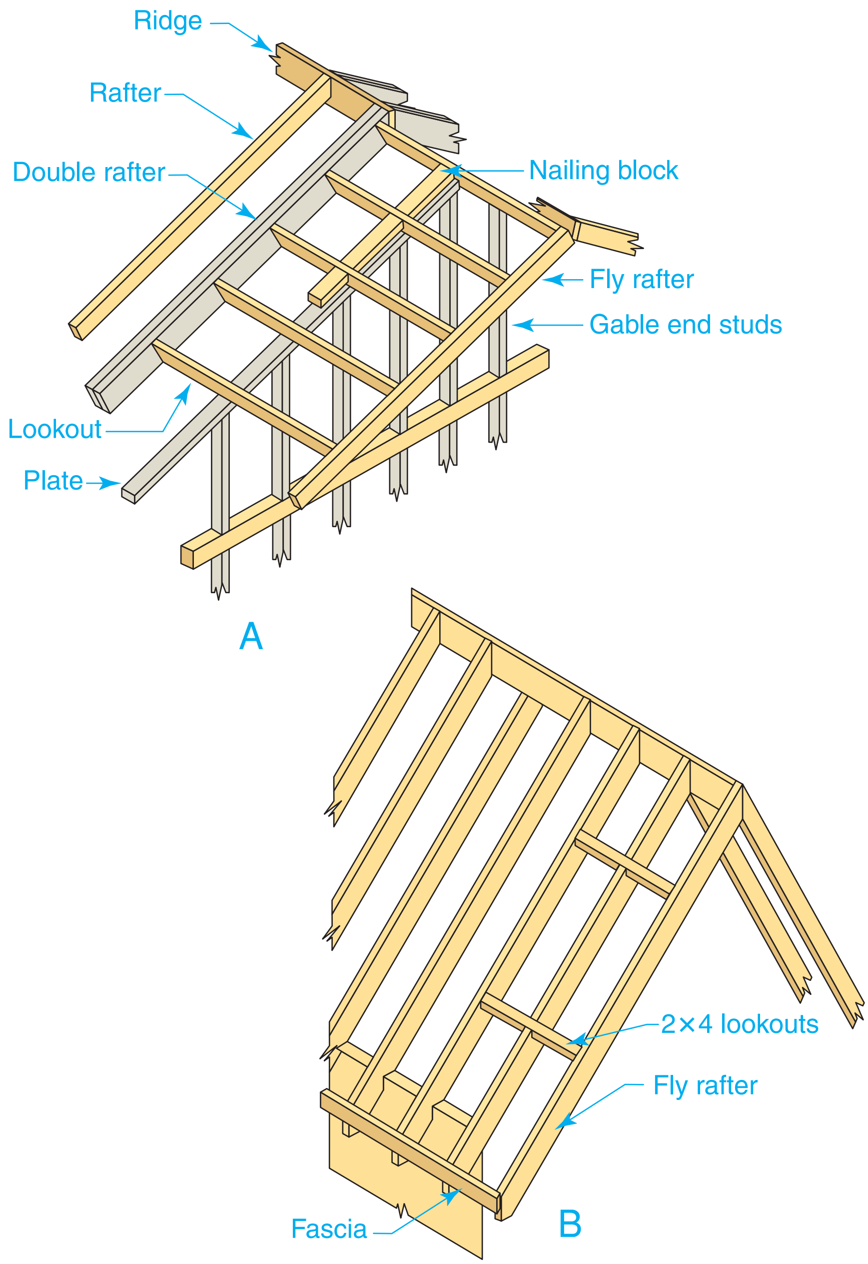

Figure 19-41 Deep Rakes
Most Protection Lookouts can **A.** rest directly on the top plate of the gable wall or **B.** fit into notches cut into the end rafter.

Cornice Returns

A cornice return provides a transition between the rake and a cornice, as shown in **Figure 19-42**. How it is built depends on how the cornice is built and on how far the rake projects beyond the side walls.

When the cornice is boxed and there is some rake extension, the cornice return is also boxed, as in Figure 19-42A. A boxed return is often used in houses of Cape Cod or Colonial design. The fascia board and shingle molding of the cornice are carried around the corner of the rake projection. When a house has open cornices, the cornice return is sometimes handled quite simply, as in Figure 19-42B. A curved piece of wood can be attached to the underside of the rake trim. This piece is sometimes called a *pork chop*.

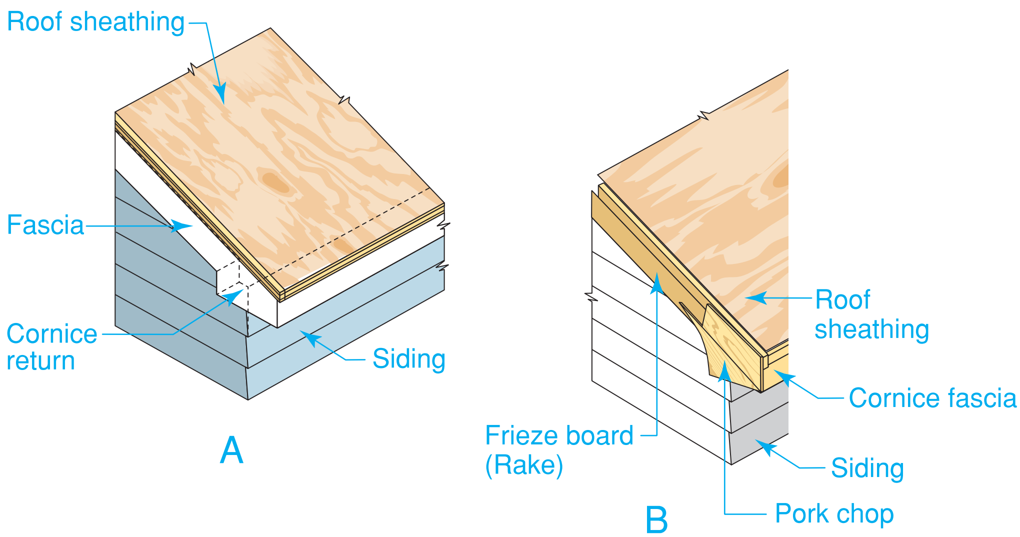

Figure 19-42 Cornice Returns
Two Methods A. A narrow cornice with boxed return. **B.** An open cornice with a pork chop.

Section 19.4 Assessment

After You Read: Self-Check

1. Name the three basic types of cornice.
2. What is the disadvantage of open cornices?
3. What is a cornice return?
4. What is a pork chop?

Academic Integration: Mathematics

5. **Perimeter and Estimation** A house measures 20' by 35'. It has a hip roof, and the rafters project 18" from the walls. The plans call for a box cornice. Calculate how many 4' × 8' sheets of plywood will be required for the soffit.

   Math Concept Perimeter is the distance around a geometric figure, such as a rectangle. The formula for finding the perimeter of a rectangle is $P = 2l \times 2w$, where l is length, and w is width.

   Step 1: Figure the perimeter of the roof at the rafter ends.

   Step 2: Determine how many feet of plywood measuring 18" wide you can get from a 4' × 8' sheet of plywood.

   Step 3: Divide the perimeter by the number of feet of plywood you can get from one sheet.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 19.5

Roof Sheathing

Panel Sheathing

How should roof panel sheathing be laid?

Sheathing provides a nailing base for the finish roof covering and gives rigidity and strength to the roof framing. Spaced boards are sometimes used to sheath roofs that will be covered with wood shingles or shakes (see Chapter 22, "Roofing & Gutters"). Other types of lumber sheathing can be used as well. Most roofs, however, are sheathed with panel products such as OSB or plywood, shown in **Figure 19-43**. Though they are manufactured in different ways, they have about the same capabilities when used as roof sheathing. The top surface of a sheathed roof is sometimes referred to as the roof deck.

Panel sheathing can be installed quickly over large areas. It provides a smooth, solid base with a minimum of joints. It can be used under almost any type of shingle or built-up roofing. Waste is minimal, which helps keep costs low.

Spans

Depending upon its thickness, panel roof sheathing can be used to span various distances. Many panels are performance rated. That means they are stamped to indicate their suitability for particular spans. The stamp

Figure 19-43 Roof Sheathing

A Base for Roofing The roof of this home was sheathed with plywood. Note that a different sheathing material covers the walls. *What are the advantages of panel sheathing?*

Courtesy of The American Engineered Lumber Association consists of a pair of numbers separated by a slash mark, such as 32/16 or 12/0. The number in front of the slash indicates the maximum spacing (in inches) of supports when the panel is used for roof sheathing. The number following the slash refers to the maximum spacing (in inches) of supports beneath panels used for subflooring. When one of the numbers is zero, the panel is unsuitable for that particular use. In this rating system, it is assumed that the long dimension of most panels will span at least three supports. Note that greater spans are generally allowed for roof sheathing than for floor sheathing.

JOB SAFETY

ROOFING HAZARDS Installing roof sheathing can be dangerous, particularly on steep roofs. Always wear skid-resistant work boots. Many sheathing panels have one surface that is lightly textured or coated to make it skid-resistant. Always place this surface facing up. Remember that wet surfaces are more slippery than dry ones, so be cautious when rain or morning dew has wetted the sheathing. When working on some roofs, climbing ropes and harnesses may be required.

Go to **glencoe.com** for this book's OLC for more on job safety.

Installation

Panel roof sheathing should be laid with the grain (the long dimension) perpendicular to the rafters. End joints should occur over rafters. The end joints of adjacent rows of panels should be staggered by using half-sheets. Unsupported edge joints can be strengthened with metal panel clips that tie them together, as shown in **Figure 19-44**. These joints can be supported by wood blocks instead, but blocks are time-consuming to install and can limit ventilation beneath the roof.

Panels shrink or swell slightly as their moisture content changes. If panels are butted tightly during installation, they may buckle as they expand. To prevent buckling, allow ⅛" between panels or as recommended

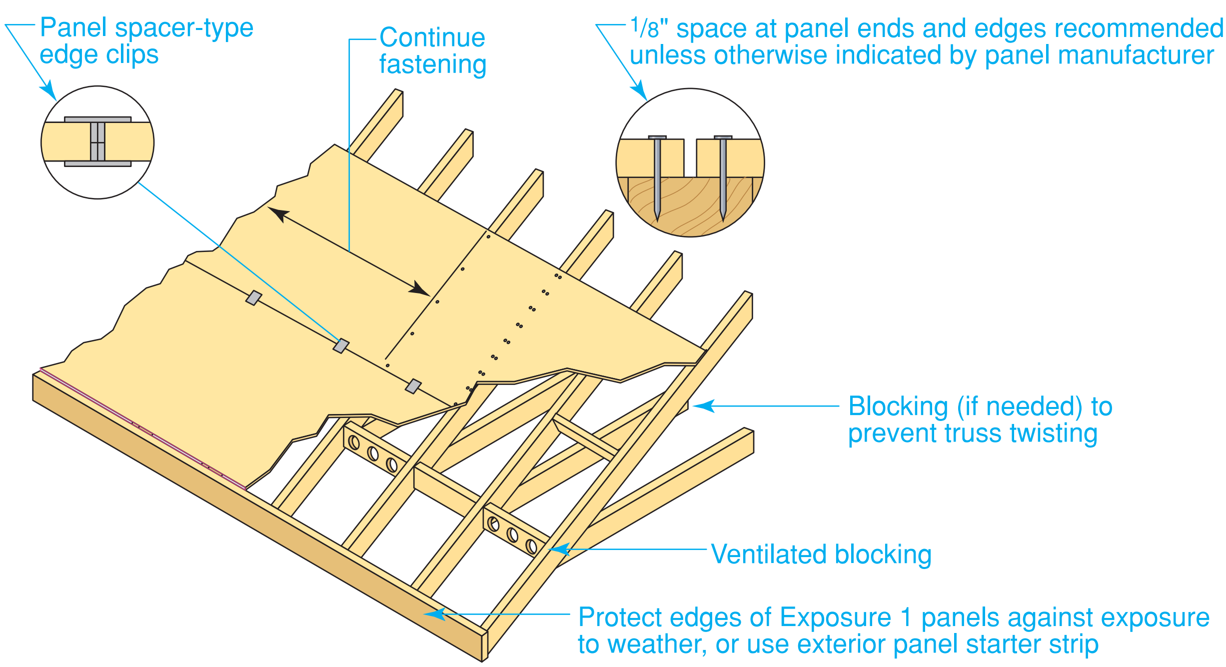

Figure 19-44 Sheathing Details

Details Are Important Seemingly small details make a big difference in the strength of a roof sheathing installation.

Table 19-1: Minimum Fastening Schedule for APA Panel Roof Sheathing						
Panel Thickness (inches)	Size	Nailing[a] Spacing (inches)		Leg Length (inches)	Stapling[b] Spacing (inches)[c]	
		Panel Edges	Intermediate		Panel Edges	Intermediate
5/16	6d	6	12	1¼	4	8
3/8	6d	6	12	1⅜	4	8
7/16, 15/32, ½	6d	6	12	1½	4	8
19/32, 5/8, 23/32, ¾, 7/8	8d	6	12[d]	–	–	–
1⅛, 1¼	8d or 10d	6	12[d]	–	–	–

[a] Use common smooth or deformed shank nails with panels to 1" thick. For 1⅛" and 1¼" panels, use 8d ring- or screw-shank or 10d common smooth-shank nails.
[b] Values are for 16-gal. galvanized wire staples with a minimum crown width of ⅜".
[c] For stapling asphalt shingles to 5/16" and thicker panels, use staples with a ¾" minimum crown width and a ¾" leg length. Space according to shingle manufacturer's recommendations.
[d] For spans 48" or greater, space nails 6" at all supports.

by the manufacturer. This spacing should be used at all edge joints and end joints. Some panel clips are constructed to automatically space panels the proper distance apart. No surface or edge should be permanently exposed to the weather.

Space nails according to **Table 19-1**. Use 6d common, ring-shank, or spiral-thread nails for plywood ½" thick or less. For plywood more than ½" thick, use 8d common nails. For additional holding power, use ring-shank or spiral-thread nails, or glue-nail the sheathing. Place nails approximately ⅜" in from panel ends and edges.

Lumber Sheathing

Why is closed sheathing rarely used?

Not all roofs are sheathed with panel products. For various reasons, a roof may be sheathed with solid wood instead. For example, plank sheathing is common where

Step-by-Step Application

Installing Panel Sheathing Always use caution when installing roof sheathing. If conditions are wet or windy, postpone installation until conditions improve. Never work on top of a panel that is not nailed securely to the rafters. To install panel sheathing:

Step 1 Position the panel on the rafters. If necessary, tack it (nail it temporarily) to the rafters to prevent it from shifting.

Step 2 Nail one end of the panel. Drive nails flush with the panel surface. Remove any temporary nails.

Step 3 Snap a chalk line across the panel to indicate the centerline of each rafter. Nail the panel across its width, starting at one end and working toward the other.

Step 4 Once the panel is secure, stand on it over the framing as you nail it. This ensures full contact between sheathing and rafter.

Step 5 When installing the next panel, allow a ⅛" space between panels (the width of a 10d box nail). Install edge clips as required by local building codes.

Step 6 Cover the sheathing with roofing felt as soon as possible to minimize exposure to the weather (see Chapter 22, Roofing & Gutters).

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post-and-beam framing techniques are used (see Chapter 14). *Open sheathing* (also called *skip sheathing* or *spaced sheathing*) is common in regions where wood shingles and shakes are popular. However, in areas where wind-driven snow conditions prevail, panel sheathing is recommended under wood shingles and shakes instead.

Another type of sheathing, called *closed sheathing*, was common before it was replaced by panel sheathing. Nominal 1" boards with T&G or shiplap edges were installed over the entire roof surface. Closed sheathing is sometimes encountered during remodeling work.

Open Sheathing

Open sheathing consists of 1×4 square-edged boards, as in **Figure 19-45**. It is often called spaced sheathing. Spaces between sheathing boards promote ventilation around wood shingles and shakes, allowing them to dry out evenly. However, open sheathing is not suitable for use in earthquake regions. In addition, in regions where the average daily temperature in January is 25°F (-4°C) or less, panel sheathing is required on portions of the roof that require an ice barrier. This area generally runs from the edge of the eaves to a point at least 24" inside the building line. Consult local building codes for specific requirements.

The boards of open sheathing are laid with on-center spacing equal to the amount of shingle exposed to the weather. The boards are laid perpendicular to the rafters. Open sheathing is nailed to each rafter with two 8d nails. Joints must be made on the rafters. Each board should bear on at least two rafters.

Reading Check

Recall *In which regions should open sheathing be avoided?*

Plank Sheathing

Plank sheathing with double tongue-and-groove edges (also called *roof decking*) provides a solid surface for roofing and an attractive ready-to-finish interior ceiling. It is available in several patterns and thicknesses,

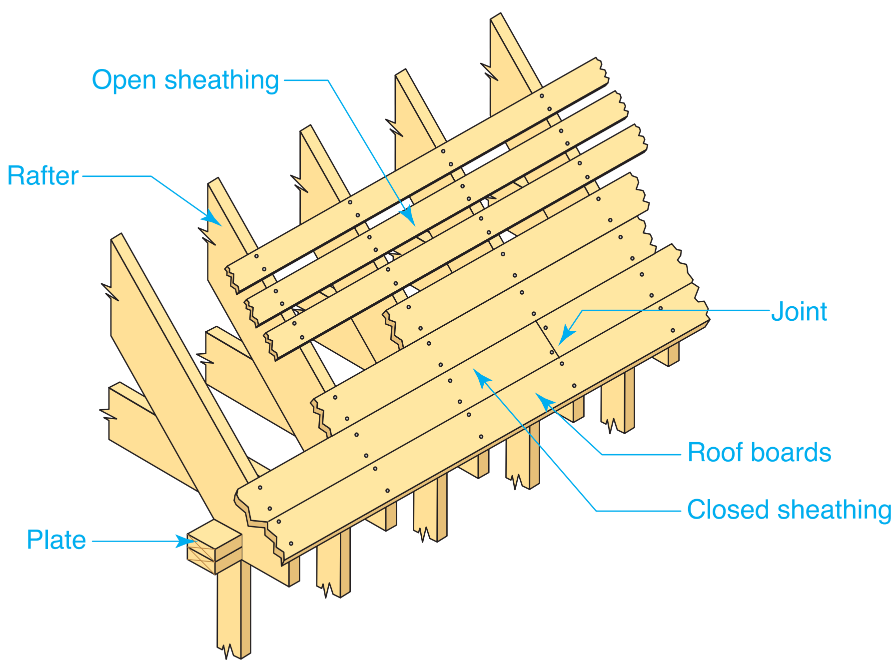


Figure 19-45 Spaced and Closed Sheathing

Old and New Installation of lumber roof sheathing, showing open (spaced) and closed types.

Estimating and Planning

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Sheathing Panels

Materials and Dimensions

To figure the area to be sheathed without actually getting on the roof and measuring, find the dimensions on the plans.

Step 1 Multiply the length of the roof times the width and include the overhang. For example, suppose that a home is 70' long and 30' wide, including the overhang. The roof has a rise of 5½":

70' × 30' = 2,100 sq. ft.

Step 2 Refer to the table. Multiply by the factor shown opposite the rise of the roof. The result will be the roof area. For a rise of 5½", the factor on the table is 1.100. The result will be the area of the roof.

2,100 sq. ft. × 1.100 = 2,310 sq. ft.

Step 3 To estimate the number of sheathing panels required, divide the roof area by 32 (the number of square feet in one 4' × 8' sheet). For example, 2,310 ÷ 32 = 72.19.

Step 4 Add 5 percent for a trim and waste allowance:

72.19 × .05 = 3.6

72.19 + 3.6 = 75.79 = 76 sheets (rounded up).

Estimating on the Job

How many sheets of panel sheathing would be required for a roof that measured 50' long and 27' wide, including the overhang, and that had a 4" rise?

Estimating Roof Sheathing from Plans

Rise (inches)	Factor	Rise (inches)	Factor
3	1.031	8	1.202
3½	1.042	8½	1.225
4	1.054	9	1.250
4½	1.068	9½	1.275
5	1.083	10	1.302
5½	1.100	10½	1.329
6	1.118	11	1.357
6½	1.137	11½	1.385
7	1.158	12	1.414

Note: When a roof has to be figured from a plan only, and the roof pitch is known, the roof area may be fairly accurately computed from this table. The horizontal or plan area (including overhangs) should be multiplied by the factor shown opposite the rise, which is given in inches per horizontal foot. The result will be the roof area.

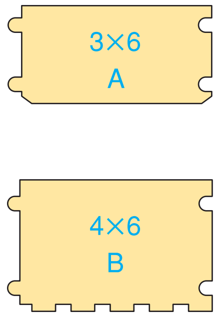


Figure 19-46 Plank Sheathing
Limited Uses Planks come in nominal widths of 4" to 12" and in nominal thicknesses of 2" to 4".

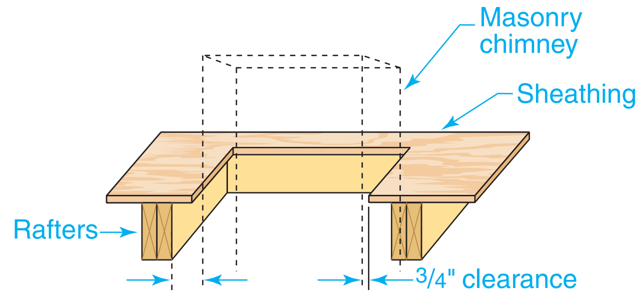


Figure 19-47 Sheathing Around a Chimney
Fire Safety Framing and sheathing around a masonry chimney should be installed so that they are not touching the masonry.

as shown in **Figure 19-46**. The patterned side of the plank sheathing faces down so that it will be exposed to the room below. Plank sheathing is no longer allowed in earthquake-prone areas.

Sheathing Details

Where gable ends have little or no extension other than the molding and trim, the roof sheathing is usually sawed flush with the outer face of the side-wall sheathing. Cuts should be even so that the trim and molding can be properly installed. The sheathing at the valleys and hips should be fitted to give a tight joint. It should be securely nailed to the valley or the hip rafter.

Roof sheathing should have a ¾" clearance from the finished masonry on all sides of a chimney opening, as shown in **Figure 19-47**. This gap is covered by flashing. Framing members should have a 2" clearance for fire protection. The sheathing should be securely nailed to the rafters and to the headers around the opening.

Section 19.5 Assessment

After You Read: Self-Check

1. A performance-rated panel is stamped 32⁄16. What does the number 32 represent?
2. What is the correct spacing for nails when installing roof sheathing panels?
3. What is the advantage of using open sheathing beneath wood shingles?
4. What clearance is recommended between roof sheathing and the finished masonry for a chimney?

Academic Integration: English Language Arts

5. **Roof Sheathing Safety** Sheathing provides a nailing base for the finish roof covering and gives rigidity and strength to the roof framing. Most roofs are sheathed with panel products. Use the Internet to locate a trade association responsible for maintaining standards for plywood roof sheathing. Search the association's Web site to find publications related to residential roof sheathing. Download and print out any publications that relate to safe working procedures during installation. After reading the publication, write a one-page summary of its contents.

Go to **glencoe.com** for this book's OLC to check your answers.

CHAPTER 19

Review and Assessment

Chapter Summary

Section 19.1

Ridges can be structural or nonstructural. Calculating the length of a ridge requires actual measurements taken from the framed building. The ridges for dormers and additions can be calculated with the assistance of a sketch of the roof plan.

Section 19.2

A careful rafter layout is important so that rafters will bear properly on the ridge board or ridge beam. Common rafters are generally installed first, then hip and valley rafters. Jack and hip jack rafters are installed last.

Section 19.3

Special framing details include collar ties, purlins and braces, gable ends, roof openings, shed dormers, and chimney saddles.

Section 19.4

Cornices can be constructed in various ways, based on the architectural style of the house and the climate. The three types of cornices are open, box, and closed. A rake is the part of a gable roof that extends beyond the end walls. Careful detailing is required at the rake, particularly at the cornice returns. The joints must be tight to prevent water from getting through.

Section 19.5

Roofs may be sheathed with panels or lumber. Panel sheathing adds considerable strength to the roof system.

Review Content Vocabulary and Academic Vocabulary

1. Use each of these content vocabulary and academic vocabulary words in a sentence or diagram.

Content Vocabulary

- ridge (p. 530)
- ridge beam (p. 530)
- collar tie (p. 542)
- purlin (p. 544)
- brace (p. 544)
- common difference (p. 546)
- eaves (p. 551)
- cornice (p. 552)
- fascia (p. 552)
- soffit (p. 552)
- lookout (p. 552)
- rake (p. 558)

Academic Vocabulary

- intermediate (p. 530)
- suspended (p. 532)
- version (p. 552)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *nonstructural ridge* (p. 530), *structural ridge* (p. 530), *shortening allowance* (p. 532), *cricket* (p. 550), *closed cornice* (p. 552), *open rake* (p. 558), *fly rafter* (p. 559), *pork chop* (p. 560), *skip sheathing* (p. 565), *roof decking* (p. 565).

Review Key Concepts

3. Name the two basic types of ridges.

4. Explain how to calculate ridge length.

5. Describe how ridge layouts are created for gable roofs, hip roofs, addition roofs, and dormers.

6. Name different types of cornice construction and name the parts.

7. Construct a simple box cornice.

8. Explain the basic requirements for the placement and nailing of panel roof sheathing.

Critical Thinking

9. **Infer** What might happen to panel roof sheathing if the panels are installed with no space between them?

Academic and Workplace Applications

STEM Mathematics

10. **Calculating Area** Estimate the number of 4×8 sheathing panels required for a roof that is 60' long and 25' wide, including overhang. The roof has a rise of 8 feet.

Math Concept Just as the length of a rafter is greater than its run, the area of a gable roof is greater than the footprint of the building it covers.

Step 1: Find the horizontal area, or plan area, of the roof in square feet.

Step 2: Refer to Table 19-1 on page 564 to obtain the rise factor. Multiply by the rise factor to obtain the area of the roof.

Step 3: Divide the area of the roof in square feet by the square footage of one sheathing panel.

Step 4: Add five percent for a trim and waste allowance.

STEM Engineering

11. **Load** In a post-and-beam house, the ridge beam bears the weight of other roof components, such as rafters and roof sheathing. If the roof has a low pitch and the house is well insulated, the beam may also have to bear the substantial weight of snow buildup. What are the characteristics of a ridge beam and what factors determine how much weight it can bear without sagging or failing? Write a list of as many factors as you can think of that affect the ability of a ridge beam to bear weight.

21st Century Skills

12. **Information Literacy** A lack of headroom often prevents attics from being converted to living space. One solution is to build a long shed dormer on one or both sides of a house. A back-to-back pair of long shed dormers are sometimes called saddlebag dormers. They increase the amount of usable attic floor space. Using library or Internet resources, locate examples of saddlebag dormers. Be sure to check sources of stock building plans. When you find at least one example, make a cross-section sketch of the house with and without the dormer. See if you can determine approximately how much usable floor space, in square feet, is lost if the dormer is removed.

Standardized TEST Practice

CERTIFICATION PREP

True/False

Directions Read each of the following statements carefully. Mark each statement as either true or false by filling in **T** or **F**.

T F **13.** An open cornice consists of frieze boards, molding, and a fascia.

T F **14.** When the width of an addition is less than the width of the main portion of the house, their roof spans are unequal.

T F **15.** When installing collar ties, nominal 1" collar ties should be nailed to the common rafters with three 16d nails at each end.

TEST-TAKING TIP

If any part of a true/false question is false, then the entire statement is false. However, just because part of a statement is true does not necessarily mean the entire statement is true.

*These questions will help you practice for national certification assessment.

UNIT 4
Hands-On Math Project

Construction Calculations

Your Project Assignment

Your company is building new houses for people who have lost their homes in a natural disaster. You will use a shed roof design. You need to calculate the rafter lengths for various design options and present them in a table. You will pick roof angles in 5 degree increments, calculate the rafter length using trigonometry, and pick a material size for the rafters.

- **Research** the safe spans of common rafter materials such as saw lumber, PSL, and LVL.
- **Build It Green** **Research** green roofing materials.
- **Calculate** the rafter lengths needed for specific roof angles and spans.
- **Calculate** the total rise of specific roof angles and spans.
- **Create** a three- to five- minute presentation.

Applied Skills

Your success in carpentry will depend on your skills. Some skills you might use include:

- **Calculate** rafter lengths using trigonometric functions.
- **Create** a span table for roof specifications given as angles.
- **Present** your results and demonstrate how to use your roof angle rafter table.

Math Standards

Measurement: Understand measurable attributes of objects and the units, systems, and processes of measurement

Measurement: Apply appropriate techniques, tools, and formulas to determine measurements

Geometry: Analyze characteristics of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships

Problem Solving: Solve problems that arise in mathematics and in other contexts

NCTM National Council of Teachers of Mathematics

The Math Behind the Project

The traditional math skills for this project are trigonometry and measurement. Remember these key concepts:

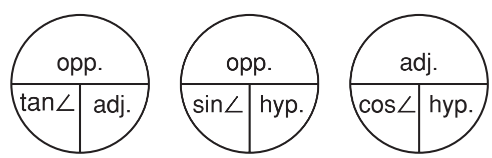
Pythagorean Theorem

The rafter of a shed roof forms the hypotenuse of a right triangle. The legs of the triangle are the rise and run of the roof. You can use the following equation derived from the Pythagorean theorem, $a^2 + b^2 = c^2$, to calculate the length of the rafter:

$$\sqrt{a^2 + b^2 = c}$$

Trigonometric Functions

You can determine the length of the rafter using trigonometric functions. The circles below show abbreviations for standard trigonometric terms–opposite, tangent, adjacent, sine, hypotenuse, and cosine. To solve for a term in the top half of any of these circles, multiply the terms in the two bottom quarters to get your answer. For example, to find the adjacent of a triangle, multiply the cosine by the hypotenuse. To solve for a term in the lower half of the circle, divide the quantity on the top by the other quantity on the bottom. For example, to solve for tangent, divide opposite by adjacent.



To find the angle of the triangle, take the result of your calculations and use the inverse or 2nd function key on a scientific calculator. Your answer will be a whole number and a decimal. Convert the decimal to a fraction. For example, to change 59.093 ft to feet and inches, use the following steps:

1. Multiply the decimal portion by 12.	$.093 \times 12 = 1.116$
2. Multiply the decimal portion of the product by 16.	$.116 \times 16 = 1.856$
3. Round to the nearest whole number.	2

This means that .116" is about 2/16" or 1/8". The final answer is 59 feet, 1 1/8 inch.

U.S. GREEN BUILDING COUNCIL

Mission: To transform the way buildings and communities are designed, built, and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life.

Go to **glencoe.com** for this book's OLC for more information on this organization.

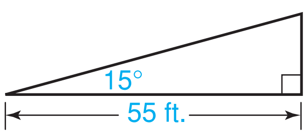
Project Steps

Step 1 Research

- Research the allowable spans for saw lumber, PSL, LVL, and I-joists. You can find this information at building centers and on manufacturers' Web sites.
- ***Build It Green*** Contact or use the online resources of the U.S. Green Building Council for guidance on selecting the most energy-efficient, sustainably produced materials suitable for roofing in your region.
- Decide on a material and material size for the rafters.

Step 2 Plan

- Specify the span length of your roof. (Remember that on a shed roof, span and run are the same.)
- Determine the roof angles you will use for your calculations. Pick three roof angles that differ in 5 degree increments.
- Sketch each of your three designs as in the example below. Label the span length and specify the roof angle.



Step 3 Apply

- Use trigonometry to calculate the rafter length for each of your three roof angle designs. Add this information to your sketches. Add a tail for eaves if desired.
- Calculate the total rise for each roof angle design. Add this information to your sketches.
- Create a chart for your three roof angles that lists the different rafter lengths needed for each.
- Write an instruction sheet that explains how to use the chart and how you calculated the data.

Step 4 Present

Prepare a presentation combining your research and measurement calculations using the checklist below.

PRESENTATION CHECKLIST
Did you remember to…
✓ Show your calculations for each roof angle?
✓ Use and present your sketches and a worksheet with your calculations?
✓ Explain how you used trigonometry to calculate rafter length?
✓ Write notes you might need for your presentation?
✓ Explain how to use the rafter chart?

Step 5 Technical and Academic Evaluation

Assess yourself before and after your presentation.

1. Was your research thorough?
2. Were your green alternatives realistic?
3. Were your calculations correct?
4. Were your sketches accurate?
5. Was your presentation creative and effective?

Go to **glencoe.com** for this book's OLC for an evaluation rubric and Academic Assessment.

McGraw Hill CONSTRUCTION

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Go to **glencoe.com** com for this book's OLC to read an article titled "Green-Roof Study Results Offer Positive Surprises" to learn more about developments in green roofing. Write a summary of the article.