Chapter 10

Rough Carpentry

Topics

Overview

Rough carpentry is critical to the strength of any building project. It forms the base to which other building components are attached. You as the Builder are responsible for the quality construction of the rough framing components.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Describe sill layout and installation.
2. Identify members used in floor construction, and the construction methods used with subfloor and bridging.
3. Identify wall framing members and explain layout and installation procedures for these members in building construction.
4. State the purpose of ceiling frame members and describe layout and installation procedures.
5. Identify the types of roofs and define common roof framing terms.
6. Describe and solve roof framing problems using the framing square.
7. Describe procedures for laying out and installing members of gable, hip, intersecting, and shed roof designs.

8. Describe the types and parts of roof trusses, and explain procedures for fabricating, handling, and erecting them.

9. Describe the types and parts of stairs, and explain procedures for fabricating, handling, and erecting them.

Prerequisites

None

This course map shows all of the chapters in Builder Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

Expeditionary Structures	↑	
Finishes		B
Moisture Protection		U
Finish Carpentry		I
Rough Carpentry		L
		D
Carpentry Materials and Methods		E
Masonry		R
Fiber Line, Wire Rope, and Scaffolding		
Concrete Construction		
Site Work		B
Construction Management		A
		S
Drawings and Specifications		I
Tools		C
Basic Math		

Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The Figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with an italicized instruction telling you where to click to activate it.

- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 FRAMING SILLS

In the normal sequence of construction events, the floor and wall activities follow the completed foundation work. In this section, we'll examine established methods of frame construction and discuss how floor and wall framing members are assembled.

1.1.0 Wood Sill Framing

Framing of the structure begins after completion of the foundation. The lowest member of the frame structure resting on the foundation is the sill plate. This sill provides a base for ***joists*** or ***studs*** resting directly over the foundation. Work in this area is critical, as it is the real point of departure for actual building activities.

1.1.1 Layout

The box sill is usually used in platform construction. It consists of a sill plate and header joist anchored to the foundation wall. The box sill supports floor joists and holds them in position as shown in *Figure 10-1*. Insulation material and metal termite shields are placed under the sill if desired or when specified. Sills are usually single, but double sills are sometimes used.

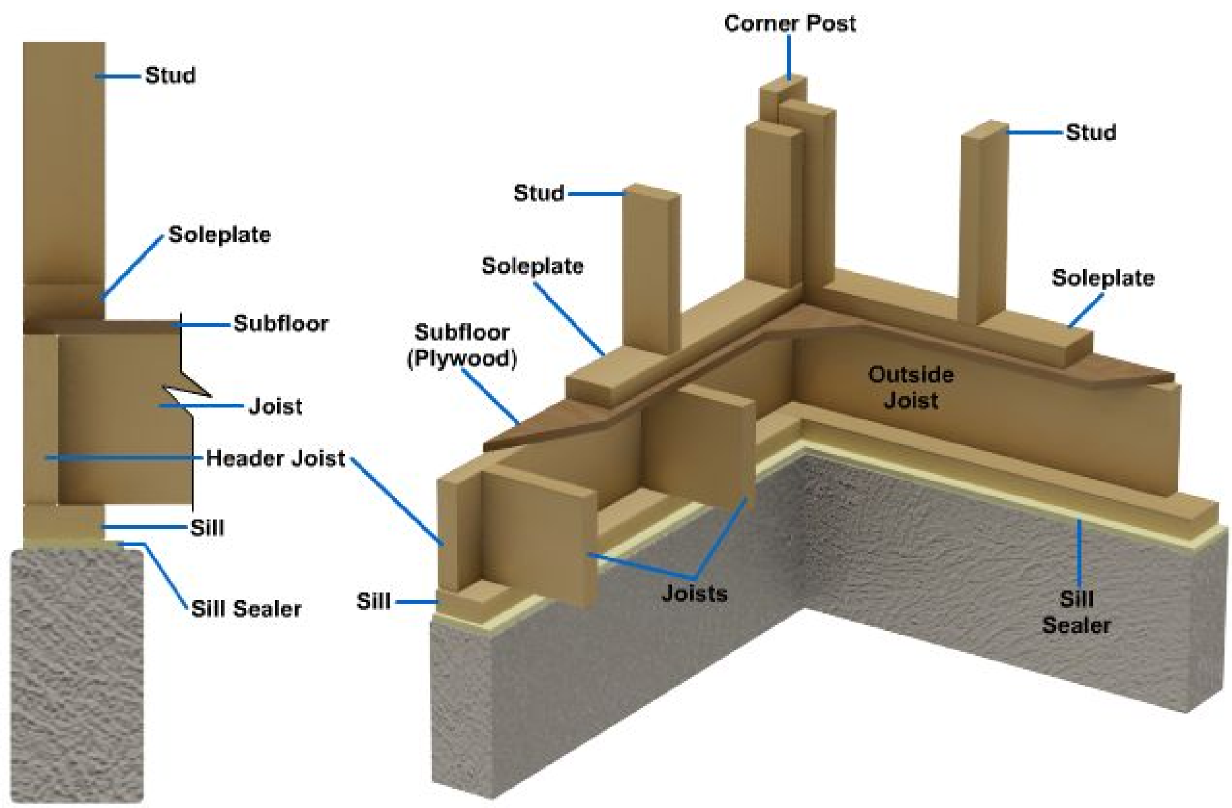


Figure 10-1 – Box-sill assembly.

Following construction of the foundation wall, the sill is normally the first member laid out. The edge of the sill is set back from the outside face of the foundation a distance equal to the thickness of the exterior sheathing. If splicing is necessary to obtain the required length, halve the splice joint at least 2 feet and bolt together. Once you have determined the required length, lay out the locations of the anchor bolt holes using the following steps:

1. Establish the building line points at each corner of the foundation.
2. Pull a chalk line at these points and snap a line for the sill location.
3. Square the ends of the sill stock. Stock received at jobsites is not necessarily squared at both ends.
4. Place the sill on edge and mark the locations of the anchor bolts.
5. Extend these marks with a square across the width of the sill. The distance X in *Figure 10-2* shows how far from the edge of the sill to bore the holes. This is the thickness of the exterior sheathing.

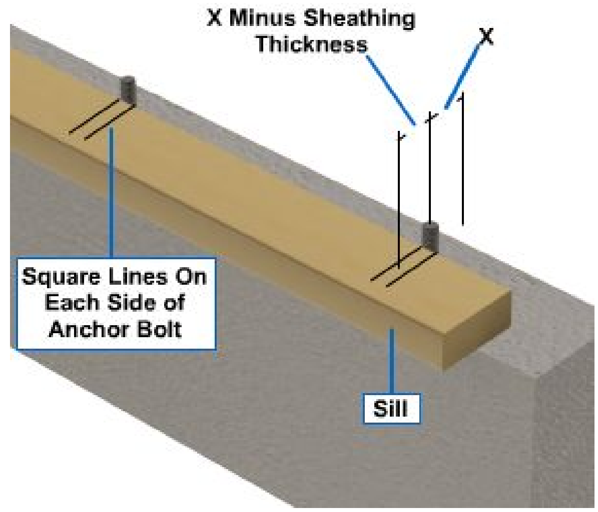


Figure 10-2 – Anchor bolt layout.

After all the holes are marked, bore the holes. Each should be about 1/4 inch larger than the diameter of the bolts to allow some adjustment for slight inaccuracies in the layout. As you bore each section, position that section over the bolts.

When all sill sections are fitted, remove them from the anchor bolts. Install sill sealer, otherwise known as insulation, as shown in *Figure 10-3*. The insulation compresses, filling the irregularities in the foundation. It also stops drafts and reduces heat loss.

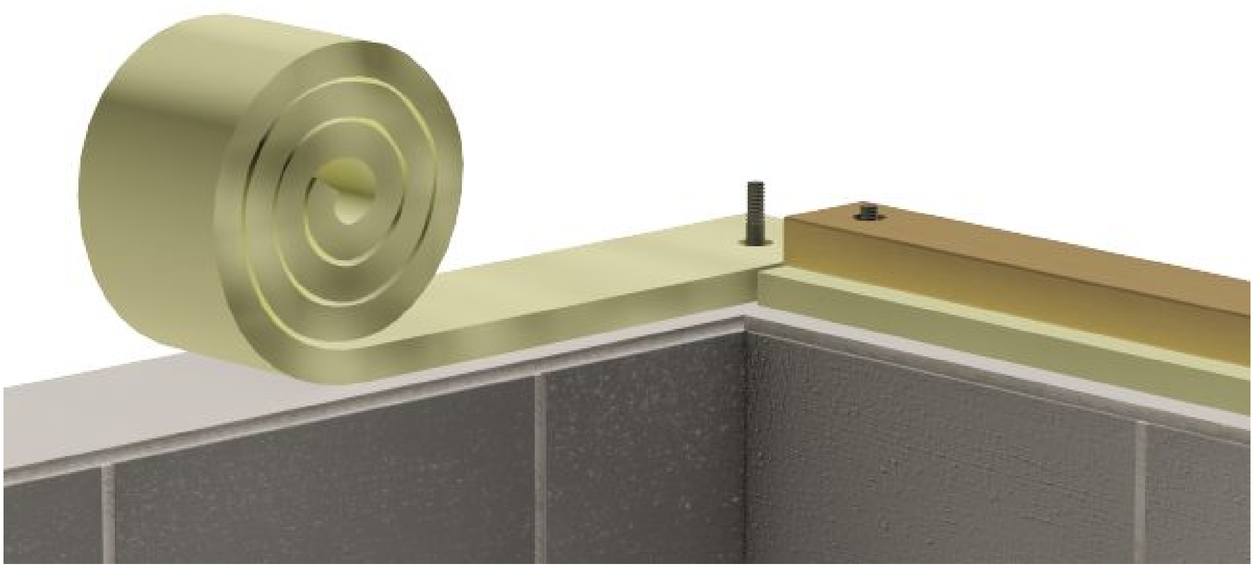


Figure 10-3 – Installing sill sealer.

Install a termite shield as shown in *Figure 10-4* if specified. A termite shield should be at least 26-gauge aluminum, copper, or galvanized sheet metal. The outer edges should be slightly bent down.

Replace the sills and install the washers and nuts. As you tighten the nuts, make sure the sills are properly aligned. Also check the distance from the edge of the foundation wall. The sill must be level and straight. Low spots can be shimmied with wooden wedges, but it is better to use grout or mortar.

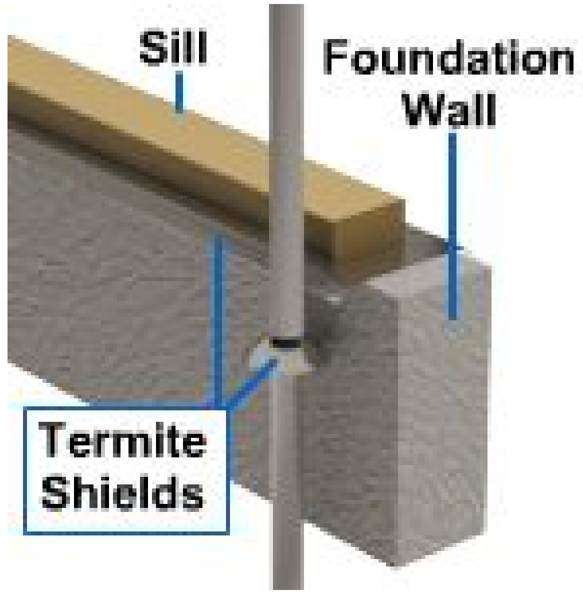


Figure 10-4 – Installing termite shields.

1.1.2 Fastening to Foundation Walls

Wood sills are fastened to masonry walls by 1/2 inch anchor bolts. These bolts, also known as j-bolts because of their shape, should be embedded 15 inches or more into the wall in unreinforced concrete as shown in *Figure 10-5, view A* and a minimum of 7 inches into reinforced concrete as shown in *view B*. The length of the anchor bolt is found in the ***specifications***. The spacing and location of the bolts are shown on the drawings.

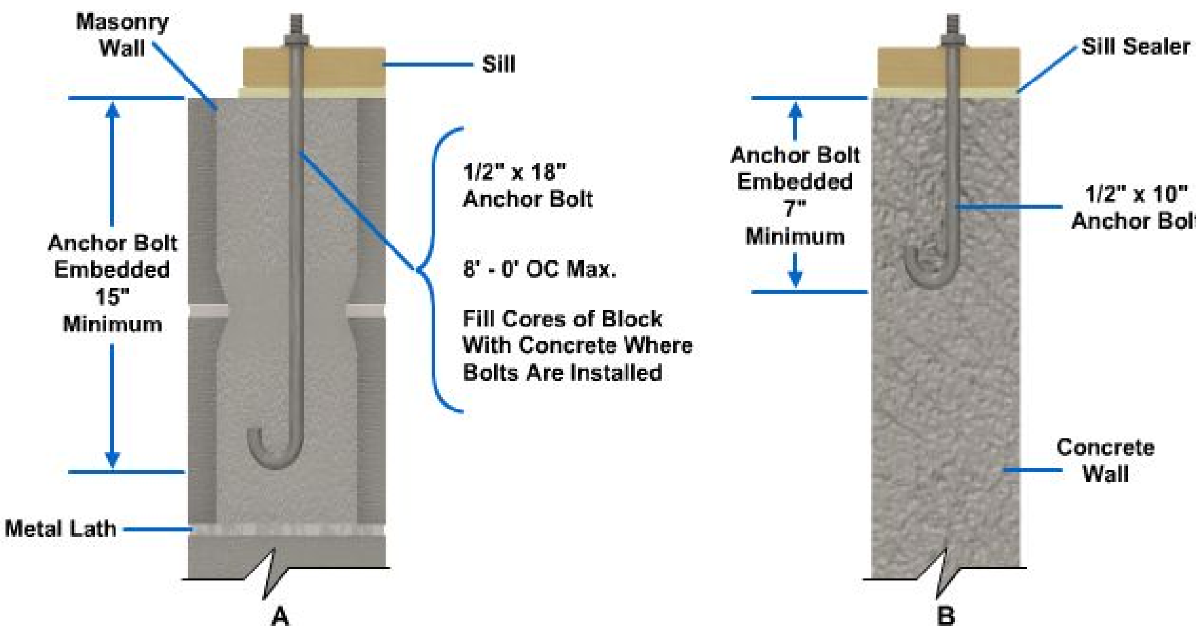


Figure 10-5 – Methods of sill fastening to foundations.

If this information is not available, anchor bolt spacing should not exceed 6 feet on center (OC). You must also place a bolt within 1 foot of the ends of each piece but no closer than 4 inches from the end, as shown in *Figure 10-6.*

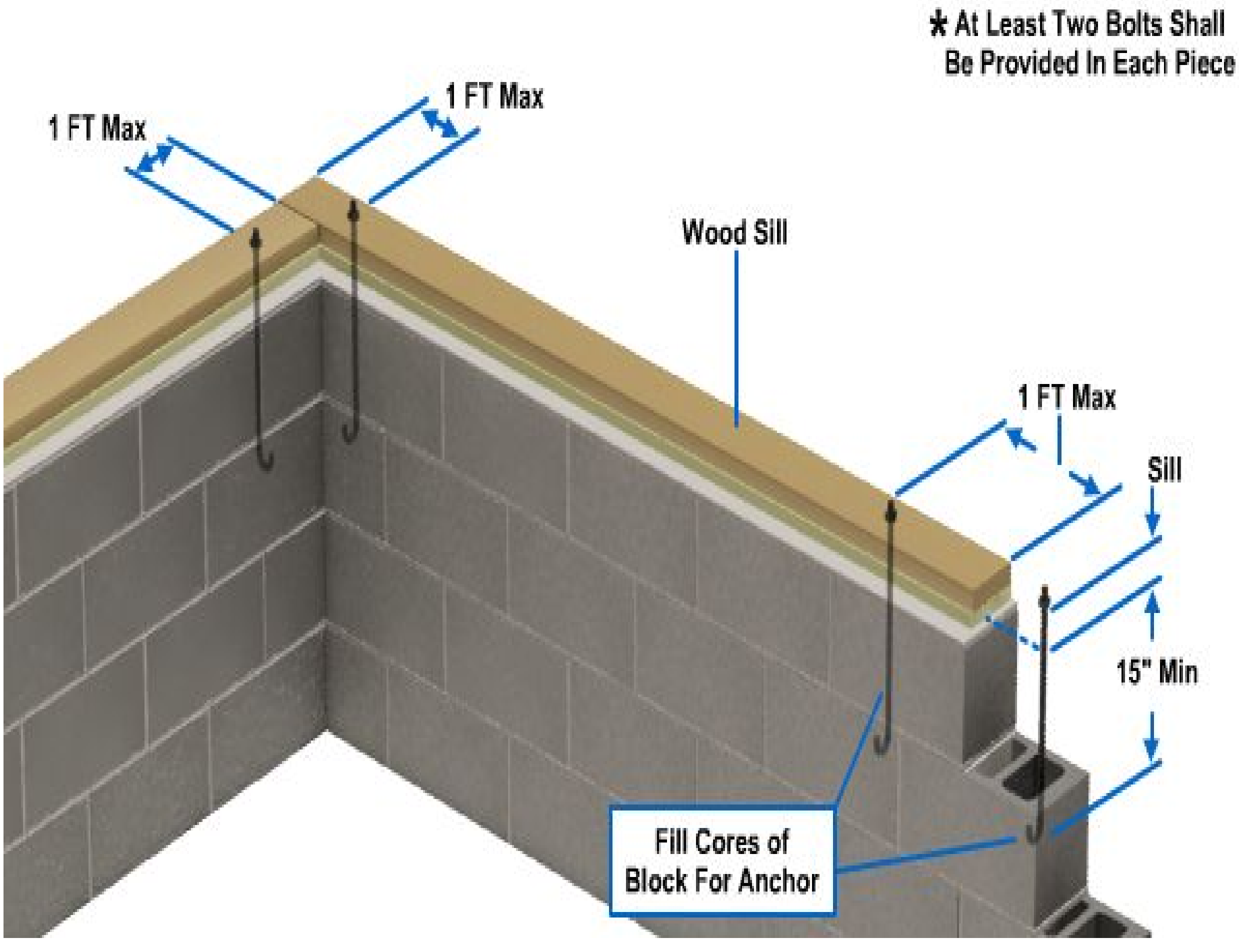


Figure 10-6 – Spacing of anchor bolts.

There are alternative ways to fasten sill plates to foundations. Location and building codes will dictate which to use. Always consult the job specifications before proceeding with construction.

Test your Knowledge (Select the Correct Response)

1. In wood frame construction, what is the lowest member resting on the foundation?

   A. Platform
   B. Plank
   C. Stud
   D. Sill plate

2.0.0 FRAMING FLOORS

Floor framing consists specifically of the posts, ***girders***, joists, and subfloor. When these are assembled as shown in *Figure 10-7*, they form a level anchored platform for the rest of the construction.

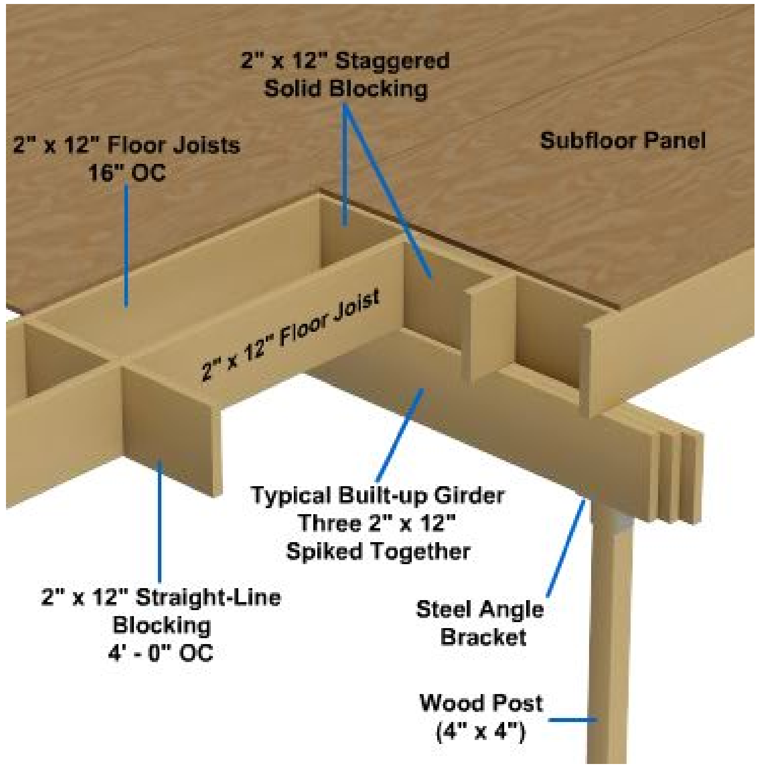


Figure 10-7 – Basic components of floor framing.

2.1.0 Posts

Wood or steel posts and girders support floor joists and the subfloor. Sizes depend on the loads carried. The dimensions and locations are shown on the foundation plan. Posts give central support to the long ***span*** of girders when required. Girders can be used to support other girders. There should be at least 18 inches clearance between the bottoms of the floor joists and the ground and at least 12 inches between the bottom of the girder and the ground, as shown in *Figure 10-8*.

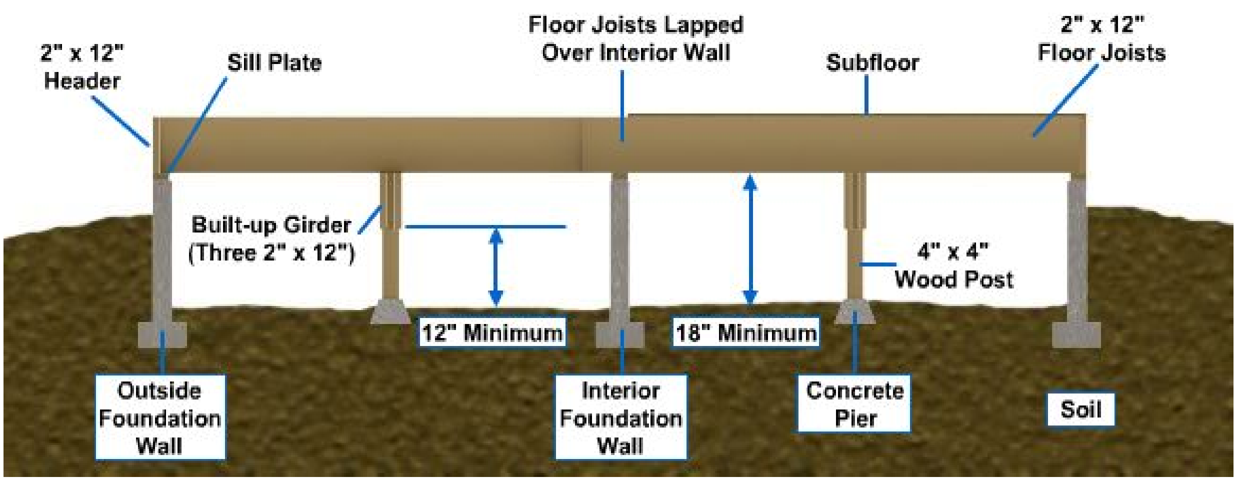


Figure 10-8 – Floor framing on sill plates with intermediate posts and built-up girders.

2.1.1 Wood

Wood posts are placed directly below wood girders. As a general rule, the width of the wood post should be equal to the width of the girder it supports. For example, a 4 inch wide girder requires a 4 by 4 or 4 by 6 inch post.

You can secure a wood post to a concrete pillar in several ways.

- Nail it to a pier block secured to the top of a concrete pier.
- Place it over a previously inserted 1/2 inch steel dowel in the concrete.
- Place it into a metal base set into the concrete pier at the time of the pour.

When using the dowel method, make sure the dowel extends at least 3 inches into the concrete and the post, as shown in *Figure 10-9*.

A metal base embedded in the concrete as shown in *Figure 10-10* is the preferred method since nothing else is needed to secure the base.

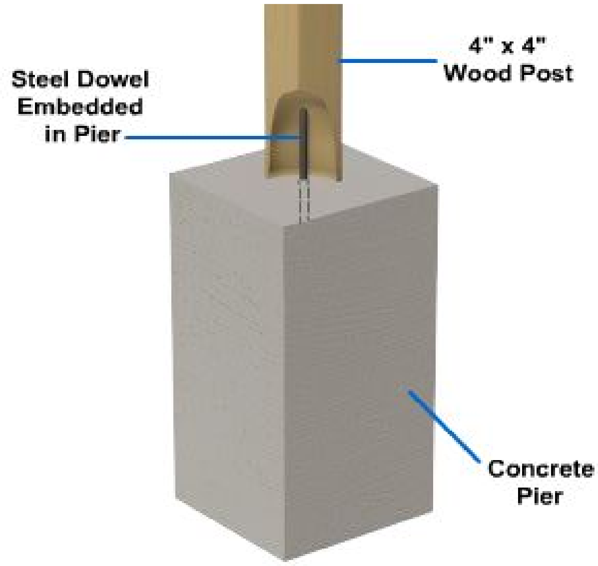


Figure 10-9 – Post fastened using dowel method.

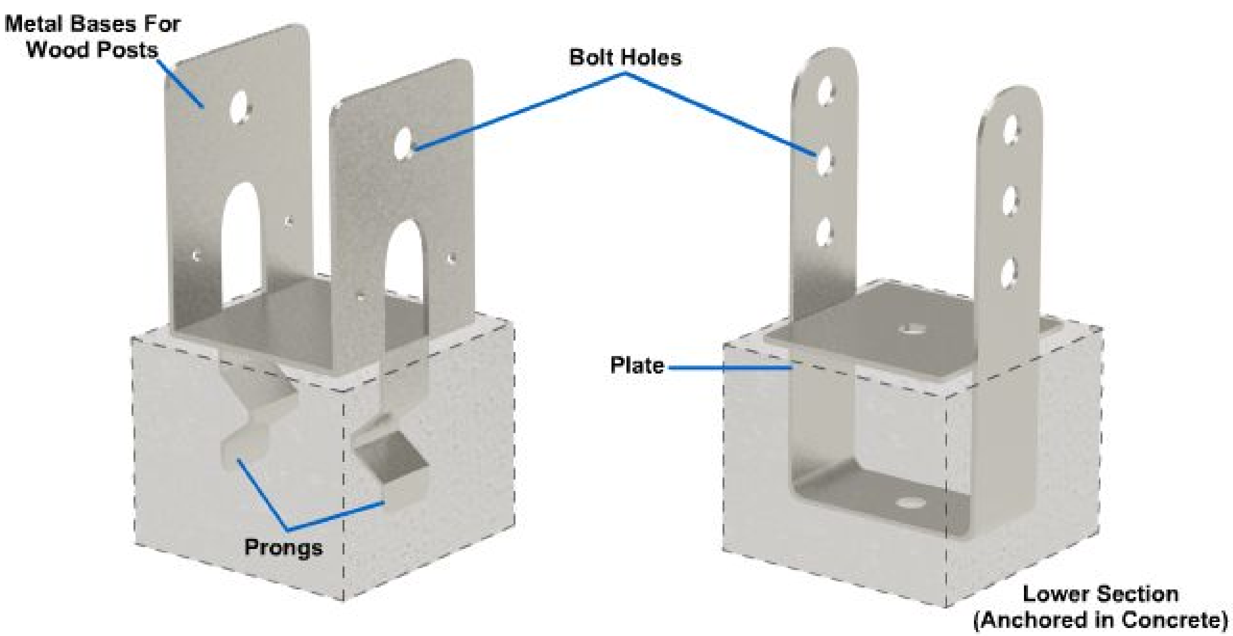


Figure 10-10 – Metal base plates for wood posts.

As with the bottom of the post, the top must also be secured to the girder. Do this using angle iron brackets or metal plates. *Figure 10-11* shows two metal post caps used with posts and girders, either nailed or bolted to the girders.

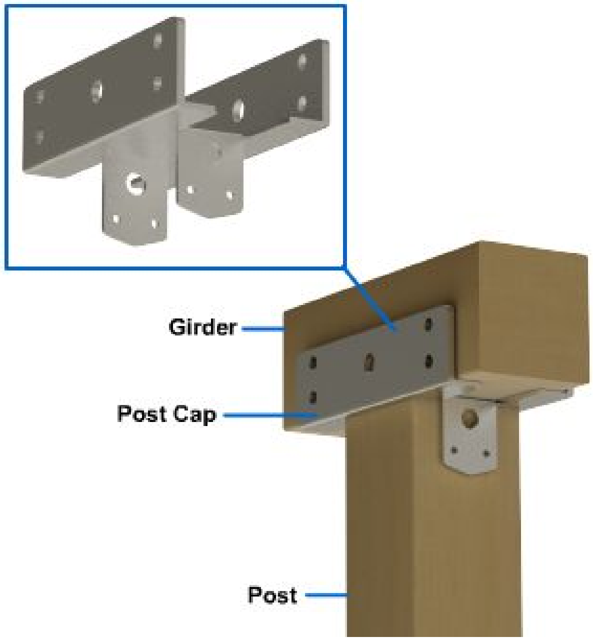


Figure 10-11 – Metal post caps.

2.1.2 Steel

Steel pipe columns, also known as Lally columns, are often used in wood frame construction, with both wood and steel girders. When using wood girders, secure the post to the girder with lag bolts. For steel girders, machine bolts are required. Bolt the base of the steel post to the top of the pier, as shown in *Figure 10-12*. You can also bolt the post to anchor bolts inserted in the slab prior to pouring.

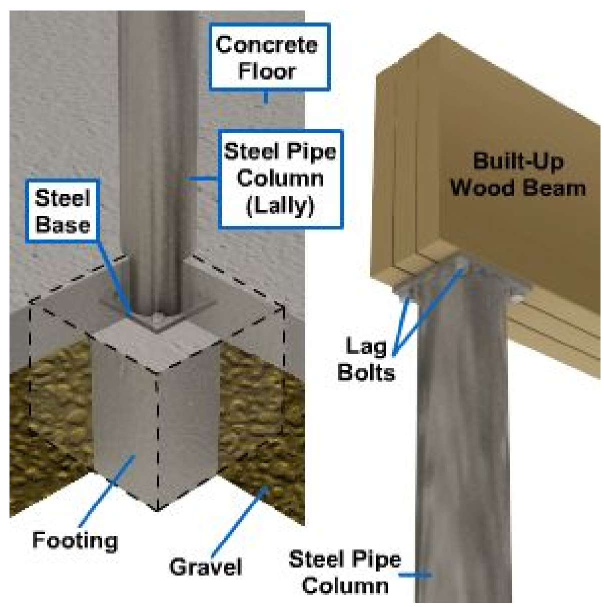


Figure 10-12 – Bolting of steel column.

2.2.0 Girders

Girders are classified as bearing and nonbearing according to the amount and type of load supported. Bearing girders must support a wall framed directly above, as well as the live load and dead load of the floor. Nonbearing girders support only the dead and live loads of the floor system directly above. The dead load is the weight of the material used for the floor unit itself. The live load is the weight created by people, furniture, appliances, and so forth.

2.2.1 Wood

Wood girders may be a single piece of timber, or they may be laminated. The built-up girder in *Figure 10-13*, for example, consists of three 2 by 12 inch planks. Stagger the joints between the planks. In framing, place a built-up girder so that the joints on the outside of the girder fall directly over a post. Drive three 16d nails at the ends of the planks, and stagger other nails 32 inches OC. The top of the girder is flush with the top sill plate, as shown in *Figure 10-13*.

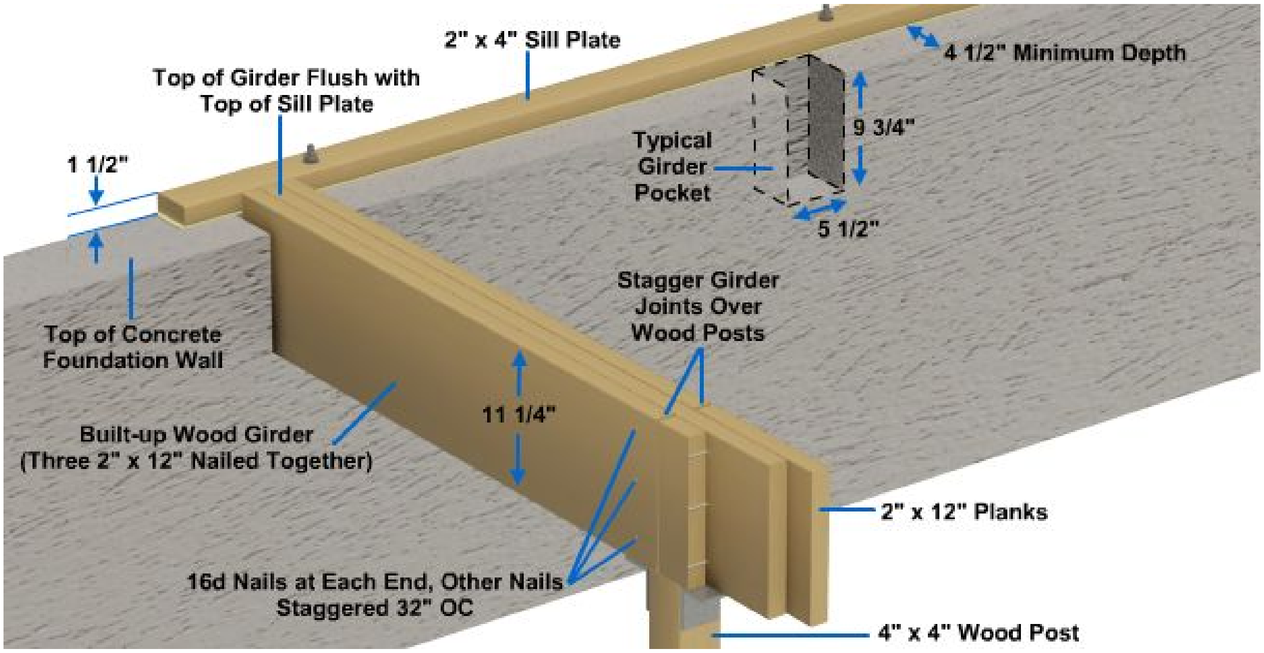


Figure 10-13 – Built-up girder.

When space is required for heat ducts in a partition supported on a girder, a spaced wood girder, such as that shown in *Figure 10-14*, is sometimes necessary. Use solid blocking at intervals between the two members. A single-post support for a spaced girder usually requires a bolster, preferably metal, with a sufficient span to support the two members.

The ends of a girder often rest in pockets prepared in a concrete wall, as shown in *Figure 10-13*. Here, the girder ends must bear at least 4 inches on the wall, and the pocket should be large enough to provide a 1/2 inch air space around the sides and end of the girder. To protect against termites, treat the ends of the girder with a preservative. As a further precaution, line the pockets with metal.

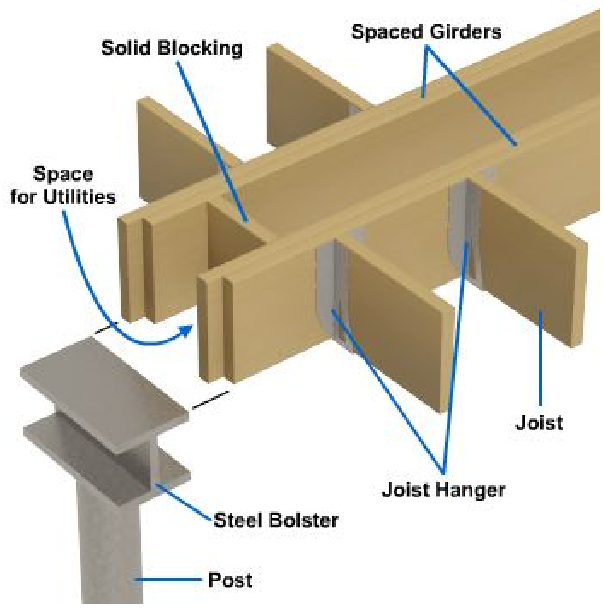


Figure 10-14 – Spaced wood girders.

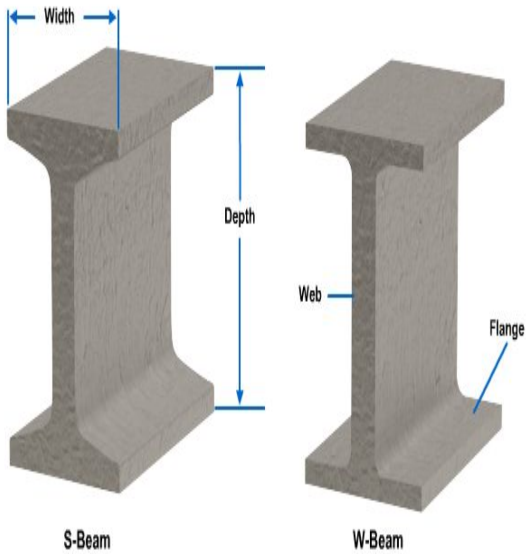


Figure 10-15 – Types of steel beams.

2.2.2 Steel

Standard or S-beams and wide flange or W-beams, both shown in *Figure 10-15*, are most often used as girders in wood framed construction. Whether the beam is wood or steel, make sure it aligns from end to end and side to side. Also make sure the length of the bearing post under the girder is correct to ensure the girder is properly supported.

2.3.0 Placing Posts and Girders

Posts must be cut to length and set up before you can install the girders. The upper surface of the girder may be in line with the foundation plate sill, or the girder ends may rest on top of the walls. Long girders must be placed in sections. Solid girders must be measured and cut so that the ends fall over the center of a post. Place built-up girders so their outside joints fall over the posts as in *Figure 10-13*.

Test your Knowledge (Select the Correct Response)

2. When placing a girder in the pocket of a concrete wall, the minimum bearing should be

   A. 1 inch
   B. 2 inches
   C. 3 inches
   D. 4 inches

2.4.0 Floor Joists

In platform framing, one end of the floor joist rests directly on the sill plate of the exterior foundation wall or on the top plate of a framed outside wall. The bearing should be at least 1 1/2 inches. The opposite end of the joist laps over or butts into an interior girder or wall. You must choose the size of joist material, 2 by 6, 2 by 10, 2 by 12, and so forth, with consideration for the span and the amount of load to be carried. The foundation plan usually specifies the joist size, the spacing between joists, and what direction the joists should travel. The usual spacing of floor joists is 16 inches OC. Floor joists are supported and held in position over exterior walls by header joists or by solid blocking between the joists. The header joist system is used most often.

2.4.1 Header

Header joists run along the outside walls. Three 16d nails are driven through the header joists into the ends of the common joists, as shown in *Figure 10-16.* The header and joists are ***toenailed*** to the sill with 16d nails. The header joists prevent the common joists from rolling or tipping. They also help support the wall above and fill in the spaces between common joists.

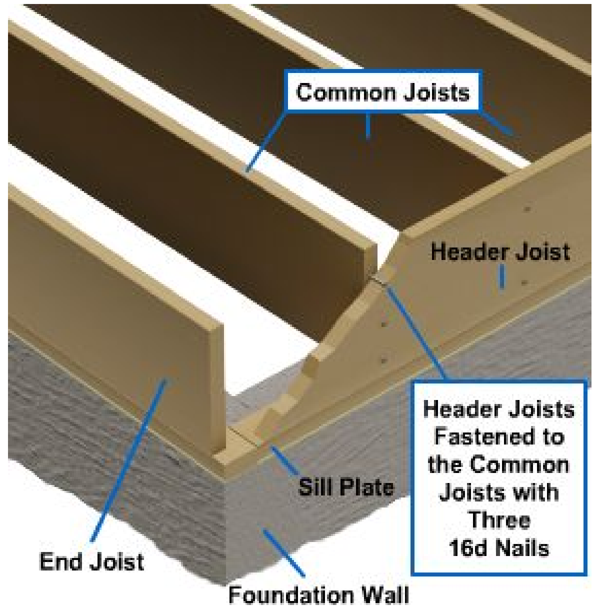


Figure 10-16 – Header joist.

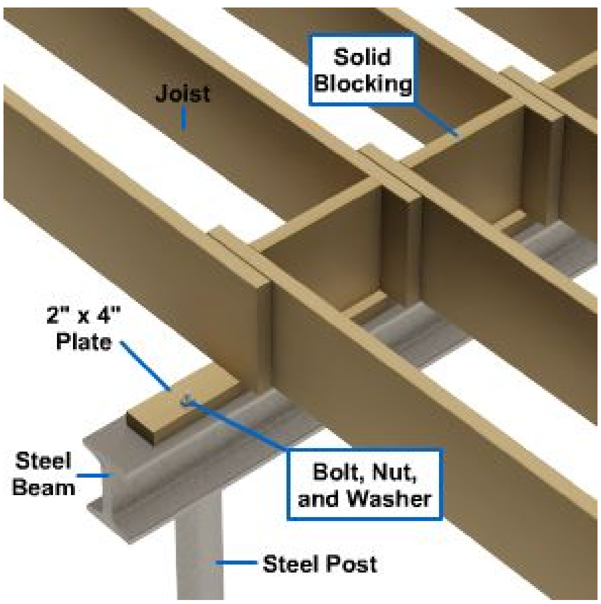


Figure 10-17 – Lapped joists.

2.4.2 Lapped

Joists are often lapped over a girder running down the center of a building. The lapped ends of the joists may also be supported by an interior foundation or framed wall. Standard procedure is to lap joists the full width of the girder or wall. The minimum lap should be 4 inches. *Figure 10-17* shows lapped joists resting on a steel girder. A 2 by 4 inch plate has been bolted to the top of a steel beam. The joists are toenailed into the plate. You may install solid blocking between the lapped ends after all the joists have been nailed down. Another system is to put in blocks when you place the joists.

2.4.3 Double

Double joists under partitions running in the same direction as the joists. Some walls have water pipes, vent stacks, or heating ducts coming up from the basement or the floor below. Place ***bridging*** between double joists to allow space for these purposes, as shown in *Figure 10-18*.

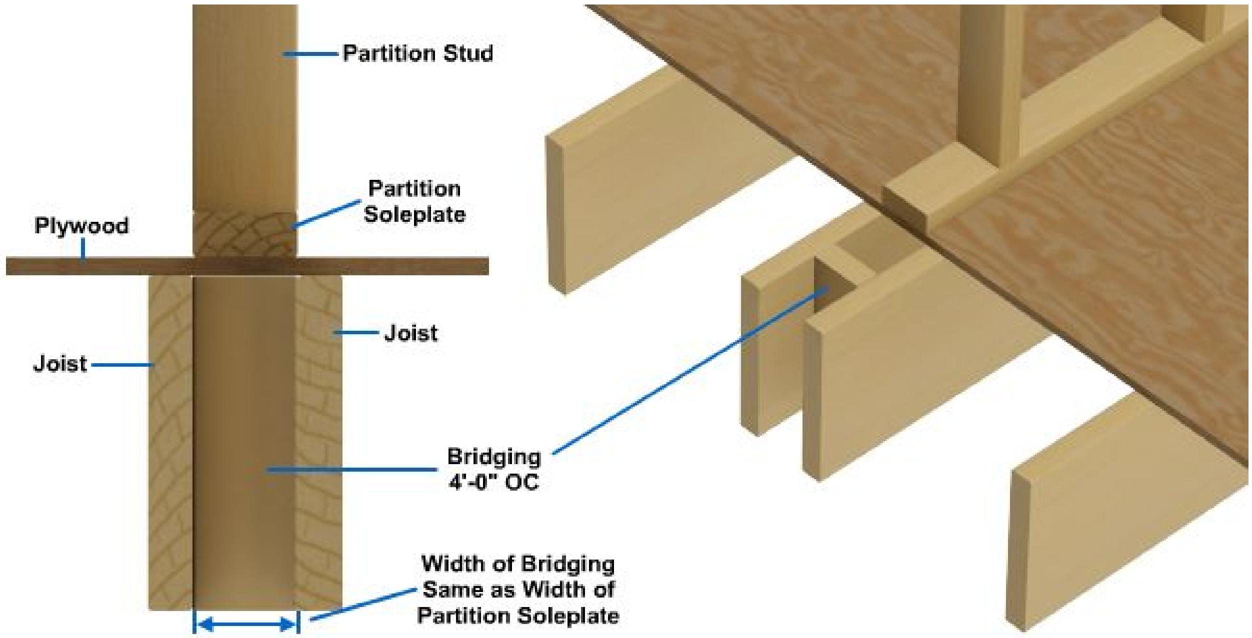


Figure 10-18 – Double joists.

2.4.4 Cantilevered

Cantilevered joists are used when a floor or balcony of a building projects past the wall below, as shown in *Figure 10-19*. Nail a header piece to the ends of the joists.

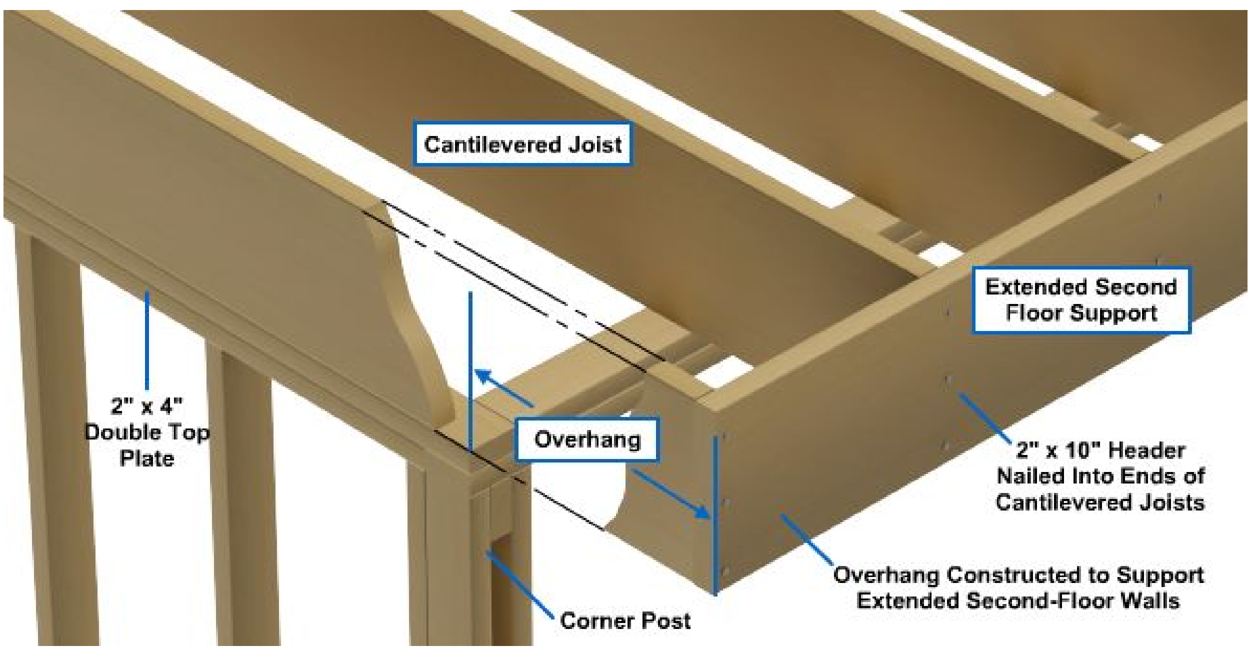


Figure 10-19 – Cantilevered joists.

When regular floor joists run parallel to the intended overhang, fasten the inside ends of the cantilevered joists to a pair of double joists as shown in *Figure 10-20*. Nail through the first regular joist into the ends of the cantilevered joists. Framing anchors are strongly recommended and often required by the specifications. Also, nail a header piece to the outside ends of the cantilevered joists.

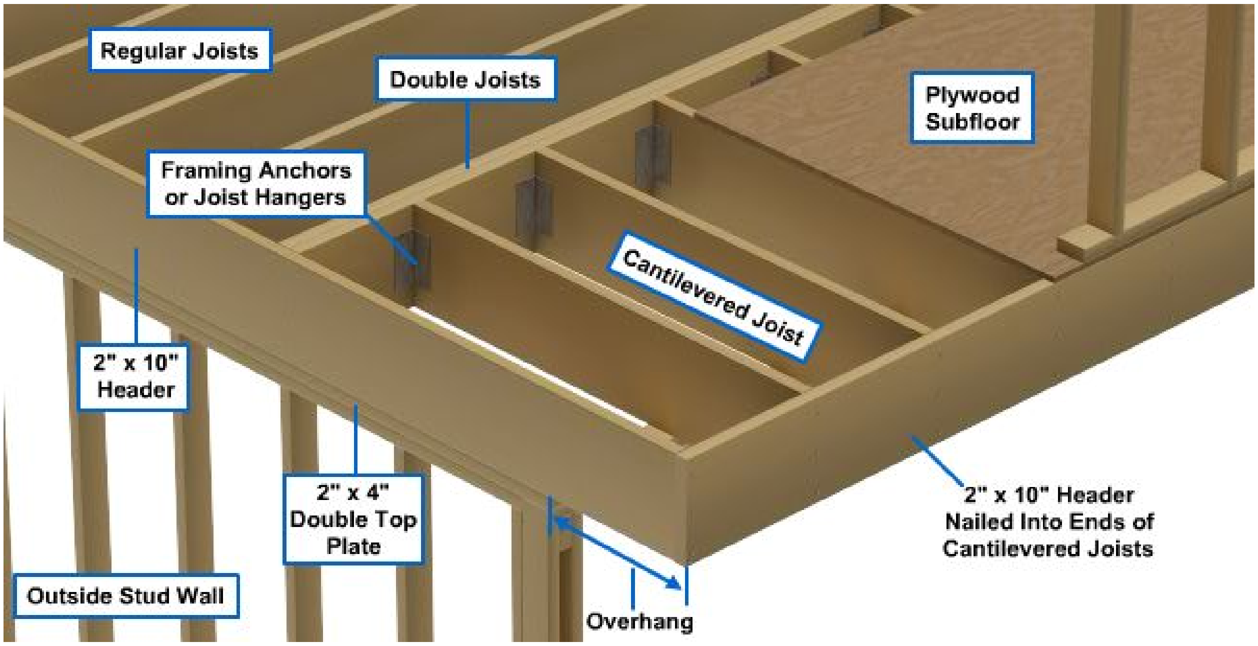


Figure 10-20 – Framing for cantilevered joists.

2.4.5 Butted over a Girder

Joist ends can also be butted, rather than lapped, over a girder. Cleat the joists together with a metal plate or wooden cleat, as shown in *Figure 10-21*. You may leave these out if the line of panels from the plywood subfloor straddles the butt joints.

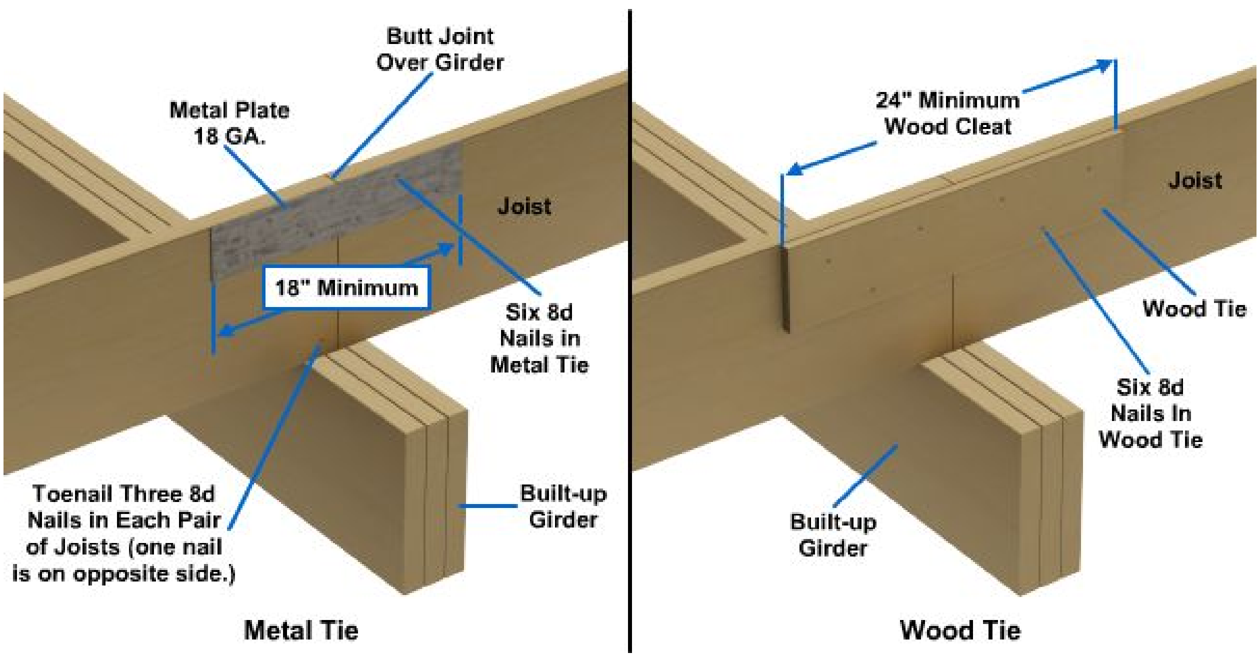


Figure 10-21 – Butting joists over a girder.

2.4.6 Butted against a Girder

Butting joists against, rather than over, a girder allows more headroom below the girder. When it is necessary for the underside of the girder to be flush with the joists to provide an unbroken ceiling surface, support the joists with joist hangers, as shown in *Figure 10-22*.

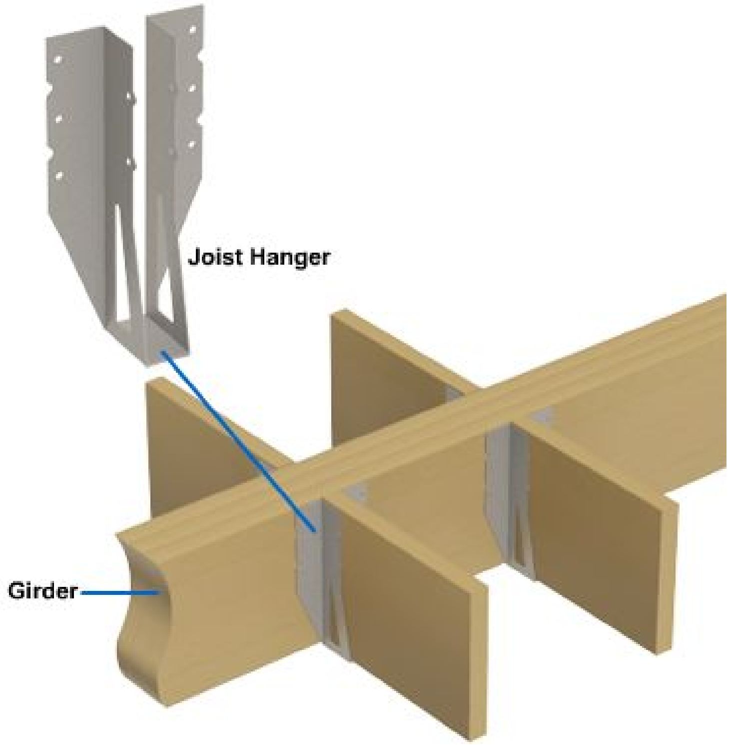


Figure 10-22 – Butting Joists against a girder.

2.4.7 Blocking between Joists

Another system of providing exterior support to joists is to place solid blocking between the outside ends of the joists. This way the ends of the joists have more bearing on the outside walls.

2.4.8 Interior Support

Floor joists usually run across the full width of the building. However, extremely long joists are expensive and difficult to handle. Two or more shorter joists are usually used. The ends of these joists are supported by lapping or butting them over a girder, butting them against a girder, or lapping them over a wall.

2.4.9 Supported by a Steel Beam

Wood joists are often supported by a steel beam rather than a wood girder. The joists may rest on top of the steel beam as shown in *Figure 10-23 view A*, or they may be butted and notched to fit against the sides of the beam as shown in *view B*.

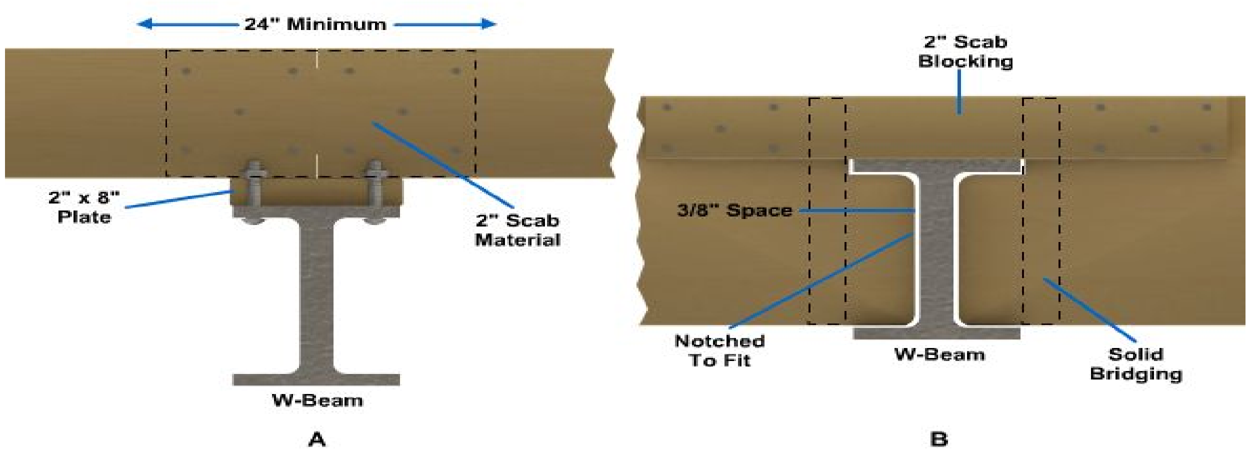


Figure 10-23 – Joists supported by steel beams.

If the joists rest on top of a steel beam, a plate is fastened to the beam and the joists toenailed into the plate. When joists are notched to fit against the sides of the beam, allowance must be made for joist shrinkage while the steel beams remain the same size. For average work with a 2 by 10 inch joist, an allowance of 3/8 inch above the top flange of the steel girder or beam is usually sufficient.

Another method of attaching butted joists to a steel girder is shown in *Figure 10-24*. A 3/8 inch space is shown above the beam to allow for shrinkage. Do not notch the joists so they rest on the lower flange of an S-beam since the flange surface does not provide sufficient bearing surface. You may bolt or weld a wide plate to the bottom of the S-beam to provide better support.

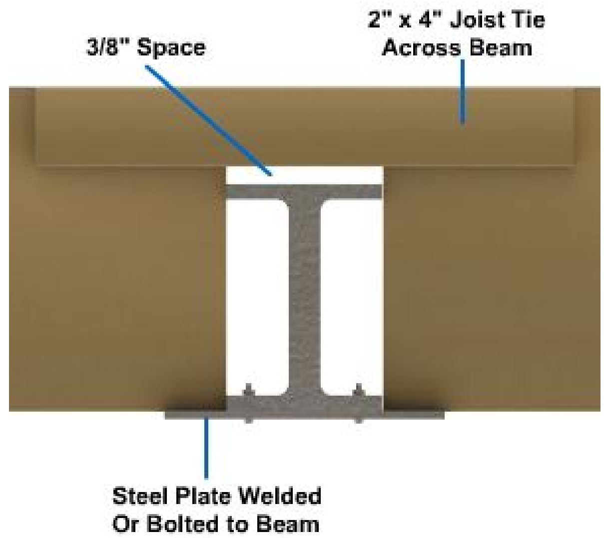


Figure 10-24 – Joists supported on steel plates.

You may also place wooden blocks at the bottoms of the joists to help keep them in position. Wide flanged beams provide sufficient support surface for this method of construction. *Figure 10-25* shows the lapped (view A) and butt (view B) methods of framing over girders.

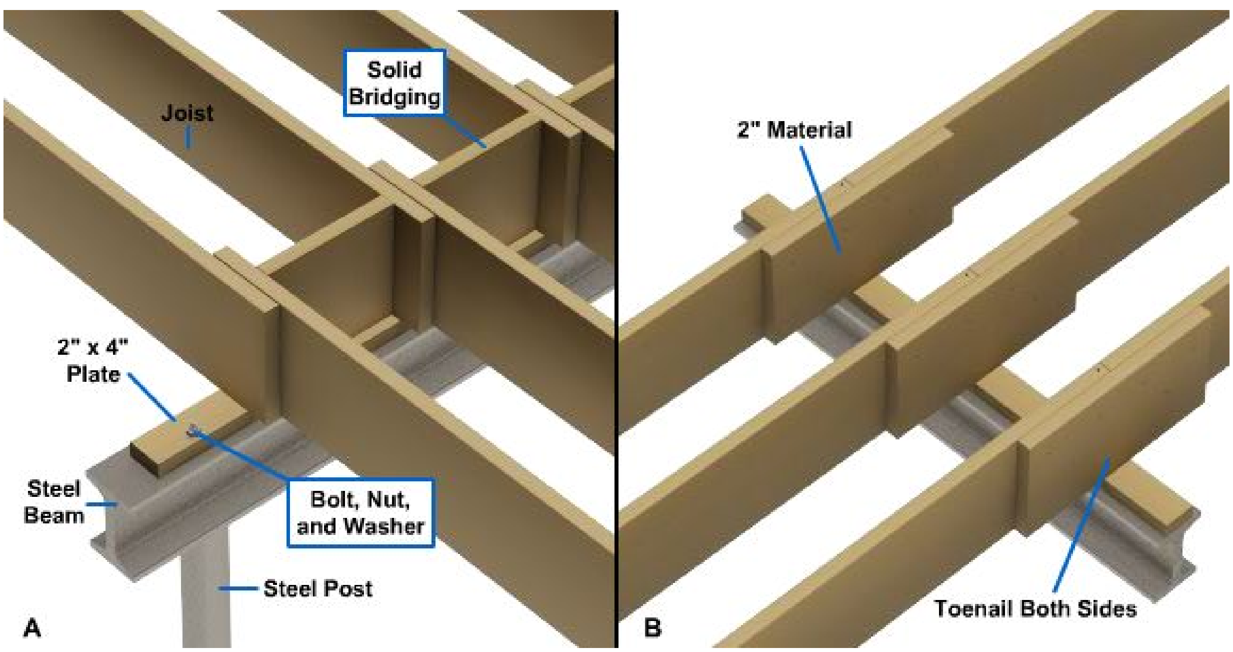


Figure 10-25 – Joists supported by S-beam using wooden blocks.

2.4.10 Bridging between Joists

Floor plans or specifications usually call for bridging between joists. Bridging holds the joists in line and helps distribute the load carried by the floor unit. It is usually required when the joist spans are more than 8 feet. Joists spanning between 8 and 15 feet need one row of bridging at the center of the span. Longer spans require two rows of bridging spaced 6 feet apart.

Cross bridging, also known as herringbone bridging, usually consists of 10 by 3 inch or 2 by 3 inch wood. It is installed as shown in *Figure 10-26.* Cross bridging is ***toenailed*** at each end with 6d or 8d nails. Pieces are usually precut on a radial-arm saw. Start nails at each end before placing the cross bridging between the joists. The usual procedure is to fasten only the top end of the cross bridging. Do not drive in the nails at the bottom end until the subfloor has been placed. Otherwise the joist could be pushed out of line when you nail the bridging in.

An efficient three step method for initial placement of cross bridging is shown in *Figure 10-26.*

1. Snap a chalk line where the bridging is to be nailed between the joists.
2. Moving in one direction, stagger and nail the tops of the bridging.
3. Reverse direction and nail the tops of the opposite pieces into place.

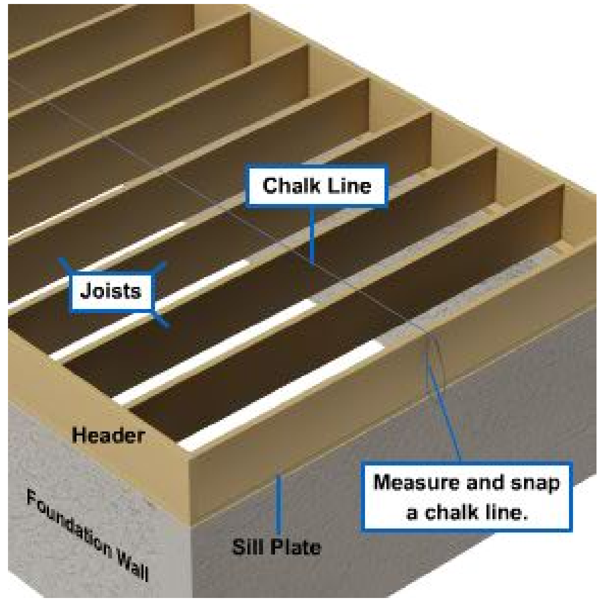


Figure 10-26 – Wood cross bridging.

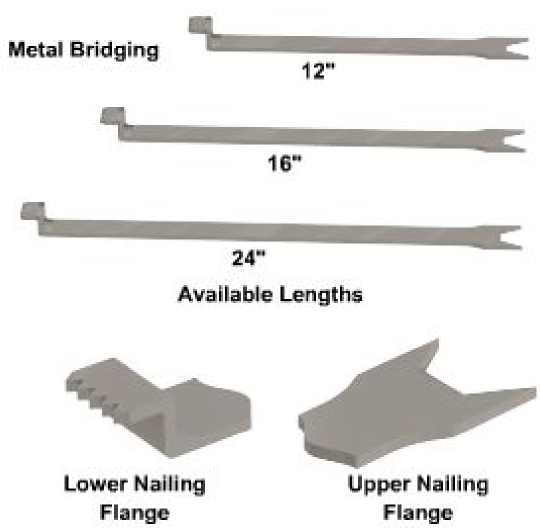


Figure 10-27 – Metal cross bridging.

Another approved system of cross bridging uses metal pieces instead of wood and requires no nails. The pieces are available for 12, 16, and 24 inch joist spacing as shown in *Figure 10-27, slide 1*. You can see how to install this type of cross bridging in *slides 2*, *3*, and *4*. In *slide 2*, strike the flat end of the lower flange, driving the flange close to the top of the joist. In *slide 3*, push the lower end of the bridging against the opposite joist. In *slide 4*, drive the lower flange into the joist.

Solid bridging, also known as solid blocking, serves the same purpose as cross bridging. Many Builders prefer this method, shown in *Figure 10-28*, over cross bridging. Cut the pieces from lumber the same width as the joist material. Install them in a straight line by toenailing or staggering.

If staggered, the blocks can be nailed from both ends, resulting in a faster nailing operation. You may need straight lines of blocking every 4 feet OC to provide a nailing base for a plywood subfloor. Start placement and work in the same direction as the layout.

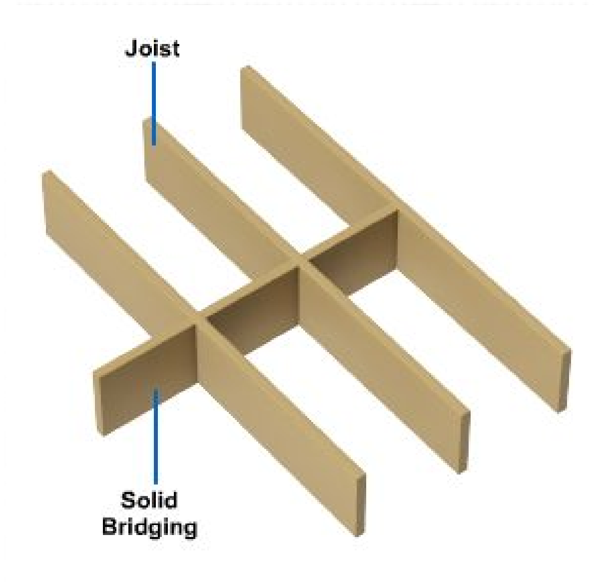


Figure 10-28 – Solid bridging.

2.4.11 Placing Floor Joists

Before placing floor joists, mark the sill plates and girders to show where the joists are to be nailed. Floor joists are usually placed 16 inches OC. For joists resting directly on foundation walls, place layout marks on the sill plates or the header joists.

You must also mark lines on top of the girders or walls over which the joists lap. If framed walls are below the floor unit, lay out the joists on top of the double plate. The floor layout should also show where any joists are to be doubled. Double joists are required where partitions resting on the floor run in the same direction as the floor joists. You must also mark floor openings for stairwells.

Lay out joists so that the edges of standard-size subfloor panels break over the centers of the joists as shown in the insert of *Figure 10-29*. This layout eliminates additional cutting of panels when you are fitting them and nailing them into place. One method of laying out joists this way is to mark the first joists 15 1/4 inches from the edge of the building. From then on, the layout is 16 inches OC.

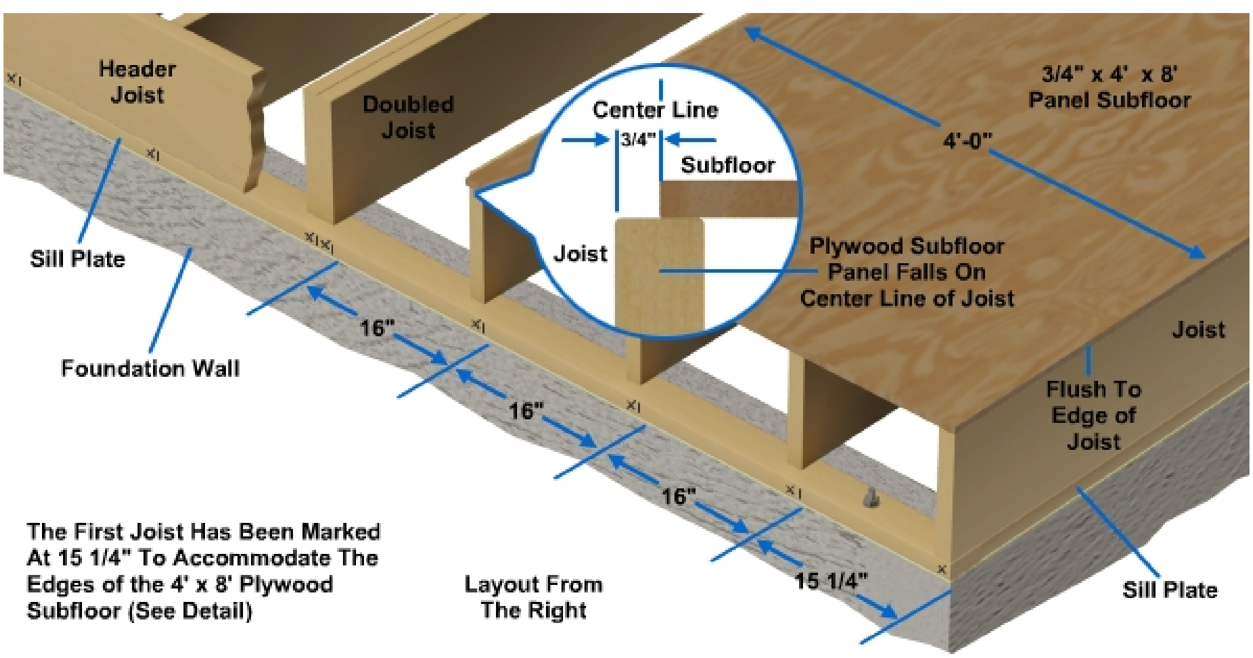


Figure 10-29 – Floor joists layout.

A layout for the entire floor is shown in *Figure 10-30*.

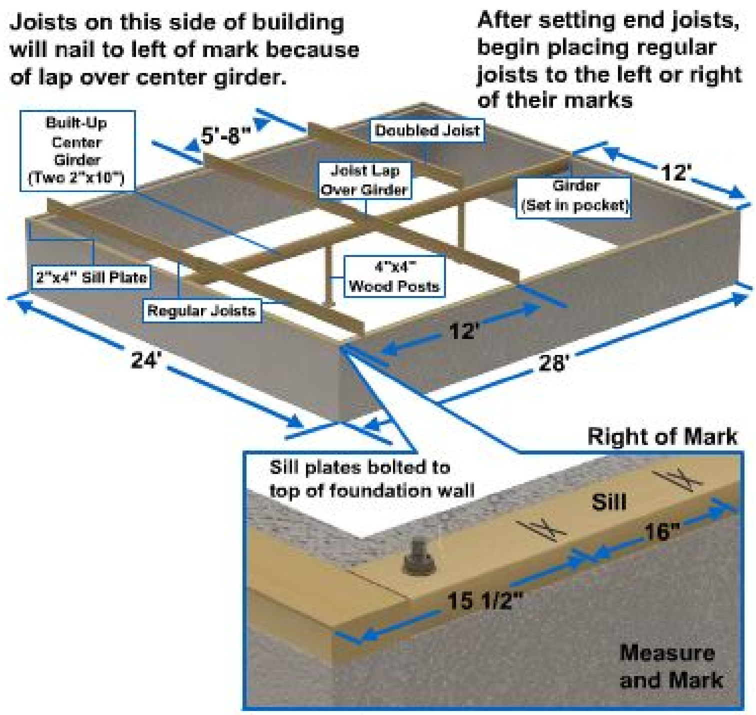


Figure 10-30 – Complete layout for floor joists.

Most of the framing members should be precut before construction begins. The joists should all be trimmed to their proper lengths. Cross bridging and solid blocks should be cut to fit between the joists with a common spacing. The distance between joists is usually 14 1/2 inches for joists spaced 16 inches OC. Cut blocking for the odd spaces afterwards.

2.4.12 Framing Floor Openings

Floor openings, where stairs rise to the floor or large duct work passes through, require special framing. When the joists are cut for such openings, there is a loss of strength in the area of the opening. You need to frame the opening in a way that restores this strength. The procedure is shown in *Figure 10-31*. Refer to the Figure as you study the following steps:

1. Measure and mark the positions of the trimmers on the outside wall and interior wall or girder.
2. Position and fasten the inside trimmers and mark the position of the double headers.
3. Place the outside pieces between the inside trimmers. Drive three 16d nails through the trimmers into the headers. Mark the position of the tail joists on the headers (the tail joists should follow the regular joist layout).
4. Fasten the tail joists to the outside headers with three 16d nails driven through the headers into the ends of the tail joists.
5. Double the header. Drive three 16d nails through the trimmer joists into the ends of the doubled header pieces. Nail the doubled header pieces to each other with 16d nails staggered 16 inches OC.

6. Double the trimmer joists and fasten them together with 16d nails staggered 16 inches OC.

Place a pair of joists called trimmers at each side of the opening. These trimmers support the headers. Double the headers if the span is more than 4 feet. Drive nails supporting the ends of the headers through the trimmer joists into the ends of the header pieces. Tail joists, also known as ***cripple*** joists, run from the header to a supporting wall or girder. Drive nails through the header into the ends of the tail joist.

You may also use various metal anchors, such as those shown in *Figure 10-32*, to strengthen framed floor openings.

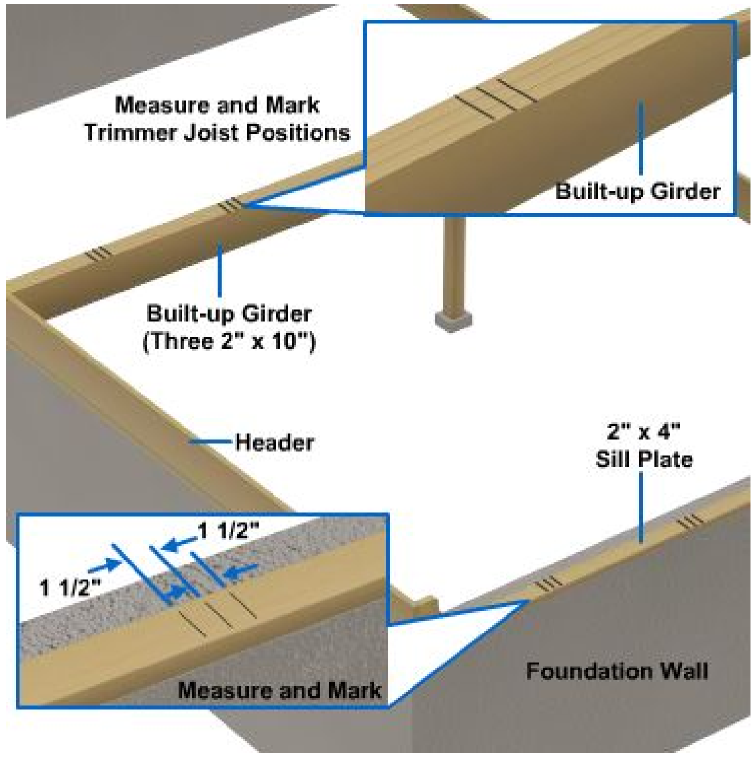


Figure 10-31 – Steps in framing a floor opening.

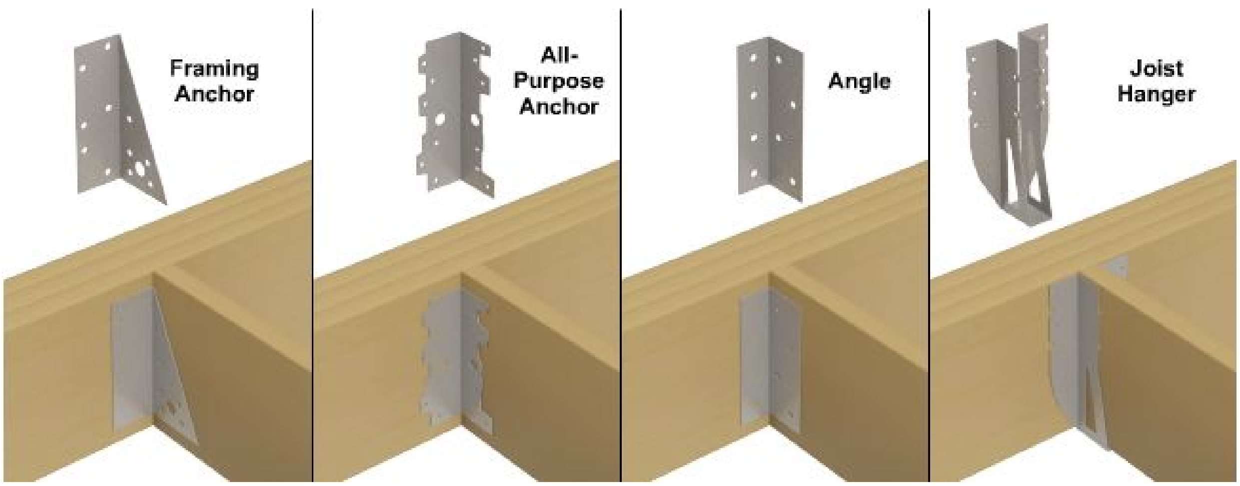


Figure 10-32 – Types of framing anchors.

2.4.13 Crowns

Most joists have a ***crown***, or a bow shape, on one side. Sight each joist before nailing it in place to make certain the crown is turned up. The joist will later settle from the weight of the floor and straighten out. Exercise caution when sighting the board for the crown. Some crowns are too large and cannot be turned up for use as a joist.

Test your Knowledge (Select the Correct Response)

3. Before placing floor joists, which of the following members must be marked to show joist nailing points?

   A. Soleplate and top plate only
   B. Sill plate and girders only
   C. Common joists and doubled joists only
   D. All of the above

4. What is the main reason for special framing around large floor openings?

   A. Appearance
   B. Providing additional nailing surface
   C. Strength
   D. Preventing floor squeaks

2.5.0 Subfloor

The subfloor, also known as rough flooring, is nailed to the top of the floor frame. It strengthens the entire floor unit and serves as a base for the finished floor. The walls of the building are laid out, framed, and raised into place on top of the subfloor.

Panel products, such as plywood, are used for subflooring. Plywood is less labor intensive than board lumber.

Plywood is the oldest type of panel product. It is still the most widely used subfloor material in residential and other light-frame construction. Other types of material available for use as subflooring include Nonveneered, or reconstituted wood, panels such as structural particleboard, waferboard, oriented strandboard, and compositeboard.

Plywood is available in many grades to meet a broad range of end uses. All interior grades are also available with fully waterproof adhesive identical to that used in exterior plywood. This type is useful where prolonged moisture is a hazard. Examples are underlayments, subfloors adjacent to plumbing fixtures, and roof sheathing that may be exposed for long periods during construction. Under normal conditions and for sheathing used on walls, standard sheathing grades are satisfactory.

Plywood suitable for the subfloor, such as standard sheathing, structural I and II, and C-C exterior grades, has a panel identification index marking on each sheet. These markings indicate the allowance spacing of ***rafters*** and floor joists for the various thicknesses when the plywood is used as roof sheathing or subfloor. For example, an index mark of 32/16 indicates the plywood panel is suitable for a maximum spacing of 32 inches for rafters and 16 inches for floor joists. There is no problem of strength differences between species, as the correct identification is shown for each panel.

Install plywood with the grain of the outer plies at right angles to the joists. Stagger panels so that end joints in adjacent panels break over different joists. The nailing schedule for most types of subfloor panels calls for 6d common nails for materials up to 7/8 inch thick and for 8d nails for heavier panels up to 1 1/8 inches thick. ***Deformed-shank*** nails are strongly recommended. They are usually spaced 6 inches OC along the edges of the panel and 10 inches OC over intermediate joists, as shown in *Figure 10-33*.

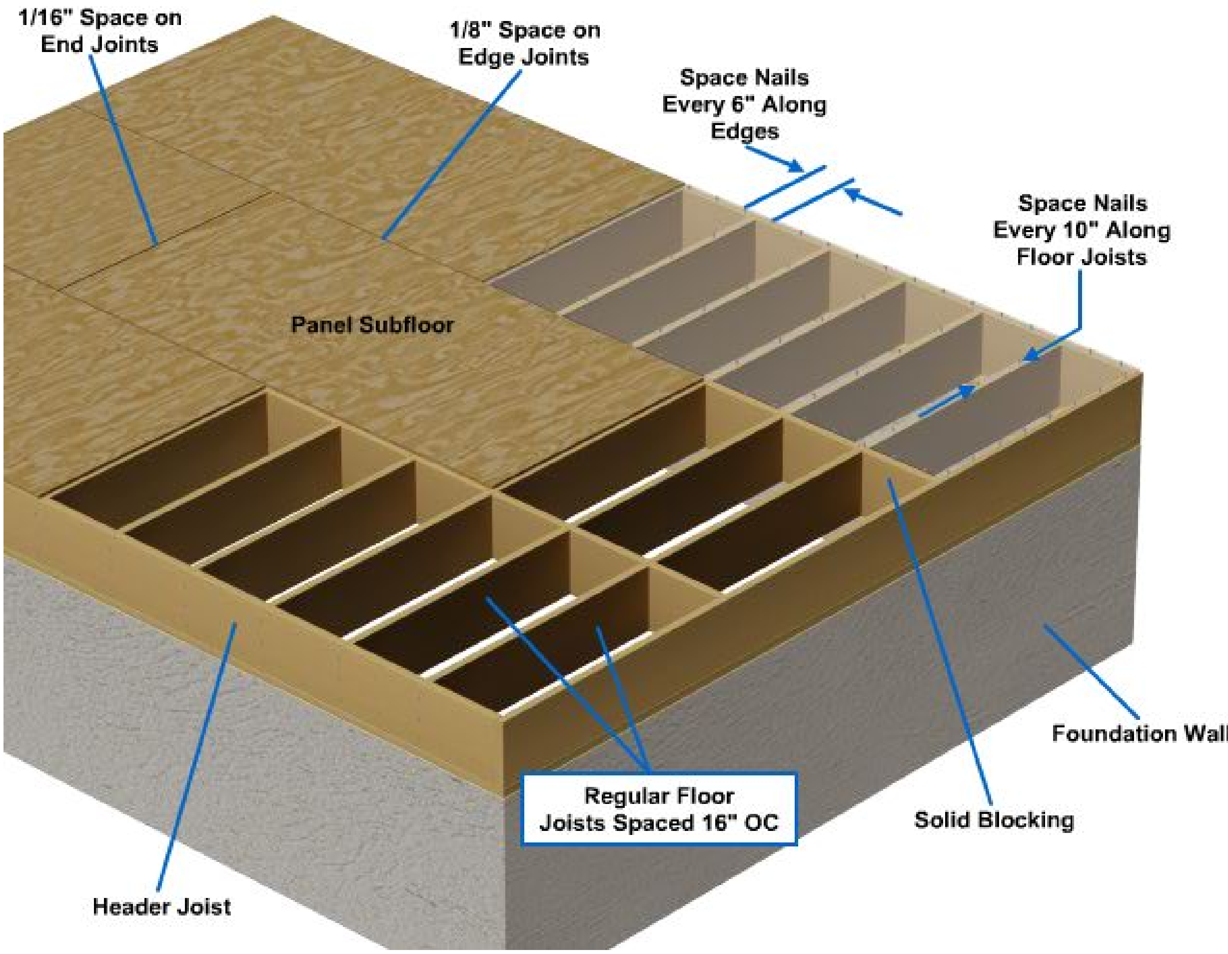


Figure 10-33 – Subfloor blocking and nailing.

CAUTION

For the best performance, do not lay up plywood with tight joints, whether interior or exterior. Allow for expansion if moisture should enter the joints.

3.0.0 FRAMING WALLS

Wall construction begins after the subfloor has been nailed in place. The wall system of a wood framed building consists of exterior (outside) and interior (inside) walls. The typical exterior wall has door and window openings, as shown in *Figure 10-33*. Interior walls, usually referred to as “partitions,” divide the inside area into separate rooms. Some interior walls have door openings or archways.

Partitions are either bearing or nonbearing. Bearing partitions support the ends of the floor joists or ceiling joists. Nonbearing partitions run in the same direction as the joists and therefore carry little weight from the floor or ceiling above.

Traditionally, 2 by 4 inch structural lumber is used for the framed walls of one-story buildings, although the use of heavier structural lumber is specified at certain locations for particular projects. Multistory buildings, for example, require heavier structural lumber. This requirement is specific to the lower levels in order to support the weight of the floors above.

3.1.0 Structural Parts

A wood framed wall consists of structural parts referred to as wall components or framing members. The components shown in *Figure 10-34* typically include studs, plates, headers, trimmers, cripples, sills, corner posts, and diagonal braces. Each component is essential to the integrity of the total wall structure.

3.1.1 Studs

Studs are upright (vertical) framing members running between the top and bottom plates. Studs are usually spaced 16 inches OC, but job specifications sometimes call for 12 inch or 24 inch OC stud spacing.

3.1.2 Plates

The plate at the bottom of a wall is the soleplate, or bottom plate. The plate at the top of the wall is the top plate. A double top plate is normally used. It strengthens the upper section of the wall and helps carry the weight of the joists and roof rafters. Since top and bottom plates are nailed into all the vertical wall members, they serve to tie the entire wall together.

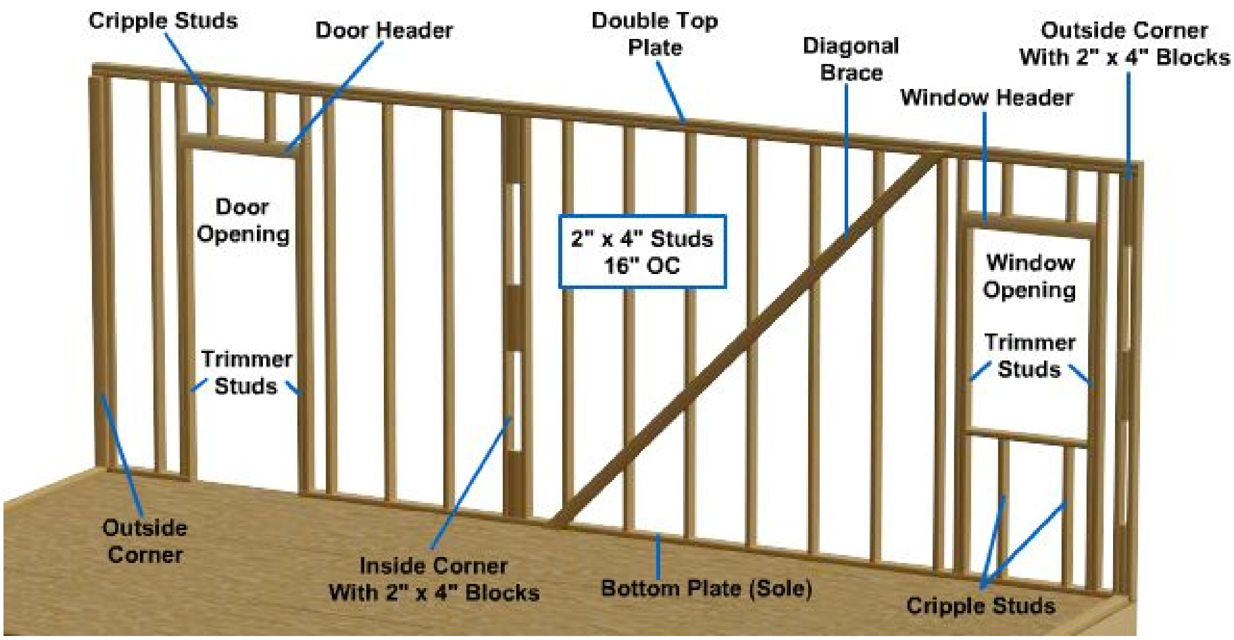


Figure 10-34 – Typical exterior wall.

3.1.3 Corner Posts

Corner posts are constructed wherever a wall ties into another wall. Outside comers are at the ends of a wall. Inside corners occur where a partition ties into a wall at some point between the ends of the wall.

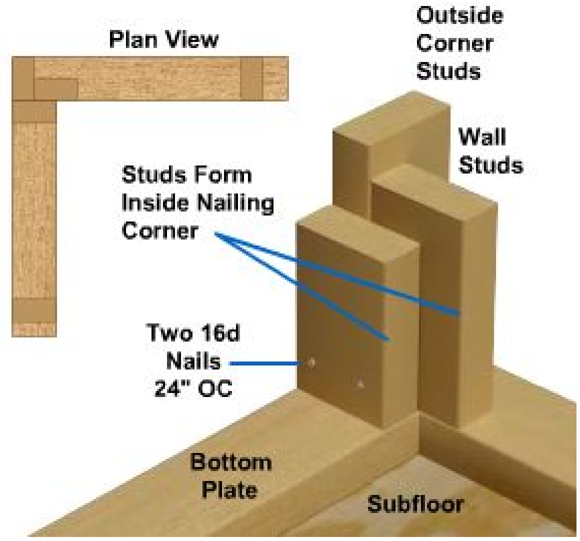


Figure 10-35 – Corner posts.

Three typical designs for corner assemblies are shown in *Figure 10-35*. *Slide 1* shows outside corner construction using only three studs. *Slide 2* shows outside corner construction using two studs with short blocks between them at the center and ends. A third full length stud can be used instead of blocks. *Slide 3* shows inside corner construction using a block laid flat. A full length stud can be used instead of a block. All corner assemblies should be constructed from straight stud material and should be well nailed. When framing corners, you can use full length studs or short blocks.

3.1.4 Rough Door and Window Openings

Frame a rough opening into a wall wherever a door or window is planned. The dimensions of the rough opening must allow for the final frame and for the required clearance around the frame.

Figure 10-36 shows details of rough openings for doors and windows in wood frame construction. The rough opening for a typical door is framed with a header, trimmer studs, and, in some cases, top cripple studs. The rough opening for a typical window includes the same members as for a door, plus a rough window sill and bottom cripples.

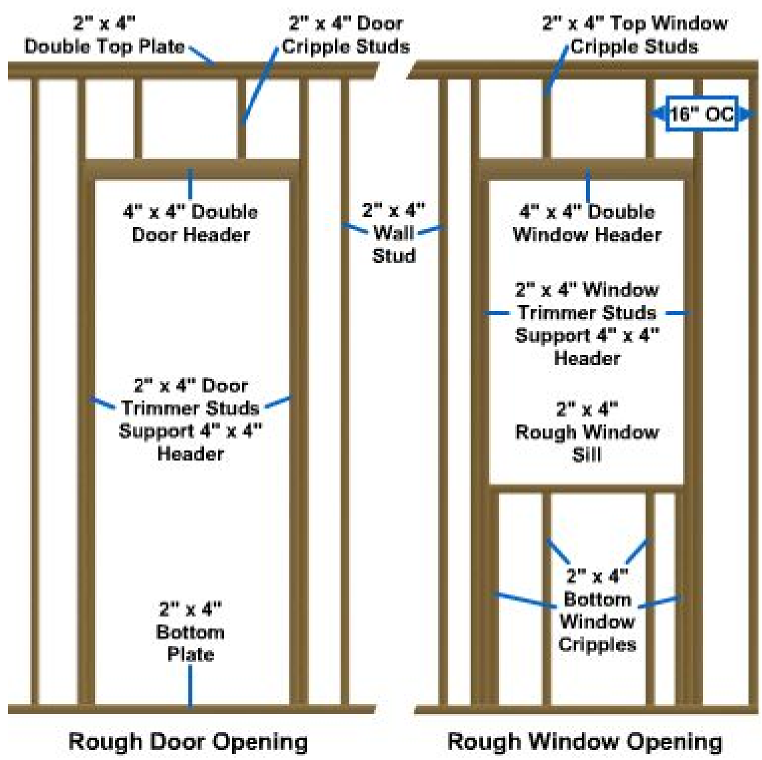


Figure 10-36 – Rough frame openings for doors and windows.

A rough opening has a header at the top that must be strong enough to carry the weight bearing down on that section of the wall. The header is supported by trimmer studs fitting between the soleplate and the bottom of the header. The trimmer studs are nailed into the regular studs at each side of the header. Nails are also driven through the regular studs into the ends of the header.

The header may be either solid or built up of two 2 by 4 pieces with a 1/2 inch spacer. The spacer is needed to bring the width of the header to 3 1/2 inches. This is the actual width of a nominal 2 by 4 stud wall. A built-up header is as strong as or stronger than a solid piece.

The type and size of the header is shown in the blueprints. The width of the opening and the amount of weight bearing down from the floor above determine header size.

The tops of all door and window openings in all walls are usually in line with each other. Therefore, all headers are usually the same height from the floor. The standard height of walls in most wood framed buildings is either 8 feet 3/4 inch or 8 feet 1 inch from the subfloor to the ceiling joists. The standard height of the doors is 6 feet 8 inches.

Cripple studs are nailed between the header and the double top plate of a door opening. These help carry the weight from the top plate to the header. The cripple studs are generally spaced 16 inches OC.

Add a rough window sill to the bottom of a rough window opening. The sill provides support for the finished window and frame to be placed in the wall. The distance between the sill and the header is determined by the dimensions of the window, the window frame, and the necessary clearances at the top and bottom of the frame. Nail cripple studs, spaced 16 inches OC, between the sill and the soleplate. You may place additional cripple studs under each end of the sill.

3.1.5 Bracing

Diagonal bracing is necessary for the lateral strength of a wall. In all exterior walls and main interior partitions, place bracing at both ends, where possible, and at 25 foot intervals. An exception to this requirement is an outside wall covered with structural sheathing nailed according to building specifications. This type of wall does not require bracing.

Diagonal bracing is most effective when installed at a 45º to 60º angle. You can do this after the wall has been squared and is still lying on the subfloor.

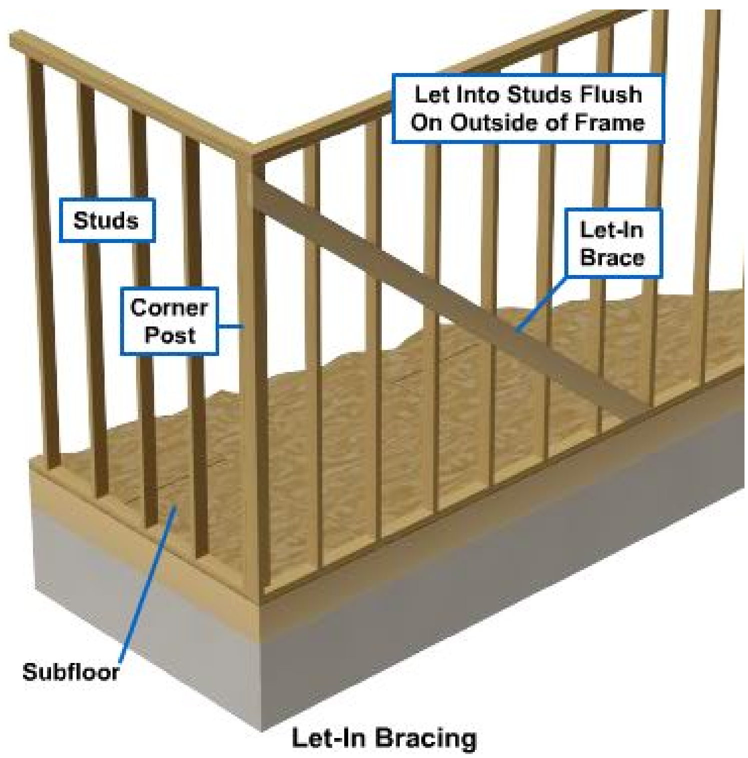


Figure 10-37 – Types of bracing.

The most widely used bracing system is the 1 by 4 let-in type, shown in *Figure 10-37.* The studs are notched so that the 1 by 4 piece is flush with the surface of the studs.

Cut-in bracing, shown in *Figure 10-37*, is another type of diagonal bracing. It usually consists of 2 by 4s cut at an angle and toenailed between studs at a diagonal from the top of a corner post down to the soleplate.

Diagonal sheathing, shown in *Figure 10-37*, is the strongest type of diagonal bracing. Each board acts as a brace for the wall. When you use plywood or other panel sheathing, you may omit other methods of bracing.

3.1.6 Fire stops

Most local building codes require fire stops, also known as fire blocks, in walls over 8 feet 1 inch high. Fire stops slow down fire travel inside walls. Nail them between the studs before or after the wall is raised. Nail fire stops in a straight line or staggered for easier nailing. *Figure 10-38* shows a section of a framed wall with fire stops.

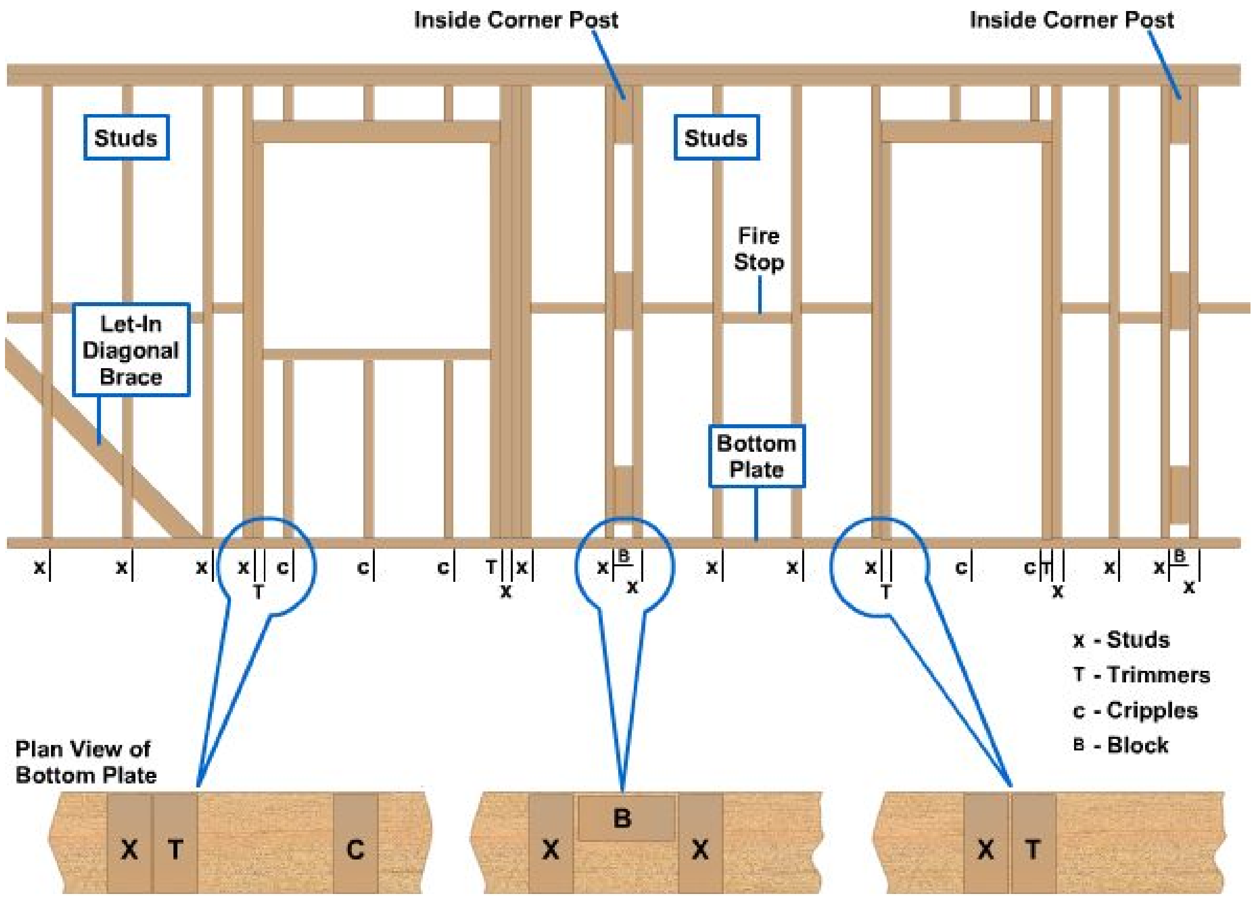


Figure 10-38 – Fire blocking.

It is not necessary to nail fire stops at the midpoint of the wall. You can position them to provide additional backing for nailing the edges of drywall or plywood.

Test your Knowledge (Select the Correct Response)

5. Which of the following framing members ties the entire wall together?

   A. Studs
   B. Posts
   C. Sills
   D. Plates

6. What component is required at the intersections and ends of a wall?

A. Corner post
B. Cripple stud
C. Diagonal brace
D. Header

3.2.0 Construction

All major components of a wall should be cut before assembly. By reading the blueprints, you can determine the number of pieces and lengths of all components. Then you can assemble the different parts of the wall. You can use any hard, level surface for assembly. After you complete nailing, raise the walls in place for securing.

Two layout procedures are used in wall layout, horizontal plate and vertical layout. In horizontal plate layout, the location of the wall is determined from the dimensions found in the floor plan of the blueprints. For vertical layout, the dimension can be found in the sectional views of the building's blueprints.

3.2.1 Horizontal Plate Layout

After snapping all the lines, cut and tack the wall plates next to the lines as shown in *Figure 10-39*. Then mark off the plates for corner posts and regular studs, as well as for the studs, trimmers, and cripples for the rough openings. Clearly mark all framing members on the plates. This allows for efficient and error-free framing. *Figure 10-39* shows a wall with framing members nailed in place according to layout markings.

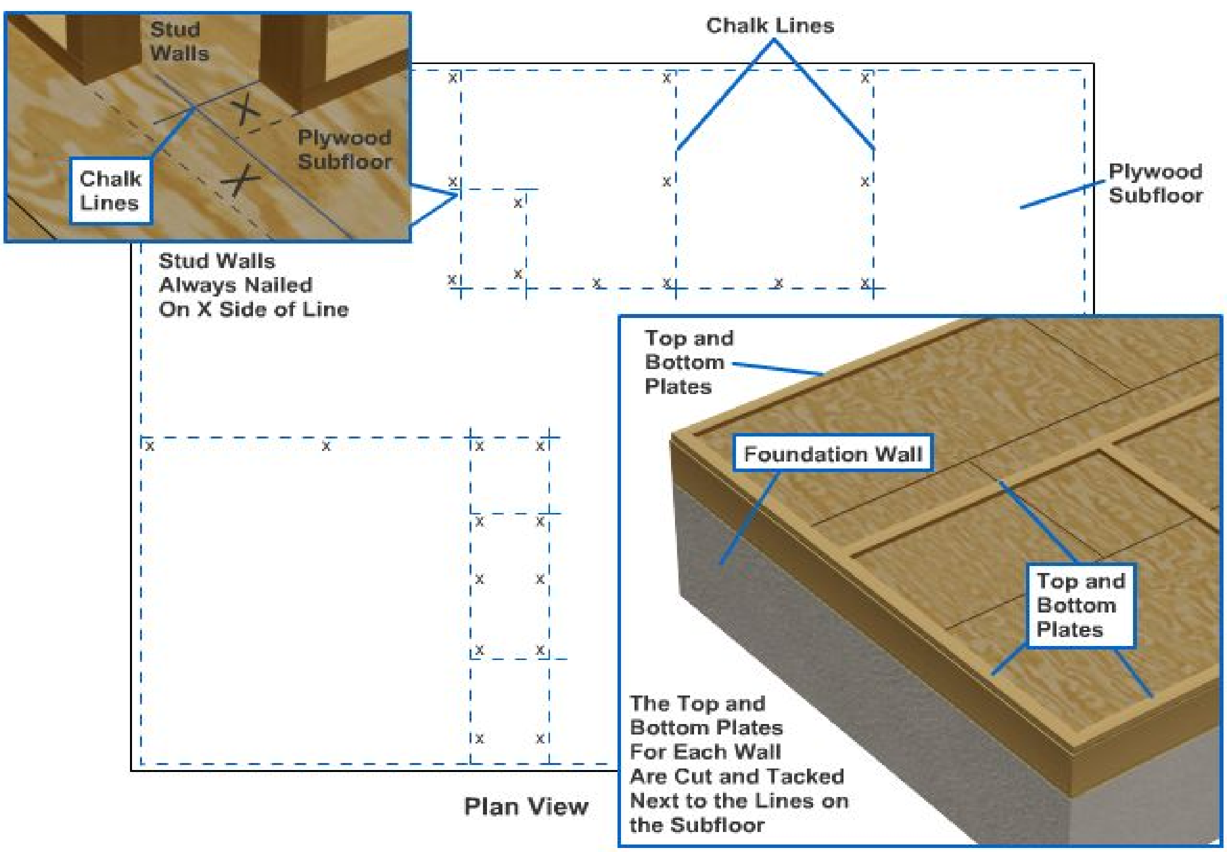


Figure 10-39 – Layout and cutting of plates.

A procedure for marking inside and outside comers for stud and block corner post construction is shown in *Figure 10-40*.

For laying out studs for the first exterior wall, see *Figure 10-41*. Mark the plates for the first stud from a corner to be placed 15 1/4 inches from the end of the corner. Studs after the first stud follow 16 inches OC layout. This ensures the edges of standard size panels used for sheathing or wallboard fall on the centers of the studs. Lay cripples out to follow the layout of the studs.

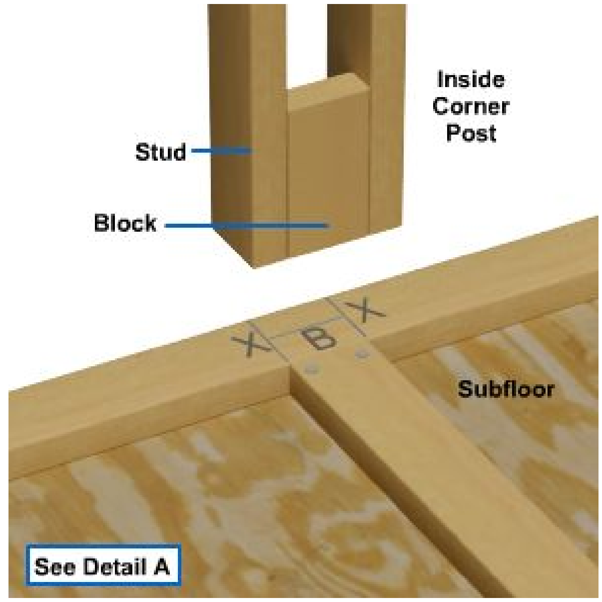


Figure 10-40 – Marking inside and outside corners.

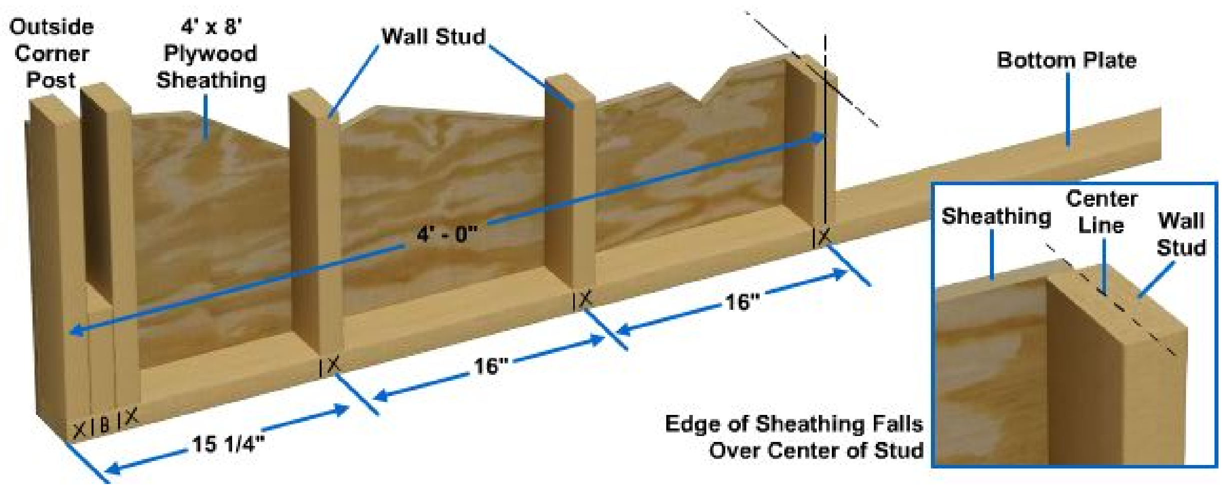


Figure 10-41 – First exterior wall stud layout.

A procedure for laying out studs for the second exterior wall is shown in *Figure 10-42*. Mark the plates for the first stud to be placed 15 1/4 inches from the outside edge of the panel thickness on the first wall. This layout allows the corner of the first panel on the second wall to line up with the edge of the first panel on the second wall. The opposite edge of the panel on the second wall will break on the center of a stud.

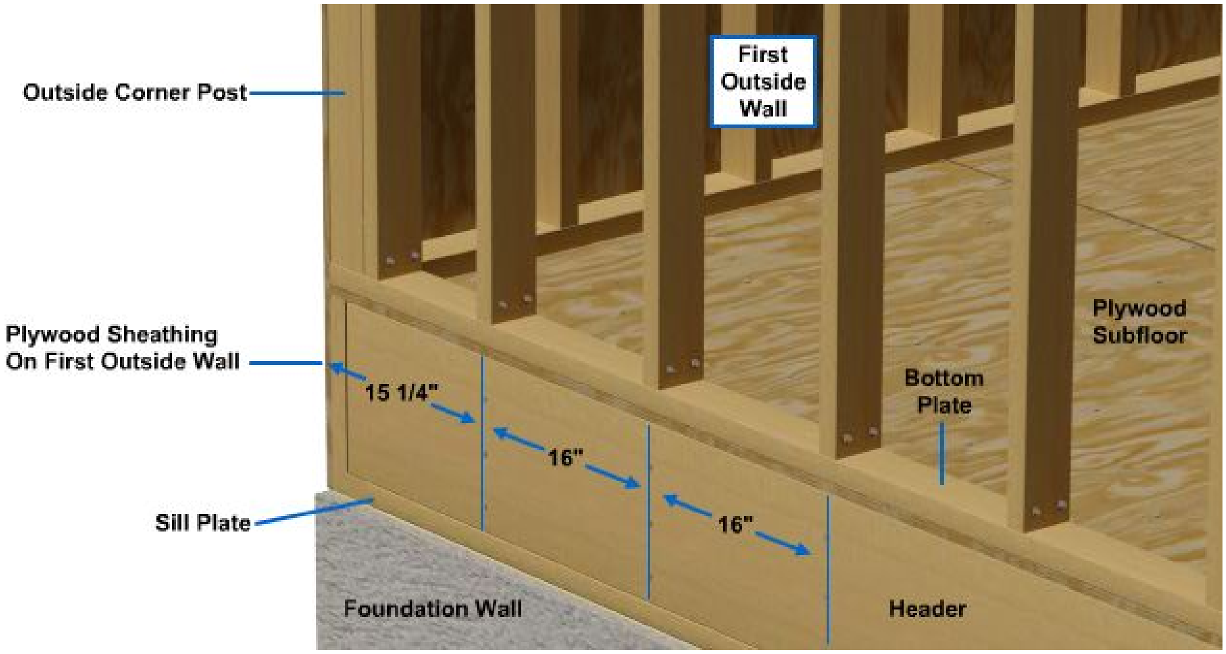


Figure 10-42 – Second exterior wall stud layout.

A procedure for laying out studs for interior walls (partitions) is shown in *Figure 10-43*. If panels are placed on the exterior wall first, mark the wall plates for the interior wall for the first stud to be placed 15 1/4 inches from the edge of the panel thickness on the exterior wall. If panels are to be placed on the interior wall, mark the wall plates of the interior wall for the first stud to be placed 15 1/4 inches from the unpaneled exterior wall.

If drywall or other interior finish panels are to be nailed to an adjoining wall as shown in *Figure 10-43, view A*, you must measure 15 1/4 inches plus the thickness of the material. When panels are to be nailed on a wall first as shown in *view B*, measure and mark the 15 1/4 inches from the front surface of the bottom plate. These procedures ensure stud alignment remains accurate throughout the nailing process.

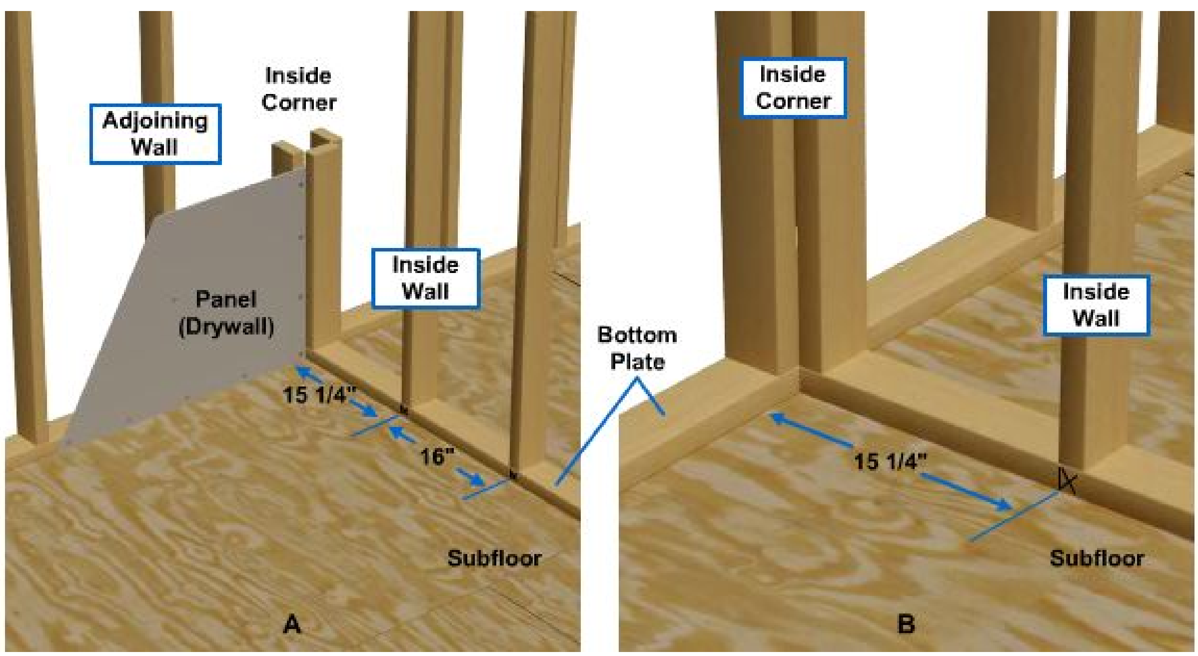


Figure 10-43 – Starting measurement for interior wall.

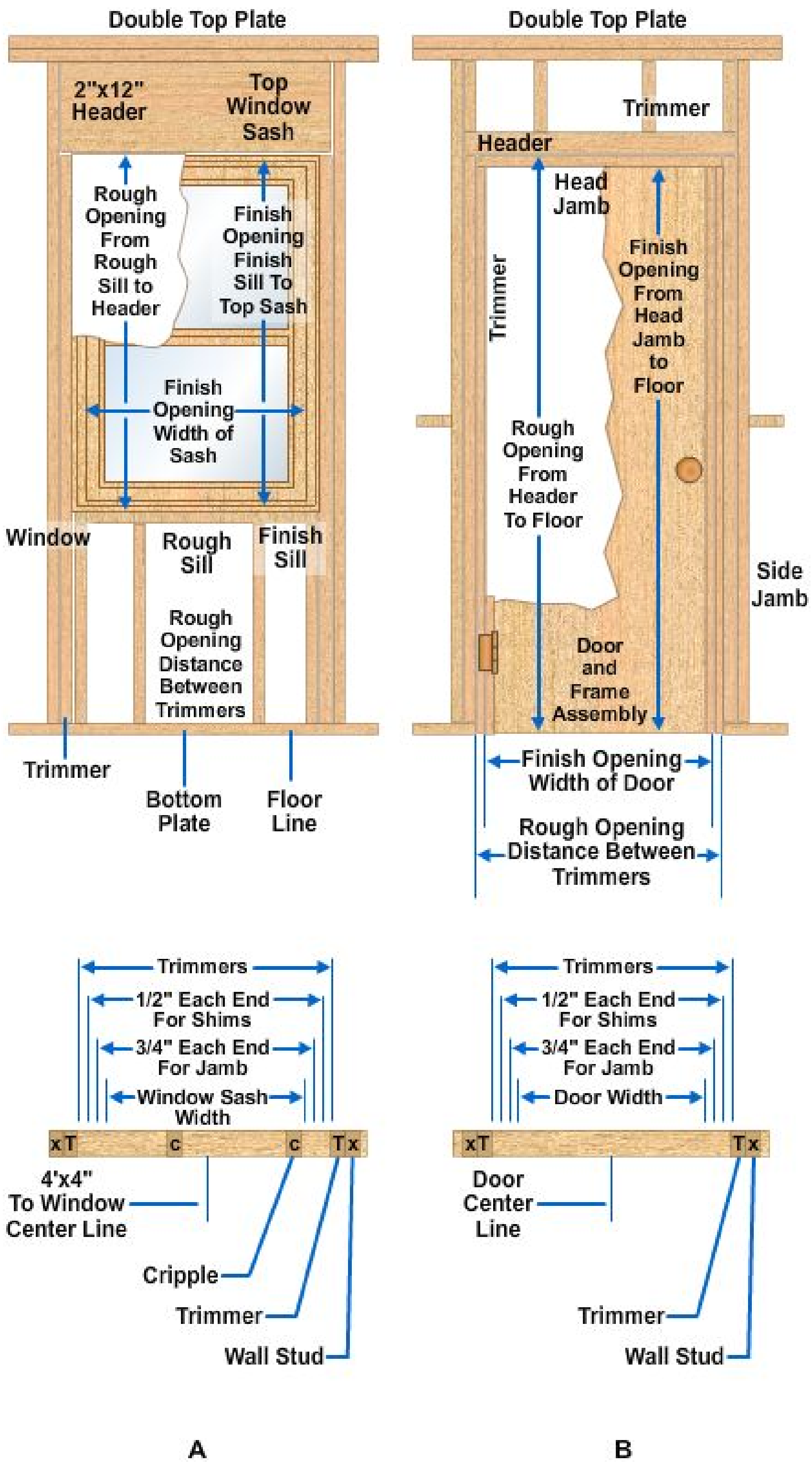


Figure 10-44 – Measurements for windows and doors.

Rough openings for doors and windows must also be marked on the wall plates. The rough opening dimensions are shown for a window, *Figure 10-44, view A,* or wood door, *view B.* These are calculated based on the window or door width, the thickness of the finish frame, and 1/2 inch clearance for shim materials at the sides of the frame. Some blueprint door and window schedules give the rough opening dimensions, simplifying the layout.

A rough opening for a metal window often requires a 1/2 inch clearance around the entire frame. When the measurements are not given in the window schedule, take them from the manufacturer's installation instructions supplied with the windows.

A completely laid out bottom plate includes markings for corner posts, rough openings, studs, and cripples. Lay out the corner posts first. Next mark the 16 inch marks for the studs and cripples. Then make the marks for the rough openings.

Some Builders prefer to lay out the rough openings before the studs and cripples are marked. There is an advantage to laying out the 16 inch OC marks first. Studs and trimmers framing a door and window often fall very close to a 16 inch OC stud mark. Slightly shifting the position of the rough opening may eliminate an unnecessary stud from the wall frame.

3.2.2 Vertical Layout

Vertical layout is the procedure for calculating the lengths of the different vertical members of a wood framed wall. This makes it possible to precut all studs, trimmers, and cripples required for a building.

Some blueprints contain section views giving the exact rough heights of walls. The rough height is the distance from the subfloor to the bottom of the ceiling joists. The rough height to the top of the door, the distance from the subfloor to the bottom of the door header, may also be noted on the section drawing. In addition, it may be given in the column for rough opening measurements on the door schedule. The rough height to the top of the door establishes the measurement for the rough height to the top of the window, as window headers are usually in line with door headers.

The distance from the bottom to the top of a rough window opening can be found by measuring down from the bottom of the window header using dimensions provided in the rough opening column of the window schedule.

Many Builders prefer to frame the door and window openings before assembling the wall. *View A* of *Figure 10-45* shows typical door framing; *view B* shows typical window framing. After stud layout, cripple studs are laid out, usually 16 inches OC, and nailed between the header and top plate and rough window sill and soleplate. It is good practice to place a cripple stud under each end of a sill.

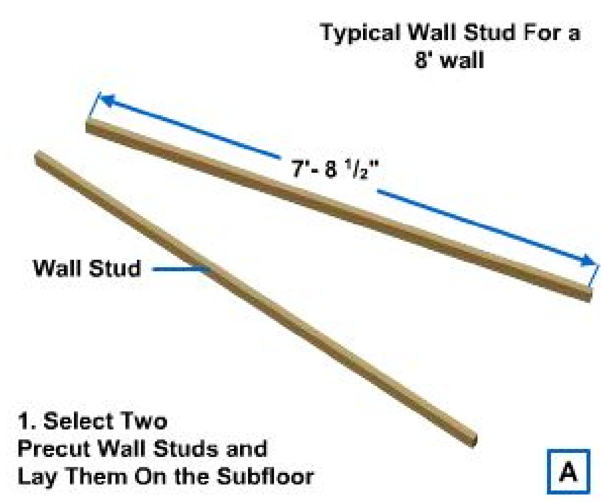


Figure 10-45 – Framing typical door and window openings.

Test your Knowledge (Select the Correct Response)

7. When you are rough framing a window opening, the trimmer studs are installed between what two components?

   A. Double top plate and header
   B. Top plate and subfloor
   C. Header and bottom plate
   D. Header and subfloor

3.3.0 Assembly

After the corners and openings for doors and windows have been made up, the entire wall can be nailed together on the subfloor, as shown in *Figure 10-46*. Place top and bottom plates at a distance slightly greater than the length of the studs. Position the corners and openings between the plates according to the plate layout. Place studs in position with the crown side up. Nail the plates into the studs, cripples, and trimmers. On long walls, the breaks in the plates should occur over a stud or cripple.

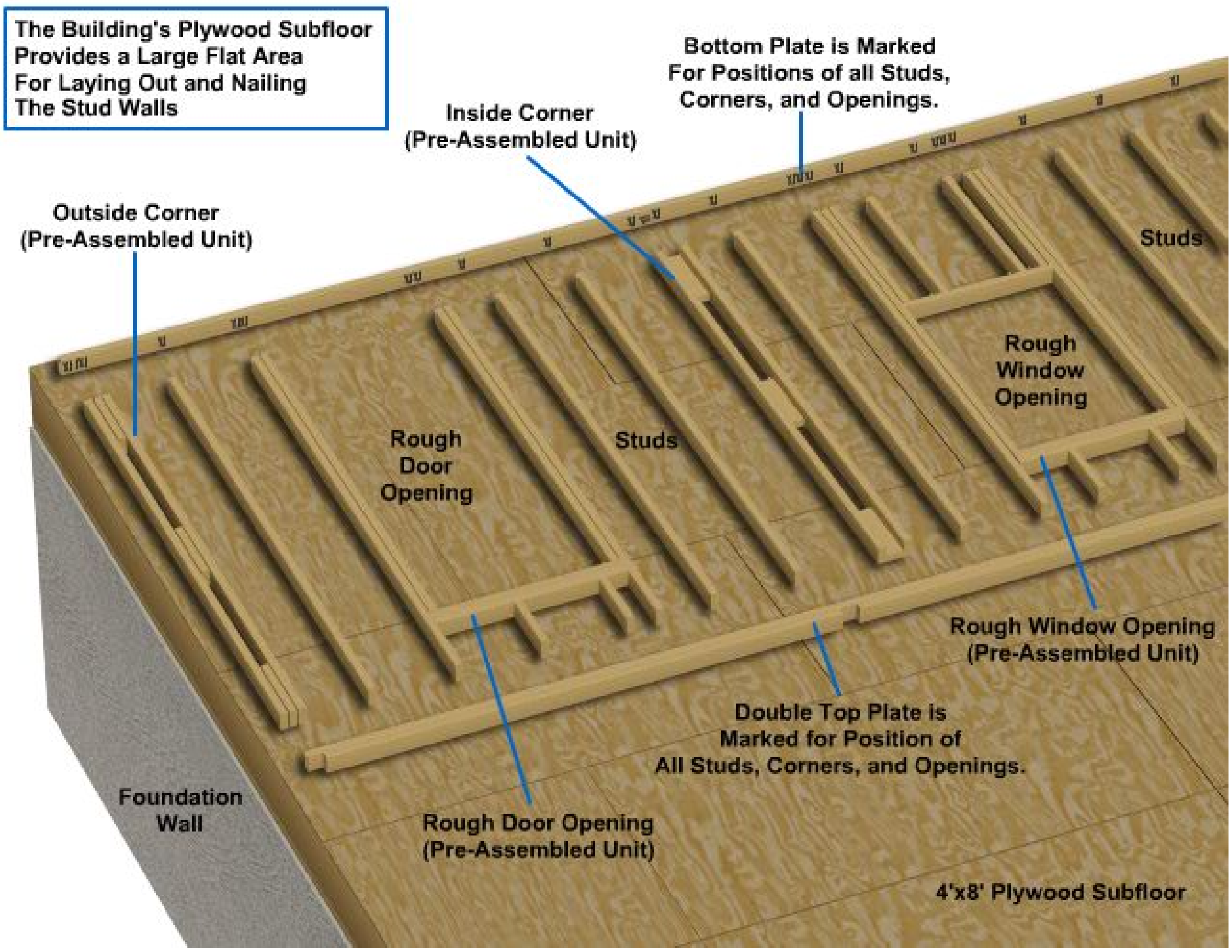


Figure 10-46 – Assembly of wall components.

3.3.1 Placing the Double Top Plate

The double top plate shown in *Figure 10-47* can be placed while the wall is still on the subfloor or after all the walls have been raised. Nail the topmost plates so that they overlap the plates below at all corners. This helps to tie the walls together. Fasten all ends with two 16d nails. Between the ends, stagger 16d nails 16 inches OC. The butt joints between the topmost plates should be at least 4 feet from any butt joint between the plates below them.

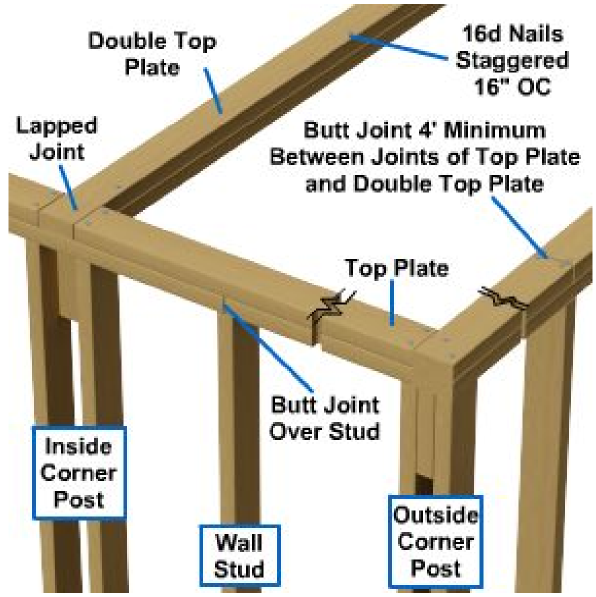


Figure 10-47 – Double top plate.

3.3.2 Squaring Walls and Placing Braces

A completely framed wall is often squared while it is still lying on the subfloor. In this way, bracing, plywood, or other exterior wall covering can be nailed before the wall is raised. When diagonal measurements are equal, the wall is square. *Figure 10-48* shows examples of unsquared and squared walls.

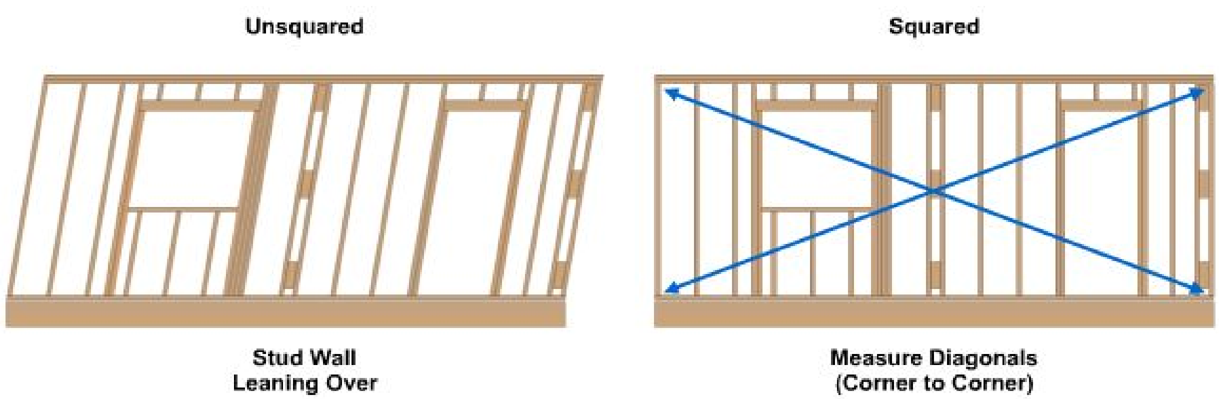


Figure 10-48 – Squaring a wall.

A let-in diagonal brace may be placed while the wall is still on the subfloor. Lay out and snap a line on the studs to show the location of the brace as shown in *Figure 10-49*. Then notch the studs for the brace. Tack the brace to the studs while the wall is still lying on the subfloor. Tacking instead of nailing allows for some adjustment after the wall is raised. After any necessary adjustment is made, securely drive the nails in.

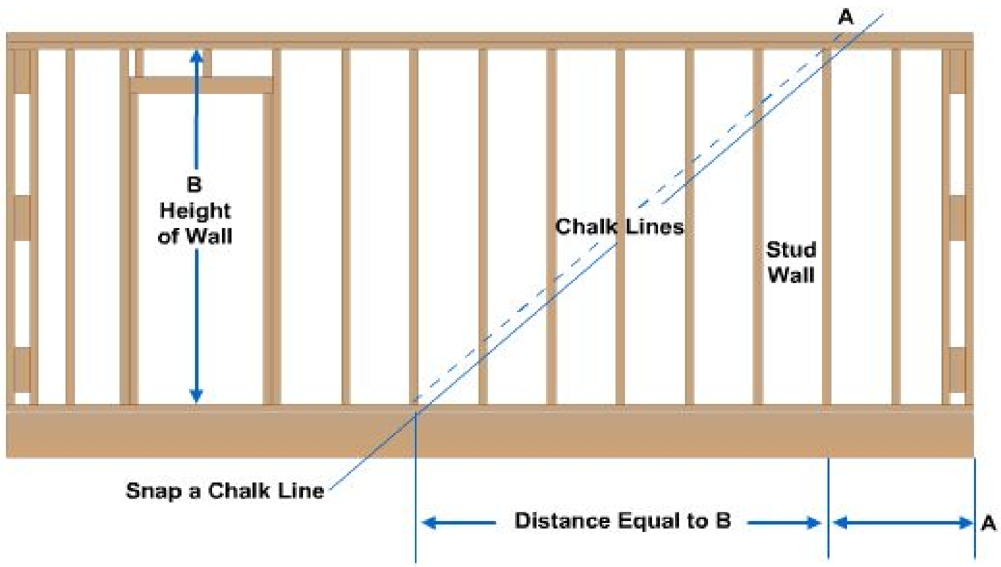


Figure 10-49 – Let-in diagonal brace.

3.3.3 Raising

Most walls can be raised by hand if enough help is available. It is advisable to have one person for every 10 feet of wall for the lifting operation.

The order in which walls are framed and raised may vary from job to job. Generally, the longer exterior walls are raised first. The shorter exterior walls are then raised, and the comers nailed together. The order of framing interior partitions depends on the floor layout.

After raising a wall has been raised, nail its bottom plates securely to the floor. Where the wall rests on a wood subfloor and joists, drive 16d nails through the bottom plate and into the floor joists below the wall.

3.3.4 Plumbing and Aligning

Accurate plumbing of the corners is possible only after all the walls are up. Most framing materials are not perfectly straight; never plumb walls by applying a hand level directly to an end stud. Always use a straightedge along with the level, as shown in *Figure 10-50, view A*. The straightedge can be a piece ripped out of plywood or a straight piece of 2 by 4 lumber. Nail 3/4 inch thick blocks to each end. The blocks make it possible to accurately plumb the wall from the bottom plate to the top plate.

Plumbing corners requires two persons working together; one working the bottom area of the brace and the other watching the level. The bottom end of the brace is renailed when the level shows a plumb wall.

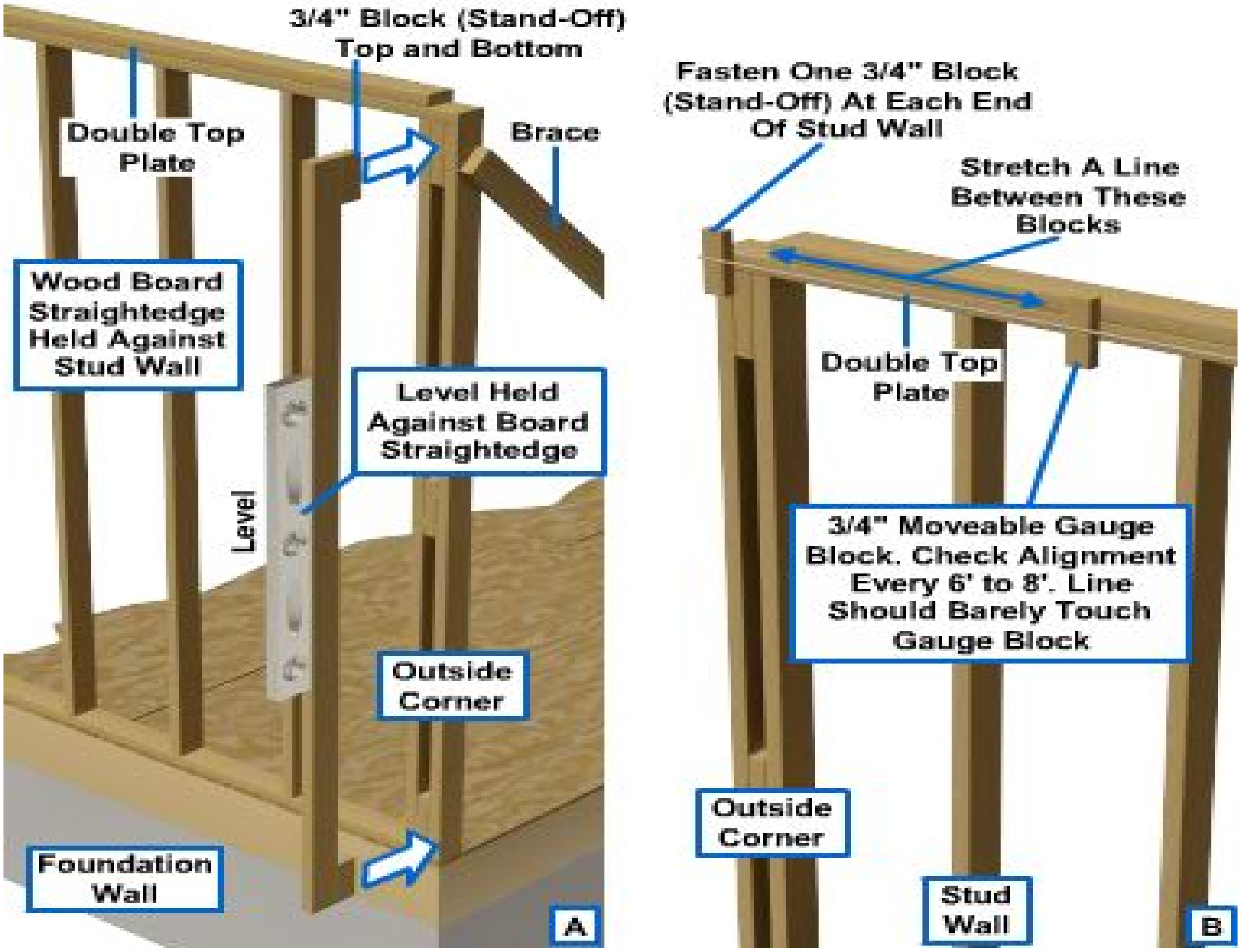


Figure 10-50 – Plumbing and aligning corners and walls.

The tops of the walls shown in *Figure 10-50, view B* are straightened (aligned or lined up) after all the corners have been plumbed. Prior to nailing the floor or ceiling joists to the tops of the walls, make sure the walls are aligned using the following steps:

1. Fasten a string from the top plate at one corner of the wall to the top plate at another corner of the wall.
2. Cut three small blocks from 1 by 2 lumber. Place one block under each end of the string so that the line is clear of the wall.
3. The third block is used as a gauge to check the wall at 6 or 8 foot intervals. At each checkpoint, fasten a temporary brace to a wall stud.
4. When fastening the temporary brace to the wall stud, adjust the wall so that the string is barely touching the gauge block. Nail the other end of the brace to a short 2 by 4 block fastened to the subfloor. Do not remove these temporary braces until the framing and sheathing for the entire building have been completed.

3.3.5 Framing over Concrete Slabs

Often, the ground floor of a wood framed building is a concrete slab. In this case, you must either bolt or nail the bottom plates of the walls to the slab with a powder actuated driver. If you use bolts, you must accurately set them into the slab at the time of the concrete pour. Lay out holes for the bolts and drill in the bottom plate when the wall is framed. When the wall is raised, slip it over the bolts and secure it with washers and nuts.

Occasionally on small projects the soleplate is bolted or fastened down first. The top plate is nailed to the studs, and the wall is lifted into position. The bottom ends of the studs are toenailed into the plate. The rest of the framing procedure is the same as for walls nailed on top of a subfloor.

3.4.0 Sheathing the Walls

Wall sheathing is the material used for the exterior covering of the outside walls. In the past, nominal 1 inch thick boards were nailed to the wall horizontally or at a 45° angle for sheathing. Today, plywood and other types of panel products (waferboard, oriented strandboard, or compositeboard) are usually used for sheathing. Plywood and nonveneered panels can be applied much more quickly than boards. They add considerable strength to a building and often eliminate the need for diagonal bracing.

Generally, wall sheathing does not include the finished surface of a wall. Siding, shingles, stucco, or brick veneer are placed over the sheathing to finish the wall. Exterior finish materials are discussed in a separate chapter.

3.4.1 Plywood

Plywood is the most widely used sheathing material. Plywood panels usually applied to exterior walls range in size from 4 by 8 feet to 4 by 12 feet with thicknesses from 5/16 inch to 3/4 inch.

The panels may be placed with the grain running vertically or horizontally as shown in *Figure 10-51*. Specifications may require blocking along the long edges of horizontally placed panels.

Typical nailing specifications require 6d nails with panels 1/2 inch or less in thickness and 8d nails for panels more than 1/2 inch thick. Space the nails 6 inches apart along the edges of the panels and 12 inches apart at the intermediate studs.

When nailing the panels, leave a 1/8 inch gap between the horizontal edges of the panels and a 1/16 inch gap between the vertical edges. These gaps allow for expansion caused by moisture and prevent panels from buckling.

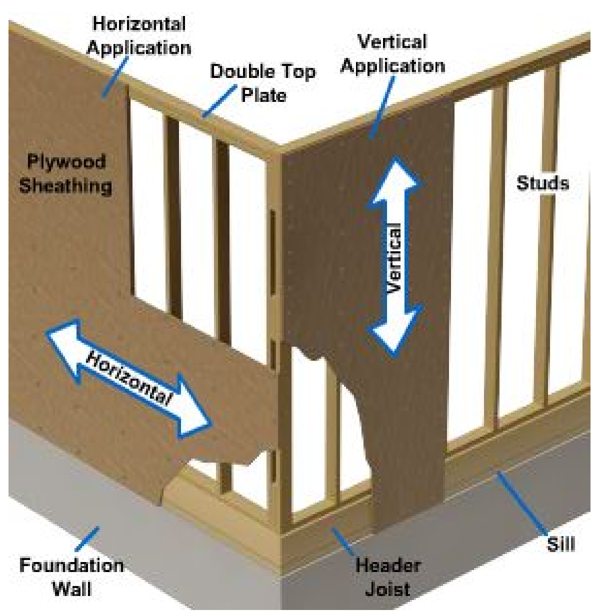


Figure 10-51 – Plywood sheathing.

In larger wood framed buildings, plywood is often nailed to some of the main interior partitions. The result is called a shear wall, which adds considerable strength to the entire building.

Plywood sheathing can be applied when the squared wall is still lying on the subfloor. Problems can occur after the wall is raised if the floor is not perfectly straight and level.

For this reason, some Builders prefer to place the plywood after framing the entire building.

Test your Knowledge (Select the Correct Response)

8. Compared to other exterior finishes, plywood panels have what advantage(s)?

   A. They provide additional strength only.
   B. They shorten installation time only.
   C. They eliminate the need for diagonal bracing only.
   D. All of the above

3.4.2 Nonveneered Panels

Although plywood is the most commonly used material for wall sheathing, specifications sometimes call for nonveneered (reconstituted wood) panels. Panels made of waferboard, oriented strandboard, and compositeboard have been approved by most local building codes for use as wall sheathing. Like plywood, these panels resist ***racking***, so no corner bracing is necessary in normal construction. However, where maximum shear strength is required, conventional veneered plywood panels are still recommended.

3.5.0 Metal Framing

Metal is an alternative to wood framing. Many buildings are framed entirely in metal, whereas some buildings are framed in a combination of metal and wood.

The metal framing members generally used are cold formed steel, electrogalvanized to resist corrosion. Thicknesses range from 18 gauge to 25 gauge, the latter being most common.

Most metal studs have notches at each end and knockouts located about 24 inches OC, as shown in *Figure 10-52*, to facilitate pipe and conduit installation. The size of the knockout, not the size of the stud, determines the maximum size of pipe or other material that can be passed through horizontally.

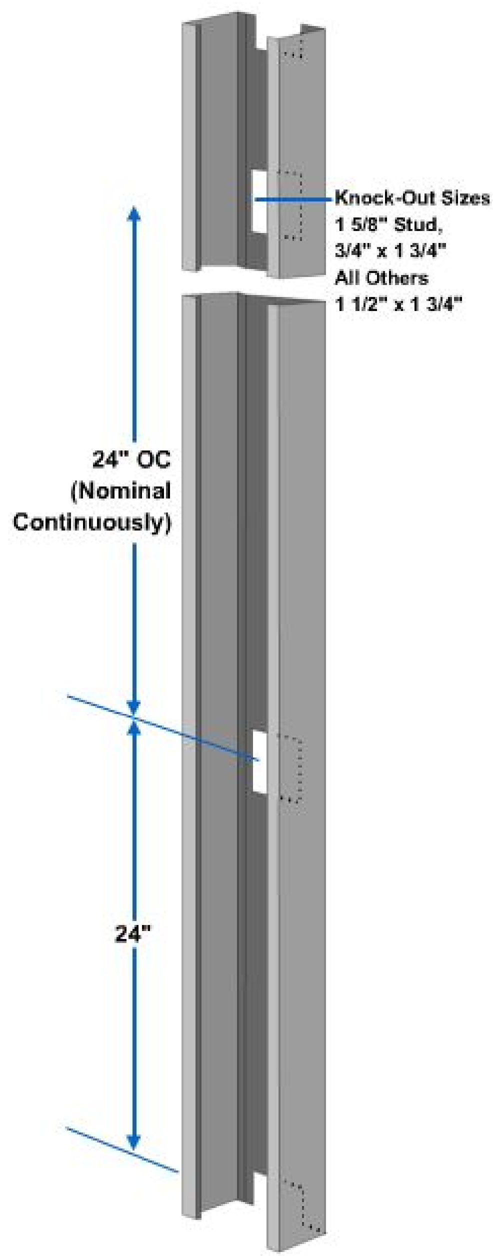


Figure 10-52 – Typical metal stud construction.

The application of nonveneered wall sheathing is similar to that of plywood. Nailing schedules usually call for 6d common nails spaced 6 inches OC above the panel edges, and 12 inches OC when nailed into the intermediate studs. Nonveneered panels are usually applied with the long edge of the panel in a vertical position.

Chase (or double stud) walls, as shown in *Figure 10-53*, are often used when large pipes, ducts, or other items must pass vertically or horizontally in the walls. Studs are generally available in widths of 1 5/8, 2 1/2, 3 5/8, 4, and 6 inches. The metal runners used are also 25 gauge (or specified gauge) steel or aluminum, sized to complement the studs. Both products have features advantageous to light frame construction. The metal studs and runners do not shrink, swell, twist, or warp.Termites cannot affect them, nor are they susceptible to dry rot. They have a high fire-resistance rating when combined with proper covering material.

A variety of systems have been developed by manufacturers to meet various requirements of attachment, sound control, and fire resistance. Many of the systems are designed for ease in erection, yet they are still remountable for revising room arrangements.

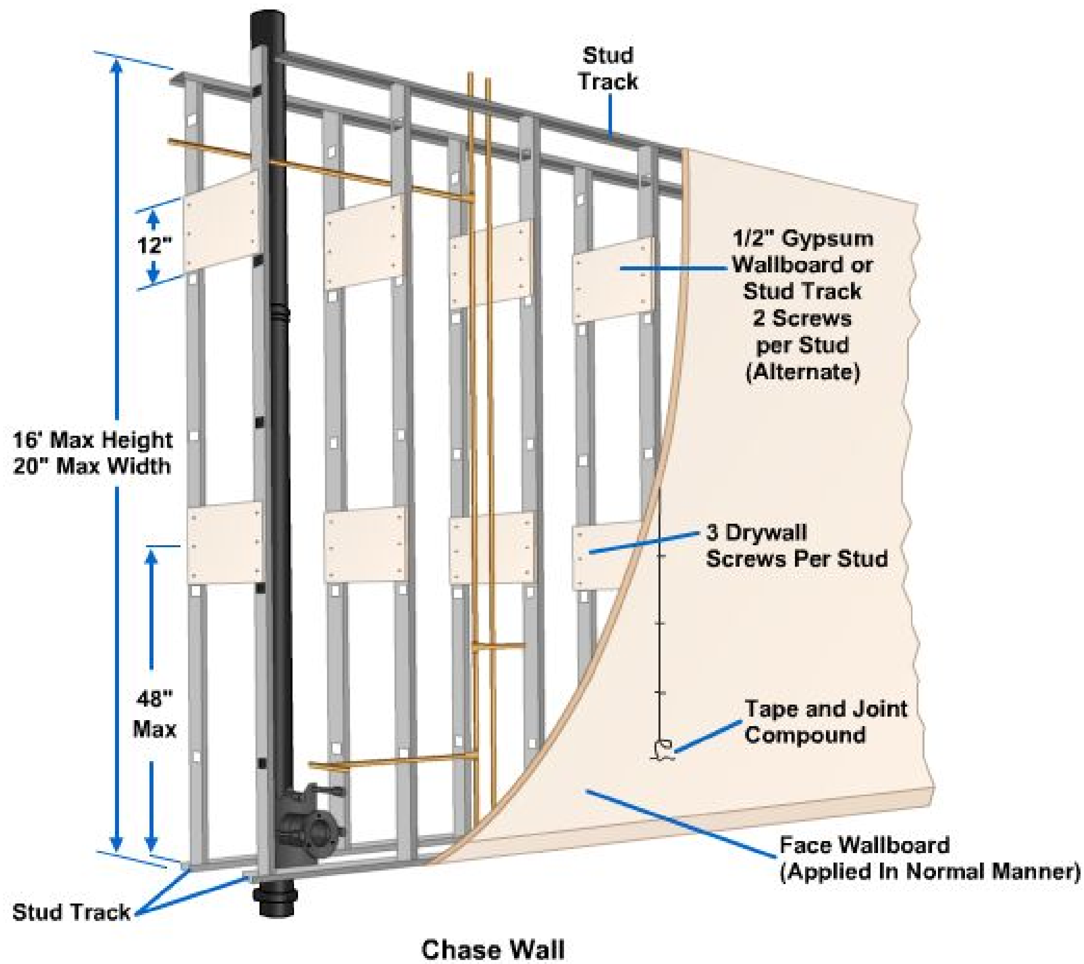


Figure 10-53 – Chase wall construction.

Assemble the framing members with power screwdrivers and using self-drilling, self-tapping screws. Fasten the floor assembly to the foundation or concrete slab with studs (special nails) driven through the stud track (runner) by a powder actuated stud driver. Install the plywood subfloor over the metal floor framing system with self-drilling, self-tapping screws and structural adhesive. Wall sections are assembled at the jobsite or delivered as preassembled panels from an off-site prefabrication shop. Attach conventional sheathing to the framework with self-tapping screws.

Door frames for both the interior partitions and exterior walls are integral with the system. They are preprinted and may come complete with necessary hinges, locks, rubber stops, and weather stripping. The windows are also integral to the system, prefabricated and painted. These units may include interior and exterior trim designed to accept 1/2 inch wallboard and 1/2 inch sheathing plus siding on the outside.

Install plumbing in prepunched stud webs. Pass wiring through insulated grommets inserted in the prepunched webs of the studs and plates. Mount wall and ceiling fixtures by attaching wood blocking spaced between the flanges of the wall studs or ***trusses*** as shown in *Figure 10-54*. Install friction-tight insulation by placing the ***batts*** between the studs on the exterior walls. Space studs 12, 16, or 24 inches OC as specified in the blueprints.

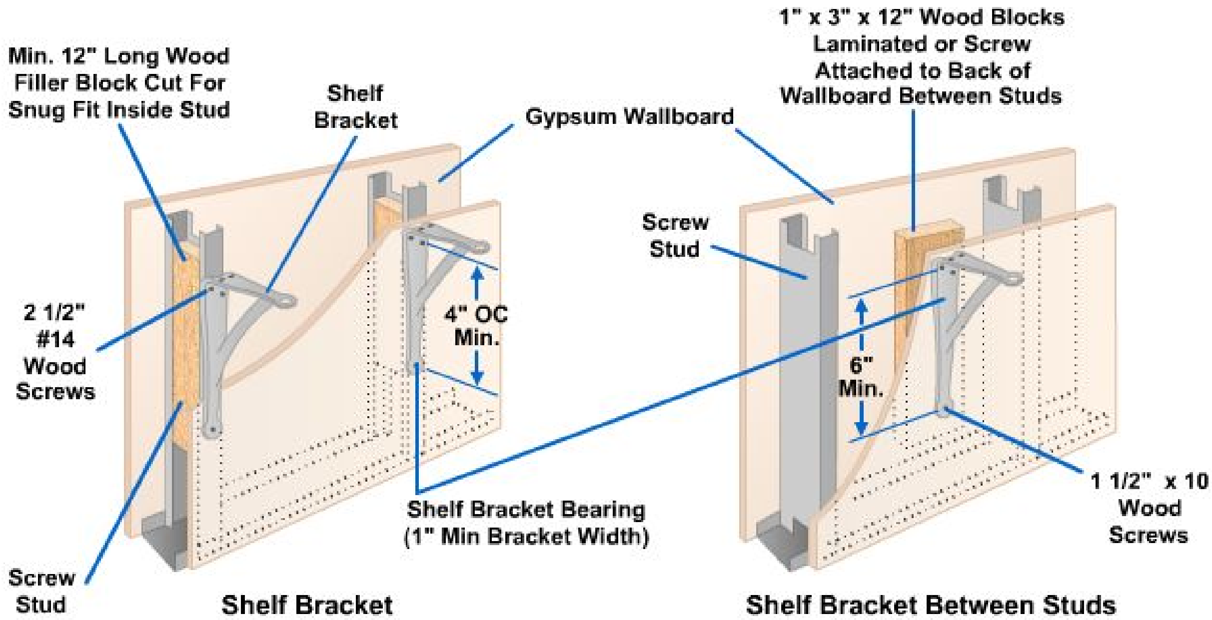
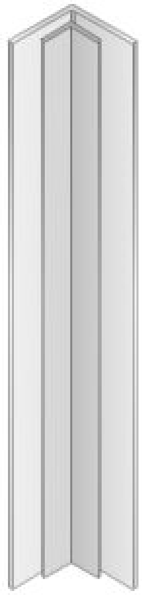


Figure 10-54 – Wood blocking for ceiling or wall mounted fixtures.

3.5.1 Corner and Casing Beads

Standard wallboard corner bead is manufactured from galvanized steel with perforated flanges, as shown in *Figure 10-55*. It provides a protective reinforcement for straight corners. The corner bead is made with 1 inch by 10 inch flanges for 3/8 or 1/2 inch single layer wallboard; 1 inch by 1 1/4 inches for 1/2 inch or 5/8 inch single layer wallboard; 1 1/4 inches by 1 1/4 inches for two layer wallboard application. It is available in 10 foot lengths.

Figure 10-55 – Standard corner bead.



Multiflex tape bead consists of two continuous metal strips on the undersurface of 2 1/8 inch-wide reinforcing tape, as shown in *Figure 10-56*. This protects corners formed at any angle. Multiflex tape bead comes in 100-foot rolls.

Figure 10-56 – Multiflex tape bead.

Casing and trim beads, shown in *Figure 10-57*, are used as edge protection and trim around window and door openings and as moldings at ceiling angles. They are made from galvanized steel in three styles to fit 3/8 inch, 1/2 inch, and 5/8 inch wallboard and come in 10-foot lengths.

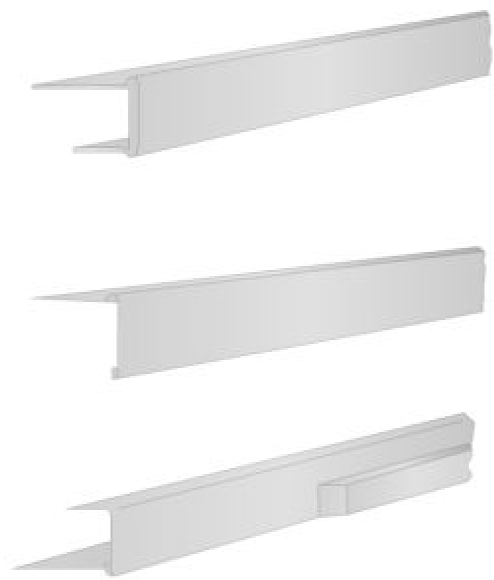


Figure 10-57 – Casing and trim beads.

Figure 10-58 – Expansion joint.

3.5.2 Expansion Joints

Expansion joints are vinyl extrusions used as control joints in drywall partitions and ceilings. A typical form is shown in *Figure 10-58*.

Figure 10-59 shows a typical metal frame layout and use of corner and casing beads for corners, partition intersections, and partition ends. It also shows a typical cross section of a metal frame stud wall control joint.

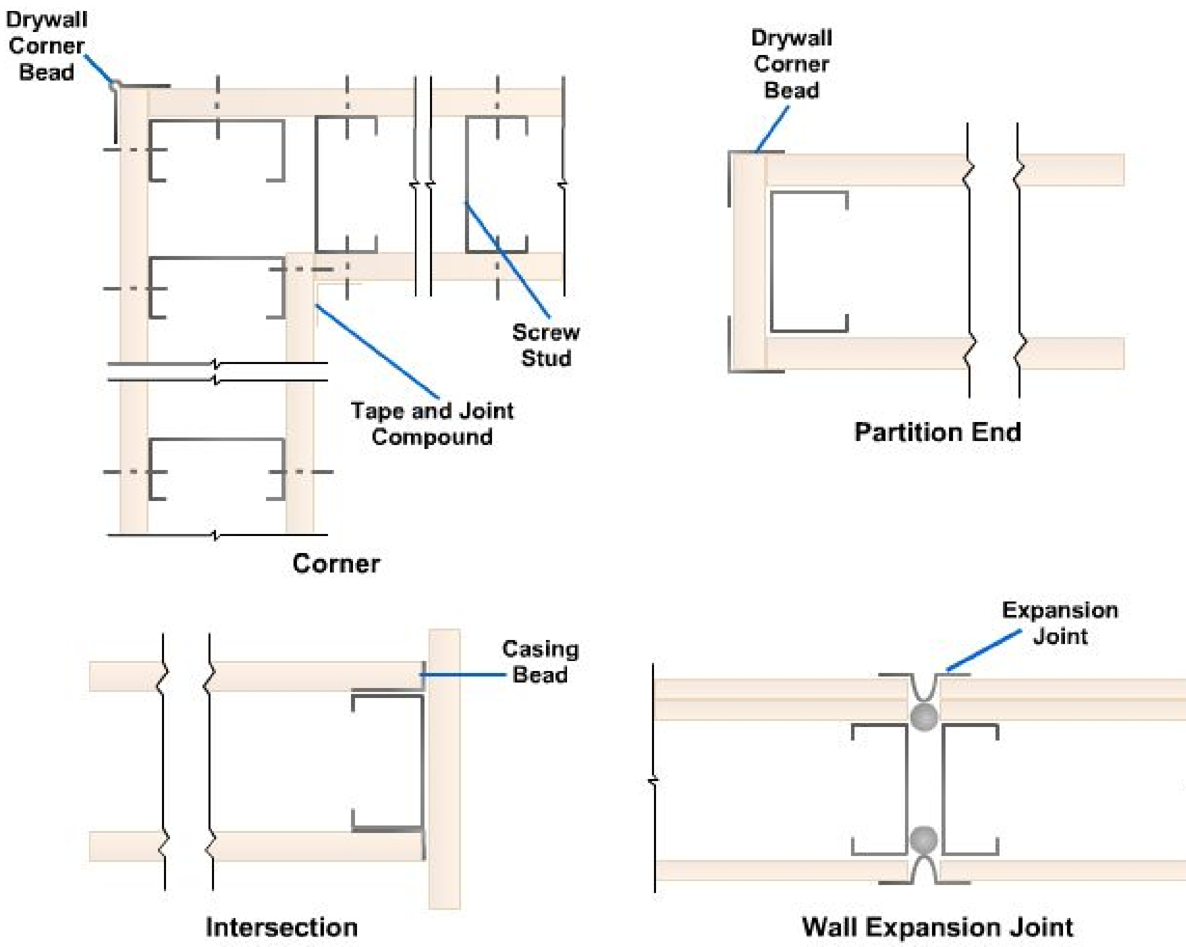


Figure 10-59 – Metal frame layout with various beads and joints.

Test your Knowledge (Select the Correct Response)

9. What is the purpose of corner and casing beads?

   A. Protect and reinforce corners and edges of drywall
   B. Add additional support for nonbearing walls
   C. Allow for expansion
   D. Improve the appearance of the finished wall

Figure 10-60 lists the different types of fasteners used in metal frame construction and explains the application of each type.

Head	Length	Fastening Application
Low Profile	1/2"	Metal-to-Metal, Reduces Drywall Bulge Over Screw
Trim	1"	Batten to Metal Stud
Trim	1 5/8"	Wood Trim on Single Layer Drywall to Metal Framing
Trim	2 1/4"	Wood Trim on Double Layer Drywall to Metal Framing
Washer Head	1/2"	Metal Lath to Steel Framing
Bugle	1 1/2"	Board-to-Board During Lamination
Bugle	1 1/4"	Drywall or Channels to Wood Framing
Pan	3/8"	Metal-to-Metal
Pan	1/2"	Metal Studs to Runners. Door Frame Clips to Metal Studs
Pan	3/8"	Metal Studs to Metal Runners Splicing Studs
Bugle	1"	1/2" or 5/8" Drywall to Metal Framing
Bugle	1 1/4"	Metal Lath to Metal Studs
Bugle	1 5/8"	Double Layer 1/2" or 5/8" Drywall to Metal Framing
Bugle	1 7/8"	Multi-Layer Drywall to Metal Framing
Bugle	1 5/8"	Laminated Drywall Up to 2 1/4" Thick to Framing
Bugle	2 3/8"	Double Layer 1" Shaftliner to Metal Framing
Bugle	2"	Laminated Drywall Up to 1 5/8" Thick to Framing
Bugle	3"	Multi-layer Drywall up to 2 1/2" Thick to Framing
Trim	1"	Batten Over Drywall to Metal Stud
Trim	1 5/8"	Wood Trim Over Drywall to Metal Stud
Trim	2 1/4"	Wood Trim Over Double Layer Drywall to Metal Stud
Bugle	1"	1/2" or 5/8" Drywall to Metal Stud Up to 20 Guage. Steel Channels to Wood Framing.
Bugle	1 1/8"	5/8" Drywall Ceiling Attachments
Bugle	1 1/4"	5/8" Drywall Ceiling On Resilient Furring Channels
Bugle	1 5/8"	Double Layer 5/8" Drywall to Metal Stud
Bugle	1 7/8"	1/2" Drywall Through Shaftliner to Metal Runners
Bugle	2 1/4"	5/8" Drywall Through Shaftliner to Metal Runners
Bugle	2 5/8"	Double Layer 1" Shaftliner to Metal Stud
Bugle	3"	1/2" Drywall Over 2 Layers of 1" Shaftliner to Metal Framing

Figure 10-60 – Drywall screws and fastening application.

4.0.0 FRAMING CEILINGS

Ceiling construction begins after all walls have been plumbed, aligned, and secured. One type of ceiling supports an attic area beneath a sloping (pitched) roof. Another type serves as the framework of a flat roof. When a building has two or more floors, the ceiling of a lower story is the floor of the story above.

One of the main structural functions of a ceiling frame is to tie together the outside walls of the building. When located under a pitched roof, the ceiling frame also resists the outward pressure placed on the walls by the roof rafters, as shown in *Figure 10-61*. The tops of interior partitions are fastened to the ceiling frame. In addition to supporting the attic area beneath the roof, the ceiling frame supports the weight of the finish ceiling materials, such as gypsum board or lath and plaster.

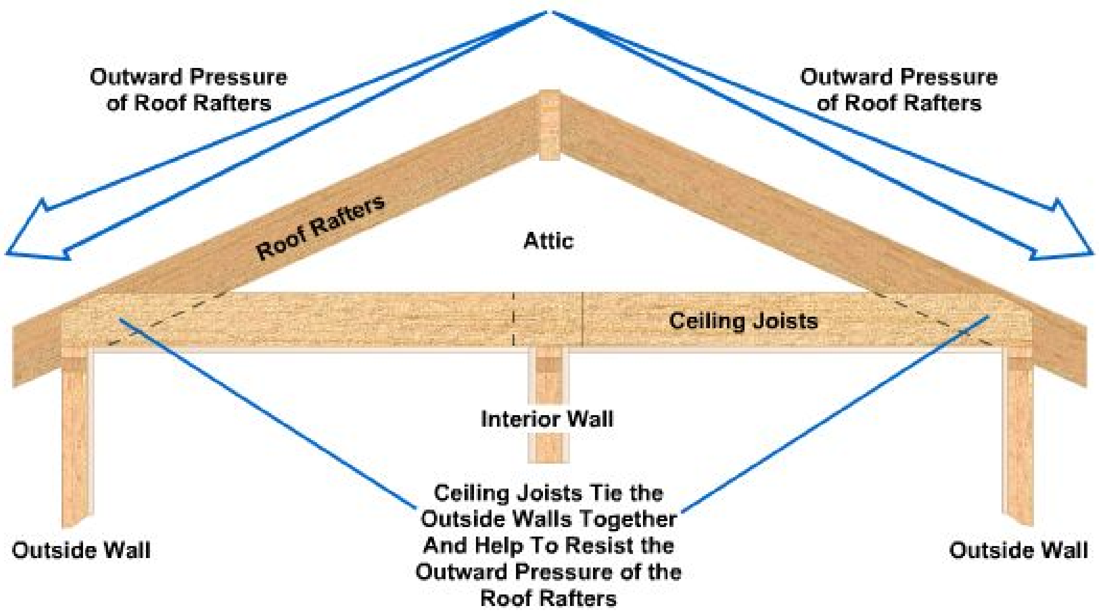


Figure 10-61 – Ceiling frame tying exterior walls together.

4.1.0 Joists

Joists are the most important framing members of the ceiling. Their size, spacing, and direction of travel are given on the floor plan. As mentioned earlier, the spacing between ceiling joists is usually 16 inches OC, although 24 inch spacing is also used. The size of a ceiling joist is determined by the weight it carries and the span it covers from wall to wall. Refer to the blueprints and specifications for size and OC spacing. Although it is more convenient to have all the joists running in the same direction, plans sometimes call for different sets of joists to run at right angles to each other.

4.1.1 Interior Support

One end of a ceiling joist rests on an outside wall. The other end often overlaps an interior bearing partition or girder. The overlap should be at least 4 inches. Ceiling joists are sometimes butted over the partition or girder. In this case, the joists must be cleated with a 3/4 inch thick plywood board, 24 inches long, or an 18 gauge metal strap, 18 inches long.

Ceiling joists may also butt against the girder, supported by joist hangers in the same manner as floor joists.

4.1.2 Roof Rafters

Whenever possible, the ceiling joists should run in the same direction as the roof rafters. Nailing the outside end of each ceiling joist to the heel of the rafter as well as to the wall plates as shown in *Figure 10-62* strengthens the tie between the outside walls of the building.

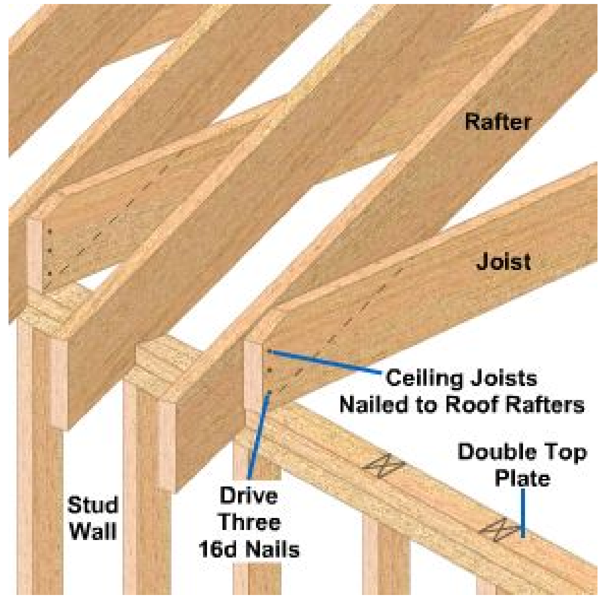


Figure 10-62 – Nailing of ceiling joists.

A building may be designed so that the ceiling joists do not run parallel to the roof rafters. The rafters are therefore pushing out on walls not tied together by ceiling joists. In this case, add 2 by 4 pieces to run in the same direction as the rafters, as shown in *Figure 10-63*. Nail the 2 by 4s to the top of each ceiling joist with 2 16D nails. Space the 2 by 4 pieces no more than 4 feet apart, and secure the ends to the heels of the rafters or to blocking over the outside walls.

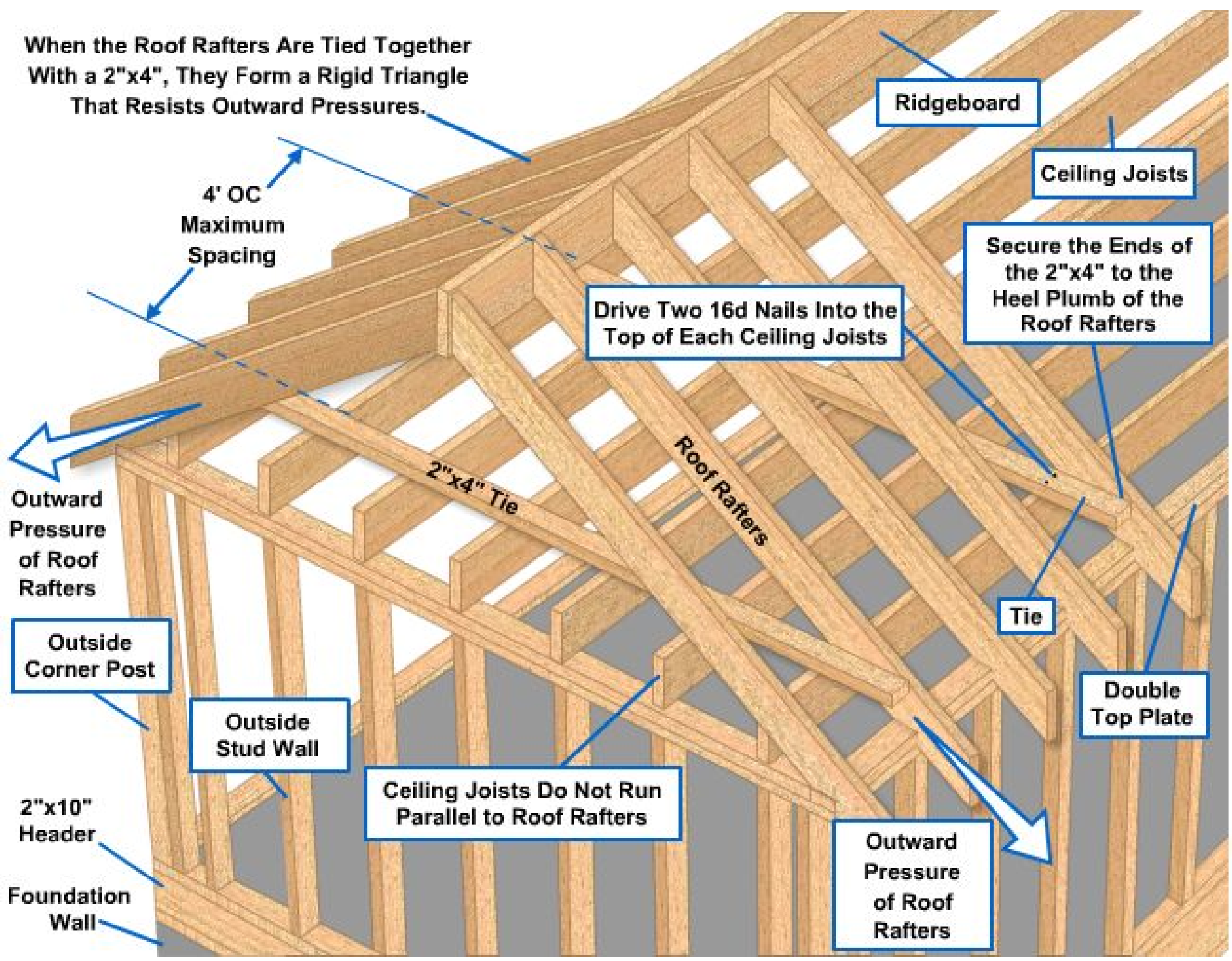


Figure 10-63 – 2 by 4 ties.

4.1.3 Roof Slope

When ceiling joists run in the same direction as the roof rafters, cut the outside ends to the slope of the roof. Ceiling frames are sometimes constructed with stub joists as shown in *Figure 10-64*. Stub joists are necessary when, in certain sections of the roof, rafters and ceiling joists do not run in the same direction. For example, a low pitched hip roof requires stub joists in the hip section of the roof.

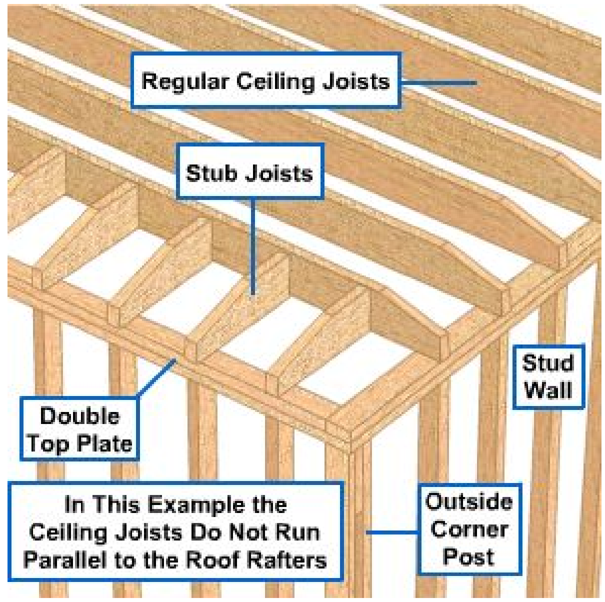


Figure 10-64 – Stub joists.

4.1.4 Ribbands and Strongbacks

Ceiling joists not supporting a floor above require no header joists or blocking. Without the additional header joists, ceiling joists may twist or bow at the centers of their span. To help prevent this, nail a 1 by 4 piece called a ribband at the center of the spans as shown in *Figure 10-65*. Lay the ribband flat and fasten it to the top of each joist with two 8d nails. Secure the end of each ribband to the outside walls of the building.

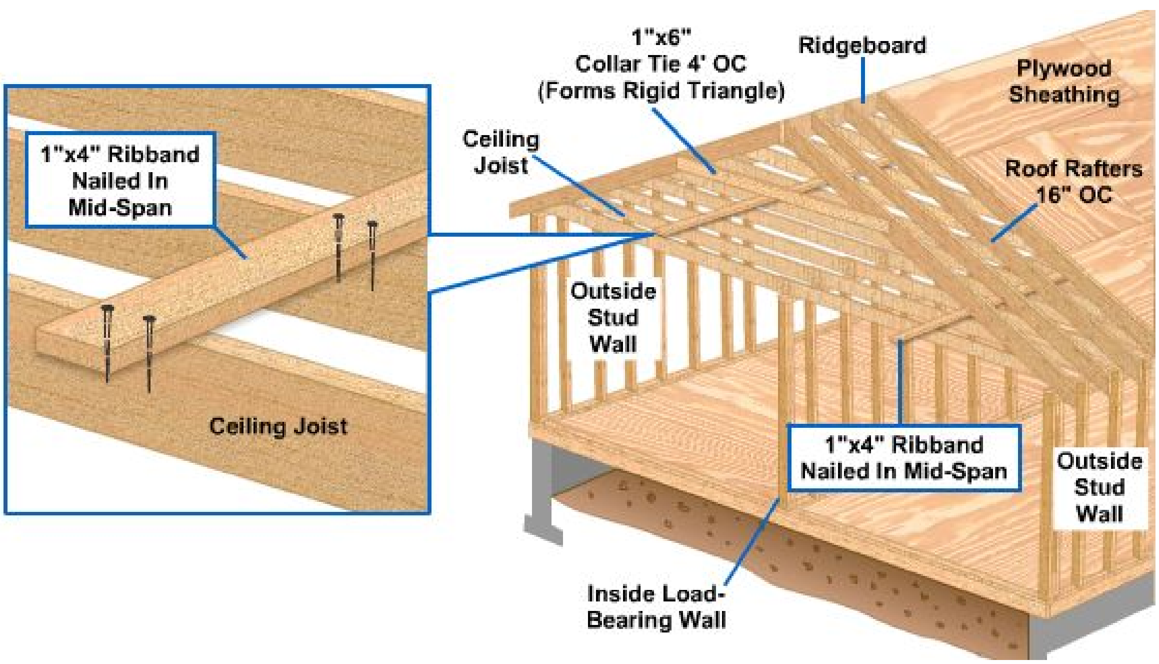


Figure 10-65 – Ribband installation.

Test your Knowledge (Select the Correct Response)

10. Which of the following components can be used to help support a ceiling joist at the center of its span?

    A. Strongback
    B. Joist hanger
    C. Ribband
    D. Diagonal brace

A more effective method of preventing twisting or bowing of the ceiling joists is to use a strongback. A strongback is made of 2 by 6 or 2 by 8 material nailed to the side of a 2 by 4 piece. Fasten the 2 by 4 piece with two 16D nails to the top of each ceiling joist, as shown in *Figure 10-66*. Block up the strongbacks and support them over the outside walls and interior partitions. Each strongback holds a ceiling joist in line and also helps support the joist at the center of its span.

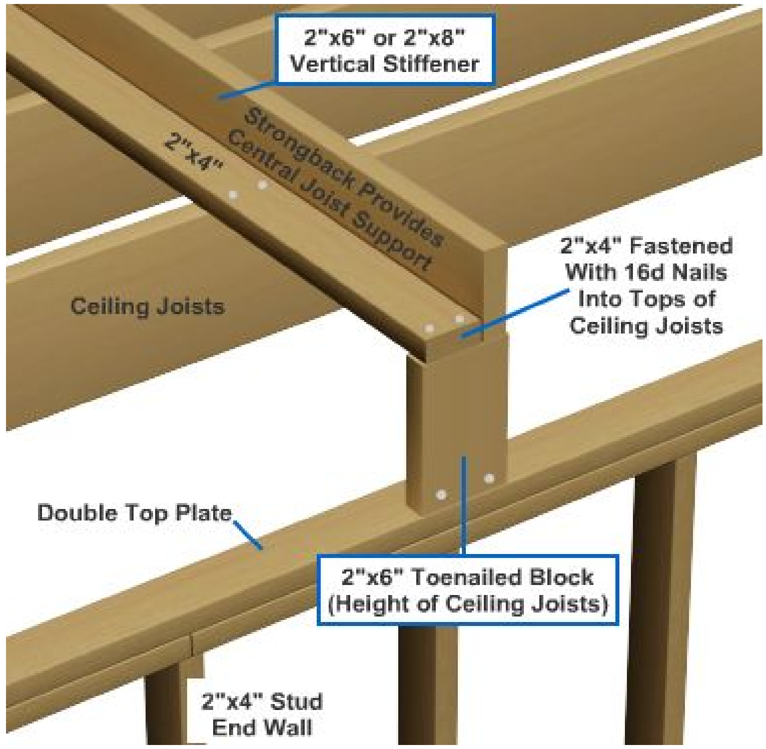


Figure 10-66 – Strongback.

4.1.5 Layout

Place ceiling directly above the studs when the spacing between the joists is the same as between the studs. This arrangement makes it easier to install pipes, flues, or ducts running up the wall and through the roof. However, for buildings with walls having double top plates, most building codes do not require ceiling joists to line up with the studs below.If the joists are being placed directly above the studs, they follow the same layout as the studs below shown in *Figure 10-67, view A*. If the joist layout is different from that of the studs below, for example, if joists are laid out 24 inches OC over a 16 inch OC stud layout, mark the first joist at 23 1/4 inches and then at every 24 inches OC as shown in *Figure 10-67, view B*.

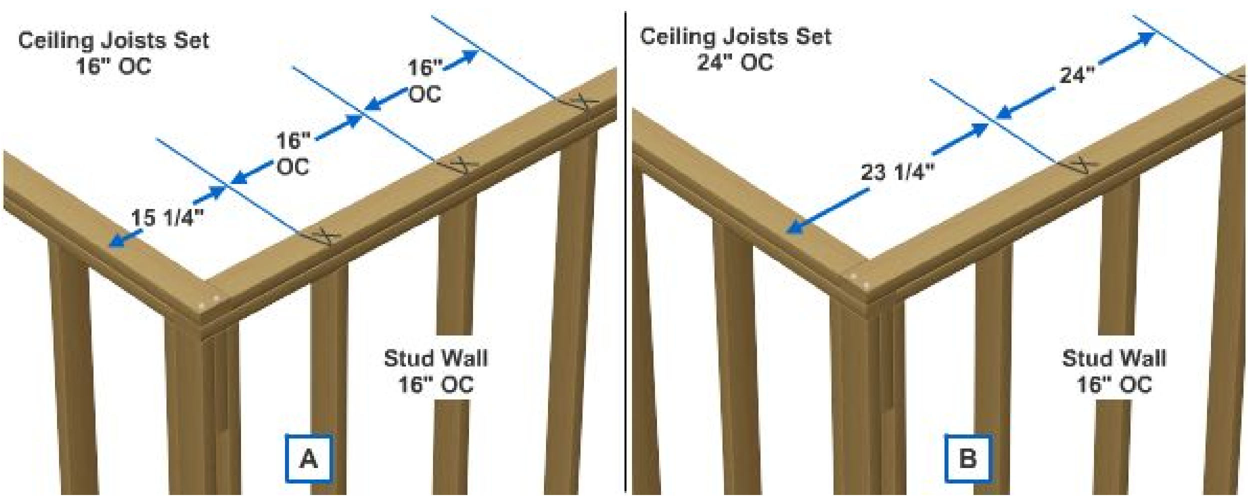


Figure 10-67 – Ceiling joist spacing.

Marking the positions of the roof rafters at the time the ceiling joists are being laid out is good practice. If the spacing between the ceiling joists is the same as between the roof railers, there will be a rafter next to every joist. Often the joists are laid out 16 inches OC and the roof rafters 24 inches OC. In this case, you can place every other rafter next to a ceiling joist.

4.2.0 Frame

Cut all the joists for the ceiling frame to length before placing them on top of the walls. On structures with pitched roofs, also trim the outside ends of the joists for the roof slope. Cut this angle on the crown (top) side of the joist. The prepared joists can then be handed up to the Builders working on top of the walls. Spread the joists in a flat position along the walls, close to where they will be nailed. *Figure 10-68* shows one procedure for constructing the ceiling frame. In this example, the joists lap over an interior partition.

Refer to the Figure as you study the following steps:

1. Measure and mark for the ceiling joists.
2. Install the ceiling joists on one side of the building.
3. Install the ceiling joists on the opposite side of the building.
4. Place backing on walls running parallel to the joists.
5. Install 2 by 4 blocks flat between joists where needed to fasten the tops of inside walls running parallel to the joists.
6. Cut and frame the attic scuttle.
7. Place strongbacks at the center of the spans.

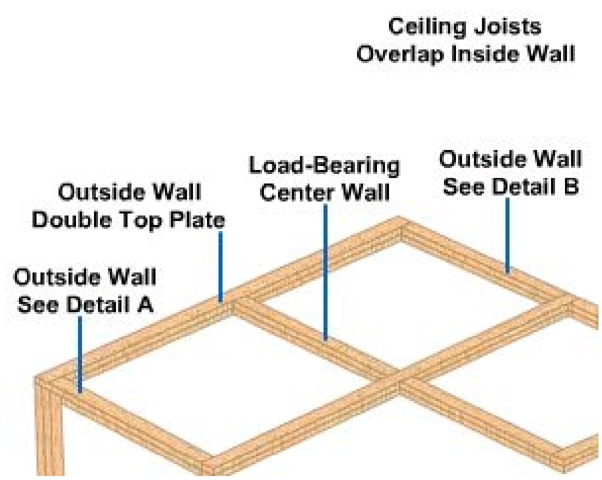


Figure 10-68 – Constructing a typical ceiling frame.

4.2.1 Fastening Walls

The tops of walls running in the same direction as the ceiling joists must be securely fastened to the ceiling frame. The method most often used is shown in *Figure 10-68*. Lay 2 by 4 inch blocks, spaced 32 inches OC, flat over the top of the partition. Fasten the ends of each block to the joists with two 16d nails. Also drive two 16d nails through each block into the top of the wall.

4.2.2 Applying Backing

Walls running in the same direction as the ceiling joists require backing. *Figure 10-68 (insert)* shows how to nail backing to the top plates to provide a nailing surface for the edges of the finish ceiling material. Lumber used for backing usually has 2 inch nominal thickness, although 1 inch boards are sometimes used.

Figure 10-69 shows backing placed on top of walls. The 2 by 4 pieces nailed to the exterior wall projects from one side of the wall. The interior wall requires a 2 by 6 or 2 by 8 piece extending from both sides of the wall. Fasten backing to the top plates with 16d nails spaced 16 inches OC.

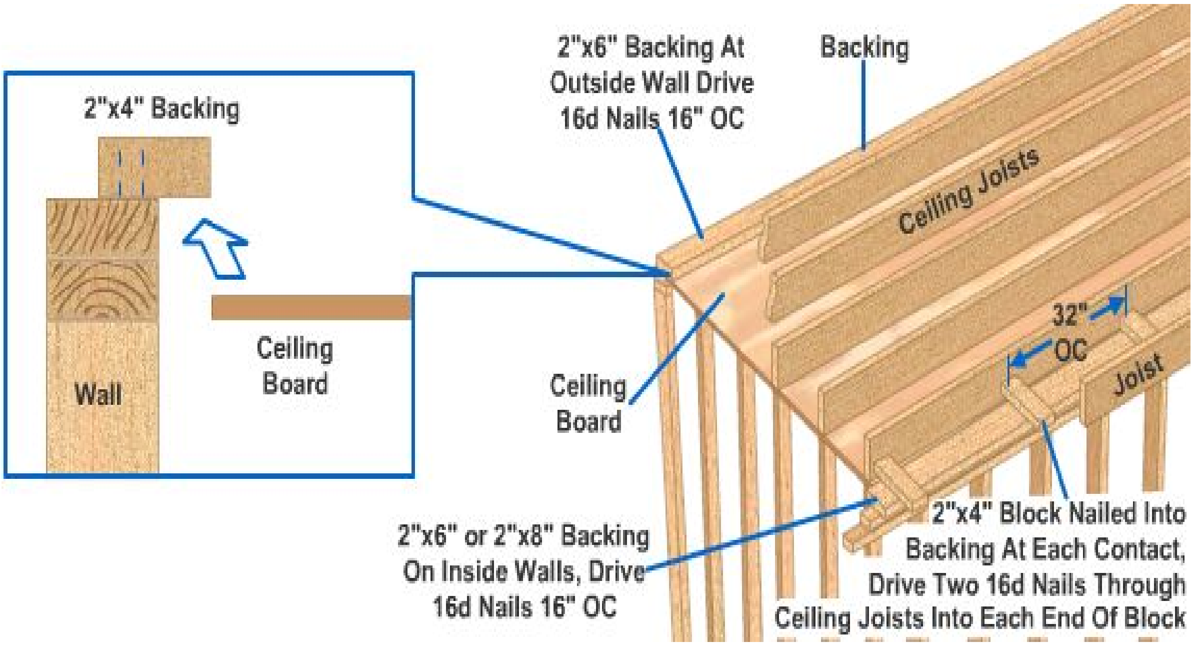


Figure 10-69 – Backing for nailing joists to ceiling frame.

Also use backing where joists run at right angles to the partition as shown in *Figure 10-70*.

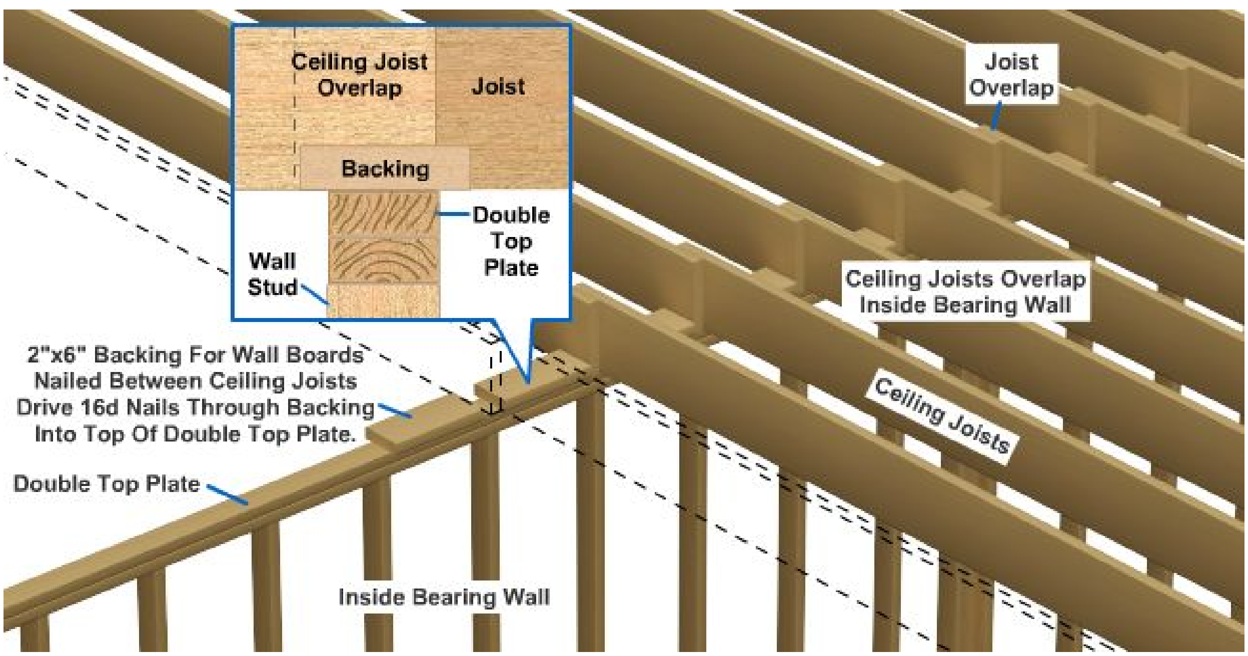


Figure 10-70 – Backing for interior wall plates.

4.2.3 Attic Scuttle

The scuttle is an opening framed in the ceiling to provide an entrance into the attic area. The size of the opening is decided by specification requirements and should be indicated in the blueprints. It must be large enough for a person to climb through easily.

The scuttle is framed in the same way as a floor opening. If the opening is no more than 3 feet square, it is not necessary to double the joists and headers. Always place scuttles away from the lower areas of a sloping roof. The opening may be covered by a piece of plywood resting on stops. Cut out the scuttle opening after nailing all the regular ceiling joists in place.

5.0.0 FRAMING ROOFS

In this section, you will learn the fundamentals of roof design and construction. Before we discuss roof framing, you will learn some basic terms and definitions used in roof construction. Next you will learn about the framing square and how it is used to solve some basic construction problems. Then you will learn about various types of roofs and rafters, and techniques for laying out, cutting, and erecting rafters. The section concludes with a discussion of the types and parts of roof trusses.

5.1.0 Terminology

The primary object of a roof in any climate is protection from the elements. Roof slope and rigidness are for shedding water and bearing any additional weight. Roofs must be strong enough to withstand high winds. In this section, you will learn the most common types of roofs and basic framing terms.

5.2.0 Types of Roofs

The most commonly used types of pitched roof construction are the gable, the hip, the gable and valley, and the shed (or lean-to). An example of each is shown in *Figure 10-71*.

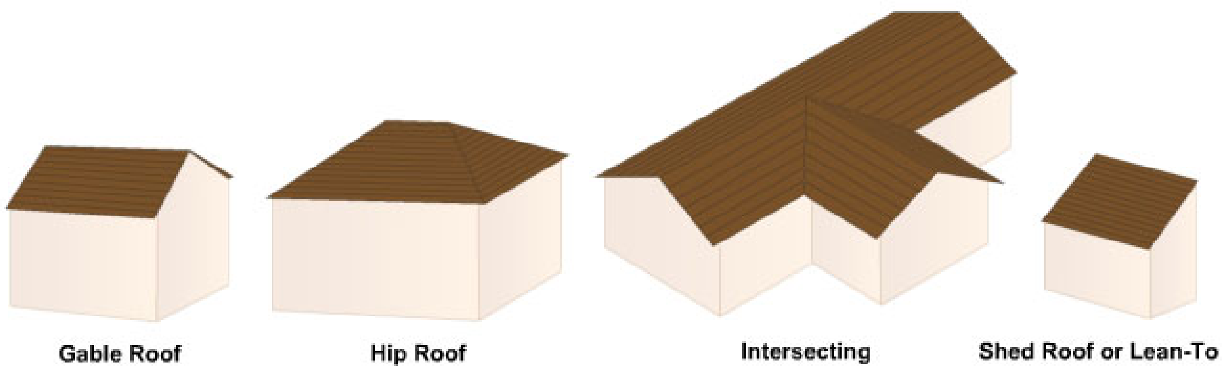


Figure 10-71 – Most common types of pitched roofs.

5.2.1 Gable

A gable roof has a ***ridge*** at the center and slopes in two directions. It is the form most commonly used by the Navy. It is simple in design, economical to construct, and can be used on any type of structure.

5.2.2 Hip

The hip roof has four sloping sides. It is the strongest type of roof because it is braced by four hip rafters. These hip rafters run at a 45° angle from each corner of the building to the ridge. A disadvantage of the hip roof is that it is more difficult to construct than a gable roof.

5.2.3 Gable and valley

The gable and valley roof consists of a gable and valley, or hip and valley. The valley is formed where the two different sections of the roof meet, generally at a 90° angle. This type of roof is more complicated than the other types and requires more time and labor to construct.

5.2.4 Shed

The shed roof, or lean-to, is a roof having only one slope, or ***pitch***. It is used where large buildings are framed under one roof, where hasty or temporary construction is needed, and where sheds or additions are erected. The roof is held up by walls or posts where one wall or the posts on one side are at a higher level than those on the opposite side.

5.3.0 Framing Terms

Knowing the basic vocabulary is a necessary part of your work as a Builder. In the following section, you will learn some of the more common roof and rafter terms you'll need. Roof framing terms are related to the parts of a triangle.

5.3.1 Roof

Features associated with basic roof framing terms are shown in *Figure 10-72*. Refer to the Figure as you study the terms discussed in the next paragraphs. **Span** is the horizontal distance between the outside top plates, or the base of two abutting right triangles.

Unit of *run* is a fixed unit of measure, always 12 inches for the common rafter. Any measurement in a horizontal direction is expressed as run and is always measured on a level plane. Unit of span is also fixed, twice the unit of run, or 24 inches. Unit of ***rise*** is the distance the rafter rises per foot of run (unit of run).

Total run is equal to half the span, or the base of one of the right triangles. Total rise is the vertical distance from the top plate to the top of the ridge, or the altitude of the triangle.

Pitch is the ratio of unit of rise to the unit of span. It describes the slope of a roof. Pitch is expressed as a fraction, such as 1/4 or 1/2 pitch. The term "pitch" is gradually being replaced by the term "cut." Cut is the angle that the roof surface makes with a horizontal plane. This angle is usually expressed as a fraction in which the numerator equals the unit of rise and the denominator equals the unit of run (12 inches), such as 6/12 or 8/12. This can also be expressed in inches per foot; for example, a 6 or 8 inch cut per foot. Here, the unit of run (12 inches) is understood.

Pitch can be converted to cut by using the following formula:

unit of span x pitch = unit of rise

For example, 1/8 pitch is given, so 24 x 1/8 equals 3, or unit of rise in inches. If the unit of rise in inches is 3, then the cut is the unit of rise and the unit of run (12 inches), or 3/12.

Line length is the hyptenuse of the triangle whose base equals the total run and whose height equals the total rise.

The distance is measured along the rafter from the outside edge of the top plate to the centerline of the ridge. Bridge measure is the hypotenuse of the triangle with the unit of run for the base and unit of rise for the altitude.

5.3.2 Rafter

The members making up the main body of the framework of all roofs are called rafters. They do for the roof what the joists do for the floor and what the studs do for the wall. Rafters are inclined members spaced from 16 to 48 inches apart. They vary in size, depending on their length and spacing. The tops of the inclined rafters are fastened in one of several ways determined by the type of roof. The bottoms of the rafters rest on the plate member, providing a connecting link between the wall and the roof. The rafters are really functional parts of both the walls and the roof.

The structural relationship between the rafters and the wall is the same in all types of roofs. The rafters are not framed into the plate, but are simply nailed to it. Some are cut to fit the plate, whereas others, in hasty construction, are merely laid on top of the plate and nailed in place. Rafters usually extend a short distance beyond the wall to form the eaves (overhang) and protect the sides of the building. Features associated with various rafter types and terminology is shown in *Figure 10-73*.

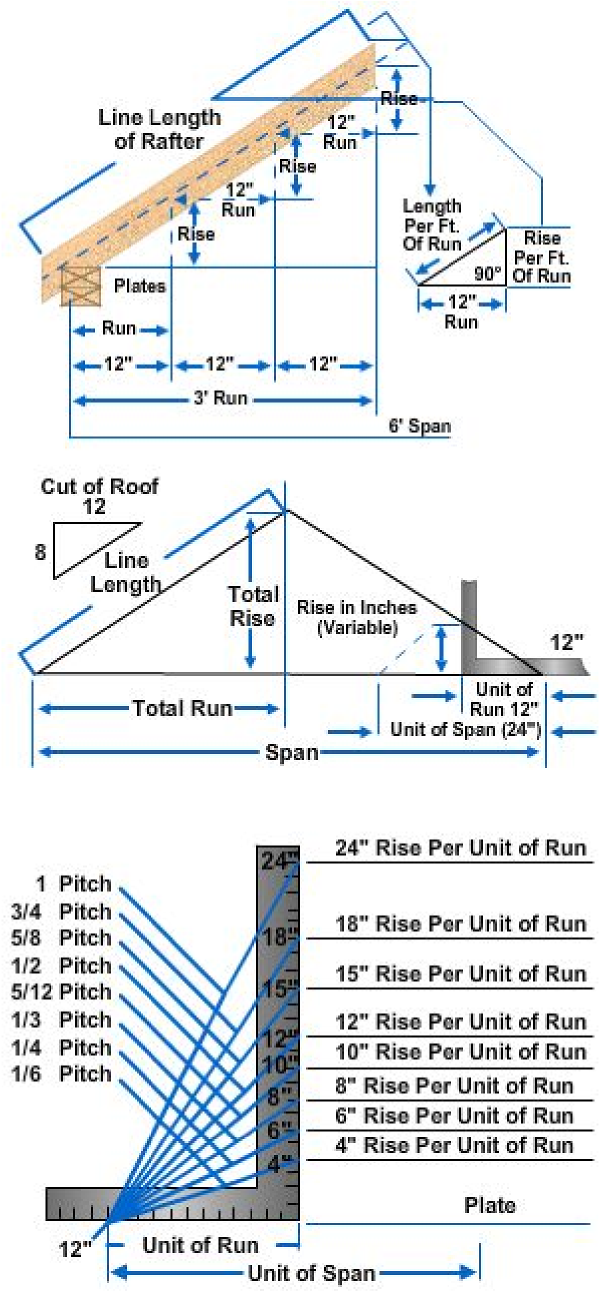


Figure 10-72 – Roof framing terms.

Common rafters extend from the plate to the ridgeboard at right angles to both. Hip rafters extend diagonally from the outside corner formed by perpendicular plates to the ridgeboard. Valley rafters extend from the plates to the ridgeboard along the lines where two roofs intersect. Jack rafters never extend the full distance from plate to ridgeboard. Jack rafters are subdivided into the hip, valley, and cripple jacks. In a hip jack, the lower ends rest on the plate and the upper ends against the hip rafter. In a valley jack the lower ends rest against the valley rafters and the upper ends against the ridgeboard. A cripple jack is nailed between hip and valley rafters.

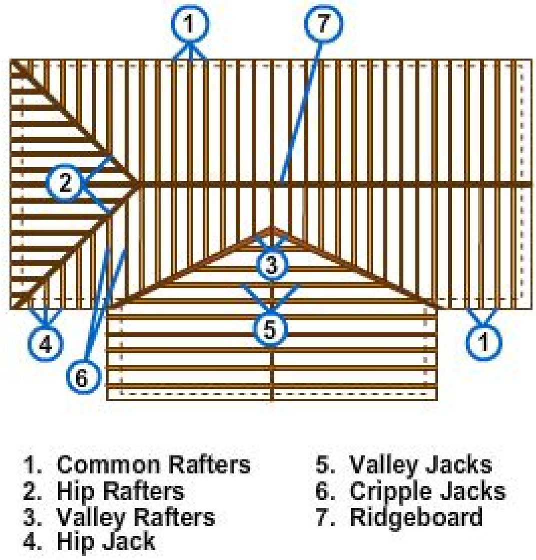


Figure 10-73 – Rafter terms.

Rafters are cut in the three basic ways shown in *Figure 10-74, view A*. The top cut, also called the plumb cut, is made at the end of the rafter to be placed against the ridgeboard or, if the ridgeboard is omitted, against the opposite rafters. A seat, bottom, or heel cut is made at the end of the rafter that is to rest on the plate. A side cut, not shown in *Figure 10-74*, also called a cheek cut, is a bevel cut on the side of a rafter to make it fit against another frame member.

Rafter length is the shortest distance between the outer edge of the top plate and the center of the ridge line. The eave, tail, or overhang is the portion of the rafter extending beyond the outer edge of the plate. A measure line shown in *Figure 10-74, view B* is an imaginary reference line laid out down the middle of the face of a rafter. If a portion of a roof is represented by a right triangle, the measure line corresponds to the hypotenuse, the rise to the altitude, and the run to the base.

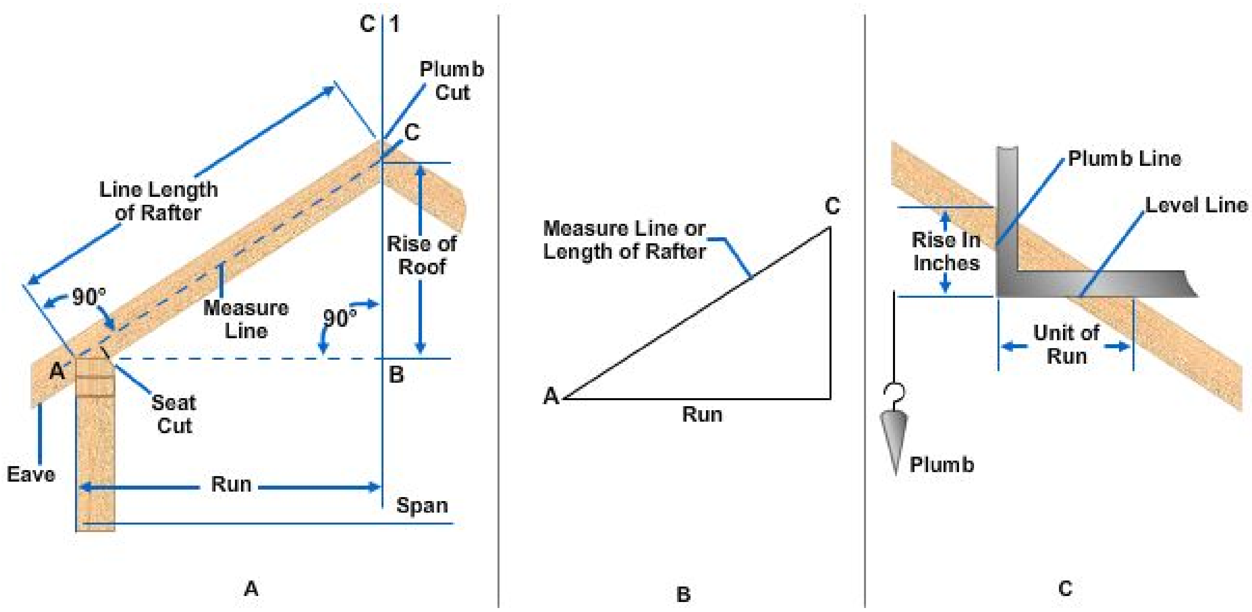


Figure 10-74 – Rafter layout.

A plumb line, like the one shown in *Figure 10-74, view C*, is any line that is vertical (plumb) when the rafter is in its proper position. A level line, shown in *Figure 10-74, view C*, is any line that is horizontal (level) when the rafter is in its proper position.

6.0.0 USING THE FRAMING SQUARE

The framing square is one of the most frequently used Builder tools. The problems it can solve are so many and varied that books have been written on the square alone. Only a few of the more common uses of the square can be presented here. For a more detailed discussion of the various uses of the framing square in solving construction problems, you are encouraged to obtain and study one of the many excellent books on the square.

6.1.0 Description

The framing square shown in *Figure 10-75, view A* consists of a wide, long member called the blade and a narrow, short member called the tongue. The blade and tongue form a right angle. The face of the square is the side you see when the square is held with the blade in the left hand, the tongue in the right hand, and the heel pointed away from the body. The manufacturer's name is usually stamped on the face. The blade is 24 inches long and 2 inches wide. The tongue varies from 14 to 18 inches long and is 1 1/2 inches wide, measured from the outer corner, where the blade and the tongue meet. This corner is called the heel of the square.

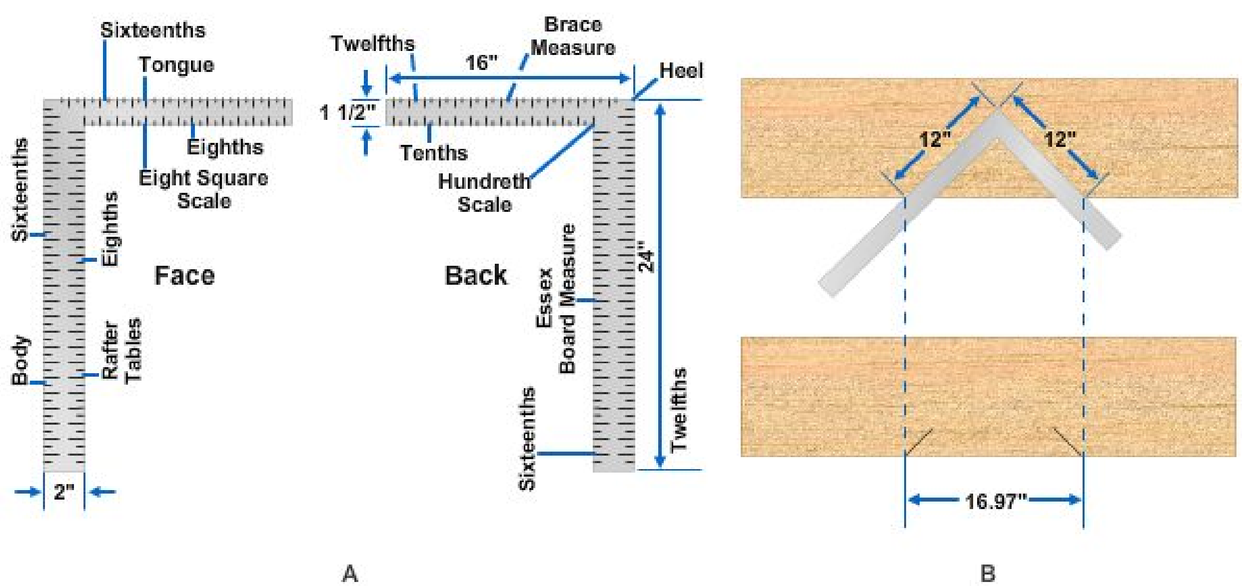


Figure 10-75 – Framing square

A. Nomenclature

B. Problem solving.

The outer and inner edges of the tongue and the blade, on both face and back, are graduated in inches. Note how inches are subdivided in the scale on the back of the square. In the scales on the face, the inch is subdivided in the regular units of carpenter's measure, 1/8 or 1/16 inch. On the back of the square, the outer edge of the blade and tongue is graduated in inches and twelfths of inches. The inner edge of the tongue is graduated in inches and tenths of inches. The inner edge of the blade is graduated in inches and thirty-seconds of inches on most squares. Common uses of the twelfths scale on the back of the framing square will be described later. The tenths scale is not normally used in roof framing.

6.2.0 Solving Basic Problems with the Framing Square

The framing square is used most frequently to find the length of the hypotenuse, the longest side, of a right triangle when the lengths of the other two sides are known. This is the basic problem involved in determining the length of a roof rafter, a brace, or any other member that forms the hypotenuse of an actual or imaginary right triangle.

Figure 10-75, view B shows how to use the framing square to determine the length of the hypotenuse of a right triangle with the other sides each 12 inches long. Place a true straightedge on a board and set the square on the board so as to bring the 12 inch mark on the tongue and the blade even with the edge of the board. Draw the pencil marks as shown. The distance between these marks, measured along the edge of the board, is the length of the hypotenuse of a right triangle with the other sides each 12 inches long. You will find that the distance, called the bridge measure, measures just under 17 inches (17.97 inches), as shown in *Figure 10-75*. For most practical purposes for Builders, round 17.97 inches to 17 inches.

6.2.1 Solving for Unit and Total Run and Rise

In *Figure 10-75*, the problem could be solved by a single set, called a cut, of the framing square. This is because the dimensions of the triangle in question lie within the dimensions of the square. Suppose you are trying to find the length of the hypotenuse of a right triangle with the two known sides each being 48 inches long. Assume the member whose length you are trying to determine is the brace shown in *Figure 10-76*. The total run of this brace is 48 inches, and the total rise is also 48 inches.

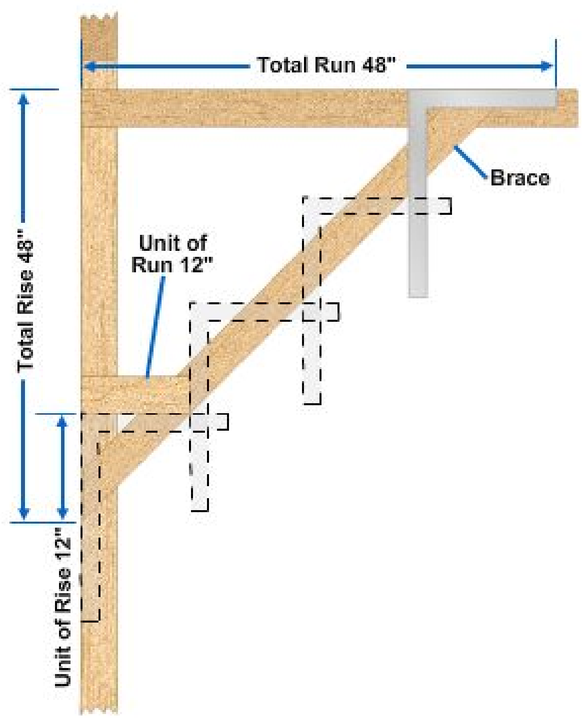


Figure 10-76 – Stepping off with a framing square.

To figure the length of the brace, first reduce the triangle in question to a similar triangle within the dimensions of the framing square. The length of the vertical side of this triangle is called the unit of rise, and the length of the horizontal side is called the unit of run. By a general custom of the trade, unit of run is always taken as 12 inches and measured on the tongue of the framing square.

Now, if the total run is 48 inches, the total rise is 48 inches, and the unit of run is 12 inches, what is the unit of rise? Since the sides of similar triangles are proportional, the unit of rise must be the value of *x* in the proportional equation *48:48::12:x.* In this case, the unit of rise is obviously 12 inches.

To get the length of the brace, set the framing square to the unit of run (12 inches) on the tongue and to the unit of rise (also 12 inches) on the blade, as shown in *Figure 10-76*. Then, step off this cut as many times as the unit of run goes into the total run. In this case, 48/12, or 4 times.

In this problem, the total run and total rise were the same, from which it followed that the unit of run and unit of rise were also the same. Suppose now that you want to know the length of a brace with a total run of 60 inches and a total rise of 72 inches, as in *Figure 10-77.* Since the unit of run is 12 inches, the unit of rise must be the value of *x* in the proportional equation *60:72::12.x.* That is, the proportion 60:72 is the same as the proportion 12:x. Working this out, you find the unit of rise is 14.4 inches. For practical purposes, you can round this to 14 3/8.

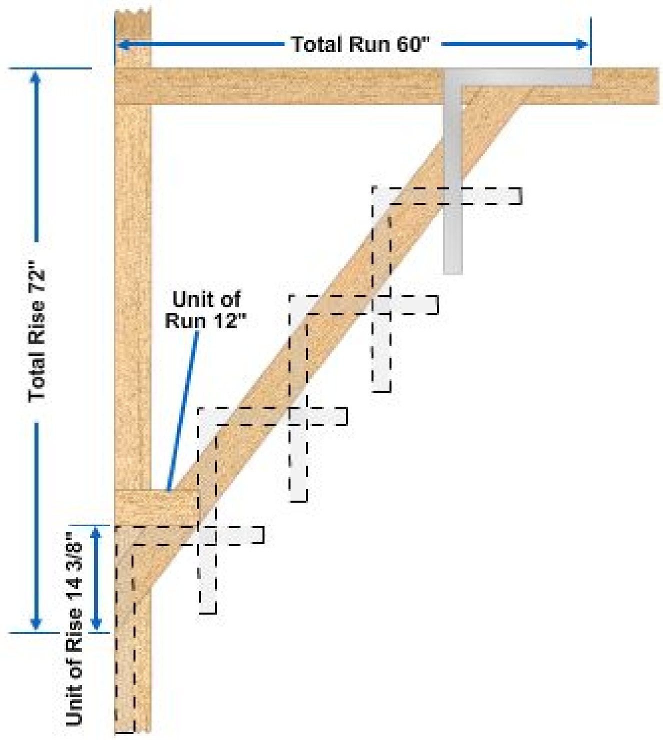


Figure 10-77 – Stepping off with a square when the unit of run and unit of rise are different.

To lay out the full length of the brace, set the square to the unit of rise, 14 3/8 inches, and the unit of run, 12 inches, as shown in *Figure 10-77.* Then step off this cut as many times as the unit of run goes into the total run which is 60/12, or 5 times.

6.2.2 Determining Line Length

If you do not go through the stepping-off procedure, you can Figure the total length of the member in question by first determining the bridge measure. The bridge measure is the length of the hypotenuse of a right triangle with the other sides equal to the unit of run and unit of rise.

Take the situation shown in *Figure 10-77*. The unit of run here is 12 inches and the unit of rise is 14 3/8 inches. Set the square to this cut, as shown in

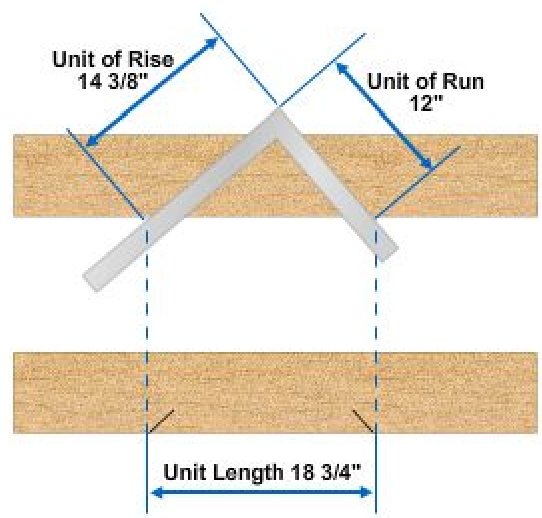


Figure 10-78 – Unit length.

Figure 10-78, and mark the edges of the board as shown. If you measure the distance between the marks, you will find it is 18 3/4 inches. Bridge measure can also be found by using the Pythagorean theorem:

$$a2 + b2 = c2$$

Here, the unit of rise is the altitude *(a),* the unit of run is the base *(b),* and the hypotenuse *(c)* is the bridge measure.

To get the total length of the member, you simply multiply the bridge measure in inches by the total run in feet. Since that is 5, the total length of the member is 18 3/4 x 5, or 93 3/4 inches. The length of the hypotenuse of a right triangle with the other sides 60 and 72 inches long is slightly more than 93.72 inches, but 93 3/4 inches is close enough for practical purposes.

Once you know the total length of the member, just measure it off and make the end cuts. To make these cuts at the proper angles, set the square to the unit of run on the tongue and the unit of rise on the blade and draw a line for the cut along the blade (lower end cut) or the tongue (upper end cut).

6.3.0 Scales

A framing square contains four scales: tenths, twelfths, hundredths, and octagon. All are found on the face or along the edges of the square. As we mentioned earlier, the tenths scale is not used in roof framing.

6.3.1 Twelfths Scale

The graduations in inches, located on the back of the square along the outer edges of the blade and tongue, are called the twelfths scale. The chief purpose of the twelfths scale is to provide various shortcuts in problem solving graduated in inches and twelfths of inches. Dimensions in feet and inches can be reduced to $1/12^{th}$ by simply allowing each graduation on the twelfths scale to represent 1 inch. For example, 2 6/12 inches on the twelfths scale may be taken to represent 2 feet 6 inches. A few examples will show you how the twelfths scale is used.

Suppose you want to know the total length of a rafter with a total run of 10 feet and a total rise of 6 feet 5 inches. Set the square on a board with the twelfths scale on the blade at 10 inches and the twelfths scale on the tongue at 6 5/12 inches and make the usual marks. If you measure the distance between the marks, you will find it is 11 11/12 inches. The total length of the rafter is 11 feet 11 inches.

Suppose now that you know the unit of run, unit of rise, and total run of a rafter, and you want to find the total rise and the total length. Use the unit of run, 12 inches, and unit of rise, 8 inches, and total run of 8 feet 9 inches. Set the square to the unit of rise on the tongue and unit of run on the blade as shown in *Figure 10-79, top view*. Then slide the square to the right until the 8 9/12 inch mark on the blade, representing the total run of 8 feet 9 inches, comes even with the edge of the board, as shown in the second view. The figure of 5 10/12 inches, now indicated on the tongue, is one twelfth of the total rise. The total rise is 5 feet 10 inches. The distance between pencil marks, 10 7/12 inches, drawn along the tongue and the blade is one twelfth of the total length. The total length is 10 feet 7 inches.

You may also use the twelfths scale to determine dimensions by inspection for proportional reductions or enlargements. Suppose you have a panel 10 feet 9 inches long by 7 feet wide. You want to cut a panel 7 feet long with the same proportions. Set the square, as shown in *Figure 10-79*, but with the blade at 10 9/12 inches and the tongue at 7 inches. Then slide the blade to 7 inches and read the Figure indicated on the tongue, which will be 4 7/12 inches if done correctly. The smaller panel should be 4 feet 7 inches wide.

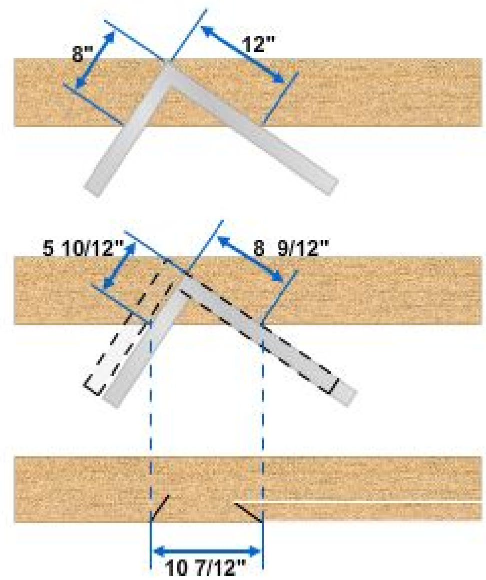


Figure 10-79 – Finding total rise and length when unit of run, unit of rise, and total run are known.

6.3.2 Hundredths Scale

The hundredths scale is on the back of the tongue, in the comer of the square, near the brace table. This scale is called the hundredths scale because 1 inch is divided into 100 parts. The longer lines indicate 25 hundredths, the next shorter lines indicate 5 hundredths, and so forth. By using dividers, you can easily obtain a fraction of an inch.

The inch is graduated in sixteenths and located below the hundredths scale. The conversion from hundredths to sixteenths can be made at a glance without the use of dividers. This can be a great help when determining rafter lengths, using the figures of the rafter tables where hundredths are given.

6.4.0 Framing Square Tables

There are three tables on the framing square: the unit length rafter table, located on the face of the blade; the brace table, located on the back of the tongue; and the ***Essex board measure*** table, located on the back of the blade. Before you can use the unit length rafter table, you must be familiar with the different types of rafters and with the methods of framing them. The use of the unit length rafter table is described later in this section. The other two tables are discussed below.

6.4.1 Brace Table

The brace table sets forth a series of equal runs and rises for every three units interval from 24/24 to 60/60, together with the brace length, or length of the hypotenuse, for each given run and rise. The table can be used to determine, by inspection, the length of the hypotenuse of a right triangle with the equal shorter sides of any length given in the table. For example, in the segment of the brace table shown in *Figure 10-80*, you can see that the length of the hypotenuse of a right triangle with two sides 24 units long is 33.94 units; with two sides 27 units long is 38.18 units; two sides 30 units long is 42.43 units; and so on.

By applying simple arithmetic, you can use the brace table to determine the hypotenuse of a right triangle with equal sides of practically any even unit length. Suppose you want to know the length of the hypotenuse of a right triangle with two sides 8 inches long. The brace table shows that a right triangle with two sides 24 inches long has a hypotenuse of 33.94 inches. Since 8 amounts to 24/3, a right triangle with two shorter sides each 8 inches long must have a hypotenuse of 33.94 ÷3, or approximately 11.31 inches.

Suppose you want to find the length of the hypotenuse of a right triangle with two sides 40 inches each. The sides of similar triangles are proportional, and any right triangle with two equal sides is similar to any other right triangle with two equal sides. The brace table shows that a right triangle with the two shorter sides being 30 inches long has a hypotenuse of 42.43 inches. The length of the hypotenuse of a right triangle with the two shorter sides being 40 inches long must be the value of *x* in the proportional equation *30:42.43::40:x,* or about 57.57 inches.

Notice that the last item in the brace table, the one farthest to the right in *Figure 10-80*, gives you the hypotenuse of a right triangle with the other proportions 18:24:30. These proportions are those of the most common type of unequal sided right triangle, with sides in the proportions of 3:4:5.

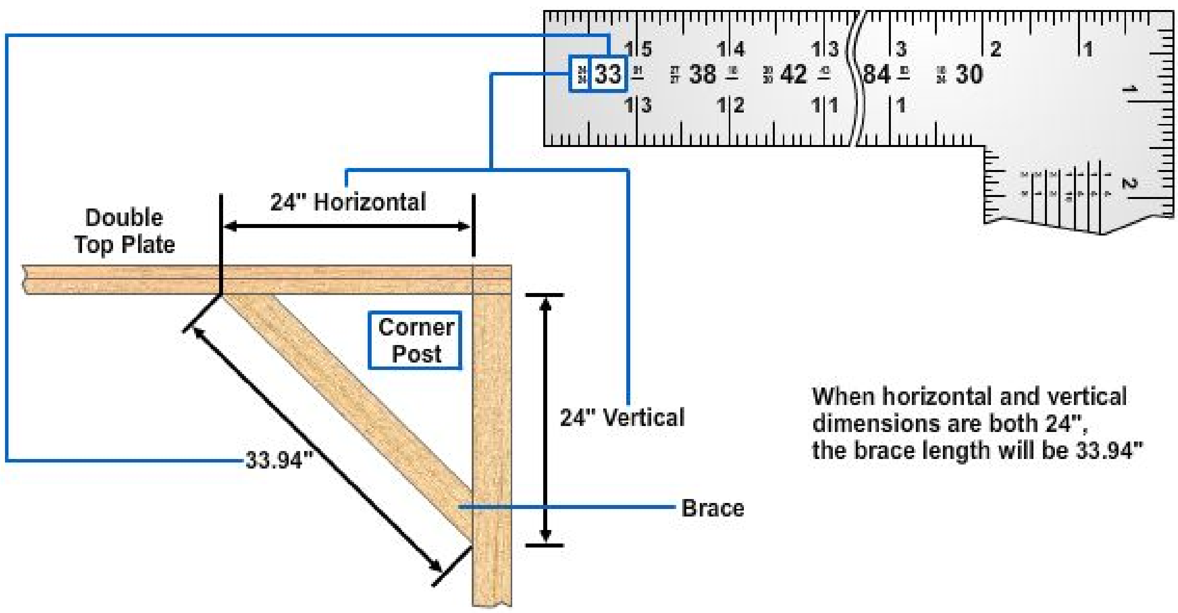


Figure 10-80 – Brace table.

6.4.2 Essex Board

The primary use of the Essex board measure table is for estimating the board feet in lumber of known dimensions. The inch graduations shown in *Figure 10-81, view A* above the table (1, 2, 3, 4, and so on) represent the width in inches of the piece to be measured. The figures under the 12 inch graduation (8, 9, 10, 11, 13, 14, and 15, arranged in columns) represent lengths in feet. The figure 12 itself represents a 12 foot length. The column headed by the figure 12 is the starting point for all calculations.

To use the table, scan down the figure 12 column to the figure that represents the length of the piece of lumber in feet. Then go horizontally to the figure directly below the inch mark that corresponds to the width of the stock in inches. The figure you find will be the number of board feet and twelfths of board feet in a 1 inch thick board.

Let's take an example. Suppose you want to figure the board measure of a piece of lumber 10 feet long by 10 inches wide by 1 inch thick. Scan down the column shown in *Figure10-81, view B* headed by the 12 inch graduation to 10, and then go horizontally to the left to the figure directly below the 10 inch graduation. You will find the figure to be 84, or 8 4/12 board feet. For easier calculating purposes, you can convert 8 4/12 to a decimal, 8.33.

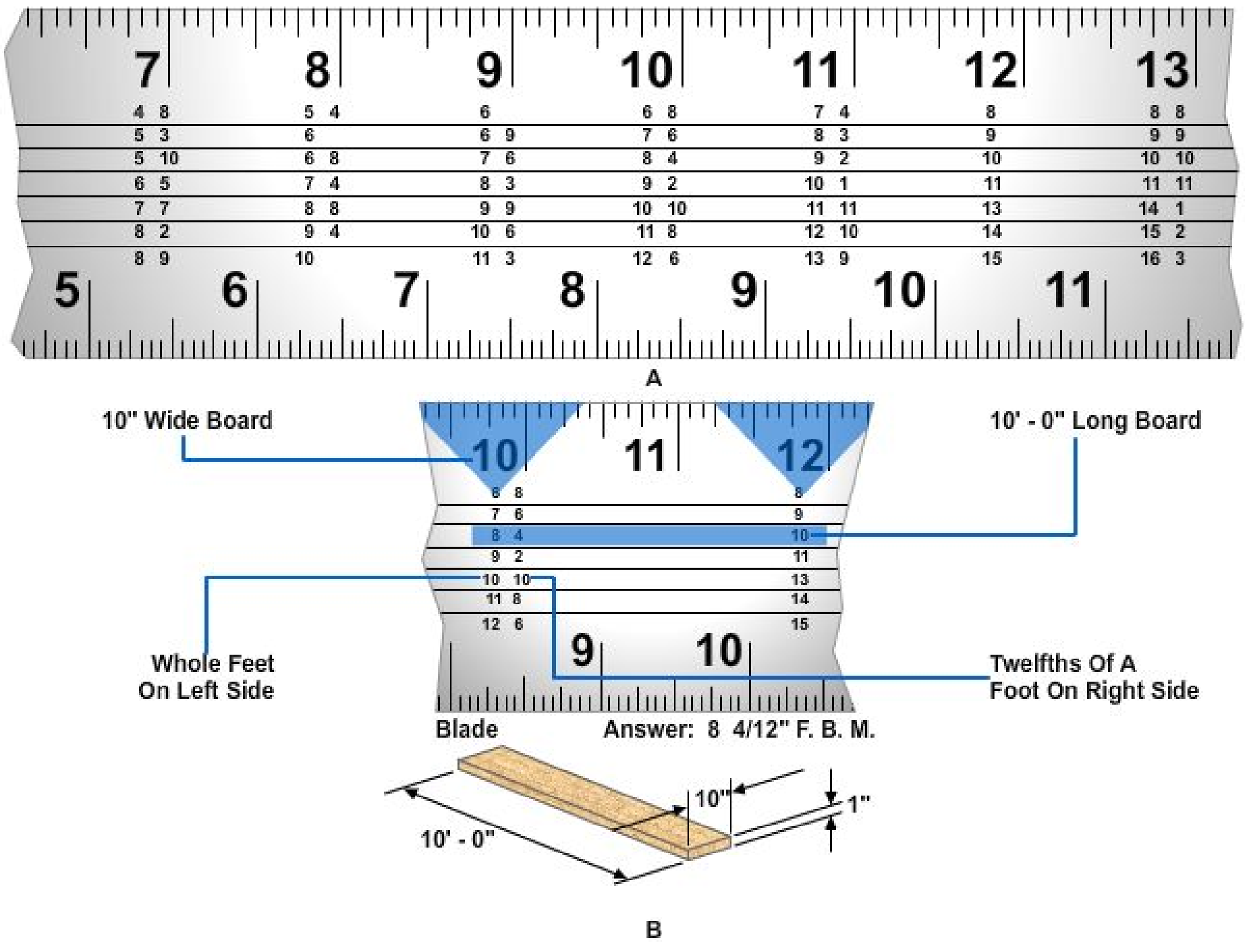


Figure 10-81 – Segment of Essex board measure table.

To calculate the cost of this piece of lumber, multiply the cost per board foot by the total number of board feet. For example, a 1 by 10 costs $1.15 per board foot. Multiply the cost per board foot, $1.15 by the number of board feet, 8.33. This calculation is as follows:

$ 1.15
x 8.33
$ 9.5795 (rounded off to $9.58)

What do you do if the piece is more than 1 inch thick? All you have to do is multiply the result obtained for a 1 inch thick piece by the actual thickness of the piece in inches. For example, if the board described in the preceding paragraph were 5 inches thick instead of 1 inch thick, you would follow the procedure described and then multiply the result by 5.

The board measure scale can be read only for lumber from 8 to 15 feet in length. If your piece is longer than 15 feet, you can proceed in one of two ways. If the length of the piece is evenly divisible by one of the lengths in the table, you can read for that length and multiply the result by the number required to equal the piece you are figuring. Suppose you want to find the number of board feet in a piece 33 feet long by 7 inches wide by 1 inch thick. Since 33 is evenly divisible by 11, scan down the 12 inch column to 11 and then go left to the 7 inch column. The figure given there, which is 65/12, or 7.42 board feet, is one third of the total board feet. The total number of board feet is 6 5/12 (7.42) x 3, or 19 3/12 (19.26) board feet.

If the length of the piece is not evenly divisible by one of the tabulated lengths, you can divide it into two tabulated lengths, read the table for these two, and add the results together. For example, suppose you want to find the board measure of a piece 25 feet long by 10 inches wide by 1 inch thick. This length can be divided into 10 feet and 15 feet. The table shows that the 10 foot length contains 8 4/12 (8.33) board feet and the 15 foot length contains 12 6/12 (12.5) board feet. The total length then contains 8 4/12 (8.33) plus 12 6/12 (12.5), or 20 10/12 (20.83) board feet.

Test your Knowledge (Select the Correct Response)

11. When the blade of a framing square is 24 inches long, the tongue usually varies within which of the following overall lengths?

    A. 12 to 16 inches
    B. 16 to 24 inches
    C. 14 to 18 inches
    D. 18 to 24 inches

7.0.0 LAYING OUT AND INSTALLING ROOFS

The four most common roof designs you will encounter as a Builder are gable, hip, gable and valley, and shed. You will learn various calculations, layouts, cutting procedures, and assembly requirements required for efficient construction.

7.1.0 Gable

Next to the shed roof, which has only one slope, the gable roof is the simplest type of sloping roof to build because it slopes in only two directions. The basic structural members of the gable roof are the ridgeboard, common rafters, and gable end studs, as shown in *Figure 10-82*.

The ridgeboard is at the peak of the roof. It provides a nailing surface for the top ends of the common rafters. The common rafters extend from the top wall plates to the ridge. The gable end studs are upright framing members that provide a nailing surface for siding and sheathing at the gable ends of the roof.

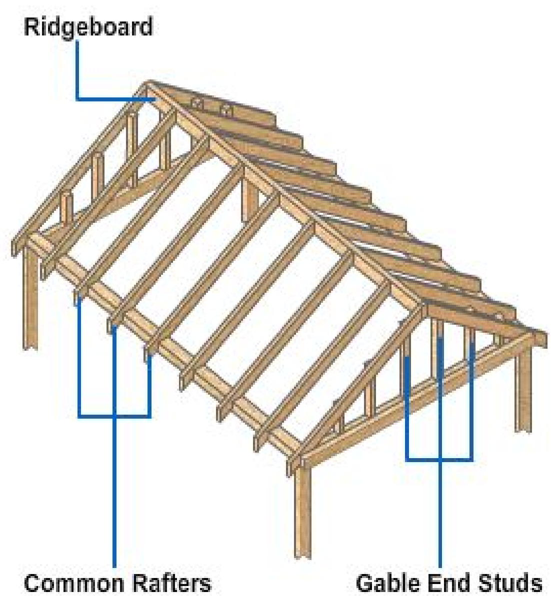


Figure 10-82 – Gable roof framework.

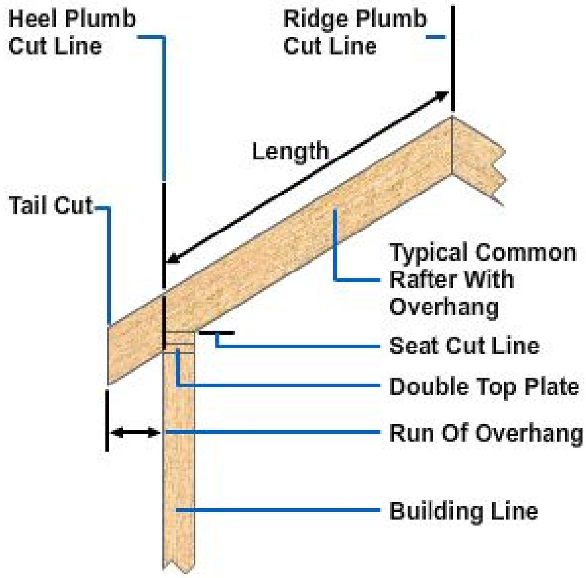


Figure 10-83 – Typical common rafter with an overhang.

7.1.1 Common Rafters

All common rafters for a gable roof are the same length. They can be precut before the roof is assembled. Today, most common rafters include an overhang. The overhang, as shown in *Figure 10-83*, is the part of the rafter that extends past the building line. The run of the overhang, called the projection, is the horizontal distance from the building line to the tail cut on the rafter. In *Figure 10-83*, note the plumb cuts at the ridge, heel, and tail of the rafter. A level seat cut is placed where the rafter rests on the top plate.

The notch formed by the seat and heel cut line shown in *Figure 10-84* is often called the ***bird's-mouth***.

The width of the seat cut is determined by the slope of the roof: the lower the slope, the wider the cut. At least 2 inches of stock should remain above the seat cut. The procedure for marking these cuts is explained later in this chapter. Layout is usually done after the length of the rafter is calculated.

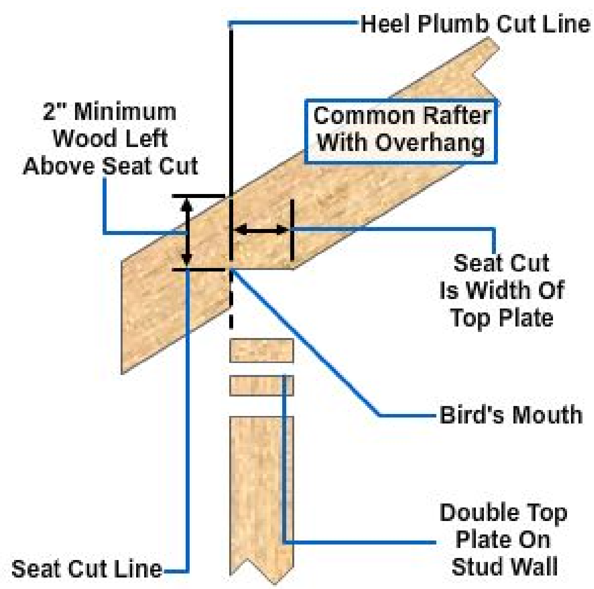


Figure 10-84 – Bird's-mouth formed by the heel plumb line and seat line.

Calculating Lengths of Common Rafters – The length of a common rafter is based on the unit of rise and total run of the roof. The unit of rise and total run are obtained from the blueprints. There are three different procedures to calculate common rafter length: using a framing square printed with a rafter table, using a book of rafter tables, or using the step-off method where rafter layout is combined with calculating length.

Framing squares are available with a rafter table printed on the face side as shown in *Figure 10-85*.

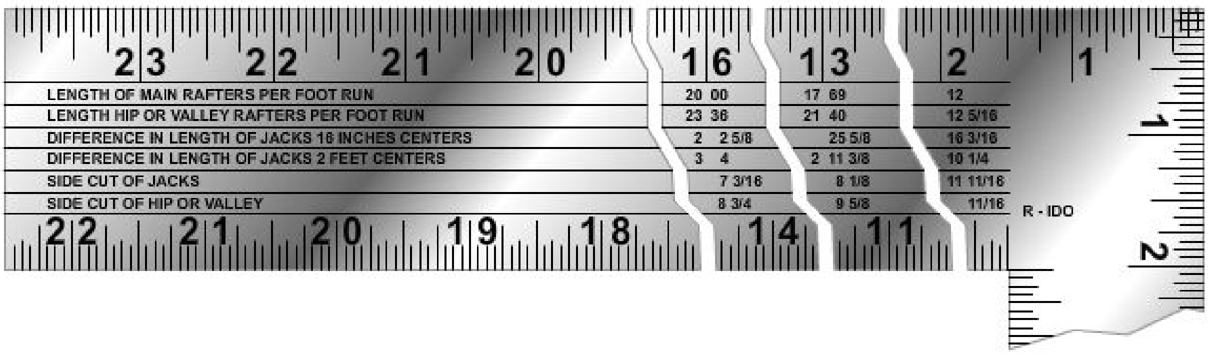


Figure 10-85 – Rafter table on face of a steel square.

The rafter table makes it possible to find the lengths of all types of rafters for pitched roofs, with unit of rises ranging from 2 inches to 18 inches. Let's look at two examples:

Example 1. The roof has a 7 inch unit of rise and a 16 foot span.

Look at the first line of the rafter table on a framing square to find LENGTH COMMON RAFTERS PER FOOT RUN, also known as the bridge measure. Since the roof in this example has a 7 inch unit of rise, locate the number 7 at the top of the square. Directly beneath the number 7 is the number 13.89. This means that a common rafter with a 7 inch unit of rise will be 13.89 inches long for every unit of run. To find the length of the rafter, multiply 13.89 inches by the number of feet in the total run. The total run is always one half the span. The total run for a roof with a 16 foot span is 8 feet; so multiply 13.89 inches by 8 to find the rafter length. *Figure 10-86* is a schematic of this procedure.

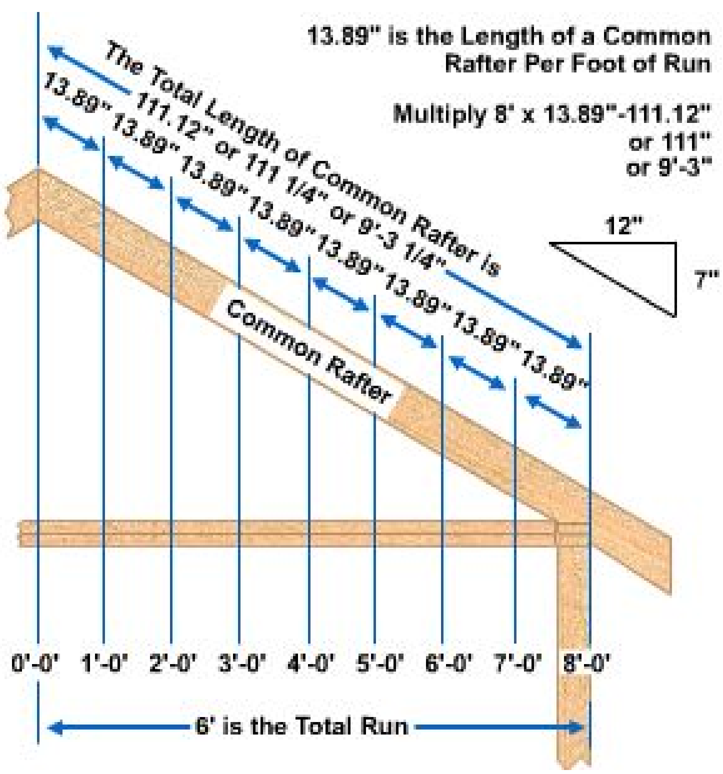


Figure 10-86 – Rafter length.

If a framing square is not available, you can find the bridge measure with the Pythagorean Theorem using the same cut of 7/12:

$$7^2 + 12^2 = 193^2$$

The square root of 193 is 13.89.

Two steps remain to complete the procedure.

1. Multiply the number of feet in the total run (8) by the length of the common rafter per foot of run (13.89 inches):

    13.89 inches
    x 8
    111.12 inches

2. To change .12 of an inch to a fraction of an inch, multiply by 16:

    .12
    x 16
    1.92

The number 1 to the left of the decimal point represents 1/16 inch. The number .92 to the right of the decimal represents ninety-two hundredths of 1/16 inch. For practical purposes, 1.92 is calculated as being equal to 2 x 1/16 inch, or 1/8 inch. As a general rule in this kind of calculation, if the number to the right of the decimal is 5 or more, add 1/16 inch to the figure on the left side of the decimal. The result of steps 1 and 2 is a total common rafter length of 111 1/8 inches, or 9 feet 3 1/8 inches.

Example 2. A roof has a 6 inch unit of rise and a 25 foot span. The total run of the roof is 12 feet 6 inches. You can find the rafter length in four steps:

1. Change 6 inches to a fraction of a foot by placing the number 6 over the number 12:

    $$\frac{6}{12} = \frac{1}{2}$$

    1/2 foot = 6 inches.

2. Change the fraction to a decimal by dividing the bottom number (denominator) into the top number (numerator):

    $$\frac{1}{2} = .5$$

    .5 foot = 6 inches.

3. Multiply the total run (12.5) by the length of the common rafter per foot of run (13.42 inches as shown in *Figure 10-85)*:

    12.5
    x 13.42
    167.75 inches

4. To change .75 inch to a fraction of an inch, multiply by 16 for an answer expressed in sixteenths of an inch.

    .75 x 16 = 12

    12 = $\frac{12}{16}$ inch, or $\frac{3}{4}$ inch

The result of these steps is a total common rafter length of 167 3/4 inches, or 13 feet 11 3/4 inches.

Shortening – Rafter length found by any of the methods discussed here is the measurement from the heel plumb line to the center of the ridge. This is known as the theoretical length of the rafter. Since a ridgeboard, usually 1 1/2 inches thick, is placed between the rafters, you must deduct one half of the ridgeboard (3/4 inch from each rafter. This calculation is known as shortening the rafter. Do this at the time the rafters are laid out. The actual length, as opposed to the theoretical length, of a rafter is the distance from the heel plumb line to the shortened ridge plumb line, as shown in *Figure 10-87*.

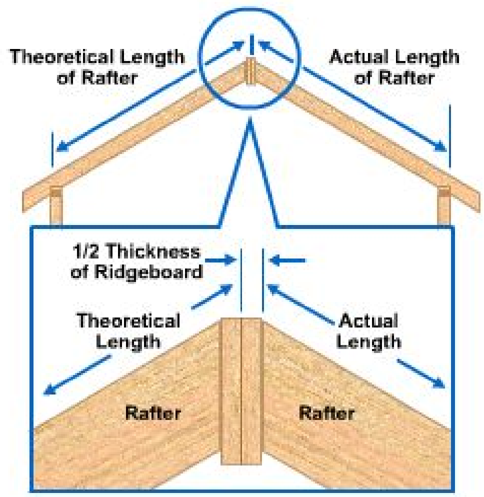


Figure 10-87 – The actual (versus theoretical) length of a common rafter.

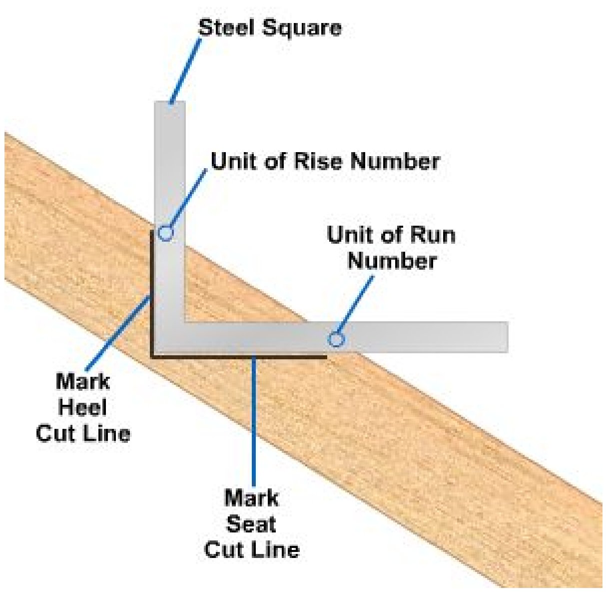


Figure 10-88 – Steel square used to lay out plumb and seat cuts.

Laying Out – Before you can cut the rafters, you must mark the angles of the cuts. Layout consists of marking the plumb cuts at the ridge, heel, and tail of the rafter, and the seat cut where the rafter will rest on the wall. Lay out the angles are laid out with a framing square as shown in *Figure 10-88*. A pair of square gauges is useful in the procedure. Secure one square gauge to the tongue of the square next to the number that is the same as the unit of rise. Secure the other gauge to the blade of the square next to the number that is the same as the unit of run (always 12 inches). After placing the square on the rafter stock, mark the plumb cut along the tongue (unit of rise) side of the square. Mark the seat cut along the blade (unit of run) side of the square.

Rafter layout also includes marking off the required overhang, or tail line length, and making the shortening calculation explained earlier. Overhang, or tail line length, is rarely given, and you must calculate it before laying out rafters. Projection, the horizontal distance from the building line to the rafter tail, must be located from drawings or specifications. To determine tail line length, use the following formula:

bridge measure (inches) times projection (feet) equals tail line length (inches)

Determine the bridge measure by using the rafter table on the framing square or calculate it by using the Pythagorean Theorem. Using *Figure 10-89* as a guide, you can see there are four basic steps remaining:

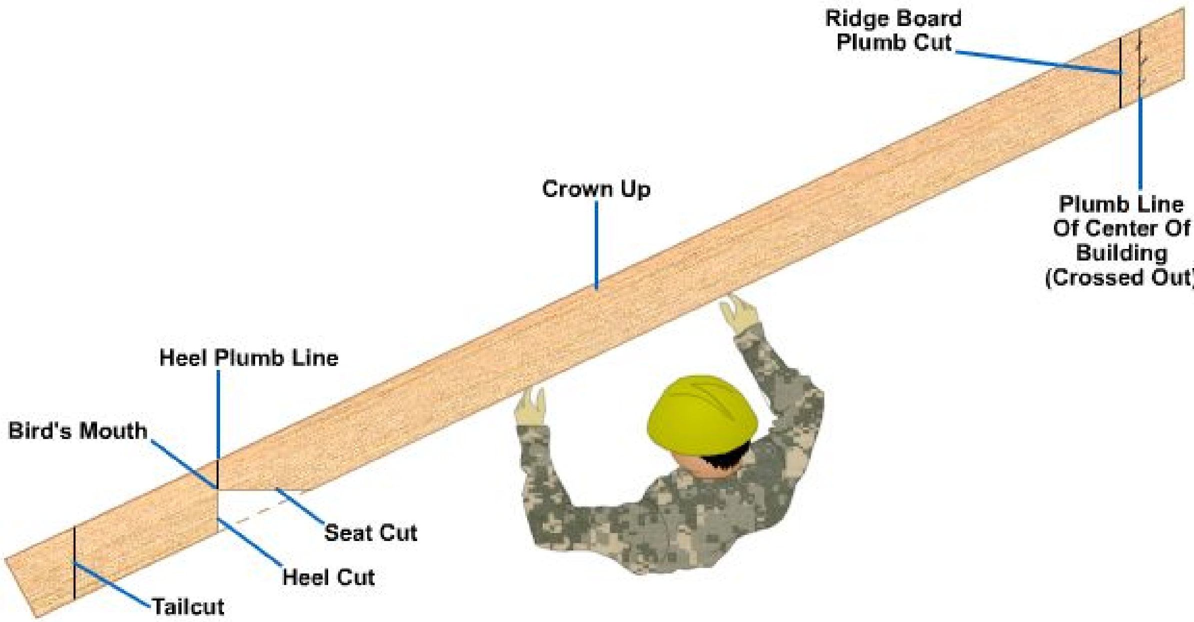


Figure 10-89 – Laying out a common rafter for a gable roof.

1. Lay out the rafter line length. Hold the framing square with the tongue in your right hand, the blade in your left, and the heel away from your body. Place the square as near the right end of the rafter as possible with the unit of rise on the tongue and the unit of run on the blade along the edge of the rafter stock. Strike a plumb mark along the tongue on the wide part of the material. This mark represents the center line of the roof. From either end of this mark, measure the line length of the rafter and mark the edge of the rafter stock. Hold the framing square in the same manner with the 6 on the tongue on the mark just made and the 12 on the blade along the edge. Strike a line along the tongue. This mark represents the plumb cut of the heel.
2. Lay out the bird's-mouth. Measure 1 1/2 inches along the heel plumb line up from the bottom of the rafter. Set the blade of the square along the plumb line with the heel at the mark just made and strike a line along the tongue. This line represents the seat of the bird's-mouth.
3. Lay out the tail line length. Measure the tail line length from the bird's-mouth heel plumb line. Strike a plumb line at this point in the same manner as the heel plumb line of the common rafter.
4. Lay out the plumb cut at the ridgeboard. Measure and mark the point along the line length half the thickness of the ridgeboard. This is the ridgeboard shortening allowance. Strike a plumb line at this point. This line represents the plumb cut of the ridgeboard.

7.1.2 Step-Off Calculations and Layout

The step-off method for rafter layout is old but still practiced. It combines procedures for laying out the rafters with a procedure of stepping off the length of the rafter as shown in *Figure 10-90.* In this example, the roof has an 8 inch unit of rise, a total run of 5 feet 9 inches, and a 10 inch projection.

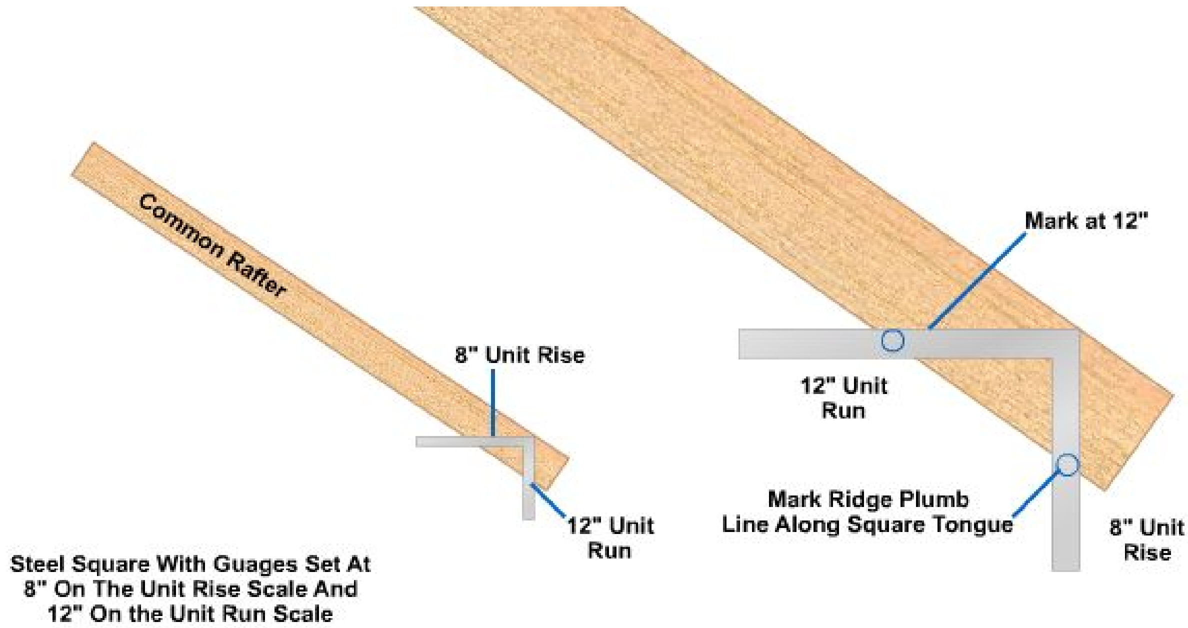


Figure 10-90 – Step-off method for calculating common rafter length.

1. Set gauges at 8 inches on the tongue and 12 inches on the blade. With the tongue in the right hand, the blade in the left hand, and the heel away from the body, place the square on the right end of the rafter stock. Mark the ridge plumb line along the tongue. Put a pencil line at the 12 inch point of the blade.
2. With the gauges pressed lightly against the rafter, slide the square to the left. Line the tongue up with the last 12 inch mark and make a second 12 inch mark along the bottom of the blade.
3. To add the 9 inch remainder of the total run, place the tongue on the last 12 inch mark. Draw another mark at 9 inches on the blade. This will be the total length of the rafter.
4. Lay out and cut the plumb cut line and the seatcut line.

7.1.3 Roof Assembly

The major part of gable roof construction is setting the common rafters in place. The most efficient method is to precut all common rafters, then fasten them to the ridgeboard and the wall plates in one continuous operation.

The rafter locations should be marked on the top wall plates when the positions of the ceiling joists are laid out. Proper roof layout ensures the rafters and joists tie into each other wherever possible.

The ridgeboard, like the common rafters, should be precut. The rafter locations are then copied on the ridgeboard from the markings on the wall plates as shown in *Figure 10-91*. The ridgeboard should be the length of the building plus the overhang at the gable ends.

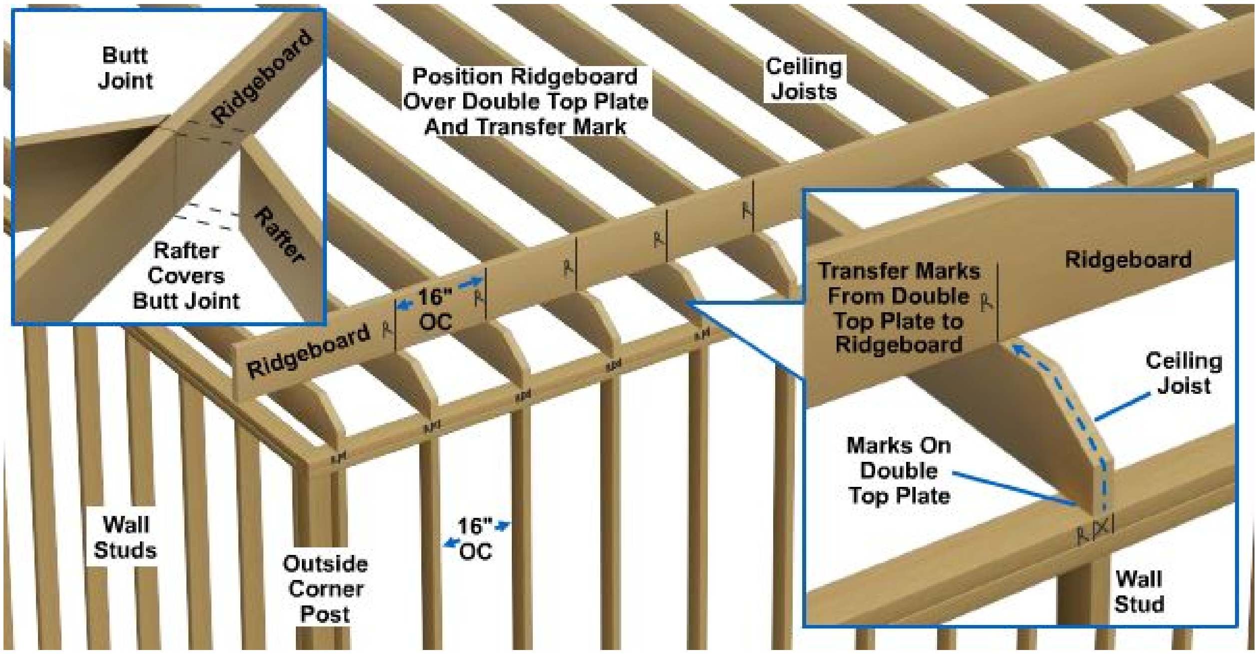


Figure 10-91 – Ridgeboard layout.

The material used for the ridgeboard is usually wider than the rafter stock. For example, a ridgeboard of 2 by 8 inch stock would be used with rafters of 2 by 6 inch stock. Some buildings are long enough to require more than one piece of ridge material. The breaks between these ridge pieces should occur at the center of a rafter.

One pair of rafters should be cut and checked for accuracy before the other rafters are cut. To check the first pair for accuracy, set them in position with a 1 1/2 inch piece of wood fitted between them. If the rafters are the correct length, they should fit the building. If the building walls are out of line, you will have to make adjustments on the rafters.

After checking the first pair of rafters for accuracy, and adjusting it if necessary, use one of the pair as a pattern for marking all the other rafters. Cutting is usually done with a circular or radial arm saw.

Collar Tie – Gable or double pitch roof rafters are often reinforced by horizontal members called collar ties, as shown in *Figure 10-92*. In a finished attic, the ties may also function as ceiling joists.

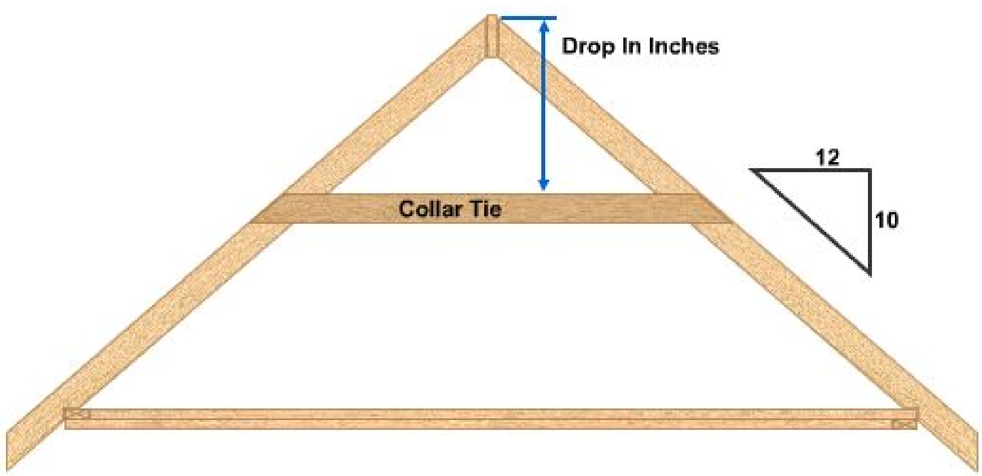


Figure 10-92 – Calculation for a collar tie.

To find the line length of a collar tie, divide the amount of drop of the tie in inches by the unit of rise of the common rafter. This will equal one half the length of the tie in feet. Double the result to get the actual length. The formula is as follows:

drop (inches) times 2 divided by unit or rise equals the length (feet)

The length of the collar tie depends on whether the drop is measured to the top or bottom edge of the collar tie shown in *Figure 10-92*. The tie must fit the slope of the roof. To obtain this angle, use the framing square. Hold the unit of run and the unit of rise of the common rafter. Mark and cut on the unit of run side as shown in *Figure 10-93*.

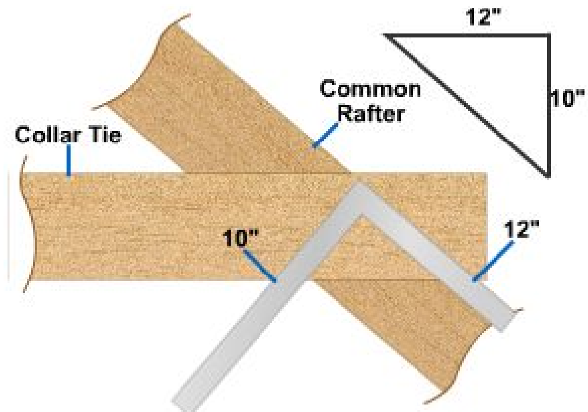


Figure 10-93 – Laying out end cut on a collar tie.

Methods of Ridge Board Assembly – Several different methods exist for setting up the ridgeboard and attaching the rafters to it.

When only a few Builders are present, the most convenient procedure is to set the ridgeboard to its required height (total rise) and hold it in place with temporary vertical props as shown in *Figure 10-94*. The builders can then nail the rafters to the ridgeboard and the top wall plates.

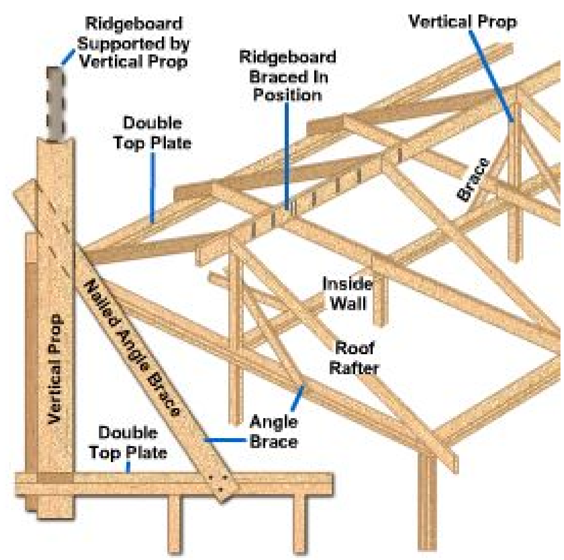


Figure 10-94 – Setting up and bracing a ridgeboard when only a few workers are available.

Lay plywood panels on top of the ceiling joists where the framing will take place. The panels provide safe and comfortable footing and a place to put tools and materials.

You can lay out and cut common rafter overhang before setting the rafters in place. Many Builders prefer to cut the overhang after the rafters are fastened to the ridgeboard and wall plates. Snap a line from one end of the building to the other, and mark the tail plumb line with a sliding

T-bevel, also called a bevel square. These procedures are shown in *Figure 10-95*. Then cut the rafters with a circular saw.This method guarantees that the line of the overhang will be perfectly straight, even if the building is not.

Over each gable end of the building, you can frame another overhang. The main framing members of the gable end overhang are the fascia, also referred to as fly or barge rafters. They are tied to the ridgeboard at the upper end and to the fascia board at the lower end. Fascia boards are often nailed to the tail ends of the common rafters to serve as a finish piece at the edge of the roof. By extending past the gable ends of the house, common rafters also help to support the basic rafters.

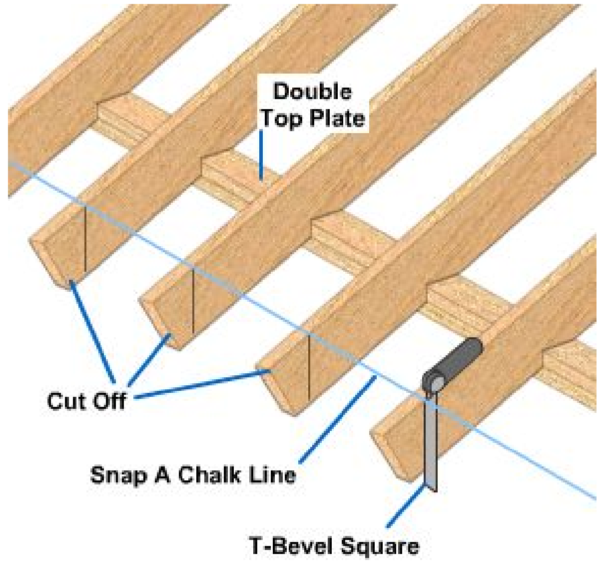


Figure 10-95 – Snapping a line and marking plumb cuts for a gable end overhang.

Figures 10-96 and *10-97* show different methods used to frame the gable end overhang. In *Figure 10-96*, a fascia rafter is nailed to the ridgeboard and to the fascia board. Blocking, which is not shown in the figures, rests on the end wall and is nailed between the fascia rafter and the rafter next to it. This section of the roof is further strengthened when the roof sheathing is nailed to it.

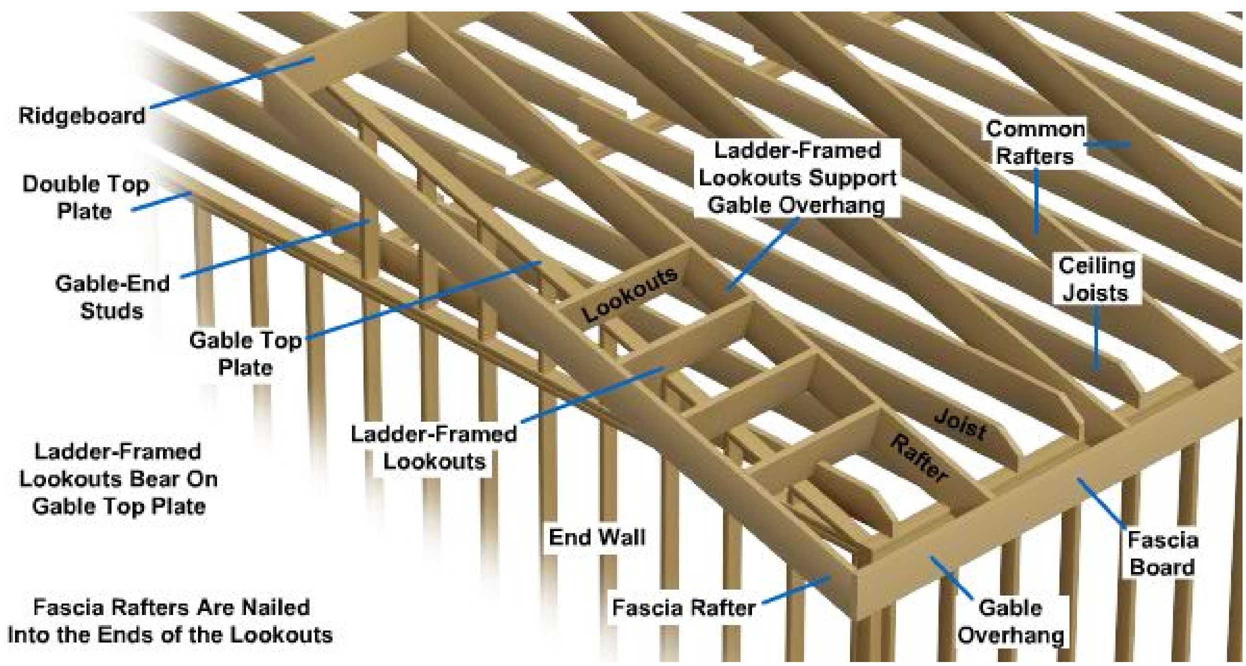


Figure 10-96 – Gable end overhang with the end wall framed under the overhang.

In *Figure 10-97*, two common rafters are placed directly over the gable ends of the building. The fascia rafters (fly rafters) are placed between the ridgeboard and the fascia boards. The gable studs should be cut to fit against the rafter above.

7.1.4 End Framing

Gable end studs rest on the top plate and extend to the rafter line in the ends of a gable roof. Place them with the edge of the stud even with the outside wall and the top notched to fit the rafter as shown in *Figure 10-97*, or install them flatwise with a cut on the top of the stud to fit the slope of the rafter.

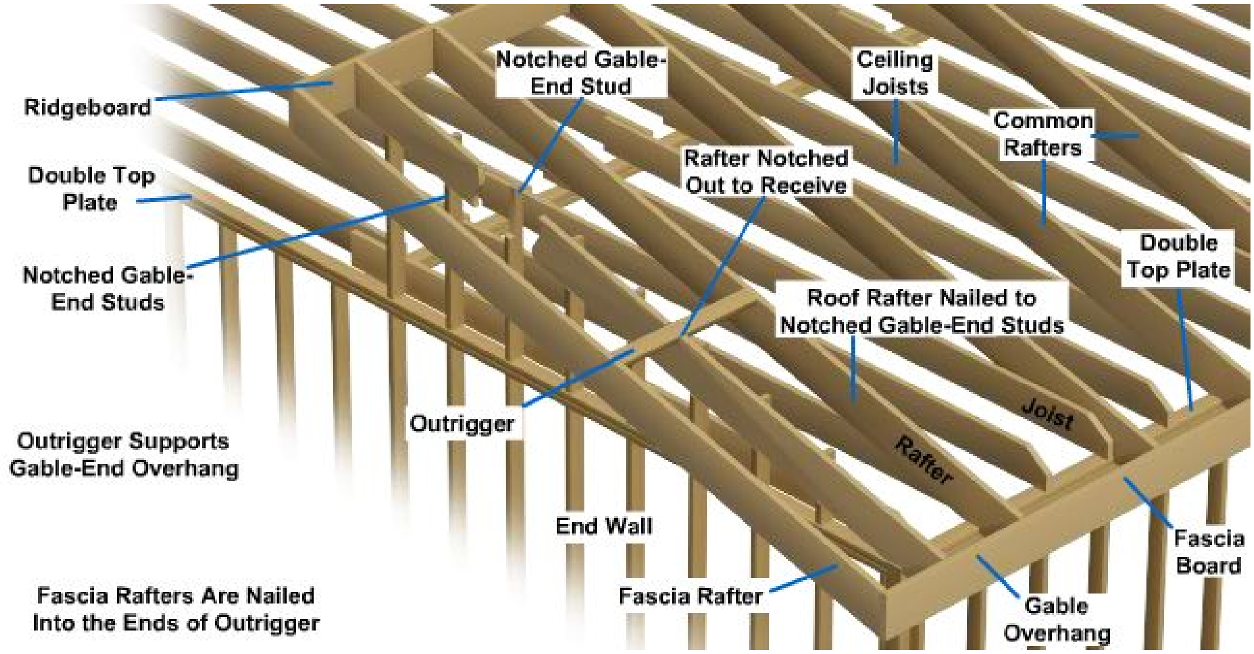


Figure 10-97 – Gable end overhang with end wall framed directly beneath rafters.

Locate the position of the gable end stud by squaring a line across the plate directly below the center of the gable. If a window or vent will be installed in the gable, measure one half of the opening size on each side of the center line and make a mark for the first stud. Start at this mark and lay out the stud spacing (16 or 24 inches OC) to the outside of the building. Plumb the gable end stud on the first mark and mark it where it contacts the bottom of the rafter, as shown in *Figure 10-98, view A*.

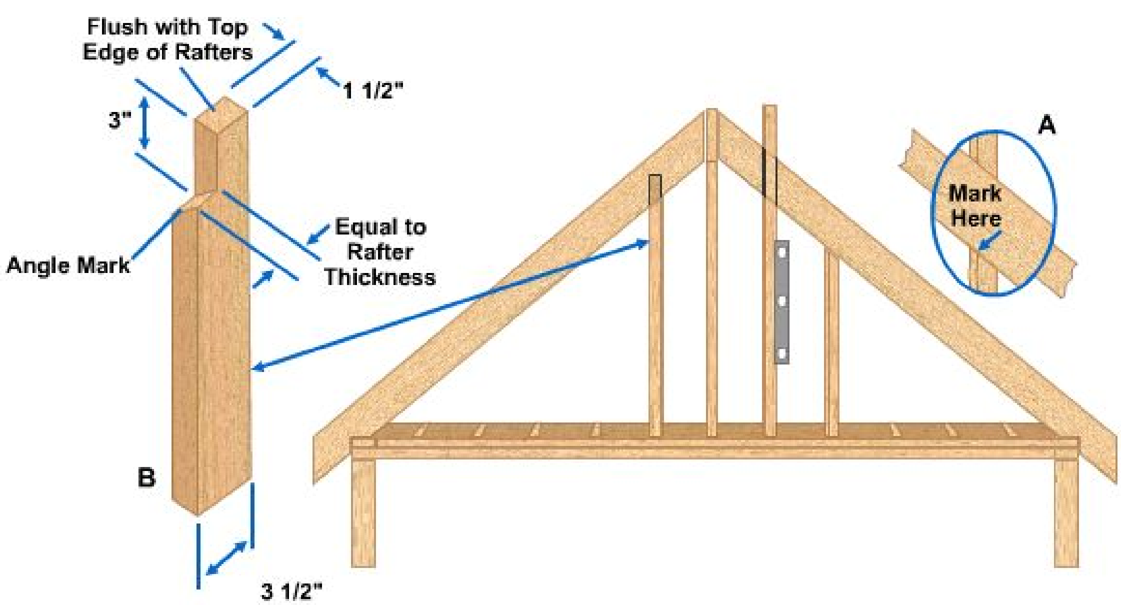


Figure 10-98 – Calculating common difference of gable end studs.

Measure and mark 3 inches above this mark and notch the stud to the depth equal to the thickness of the rafter, as shown in *view B*. The lengths of the other gable studs depend on the spacing.

The common difference in the length of gable studs is figured by the following formula:

$$\frac{\text{24 inches (OC spacing)}}{\text{12 inches (unit of run)}} = \text{2 and 2 x 6 inches (unit of rise) or 12 inches (common difference).}$$

The common difference in the length of the gable studs may also be laid out directly with the framing square as shown in *Figure 10-99*. Place the framing square on the stud to the cut of the roof (6 and 12 inches for this example). Draw a line along the blade at A. Slide the square along this line in the direction of the arrow at B until the desired spacing between the studs (16 inches for this example) is at the intersection of the line drawn at A and the edge of the stud. Read the dimension on the tongue aligned with the same edge of the stud (indicated by C). This is the common difference (8 inches for this example) between the gable studs.

Toenail the studs to the plate with two 8d nails in each side. As you nail the studs in place, take care not to force a crown into the top of the rafter.

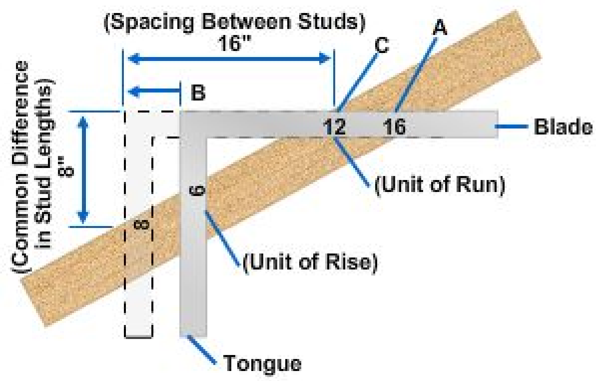


Figure 10-99 – Calculating common difference with framing square.

7.2.0 Hip

Most hip roofs are equal pitch. This means the angle of slope on the roof end or ends is the same as the angle of slope on the sides. Unequal pitch hip roofs do exist, but they are quite rare. They also require special layout methods. The unit length rafter table on the framing square applies only to equal pitch hip roofs. The next paragraphs discuss an equal pitch hip roof.

The length of a hip rafter, like the length of a common rafter, is calculated on the basis of bridge measure multiplied by the total run (half span). You may use any of the methods previously described for a common rafter, although some of the dimensions for a hip rafter are different.

Figure 10-100 shows part of a roof framing diagram for an equal pitch hip roof. A roof framing diagram may be included among the working drawings; if not, you should lay one out for yourself. Determine what scale will be used, and lay out all framing members to scale. Lay the building lines out first. You can find the span and the length of the building on the working drawings. Then draw a horizontal line along the center of the span.

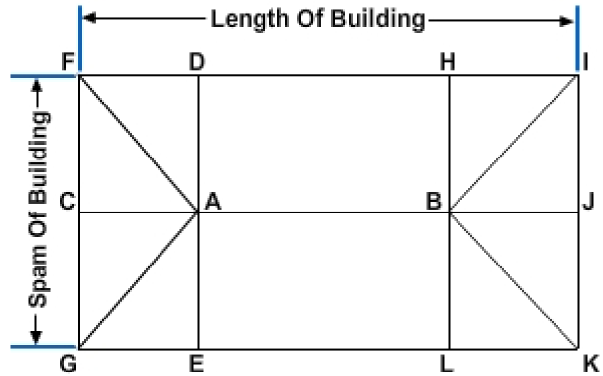


Figure 10-100 – Equal pitch hip roof framing diagram.

In an equal pitch hip roof framing diagram, the lines indicating the hip rafters (AF, AG, BI, and BK in *Figure10-100* form 45° angles with the building lines. Draw these lines at 45°, as shown. The points where they meet the center line are the theoretical ends of the ridge piece. The ridge end common rafters AC, AD, AE, BH, BJ, and BL join the ridge at the same points.

A line indicating a rafter in the roof framing diagram is equal in length to the total run of the rafter it represents. You can see from the diagram that the total run of a hip rafter (represented by lines AF-AG-BI-BK) is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter. You know the total run of a common rafter: It is one half the span, or one half the width of the building. Knowing this, you can find the total run of a hip rafter by applying the Pythagorean Theorem.

Suppose that the span of the building is 30 feet. One half the span, which is the same as the total run of a common rafter, is 15 feet. Applying the Pythagorean Theorem, the total run of a hip rafter is:

$$\sqrt{15^2 + 15^2} = 21.21 \text{ feet}$$

What is the total rise? Since a hip rafter joins the ridge at the same height as a common rafter, the total rise for a hip rafter is the same as the total rise for a common rafter. You know how to figure the total rise of a common rafter. Assume that this roof has a unit of run of 12 and a unit of rise of 8. Since the total run of a common rafter in the roof is 15 feet, the total rise of a common rafter is the value of *x* in the proportional equation *12:8::15:x,* or 10 feet.

Knowing the total run of the hip rafter (21.21 feet) and the total rise (10 feet), you can figure the line length by applying the Pythagorean Theorem. The line length is:

$$\sqrt{21.21^2 + 10^2} = 23.45 \text{ feet or about 23 feet 5 3/8 inches}$$

To find the length of a hip rafter on the basis of a bridge measure, you must first determine the bridge measure. As with a common rafter, the bridge measure of a hip rafter is the length of the hypotenuse of a triangle with its altitude and base equal to the unit of run and unit of rise of the rafter. The unit of rise of a hip rafter is always the same as that of a common rafter, but the unit of run of a hip rafter is a fixed unit of measure, always 17.97.

The unit of run of a hip rafter in an equal pitch roof is the hypotenuse of a right triangle with its altitude and base equal to the unit of run of a common rafter, 12. Therefore, the unit of run of a hip rafter is:

$$\sqrt{12^2 + 12^2} = 16.97$$

If the unit of run of a hip rafter is 17.97 and the unit of rise in this particular case is 8, the bridge measure of the hip rafter must be:

$$\sqrt{16.97^2 + 8^2} = 18.76$$

This means that for every unit of run (17.97) the rafter has a line length of 18.76 inches. Since the total run of the rafter is 21.21 feet, the length of the rafter must be the value of x in the proportional equation *17.97:18.76::21.21:x,* or 23.45 feet.

Like the unit length of a common rafter, the bridge measure of a hip rafter can be obtained from the unit length rafter table on the framing square. If you turn back to *Figure 10-85*, you will see that the second line in the table is headed LENGTH HIP OR VALLEY PER FT RUN. This means "per foot run of a common rafter in the same roof." The unit length given in the tables is the unit length for every 17.97 units of run of the hip rafter itself. If you go across to the unit length given under 8, you will find the same figure, 18.76 units, that you calculated above.

An easy way to calculate the length of an equal pitch hip roof is to multiply the bridge measure by the number of feet in the total run of a common rafter, which is the same as the number of feet in one half of the building span. One half of the building span in this case is 15 feet. The length of the hip rafter is calculated as

8.76 x 15 = 281.40 inches, 23.45 feet once converted.

You step off the length of an equal pitch hip roof just as you do the length of a common rafter, except that you set the square to a unit of run of 17.97 inches instead of to a unit of run of 12 inches. Since 17.97 inches is the same as 16 and 15.52 sixteenths of an inch, setting the square to a unit of run of 17 inches is close enough for most practical purposes. Bear in mind that for any plumb cut line on an equal pitch hip roof rafter, you set the square to the unit of rise of a common rafter and to a unit of run of 17.

You step off the same number of times as there are feet in the total run of a common rafter in the same roof; only the size of each step is different. For every 12 inch step in a common rafter, a hip rafter has a 17 inch step. For the roof on which you are working, the total run of common rafter is exactly 15 feet; this means that you would step off the hip rafter cut (17 inches and 8 inches) exactly 15 times.

Suppose that there was an odd unit in the common rafter total run. Assume that the total run of a common rafter is 15 feet 10 1/2 inches. How would you make the odd fraction of a step on the hip rafter?

Remember that the unit of run of a hip rafter is the hypotenuse of a right triangle with the other sides each equal to the unit of run of a common rafter. In this case, the run of the odd unit on the hip rafter must be the hypotenuse of a right triangle with the altitude and base equal to the odd unit of run of the common rafter (10 1/2 inches). You can figure this using the Pythagorean Theorem:

$$\sqrt{10.5^2 + 10.5^2}$$

or you can set the square on a true edge to 10 1/2 inches on the blade and measure the distance between the marks. It comes to 14.84 inches. Rounded off to the nearest 1/16 inch, this equals 14 13/16 inches.

To lay off the odd unit, set the tongue of the framing square to the plumb line for the last full step made and measure off 14 13/16 inches along the blade. Place the tongue of the square at the mark, set the square to the hip rafter plumb cut of 8 inches on the tongue and 17 inches on the blade, and draw the line length cut.

7.2.1 Rafter Shortening Allowance

As is the case with a common rafter, the line length of a hip rafter does not take into account the thickness of the ridge piece. The size of the ridge end shortening allowance for a hip rafter depends upon the way the ridge end of the hip rafter is joined to the other structural members. As shown in Figure *10-101*, the ridge end of the hip rafter can be framed against the ridgeboard (*view A*) or against the ridge end common rafters (*view B*). To calculate the actual length, deduct one half the 45° thickness of the ridge piece that fits between the rafters from the theoretical length.

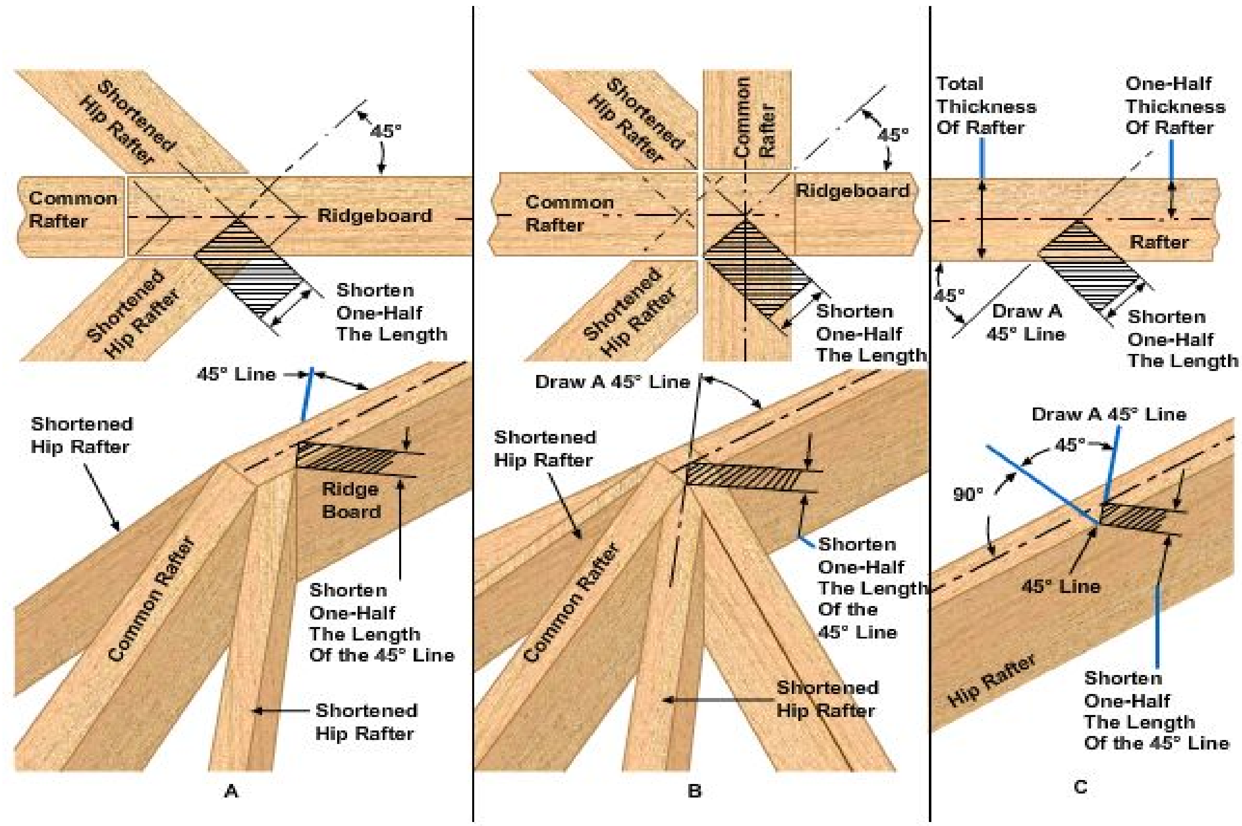


Figure 10-101 – Shortening a hip rafter.

When no common rafters are placed at the ends of the ridgeboard, the hip rafters are placed directly against the ridgeboard. They must be shortened one half the length of the 45° line (one half the thickness of the ridgeboard). When common rafters are placed at the ends of the ridgeboard as shown in *Figure 10-101, view B*, the hip rafter will fit between the common rafters. The hip rafter must be shortened one half the length of the 45° line (one half the thickness of the common rafter.)

If the hip rafter is framed against the ridge piece, the shortening allowance is one half of the 45° thickness of the ridge piece, as shown in *Figure 10-101, view C*. The 45° thickness of stock is the length of a line laid at 45° across the thickness dimension of the stock. If the hip rafter is framed against the common rafter, the shortening allowance is one half of the 45° thickness of a common rafter.

To lay off the shortening allowance, first set the tongue of the framing square to the line length ridge cut line. Then measure off the shortening allowance along the blade, set the square at the mark to the cut of the rafter (8 inches and 17 inches), and then draw the actual ridge plumb cut line. To find the 45° thickness of a piece of lumber, draw a 45º line across the edge, measure the length of the line, and then divide by 2.

7.2.2 Rafter Projection

A hip or valley rafter overhang, like a common rafter overhang, is figured as a separate rafter. The projection, however, is not the same as the projection of a common rafter overhang in the same roof. The projection of the hip or valley rafter overhang is the hypotenuse of a right triangle whose shorter sides are each equal to the run of a common rafter overhang, as shown in *Figure 10-102*. If the run of the common rafter overhang is 18 inches for a roof with an 8 inch unit of rise, figure the length of the hip or valley rafter tail as follows:

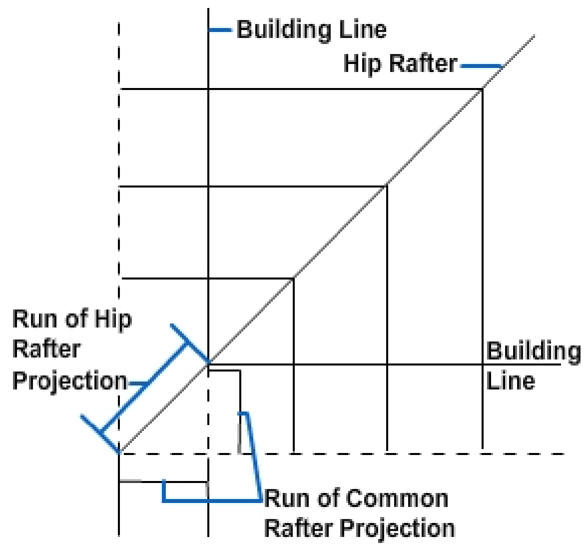


Figure 10-102 – Run of hip rafter projection.

1. Multiply the bridge measure in inches of the hip or valley rafter by the projection in feet of the common rafter overhang:

   18.76 inches (bridge measure)
   x 1.5 feet (projection of the common rafter)
   28.14
   or 28 1/8 inches

2. Add this product to the theoretical rafter length.

You may also step off the overhang as described earlier for a common rafter. When stepping off the length of the overhang, set the 17 inch mark on the blade of the square even with the edge of the rafter. Set the unit of rise, whatever it might be, on the tongue even with the same rafter edge.

7.2.3 Rafter Side Cuts

Since a common rafter runs at 90° to the ridge, the ridge end of a common rafter is cut square, or at 90° to the lengthwise line of the rafter. A hip rafter, however, joins the ridge, or the ridge ends of the common rafter, at other than a 90° angle, and the ridge end of a hip rafter must therefore be cut to a corresponding angle, called a side cut. The angle of the side cut is more acute for a high rise than for a low one.

The angle of the side cut is laid out as shown in *Figure 10-103*. Place the tongue of the framing square along the ridge cut line, as shown, and measure off one half the thickness of the hip rafter along the blade. Shift the tongue to the mark, set the square to the cut of the rafter (17 inches and 8 inches), and draw the plumb line marked "A" in the figure. Then turn the rafter edge up, draw an edge centerline, and draw in the angle of the side cut, as indicated in the lower view of *Figure 10-103*. For a hip rafter to be framed against the ridge, you will make only a single side cut, as indicated by the dotted line in the figure. For one to be framed against the ridge ends of the common rafters, you will make a double side cut, as shown in the figure. The tail of the rafter must have a double side cut at the same angle, but in the reverse direction.

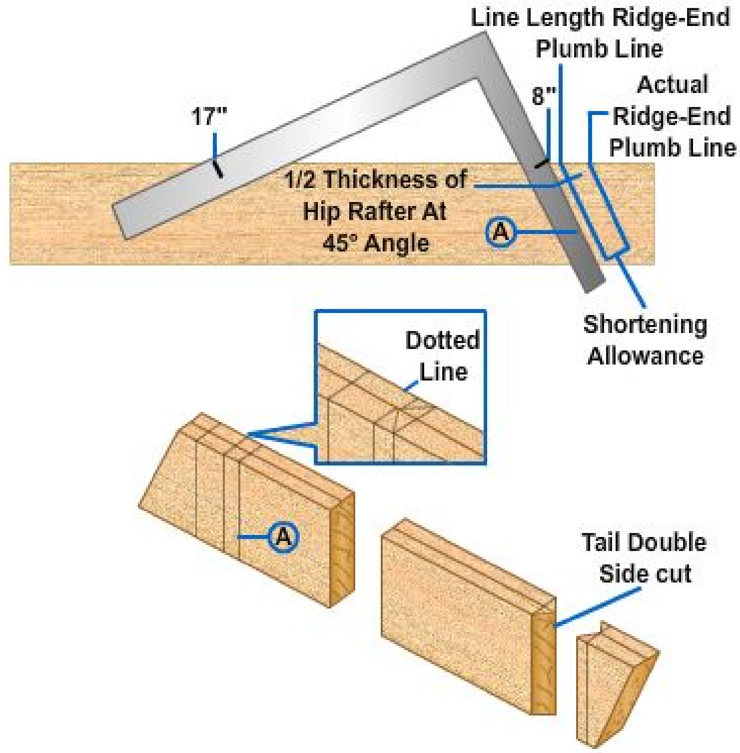


Figure 10-103 – Laying out hip rafter side cut.

The angle of the side cut on a hip rafter may also be laid out by referring to the unit length rafter table on the framing square. Look ahead to *Figure 10-110*. You will see that the bottom line in the table is headed SIDE CUT HIP OR VALLEY USE. Follow this line over to the column headed by the figure 8 (for a unit of rise of 8) and you will find the figure 10 7/8. If you place the framing square face up on the rafter edge with the tongue on the ridge end cut line, and set the square to a cut of 10 7/8 inches on the blade and 12 inches on the tongue, you can draw the correct side cut angle along the tongue.

7.2.4 Bird's-Mouth

Laying out the bird's-mouth for a hip rafter is much the same as for a common rafter. There are a couple of things to remember. When you lay out the plumb (heel) cut and level (seat) cut lines for a bird's-mouth on a hip rafter, set the body of the square at 17 inches and the tongue to the unit of rise (for example, 8 inches depending on the roof pitch) as shown in *Figure 10-104, view A*. When laying out the depth of the heel for the bird's-mouth, measure along the heel plumb line down from the top edge of the rafter a distance equal to the same dimension on the common rafter. You must do this so that the hip rafter, which is usually wider than a common rafter, will be level with the common rafters.

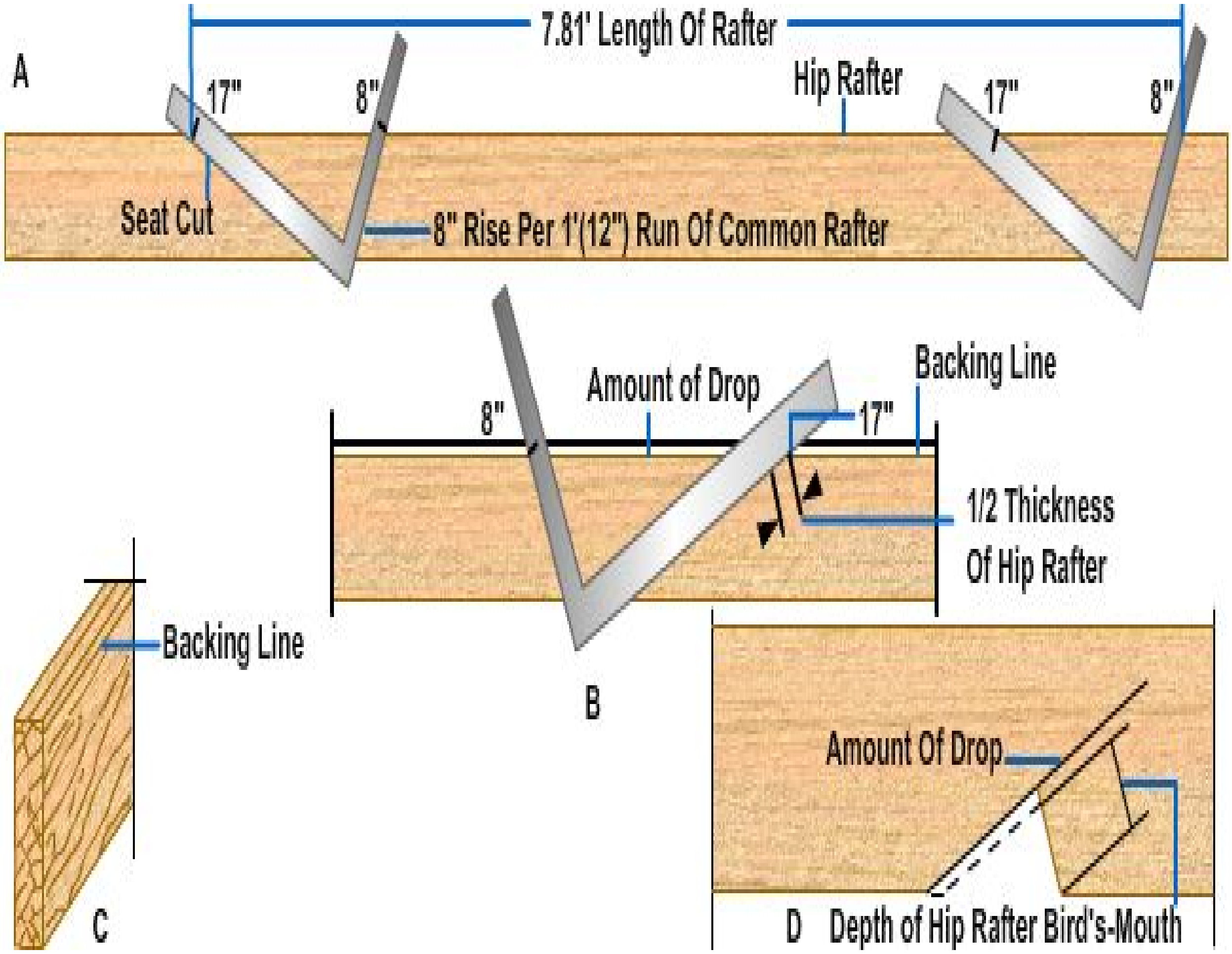


Figure 10-104 – Backing or dropping a hip rafter

A. Marking the top (plumb) cut and the seat (level) cut of a hip rafter
B. Determining amount of backing or drop
C. Bevel line for backing the rafter
D. Deepening the bird's-mouth for dropping the rafter.

If the bird's-mouth on a hip rafter has the same depth as the bird's-mouth on a common rafter, the edge of the hip rafter will extend above the upper ends of the jack rafters. Correct this by either backing or dropping the hip rafter. Backing means to bevel the top edges of the hip rafter as shown in *Figure 10-105*. The amount of backing is taken at a right angle to the roof surface on the top edge of the hip rafters. Dropping means to deepen the bird's-mouth so as to bring the top edge of the hip rafter down to the upper ends of the jacks. The amount of drop is taken on the heel plumb line as shown in *Figure 10-104, view D*.

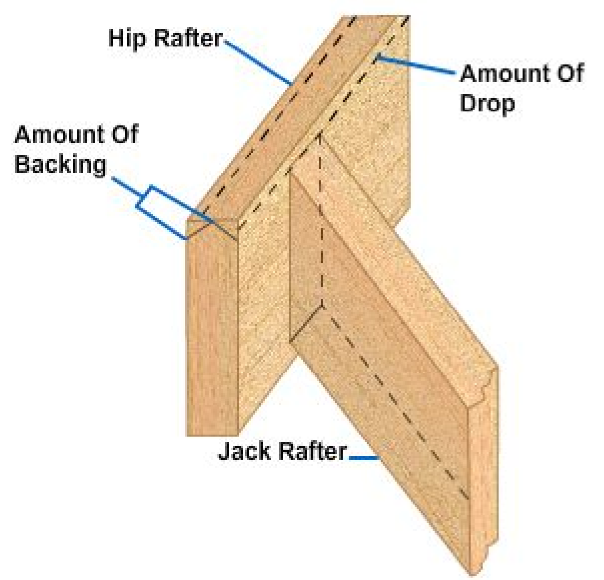


Figure 10-105 – Determining amount of backing or drop on a hip rafter.

Calculate the backing or drop required as shown in *Figure 10-104, view B*. Set the framing square to the cut of the rafter (8 inches and 17 inches) on the upper edge, and measure off one half the thickness of the rafter from the edge along the blade. A line drawn through this mark and parallel to the edge (*view C*) indicates the bevel angle if the rafter is to be backed. The perpendicular distance between the line and the edge of the rafter is the amount of the drop. This represents the amount the depth of the hip rafter bird's-mouth should exceed the depth of the common rafter bird's-mouth (*view D*).

Test your Knowledge (Select the Correct Response)

12. A gable roof slopes in how many directions?

    A. One
    B. Two
    C. Three
    D. Four

13. A birds'-mouth is formed by what two cuts?

    A. Tail and heel
    B. Ridge and tail
    C. Seat and ridge
    D. Heel and seat

7.3.0 Gable and Valley

A gable and valley roof, also known as a combination roof, consists of two or more sections sloping in different directions. A valley is formed where the different sections come together.

The two sections of a gable and valley roof may or may not be the same width. If they are the same width, the roof is said to have equal spans. If they are not the same width, the roof is said to have unequal spans.

7.3.1 Spans

In a roof with equal spans, the height (total rise) is the same for both ridges, as shown in *Figure 10-106*. Both sections are the same width, and the ridgeboards are the same height. A pair of valley rafters is placed where the slopes of the roof meet to form a valley between the two sections. These rafters go from the inside corners formed by the two sections of the building to the corners formed by the intersecting ridges. Valley jack rafters run from the valley rafters to both ridges. Hip valley cripple jack rafters are placed between the valley and hip rafters.

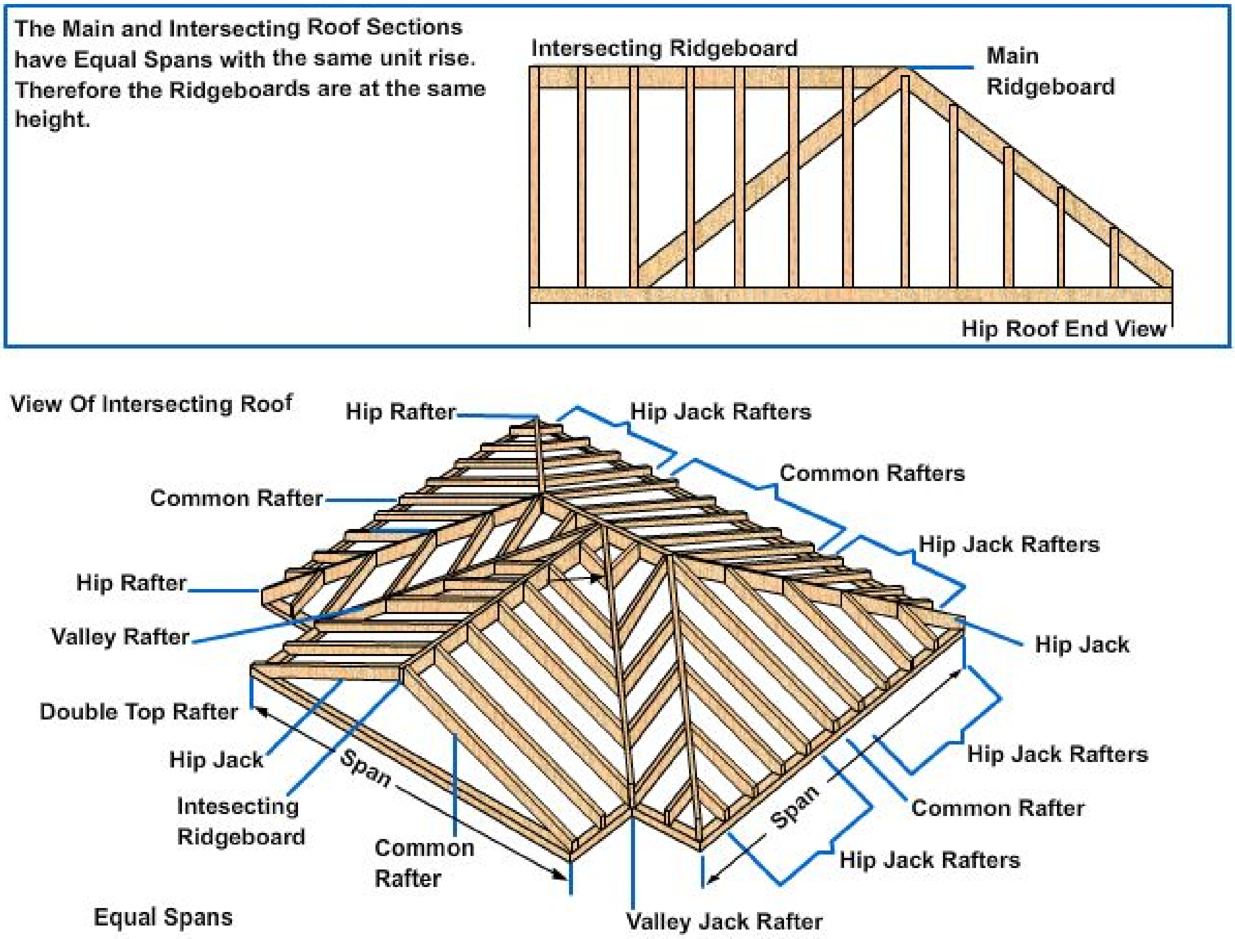


Figure 10-106 – Gable and valley roof with equal spans.

A gable and valley roof with unequal spans requires a supporting valley rafter to run from the inside corner formed by the two sections of the building to the main ridge, as shown in *Figure 10-107*. A shortened valley rafter runs from the other inside comer of the building to the supporting valley rafter. Like a gable and valley roof with equal spans, one with unequal spans requires valley jack rafters and hip valley cripple jack rafters. In addition, a valley cripple jack rafter is placed between the supporting and shortened valley rafters. Note that the ridgeboard is lower on the section with the shorter span.

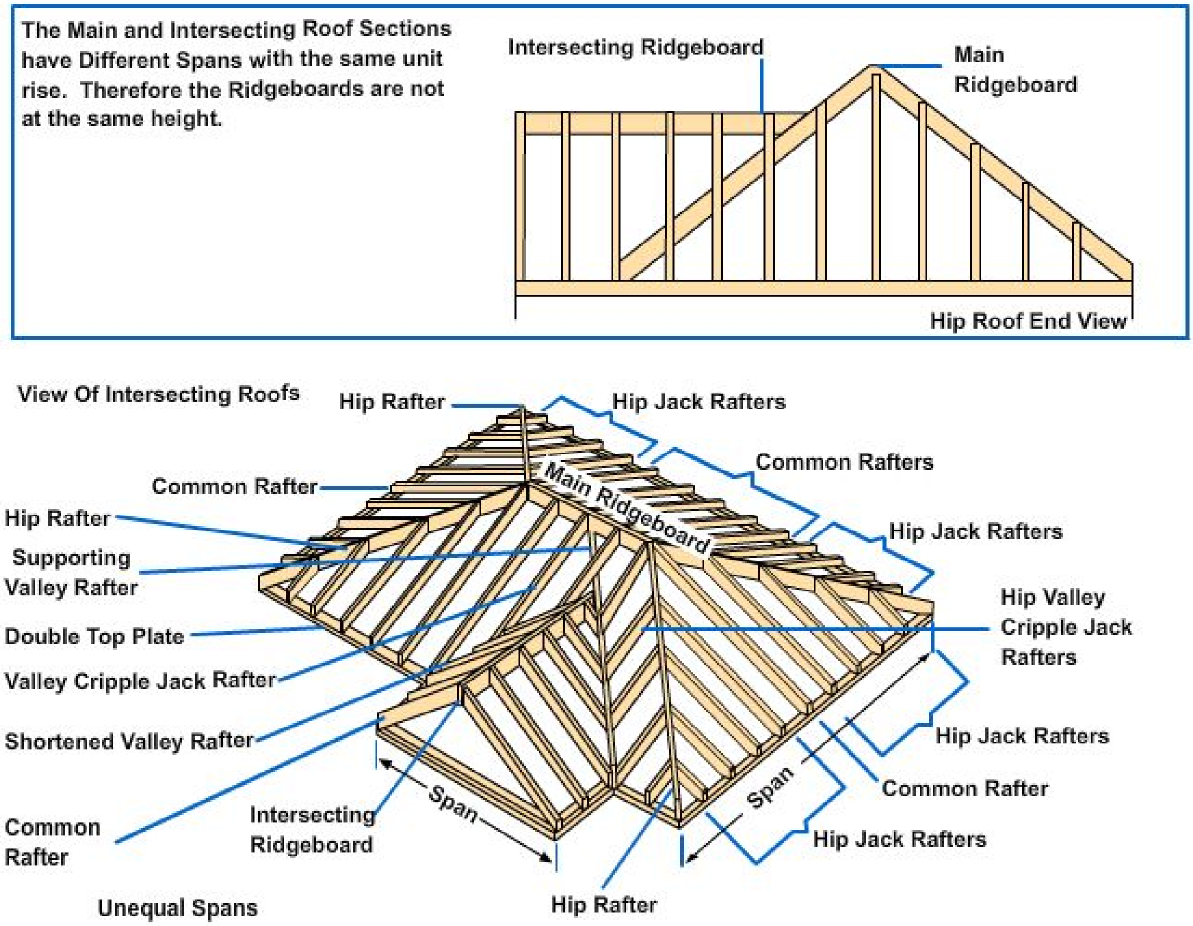


Figure 10-107 – Gable and valley roof with unequal spans.

7.3.2 Valley Rafters

Valley rafters run at a 45° angle to the outside walls of the building. This places them parallel to the hip rafters. Consequently, they are the same length as the hip rafters.

A valley rafter follows the line of intersection between a main roof surface and a gable roof addition or a gable roof dormer surface. Most roofs having valley rafters are equal pitch roofs, in which the pitch of the addition or dormer roof is the same as the pitch of the main roof. There are unequal pitch valley rafter roofs, but they are quite rare and require special framing methods.

In the discussion of valley rafter layout, it is assumed that the roof is equal pitch. Also, the unit of run and unit of rise of an addition or dormer common rafter are assumed to be the same as the unit of run and rise of a main roof common rafter. In an equal pitch roof, the valley rafters always run at 45° to the building lines and the ridge pieces.

Figure 10-108 shows an equal span framing situation, in which the span of the addition is the same as the span of the main roof. Since the pitch of the addition roof is the same as the pitch of the main roof, equal spans bring the ridge pieces to equal heights.

Looking at the roof framing diagram in the figure, you can see the total run of a valley rafter, indicated by AB and AC in the diagram, is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter in the main roof. The unit of run of a valley rafter is 17.97, the same as the unit of run for a hip rafter. It follows that figuring the length of an equal span valley rafter is the same as figuring the length of an equal pitch hip roof hip rafter.

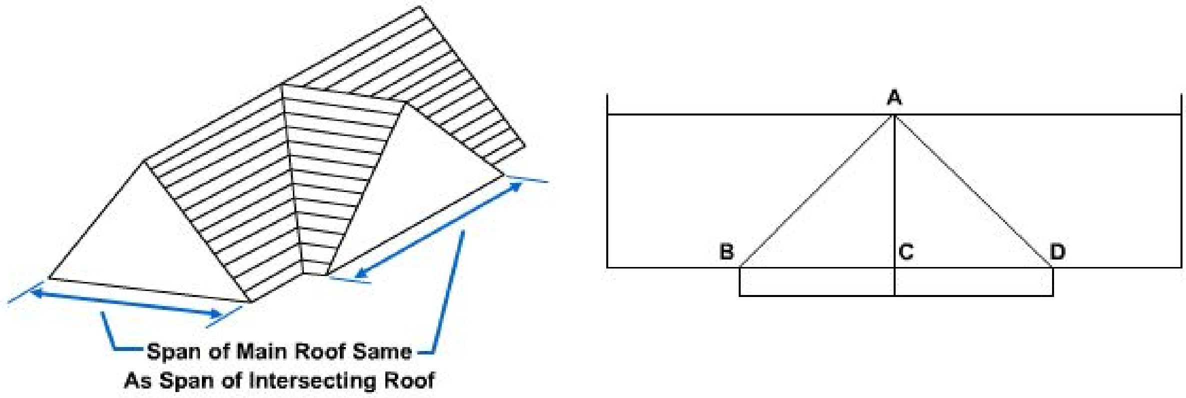


Figure 10-108 – Equal span gable and valley roof.

A valley rafter does not require backing or dropping. The projection, if any, is figured just as it is for a hip rafter. Side cuts are laid out as they are for a hip rafter. The valley rafter tail has a double side cut, like the hip rafter tail, but in the reverse direction. This is because the tail cut on a valley rafter must form an inside, rather than an outside, corner. As indicated in *Figure 10-109*, the ridge end shortening allowance in this framing situation amounts to one half of the 45° thickness of the ridge.

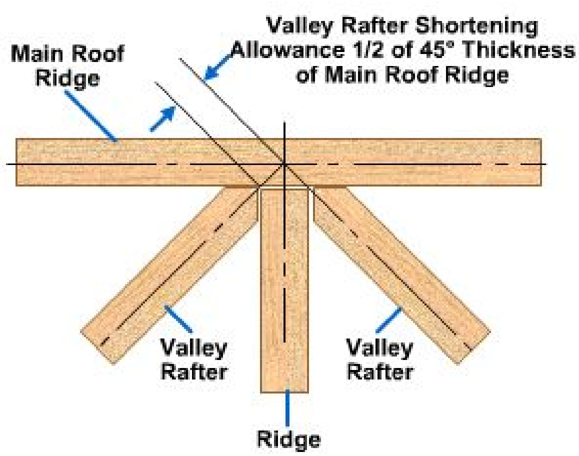


Figure 10-109 – Ridge end shortening allowance for equal span gable and valley rafter.

Figure 10-110 shows a framing situation in which the span of the addition is shorter than the span of the main roof. Since the pitch of the addition roof is the same as the pitch of the main roof, the shorter span of the addition brings the addition ridge down to a lower level than that of the main roof ridge.

There are two ways of framing an intersection of this type. In the method shown in *Figure 10-110*, a full length valley rafter (AD in the figure) is framed between the top plate and the main roof ridgeboard. A shorter valley rafter (BC in the figure) is then framed to the longer one. If you study the framing diagram, you can see that the total run of the longer valley rafter is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter in the main roof. The total run of the shorter valley rafter, on the other hand, is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter in the addition. The total run of a common rafter in the main roof is equal to one half the span of the main roof. The total run of a common rafter in the addition is equal to one half the span of the addition.

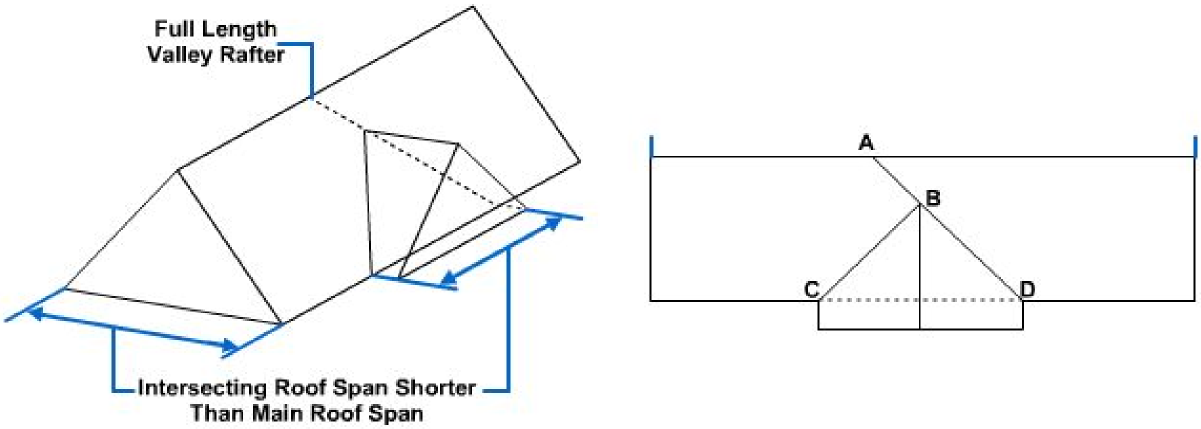


Figure 10-110 – Equal pitch but unequal span framing.

Knowing the total run of a valley rafter, or of any rafter for that matter, you can always find the line length by applying the bridge measure times the total run. Suppose that the span of the addition in *Figure 10-110* is 30 feet and that the unit of rise of a common rafter in the addition is 9. The total run of the shorter valley rafter is:

$$\sqrt{15^2 + 15^2} = 21.21 \text{ feet}$$

Referring to the unit length rafter table in *Figure 10-111*, you can see the bridge measure for a valley rafter in a roof with a common rafter unit of rise of 9 is 19.21. Since the unit of run of a valley rafter is 17.97, and the total run of this rafter is 21.21 feet, the line length must be the value of *x* in the proportional equation *17.97:19.21::21.21:x,* or 24.01 feet.

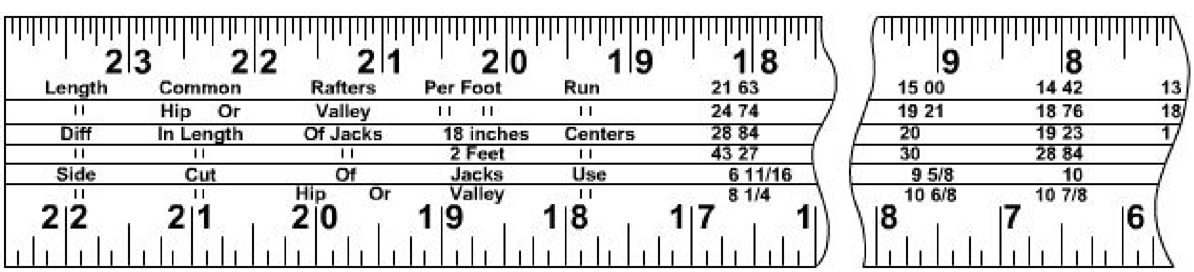


Figure 10-111 – Rafter table method.

An easier way to find the length of a valley rafter is to multiply the bridge measure by the number of feet in one half the span of the roof. The length of the longer valley rafter in *Figure 10-110*, for example, would be 19.21 times one half the span of the main roof. The length of the shorter valley rafter is 19.21 times one half the span of the addition. Since one half the span of the addition is 15 feet, the length of the shorter valley rafter is 15 x 9.21 = 288.15 inches or approximately 24.01 feet.

Figure 10-112 shows the long and short valley rafter shortening allowances. Note that the long valley rafter has a single side cut for framing to the main roof ridge piece, whereas the short valley rafter is cut square for framing to the long valley rafter.

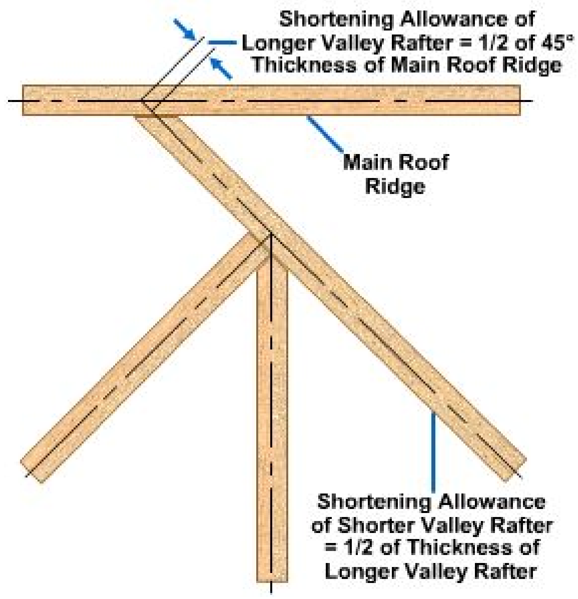


Figure 10-112 – Long and short valley rafter shortening allowance.

Figure 10-113 shows another method of framing an equal pitch unequal span addition. In this method, the inboard end of the addition ridge is nailed to a piece that hangs from the main roof ridge. As shown in the framing diagram, this method calls for two short valley rafters (AB and AC), each of which extends from the top plate to the addition ridge.

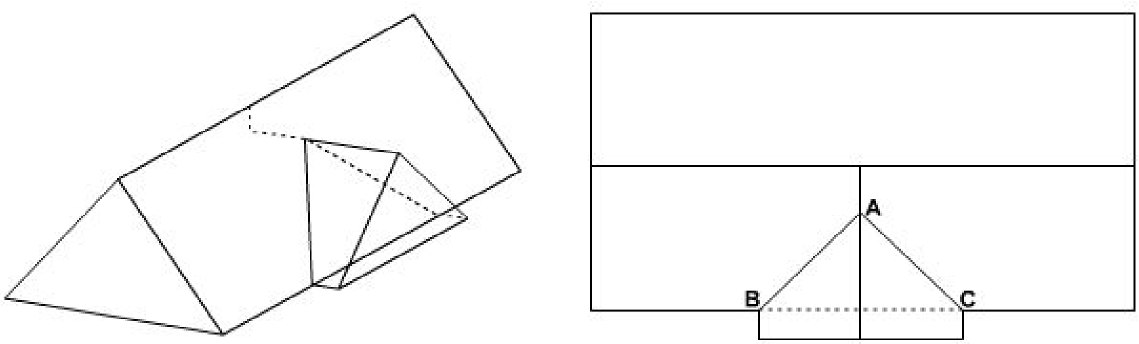


Figure 10-113 – Framing equal pitch unequal span intersection.

As indicated in *Figure 10-114*, the shortening allowance of each of the short valley rafters is one half the 45° thickness of the addition ridge. Each rafter is framed to the addition ridge with a single side cut.

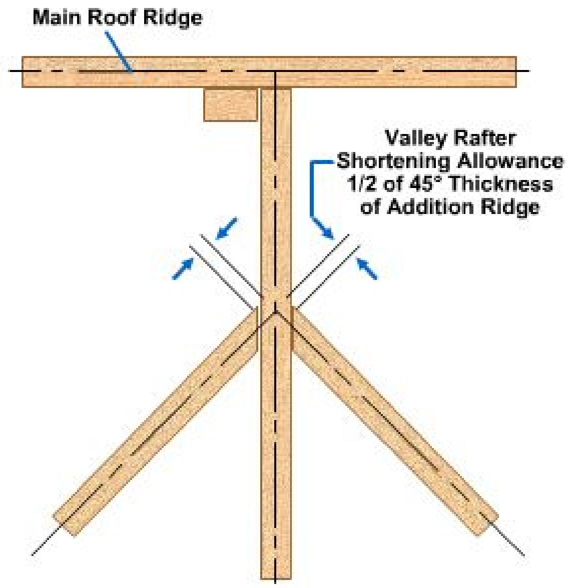


Figure 10-114 – Shortening allowance of valley rafters suspended ridge method of gable and valley roof framing.

Figure 10-115 shows a method of framing a gable dormer without sidewalls. The dormer ridge is framed to a header set between a pair of doubled main roof common rafters. The valley rafters (AB and AC) are framed between this header and a lower header. As indicated in the framing diagram, the total run of a valley rafter is the hypotenuse of a right triangle with the shorter sides equal to the total run of a common rafter in the dormer.

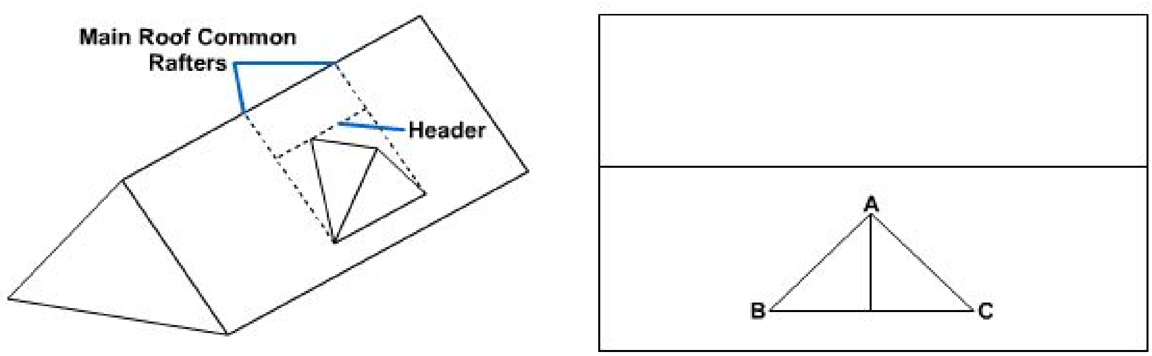


Figure 10-115 – Framing dormer without sidewall.

Figure 10-116 shows the arrangement and names of framing members in this type of dormer framing. The upper edges of the header must be beveled to the cut of the main roof.

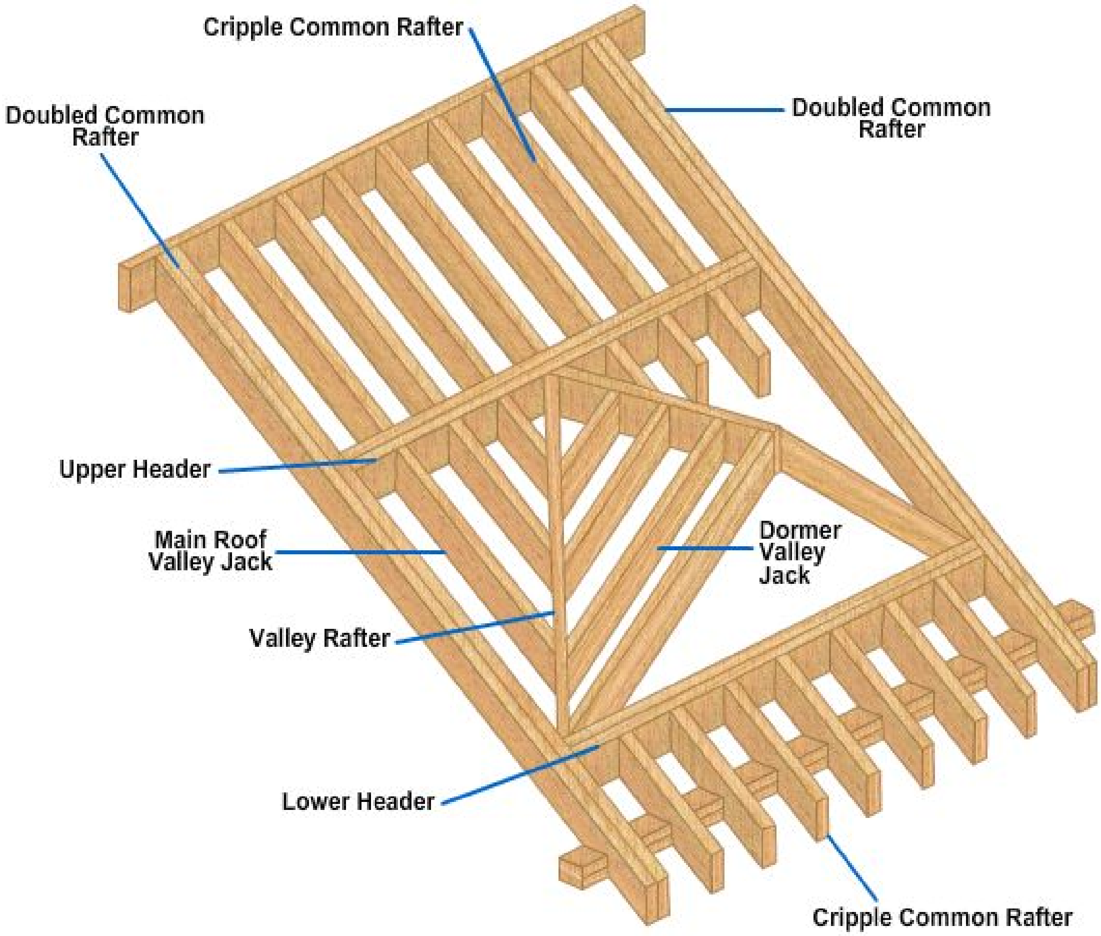


Figure 10-116 – Arrangement and names of framing members for dormer without sidewalls.

Figure 10-117 shows that in this method of framing, the shortening allowance for the upper end of a valley rafter is one half the 45° thickness of the inside member in the upper doubled header. There is also a shortening allowance for the lower end, consisting of one half the 45° thickness of the inside member of the doubled common rafter. The figure also shows that each valley rafter has a double side cut at the upper and lower ends.

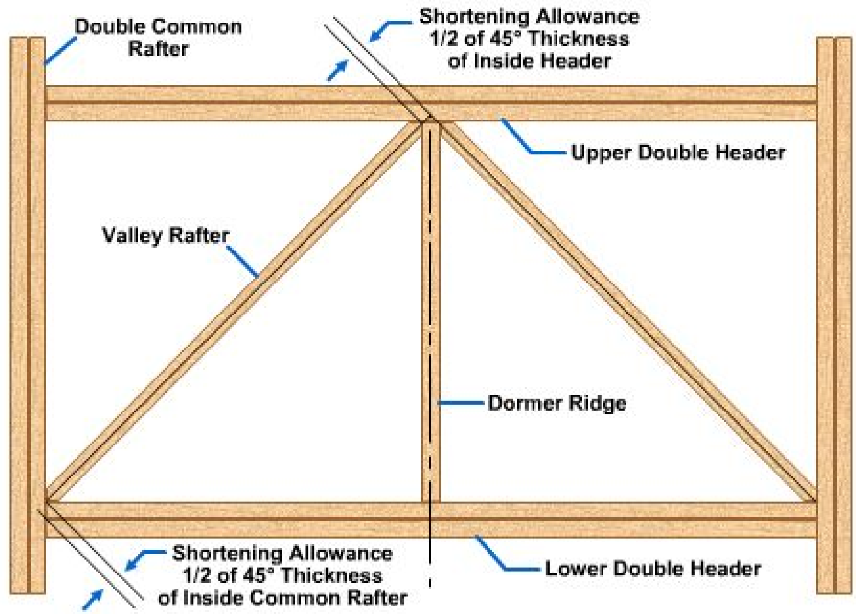


Figure 10-117 – Valley rafter shortening allowance for dormer without sidewalls.

Figure 10-118 shows a method of framing a gable dormer with sidewalls. As indicated in the framing diagram, the total run of a valley rafter is again the hypotenuse of a right triangle with the shorter sides each equal to the run of a common rafter in the dormer. Figure the lengths of the dormer corner posts and side studs just as you do the lengths of gable end studs, and lay off the lower end cutoff angle by setting the square to the cut of the main roof.

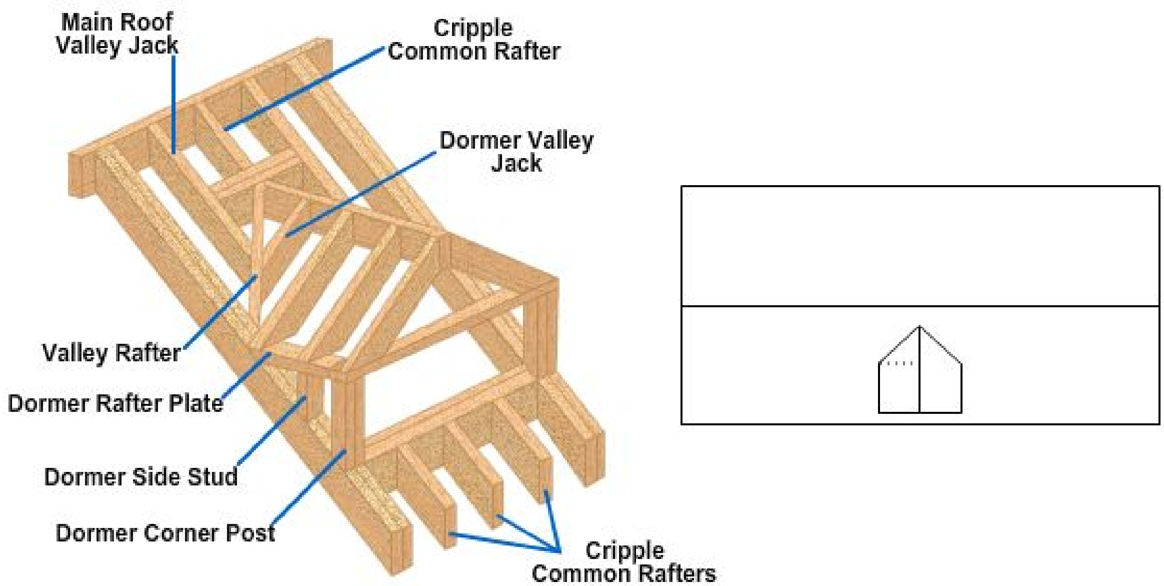


Figure 10-118 – Method of framing gable dormer with sidewalls.

Figure 10-119 shows the valley rafter shortening allowance for this method of framing a dormer with sidewalls.

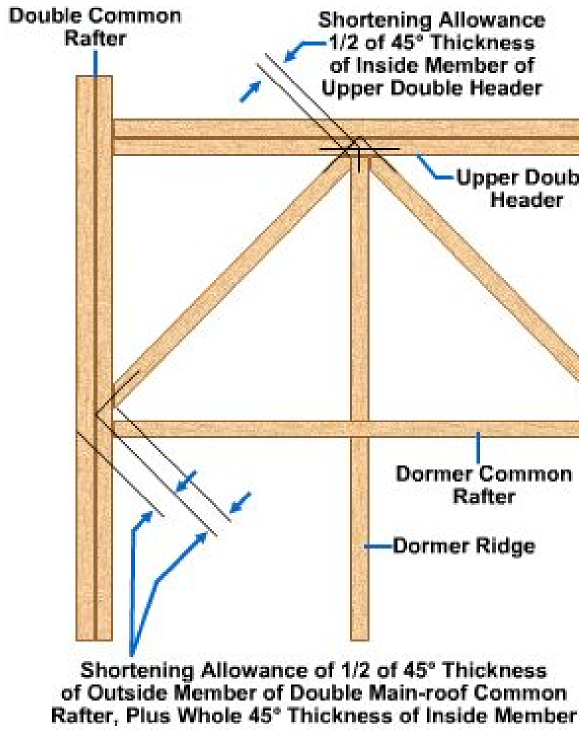


Figure 10-119 – Valley rafter shortening allowance for dormers with sidewalls.

7.3.3 Jack Rafters

A jack rafter is a part of a common rafter, shortened for framing a hip rafter, a valley rafter, or both. This means that in an equal pitch framing situation, the unit of rise of a jack rafter is always the same as the unit of rise of a common rafter. *Figure 10-120* shows various types of jack rafters.

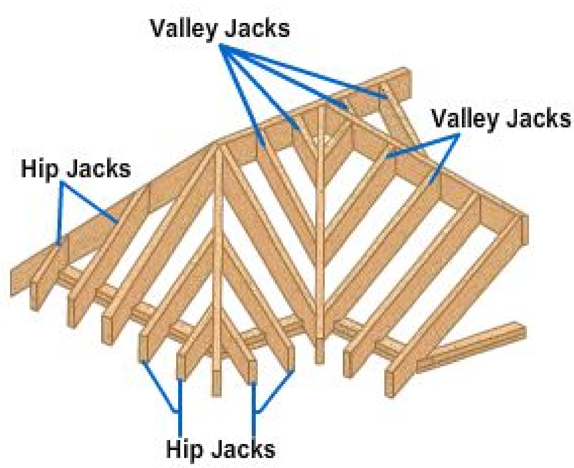
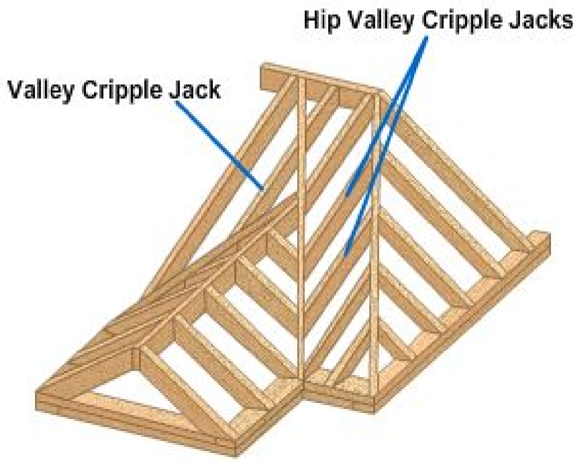


Figure 10-120 – Types of jack rafters.



A hip jack rafter extends from the top plate to a hip rafter. A valley jack rafter extends from a valley rafter to a ridge. Both types are shown in *Figure 10-121*. A cripple jack rafter does not contact either a top plate or a ridge. A valley cripple jack extends between two valley rafters in the long and short valley rafter method of framing. A hip valley cripple jack extends from a hip rafter to a valley rafter.

Figure 10-121 – Valley cripple jack and hip valley cripple jack.

Lengths – *Figure 10-122* shows a roof framing diagram for a series of hip jack rafters. The jacks are always on the same OC spacing as the common rafters. Suppose the spacing in this instance is 16 inches OC. You can see that the total run of the shortest jack is the hypotenuse of a right triangle with the shorter sides each 16 inches long. The total run of the shortest jack is:

$\sqrt{16^2 + 16^2}$ = 22.62 inches

Suppose that a common rafter in this roof has a unit of rise of 8. The jacks have the same unit of rise as a common rafter. The unit length of a jack in this roof is:

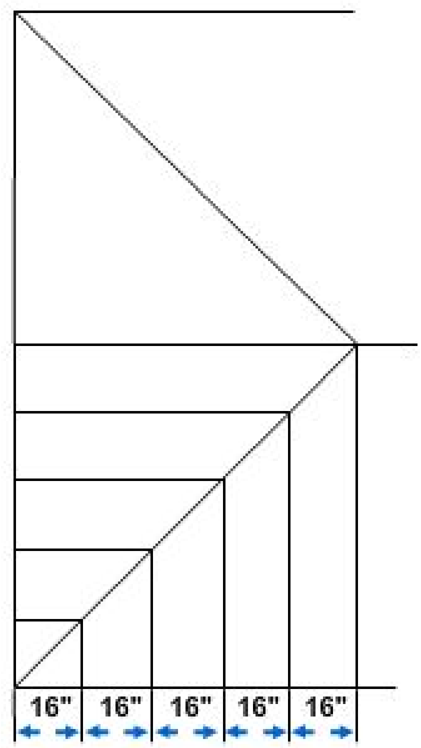


Figure 10-122 – Hip jack framing diagram.

$\sqrt{12^2 + 8^2}$ = 14.42 inches

This means that a jack is 14.42 units long for every 12 units of run. The length of the shortest hip jack in this roof is the value of *x* in the proportional equation *12:14.42::16:x,* or 19.23 inches.

This is always the length of the shortest hip jack when the jacks are spaced 16 inches OC and the common rafter in the roof has a unit of rise of 8. It is also the common difference of jacks, meaning that the next hip jack will be 2 times 19.23 inches.

The common difference for hip jacks spaced 16 inches OC, or 24 inches OC, is given in the unit length rafter table on the framing square for unit of rise ranging from 2 to 18, inclusive. Turn back to *Figure 10-111*, which shows a segment of the unit length rafter table. Note the third line in the table, which reads DIFF IN LENGTH OF JACKS 16 INCHES CENTERS. If you follow this line over to the figure under 8 (for a unit of rise of 8), you'll find the same unit length (19.23) that you worked out above.

The best way to determine the length of a valley jack or a cripple jack is to apply the bridge measure to the total run. The bridge measure of any jack is the same as the bridge measure of a common rafter having the same unit of rise as the jack. Suppose the jack has a unit of rise of 8. In *Figure 10-111*, look along the line on the unit length rafter tables headed LENGTH COMMON RAFTER PER FOOT RUN for the figure in the column under 8; you'll find a unit length of 14.42. You should know by this time how to apply this to the total run of a jack to get the line length.

The best way to figure the total runs of valley jacks and cripple jacks is to lay out a framing diagram and study it to determine what these runs must be. *Figure 10-123* shows part of a framing diagram for a main hip roof with a long and short valley rafter gable addition. By studying the diagram, you can figure the total runs of the valley jacks and cripple jacks as follows:

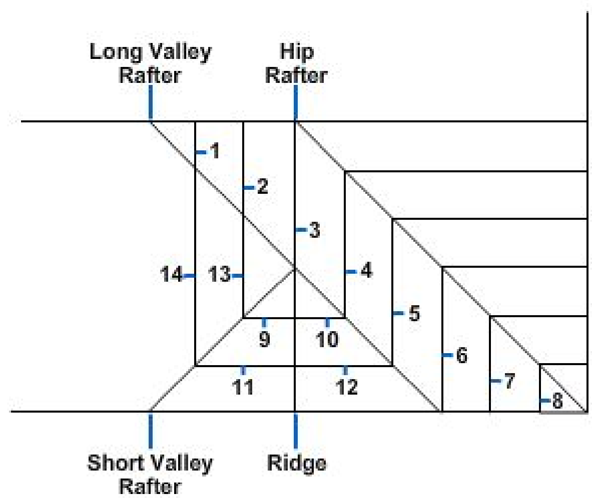


Figure 10-123 – Jack rafter framing diagram.

- The run of valley jack No. 1 is the same as the run of hip jack No. 8, which is the run of the shortest hip jack. The length of valley jack No. 1 is equal to the common difference of jacks.
- The run of valley jack No. 2 is the same as the run of hip jack No. 7, so the length is twice the common difference of jacks.
- The run of valley jack No. 3 is the same as the run of hip jack No. 6, so the length is three times the common difference of jacks.
- The run of hip valley cripple Nos. 4 and 5 is the same as the run of valley jack No. 3.
- The run of valley jack Nos. 9 and 10 is equal to the spacing of jacks OC. The length of one of these jacks is equal to the common difference of jacks.
- The run of valley jacks Nos. 11 and 12 is twice the run of valley jacks Nos. 9 and 10, and the length of one of these jacks is twice the common difference of jacks.
- The run of valley cripple No. 13 is twice the spacing of jacks OC, and the length is twice the common difference of jacks.
- The run of valley cripple No. 14 is twice the run of valley cripple No. 13, and the length is four times the common difference of jacks.

Shortening Allowances – A hip jack has a shortening allowance at the upper end, consisting of one half the 45° thickness of the hip rafter. A valley jack rafter has a shortening allowance at the upper end, consisting of one half the 45° thickness of the ridge, and another at the lower end, consisting of one half the 45° thickness of the valley rafter. A hip valley cripple has a shortening allowance at the upper end, consisting of one half the 45° thickness of the hip rafter, and another at the lower end, consisting of one half the 45° thickness of the valley rafter. A valley cripple has a shortening allowance at the upper end, consisting of one half the 45° thickness of the long valley rafter, and another at the lower end, consisting of one half the 45° thickness of the short valley rafter.

Side Cuts – The side cut on a jack rafter can be laid out using the same method as for laying out the side cut on a hip rafter. Another method is to use the fifth line of the unit length rafter table, which is headed SIDE CUT OF JACKS USE in *Figure 10-111*. If you follow that line over to the figure under 8 (for a unit of rise of 8), you will see that the figure given is 7. To lay out the side cut on a jack set the square face up on the edge of the rafter to 12 inches on the tongue and 10 inches on the blade, and draw the side cut line along the tongue.

Bird's-Mouth and Projection – A jack rafter is a shortened common rafter, so the bird's-mouth and projection on a jack rafter are laid out just as they are on a common rafter.

7.3.4 Ridge Layout

Laying out the ridge for a gable roof presents no particular problem since the line length of the ridge is equal to the length of the building. The actual length includes any overhang. For a hip main roof, however, the ridge layout requires a certain amount of calculation.

In an equal pitch hip roof, the line length of the ridge is the length of the building minus the span. The actual length depends on the way the hip rafters are framed to the ridge.

In *Figure 10-124*, the line length ends of the ridge are at the points where the ridge centerline and the hip rafter center line cross. The hip rafter is framed against the ridge. The actual length of the ridge exceeds the line length at each end by one half the thickness of the ridge, plus one half the 45° thickness of the hip rafter. The hip rafter is also framed between the common rafters. The actual length of the ridge exceeds the line length at each end by one half the thickness of a common rafter.

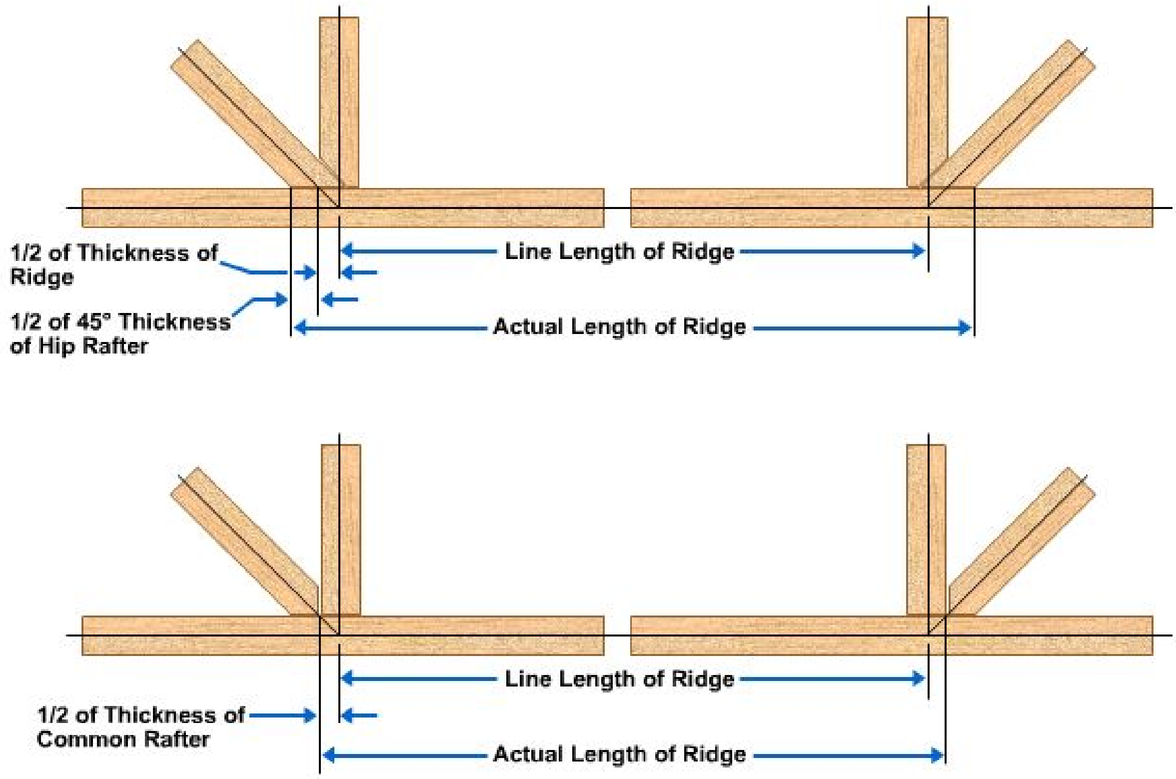


Figure 10-124 – Line and actual lengths of hip roof ridgeboard.

Figure 10-125, view A shows that the length of the ridge for an equal span addition is equal to the length of the addition top plate plus one half the span of the building minus the shortening allowance at the main roof ridge. The shortening allowance amounts to one half the thickness of the main roof ridge.

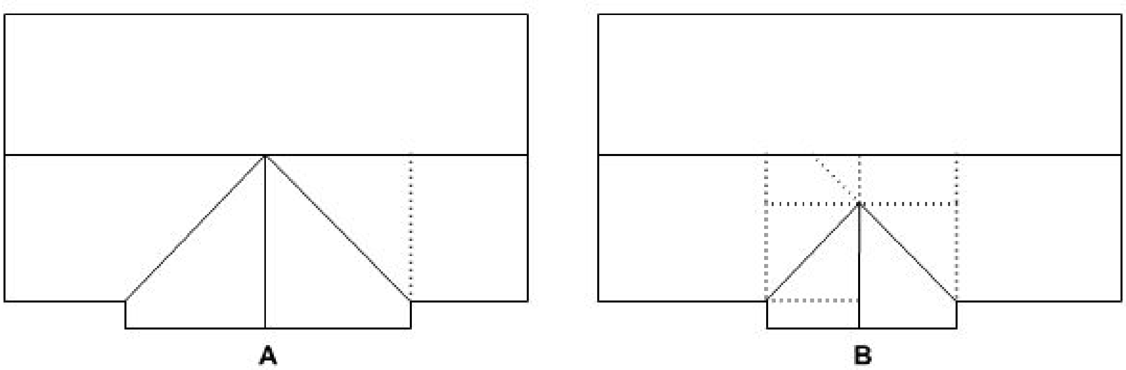


Figure 10-125 – Lengths of addition ridge.

View B shows the length of the ridge for an unequal span addition varies with the method of framing the ridge. If the addition ridge is suspended from the main roof ridge, the length is the length of the addition top plate plus one half the span of the building. If the addition ridge is framed by the long and short valley rafter method, the length is the length of the addition top plate, plus one half the span of the addition, minus a shortening allowance one half the 45° thickness of the long valley rafter. If the addition ridge is framed to a double header set between a couple of double main roof common rafters, the length of the ridge is the length of the addition sidewall rafter plate, plus one half the span of the addition, minus a shortening allowance one half the thickness of the inside member of the double header.

Figure 10-126, view A shows that the length of the ridge on a dormer without sidewalls is one half the span of the dormer, less a shortening allowance one half the thickness of the inside member of the upper double header. *View B* shows that the length of the ridge on a dormer with sidewalls is the length of the dormer rafter plate, plus one half the span of the dormer, minus a shortening allowance one half the thickness of the inside member of the upper double header.

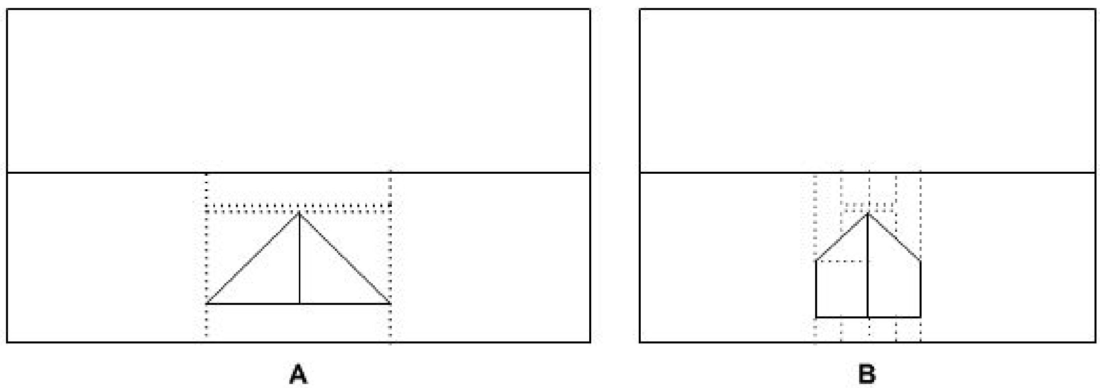


Figure 10-126 – Lengths of dormer ridge.

7.4.0 Shed

A shed roof is essentially one half of a gable roof. Like the full length rafters in a gable roof, the full length rafters in a shed roof are common rafters. The total run of a shed roof common rafter is equal to the span of the building minus the width of the top plate on the higher rafter end wall, as shown in *Figure 10-127*. The run of the overhang on the higher wall is measured from the inner edge of the top plate. With these exceptions, shed roof common rafters are laid out like gable roof common rafters. A shed roof common rafter has two bird's-mouths, but they are laid out just like the bird's-mouth on a gable roof common rafter.

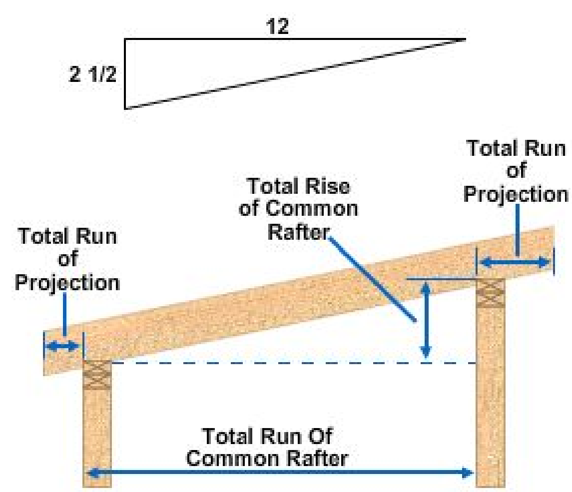


Figure 10-127 – Shed roof framing.

For a shed roof, the height of the higher rafter end wall must exceed the height of the lower by an amount equal to the total rise of a common rafter.

Figure 10-128 shows a method of framing a shed dormer. This type of dormer can be installed on almost any type of roof. There are three layout problems to solve here; determining the total run of a dormer rafter, determining the angle of cut on the inboard ends of the dormer rafters, and determining the lengths of the dormer sidewall studs.

To determine the total run of a dormer rafter, divide the height of the dormer end wall, in inches, by the difference between the unit of rise of the dormer roof and the unit of rise of the main roof.

Figure 10-128 – Framing a shed dormer.

Take the dormer shown in *Figure 10-129*, for example. The height of the dormer end wall is 9 feet, or 108 inches. The unit of rise of the main roof is 8, the unit of rise of the dormer roof is 2 1/2, and the difference is 5 1/2. The total run of a dormer rafter is 108 divided by 5 1/2, or 19.63 feet. Knowing the total run and the unit of rise, you can figure the length of a dormer rafter by any of the methods already described.

As indicated in *Figure 10-129*, the inboard ends of the dormer rafters must be cut to fit the slope of the main roof. To get the angle of this cut, set the square on the rafter to the cut of the main roof, as shown in the bottom view of *Figure 10-129*. Measure off the unit of rise of the dormer roof from the heel of the square along the tongue as indicated and make a mark at this point. Draw the cutoff line through this mark from the 12 inch mark.

Figure the lengths of the sidewall studs on a shed dormer as follows:

In the roof shown in *Figure 10-129*, a dormer rafter raises 2 1/2 units for every 12 units of run. A main roof common rafter rises 8 units for every 12 units of run. If the studs were spaced 12 inches OC, the length of the shortest stud, which is also the common difference of studs, would be the difference between 8 and 2 1/2 inches, or 5 1/2 inches. If the stud spacing is 16 inches, the length of the shortest stud is the value of *x* in the proportional equation:

12:5 1/2::16:x

Or

7 5/16 inches

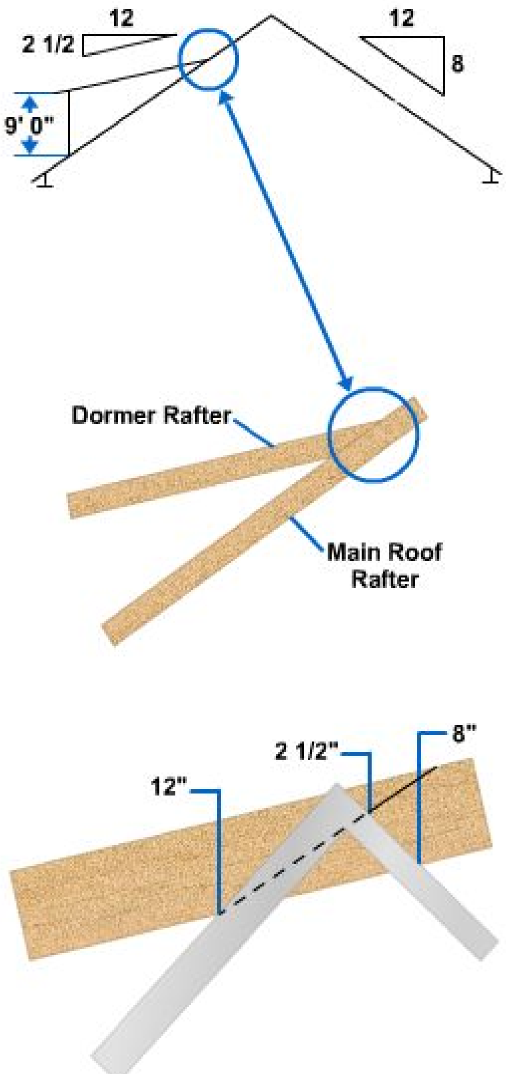


Figure 10-129 – Shed dormer framing calculation.

The shortest stud, then, will be 7 5/16 inches long. To get the lower end cutoff angle for studs, set the square on the stud to the cut of the main roof. To get the upper end cutoff angle, set the square to the cut of the dormer roof.

7.5.0 Installation

Rafter locations are laid out on wall plates and ridgeboards with matching lines and marked with X's, as used to lay out stud and joist locations. For a gable roof, the rafter locations are laid out on the rafter plates first. The locations are then transferred to the ridge by matching the ridge against a rafter plate.

7.5.1 Rafter Locations

The rafter plate locations of the ridge end common rafters in an equal pitch hip roof measure one half of the span (or the run of a main roof common rafter) away from the building comers. These locations, plus the rafter plate locations of the rafters lying between the ridge end common rafters, can be transferred to the ridge by matching the ridgeboads against the rafter plates.

The locations of additional ridge and valley rafters can be determined as indicated in *Figure 10-130*. In an equal span situation (*views A and B*), the valley rafter locations on the main roof ridge lie alongside the addition ridge location. In *view A*, the distance between the end of the main roof ridge and the addition ridge location is equal to A plus distance B, distance B being one half the span of the addition. In *view B*, the distance between the line length end of the main roof ridge and the addition ridge location is the same as distance A. In both cases, the line length of the addition ridge is equal to one half the span of the addition, plus the length of the addition sidewall rafter plate.

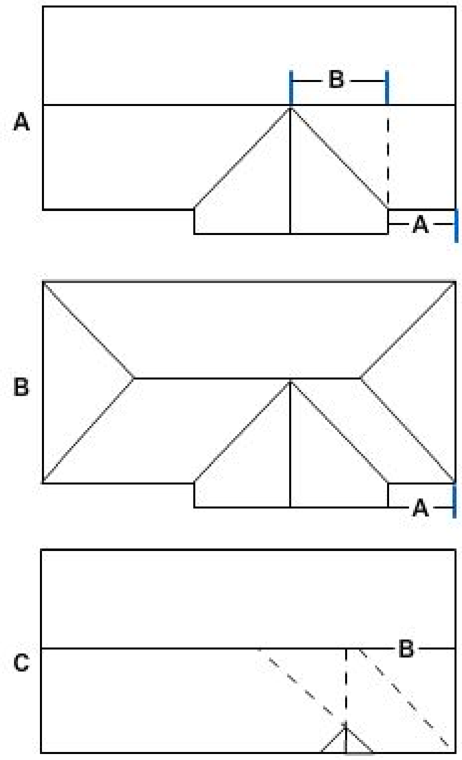


Figure 10-130 – Intersection ridge and valley rafter location layout.

Figure 10-130, view C, shows an unequal span situation. If framing is by the long and short valley rafter method, the distance from the end of the main roof ridge to the upper end of the longer valley rafter is equal to distance A plus distance B, distance B being one half the span of the main roof. To determine the location of the inboard valley rafter, first calculate the unit length of the longer valley rafter, or obtain it from the unit length rafter tables. Suppose that the common rafter unit of rise is 8. In that case, the unit length of a valley rafter is 18.77.

The total run of the longer valley rafter between the shorter rafter tie in and the rafter plate is the hypotenuse of a right triangle with the altitude and base equal to one half the span of the addition. Suppose the addition is 20 feet wide. Then, the total run is:

$$\sqrt{10^2 + 10^2} = 14.14 \text{ feet}$$

You know that the valley rafter is 18.76 units long for every 17.97 units of run. The length of rafter for 14.14 feet of run must therefore be the value of x in the proportional equation *17.97:18.76::14.14:x,* or 15.63 feet. The location mark for the inboard end of the shorter valley rafter on the longer valley rafter will be 15.63 feet, or 15 feet 7 9/16 inches, from the heel plumb cut line on the longer valley rafter. The length of the additional ridge will be equal to one half the span of the addition, plus the length of the additional sidewall top plate, minus a shortening allowance one half the 45° thickness of the longer valley rafter.

If framing is by the suspended ridge method, the distance between the suspension point on the main roof and the end of the main roof ridge is equal to distance A plus distance C. Distance C is one half the span of the addition. The distance between the point where the inboard ends of the valley rafters (both short in this method of framing) tie into the addition ridge and the outboard end of the ridge is equal to one half the span of the addition, plus the length of the additional ridge (which is equal to one half of the span of the main roof), plus the length of the addition sidewall rafter plate.

7.5.2 Roof Frame Erection

Roof framing should be done from a scaffold with planking not less than 4 feet below the level of the main roof ridge. The usual type of roof scaffold consists of diagonally braced two legged horses, spaced about 10 feet apart and extending the full length of the ridge.

If the building has an addition, frame as much as possible of the main roof before starting the addition framing. Cripples and jack rafters are usually left out until after the headers, hip rafters, valley rafters, and ridges to which they will be framed have been installed. For a gable roof, the two pairs of gable end rafters and the ridge are usually erected first.

Two crewmembers, one at each end of the scaffold, hold the ridge in position. Another crewmember sets the gable end rafters in place and toenails them at the rafter plate with 8d nails, one on each side of a rafter. Before we proceed any further, see *Table 10-1* for the type and size nails used in roof framing erection. Each crewmember on the scaffold then end nails the ridge to the end of the rafter. They then toenail the other rafter to the ridge and to the first rafter with two 10d nails, one on each side of the rafter.

Table 10-1 – Recommended Schedule for Nailing the Framing and Sheathing of a Wood frame Structure.

Joining	Nailing Method	Nails		
		Nr.	Size	Placement
Header to joist	End-nail	3	16d	
Joist to sill or girder	Toenail	2 3	10d or 8d	
Header and stringer joist to sill	Toenail		10d	16 inches OC
Bridging to joist	Toenail each end	2	8d	
Ledger strip to beam, 2 inches thick		3	16d	At each joist
Subfloor, boards:				
1 by 6 inch and smaller		2	8d	To each joist
1 by 8 inch		3	8d	To each joist
Subfloor, plywood				
At edges			8d	6 inches OC
At intermediate joists			8d	8 inches OC
Subfloor (2 by 6 inch, T&G) to joist or girder	Blind nail (casing) and face-nail	2	16d	
Soleplate to stud, horizontal assembly	End-nail	2	16d	At each stud
Top plate to stud	End-nail	2	16d	
Stud to soleplate	Toenail	4	8d	
Soleplate to joist or blocking	Face-nail		16d	16 inches OC
Doubled studs	Face-nail, stagger		10d	16 inches OC
End stud of intersecting wall to exterior wall stud	Face-nail		16d	16 inches OC
Upper top plate to lower top plate	Face-nail		16d	16 inches OC
Upper top plate, laps and instersections	Face-nail	2	16d	
Continuous header, two pieces, each edge			12d	12 inches OC
Ceiling joist to top wall plates	Toenail	3	8d	
Ceiling joist laps at partition	Face-nail	4	16d	
Rafter to top plate	Toenail	2	8d	
Rafter to ceiling joist	Face-nail	5	10d	
Rafter to valley or hip rafter	Toenail	3	10d	
Ridgeboard to rafter	End-nail	3	10d	
Rafter to rafter through ridgeboard	Toenail	2	10d	
	Edge-nail	4	8d	
Collar tie to rafter:				
2 inch member	Face-nail	2	12d	
1 inch member	Face-nail	3	8d	
1 inch diagonal let-in brace to each stud and				

plate (four nails at top)		2	8d	
Built-up corner studs:				
Studs to blocking	Face-nail	2	10d	Each side
Intersecting stud to corner studs	Face-nail		6d	12 inches OC
Built-up girders and beams, three or more members	Face-nail		20d	32 inches OC each side
Wall sheathing:				
1 by 8 inch or less, horizontal	Face-nail	2	8d	At each stud
1 by 6 inch or greater, diagonal	Face-nail	3	8d	At each stud
Wall sheathing, vertically applied plywood:				
3/8 inch and less thick	Face-nail		6d	6 inches edge
1/2 inch and over thick	Face-nail		8d	12 inches inermdeiate
Wall sheathing, vertically applied fiberboard:			1 1/2 inch roofing nail 3 inches	
1/2 inch thick	Face-nail		from edge and 1 3/4 inch roofing	
25/32 inch thick	Face-nail		nail 6 inches intermediate	
Roof sheathing, boards, 5, 6, 8 inch width	Face-nail	2	8d	At each rafter
Roof sheathing, plywood:				
3/8 inch and less thick	Face-nail		6d	6 inches edge and 12
1/2 inch and over thick	Face-nail		8d	inches intermediate

Set up temporary braces, like those for a wall, at the ridge ends to hold the rafter approximately plumb, then erect the rafters between the end rafters. Then release the braces, and plumb the pair of rafters at one with a plumb line fastened to a stick extended from the end of the ridge. After that, reset the braces, and leave them in place until you have installed enough sheathing to hold the rafters plumb. Collar ties, if any, are nailed to common rafters with 8d nails, three to each end of a tie. Ceiling joist ends are nailed to adjacent rafters with 10d nails.

On a hip roof, erect the ridge end common rafters and ridges first, in about the same manner as for a gable roof. Then fill in the intermediate common rafters. After that, erect the ridge end common rafters extending from the ridge ends to the midpoints on the end walls. Install the hip rafters and hip jacks next. The common rafters in a hip roof do not require plumbing. When correctly cut and installed, hip rafters will bring the common rafters to plumb. Toe nail hip rafters are to plate comers with 10d nails. Toe nail hip jacks to hip rafters with 10d nails.

For an addition or dormer, the valley rafters are usually erected first. Valley rafters are toe nailed with 10d nails.

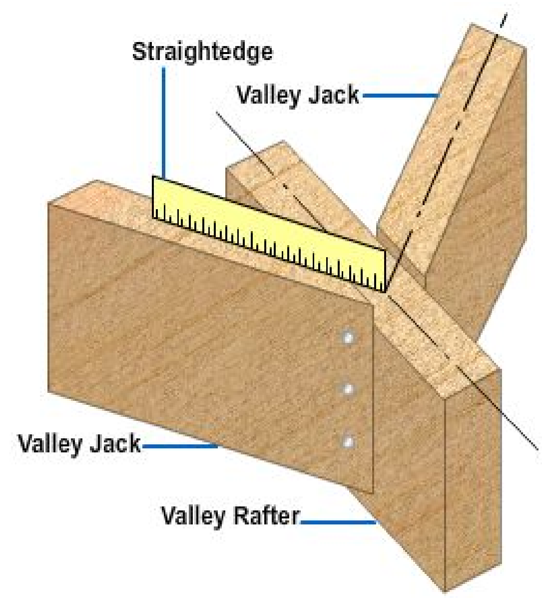


Figure 10-131 – Correct position for nailing a valley jack rafter.

Erect ridges and ridge end common rafters next, then other addition common rafters, and valley and cripple jacks last. A valley jack should be held in position for nailing as shown in *Figure 10-131*. When properly nailed, the end of a straightedge laid along the top edge of the jack should contact the centerline of the valley rafter, as shown.

Test your Knowledge (Select the Correct Response)

14. How long should the temporary bracing used in roof erection be left in place?

    A. Until sufficient sheathing has been installed to hold the rafters in place
    B. Until the wind has died down
    C. 3 days
    D. 4 days

8.0.0 ROOF TRUSSES

Roof truss members are usually connected at the joints by ***gussets***. Gussets are made of boards, plywood, or metal. They are fastened to the truss by nails, screws, bolts, or adhesives. A roof truss is capable of supporting loads over a long span without intermediate supports.

Roof trusses save material and on-site labor costs. It is estimated that a material savings of about 30 percent is made on roof members and ceiling joists. When you are building with trusses, the double top plates on interior partition walls and the double floor joists under interior bearing partitions are not necessary. Roof trusses also eliminate interior bearing partitions because trusses are self-supporting.

The basic components of a roof truss are the top and bottom chords and the web members as shown in *Figure 10-132*. The top chords serve as roof rafters. The bottom chords act as ceiling joists. The web members run between the top and bottom chords. The truss parts are usually made of 2 by 4 inch or 2 by 6 inch material and are tied together with metal or plywood gusset plates. Gussets shown in this figure are made of plywood.

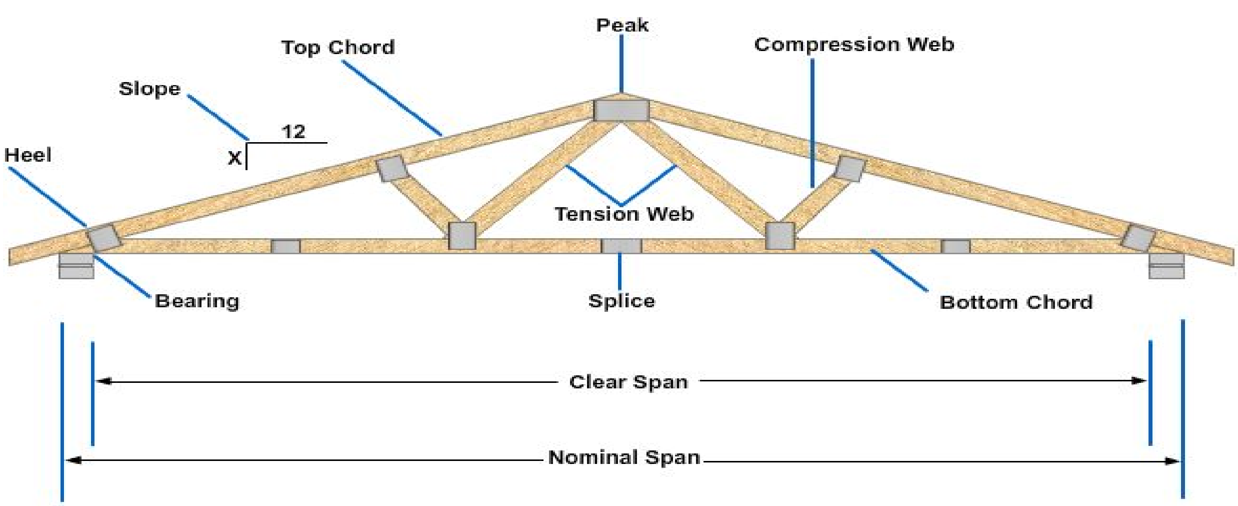


Figure 10-132 – Truss construction.

8.1.0 Types

Roof trusses come in a variety of shapes. The ones most commonly used in light framing are the king post, the W-type (or fink), and the scissors. *Figure 10-133* shows an example of each.

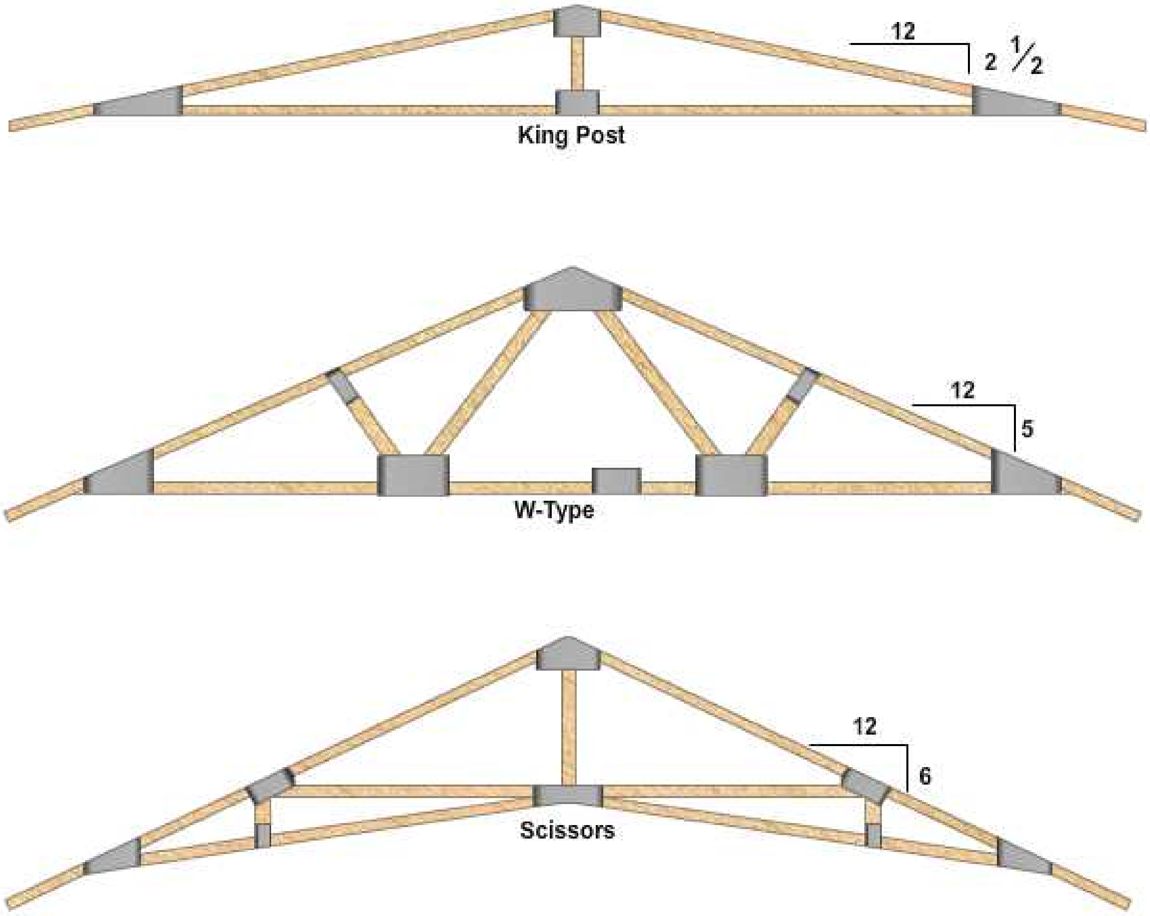


Figure 10-133 – Truss types.

8.1.1 King Post

The simplest type of truss used in frame construction is the king-post truss. It consists of top and bottom chords and a vertical post at the center.

8.1.2 W-Type (Fink)

The most widely used truss in light-frame construction is the W-type (fink) truss. It consists of top and bottom chords tied together with web members. The W-type truss provides a uniform load-carrying capacity.

8.1.3 Scissors

The scissor truss is used for building with sloping ceilings. Many residential, church, and commercial buildings require this type of truss. Generally, the slope of the bottom chord of a scissor truss equals one half the slope of the top chord.

8.2.0 Design Principles

A roof truss is an engineered structural frame resting on two outside walls of a building. The load carried by the truss is transferred to these outside walls.

8.2.1 Weight and Stress

The design of a truss includes consideration of snow and wind loads and the weight of the roof itself. Design also takes into account the slope of the roof. Generally, the flatter the slope, the greater the stresses. Flatter slopes, therefore, require larger members and stronger connections in roof trusses.

A great majority of the trusses used are fabricated with plywood gussets; as shown in *Figure 10-134, views A* through *E;* which are nailed, glued, or bolted in place.

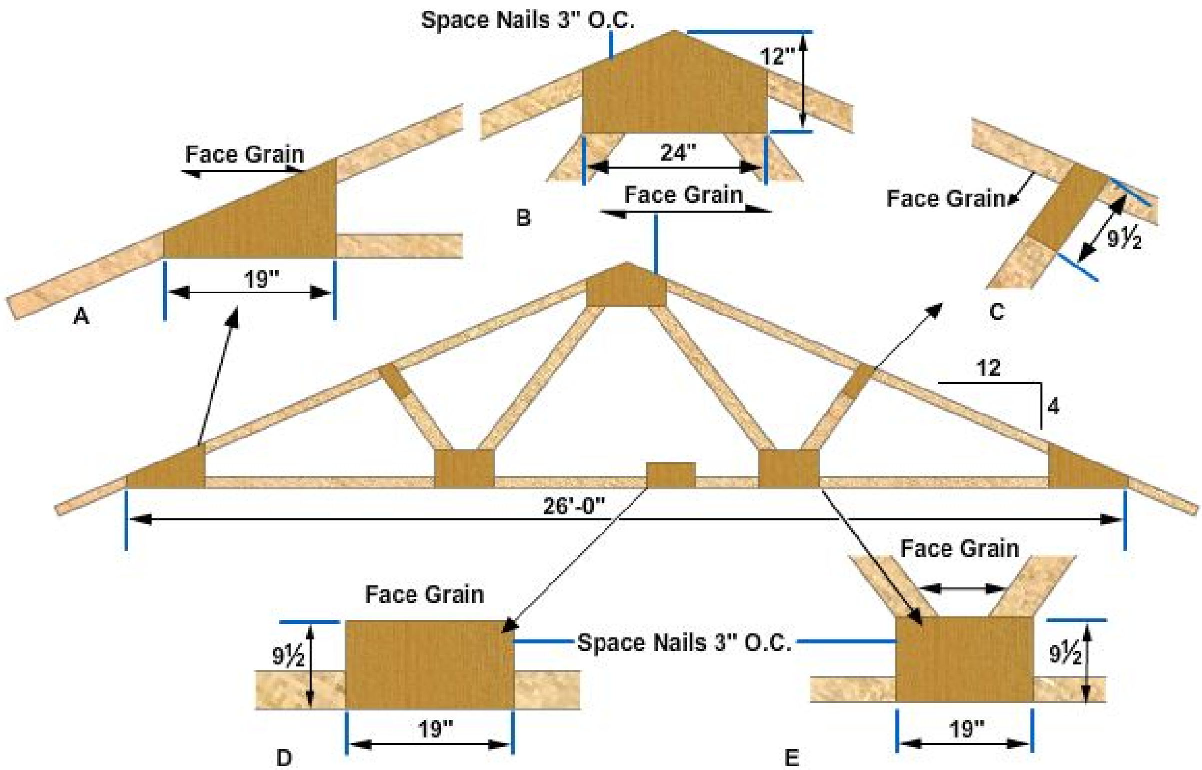


Figure 10-134 – Plywood gussets.

The metal gusset plates shown in *Figure 10-135* are also used. These are flat pieces usually manufactured from 20 gauge zinc-coated or galvanized steel. The holes for the nails are prepunched.

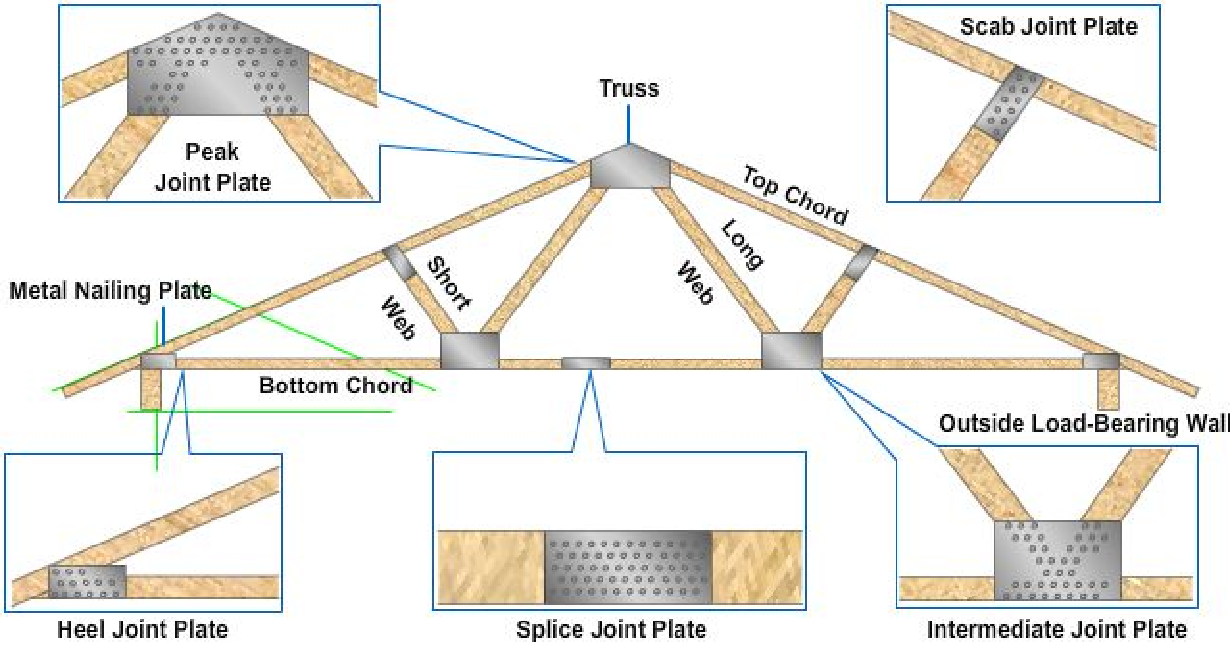


Figure 10-135 – Metal gusset plates.

Others are assembled with the split-ring connectors shown in *Figure 10-136*, which prevent any movement of the members. Some trusses are designed with a 2 by 4 inch soffit return at the end of each upper chord to provide nailing for the soffit of a wide box cornice.

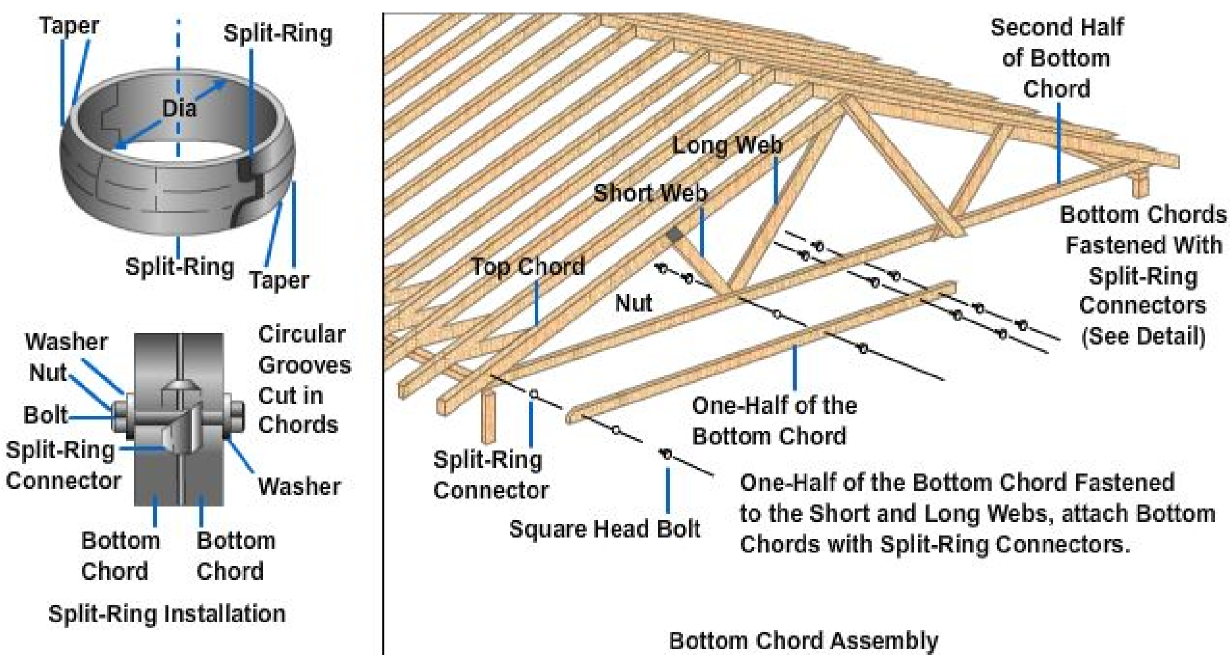


Figure 10-136 – Truss members fastened together with split-ring connectors.

8.2.2 Tension and Compression

Each part of a truss is in a state of either tension or compression. The parts in a state of tension are subjected to a pulling apart force. Those under compression are subjected to a pushing together force. The balance of tension and compression gives the truss its ability to carry heavy loads and cover wide spans.

In *Figure 10-137 view A*, the ends of the two top chords (A-B and A-C) are being pushed together (compressed). The bottom chord prevents the lower ends (B and C) of the top chords from pushing out; therefore, the bottom chord is in a pulling apart state (tension). Because the lower ends of the top chords cannot pull apart, the peak of the truss (A) cannot drop down.

In *view B*, the long webs are secured to the peak of the truss (A) and also fastened to the bottom chord at points D and E. This gives the bottom chord support along the outside wall span. The weight of the bottom chord has a pulling apart effect (tension) on the long webs.

In *view C*, the short webs run from the intermediate points F and G of the top chord to points D and E of the bottom chord. Their purpose is to provide support to the top chord. This exerts a downward, pushing together force (compression) on the short web.

In *view D*, you can see that the overall design of the truss roof transfers the entire load (roof weight, snow load, wind load, and so forth) down through the outside walls to the foundation.

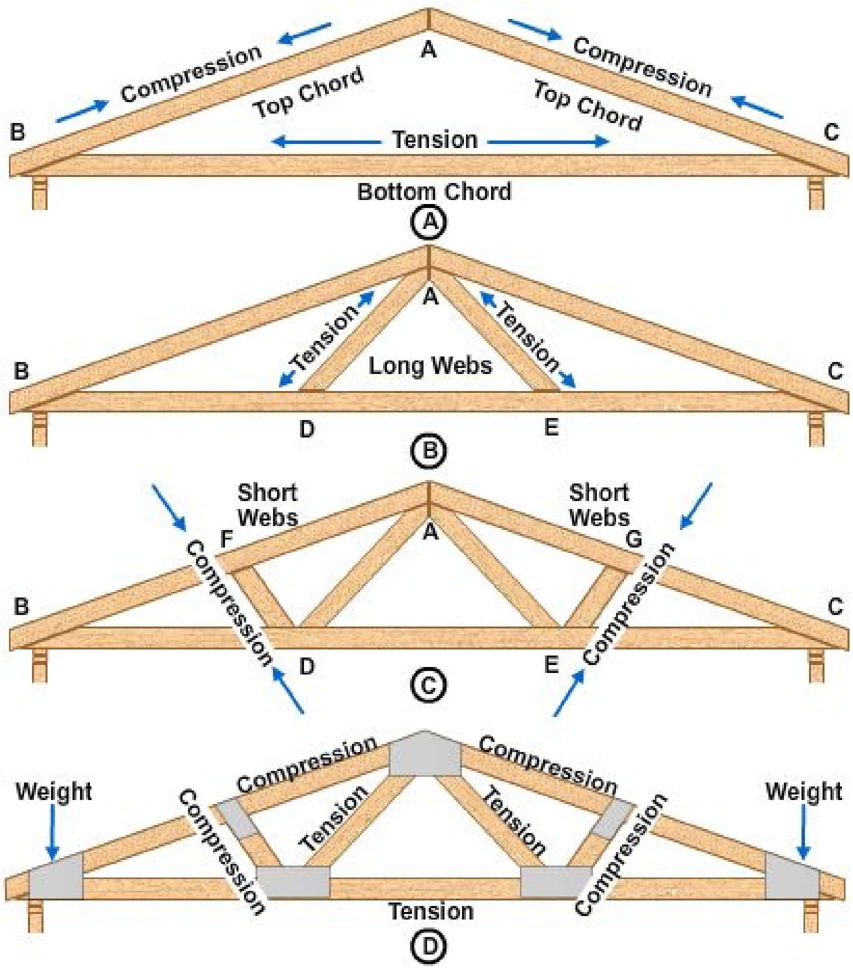


Figure 10-137 – Tension and compression in a truss.

Web members must be fastened at certain points along the top and bottom chords in order to handle the stress and weight placed upon the truss. *Figure 10-138* shows a typical layout for a W-type (fink) truss. The points at which the lower ends of the web members fasten to the bottom chord divide the bottom chord into three equal parts. Each short web meets the top chord at a point that is one-fourth the horizontal distance of the bottom chord.

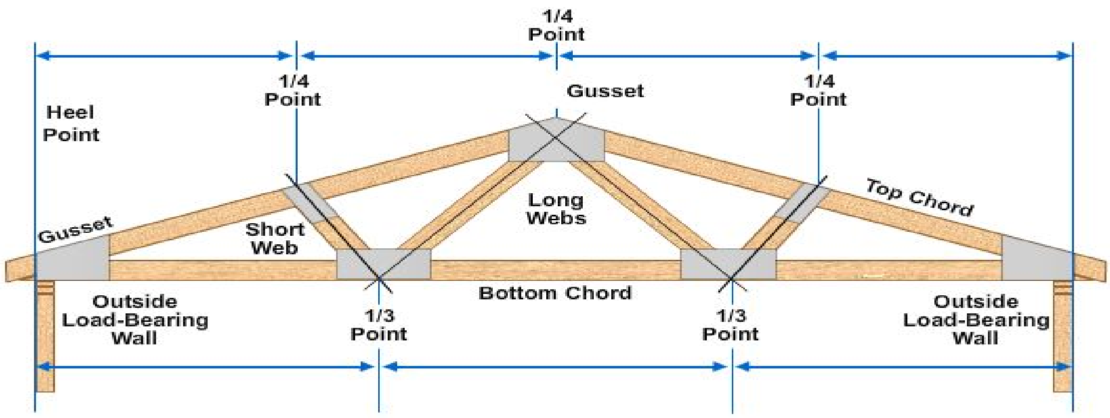


Figure 10-138 – Layout for a W-type (fink) truss.

8.3.0 Fabrication

The construction features of a typical W-truss are shown in *Figure 10-138*. Also shown are gusset cutout sizes and nailing patterns for nail gluing. The span of this truss is 26 feet and roof cut is 4/12. When spaced 24 inches apart and made of good quality 2 by 4 inch members, the trusses should be able to support a total roof load of 40 pounds per square foot.

Gussets for light wood trusses are cut from 3/8 or 1/2 inch standard plywood with an exterior glue line, or from sheathing grade exterior plywood. Glue is spread on the clean surfaces of the gussets and truss members. Staples are used to supply pressure until the glue is set. Under normal conditions and where the relative humidity of air in attic spaces tends to be high, resorcinol glue is applied. In areas of low humidity, a casein or similar glue is used. Two rows of 4d nails are used for either the 3/8 or 1/2 inch thick gusset. The nails are spaced so that they are 3 inches apart and 3/4 inches from the edges of the truss members. Gussets are nail glued to both sides of the truss.

Plywood gusset, king-post trusses are limited to spans of 26 feet or less if spaced 24 inches apart and fabricated with 2 by 4 inch members and a 4/12 roof cut. The spans are somewhat less than those allowed for W-trusses having the same sized members. The shorter span for the king-post truss is due, in part, to the unsupported upper chord. On the other hand, because it has more members than the king-post truss and distances between connections are shorter, the W-truss can span up to 32 feet without intermediate support, and its members can be made of lower grade lumber.

8.4.0 Installation

Trusses are usually spaced 24 inches OC. They must be lifted into place, fastened to the walls, and braced. Small trusses can be placed by hand using the procedure shown in *Figure 10-139*. Builders are required on the two opposite walls to fasten the ends of the trusses. One or two workers on the floor below can push the truss to an upright position. If appropriate equipment is available, use it to lift trusses into place.

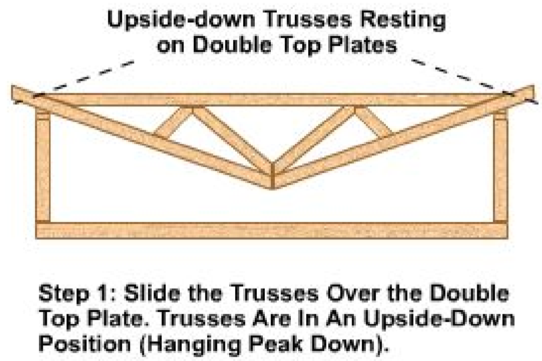


Figure 10-139 – Placing trusses by hand.

In handling and storing completed trusses, avoid placing unusual stresses on them. They were designed to carry roof loads in a vertical position; it is important that they be lifted and stored upright. If they must be handled in a flat position, use enough support along their length to minimize bending deflections. Never support the trusses only at the center or only at each end when they are in a flat position.

8.4.1 Bracing

After the truss bundles have been set on the walls, move them individually into position, nail them down, and temporarily brace them. Without temporary bracing, a truss may topple over, cause damage to the truss, and possibly injure workers. *Figure 10-140* shows a recommended procedure for bracing trusses as they are being set in place. Refer to the figure as you study the following steps:

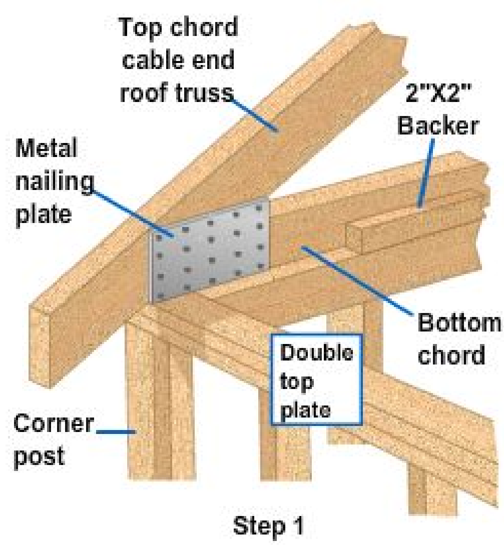


Figure 10-140 – Installing roof trusses and temporary bracing.

1. Position the first roof truss. Fasten it to the double top plate with toenails or metal anchor brackets. A 2 by 2 inch backer piece is sometimes used for additional support.
2. Fasten two 2 by 4 braces to the roof truss. Drive stakes at the lower ends of the two braces. Plumb the truss and fasten the lower ends of the braces to the stakes driven into the ground.
3. Position the remaining roof trusses. As each truss is set in place, fasten a lateral brace to tie it to the preceding trusses. Use 1 by 4 or 2 by 4 material for lateral braces. They should overlap a minimum of three trusses. On larger roofs, diagonal bracing should be placed at 20 foot intervals.

Remove the temporary bracing as you nail the roof sheathing. Properly nailed plywood sheathing is sufficient to tie together the top chords of the trusses. Permanent lateral bracing of 10 by 4 inch material is recommended at the bottom chords as shown in *Figure 10-141*. Tie the braces to the end walls and space them 10 feet OC.

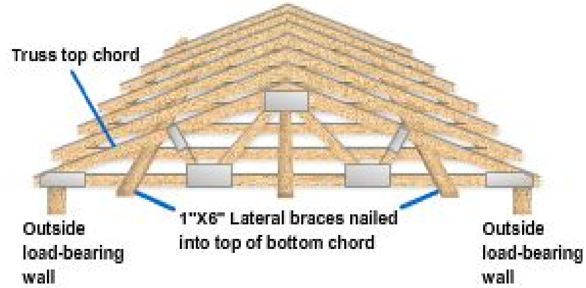


Figure 10-141 – Permanent lateral bracing in a truss.

8.4.2 Anchoring Trusses

When fastening trusses, you must consider resistance to uplift stresses as well as thrust. Trusses are fastened to the outside walls with nails or framing anchors. The ring-shank nail provides a simple connection that resists wind uplift forces. Toenailing is sometimes done, but this is not always the most satisfactory method. The heel gusset and a plywood gusset or metal gusset plate are located at the wall plate and make toenailing difficult. Two 10d nails on each side of the truss, as shown in *Figure 10-142, view A*, can be used in nailing the lower chord to the plate. Predrilling may be necessary to prevent splitting. Because of the single member thickness of the truss and the presence of gussets at the wall plates, it is usually a good idea to use some type of metal connector to supplement the toenailings.

The same types of metal anchors shown in *Figure 10-142, view B* used to tie regular rafters to the outside walls are equally effective for fastening the ends of the truss. The brackets are nailed to the wall plates at the side and top with 8d nails and to the lower chords of the truss with 6d or 1 1/2 inch rooting nails.

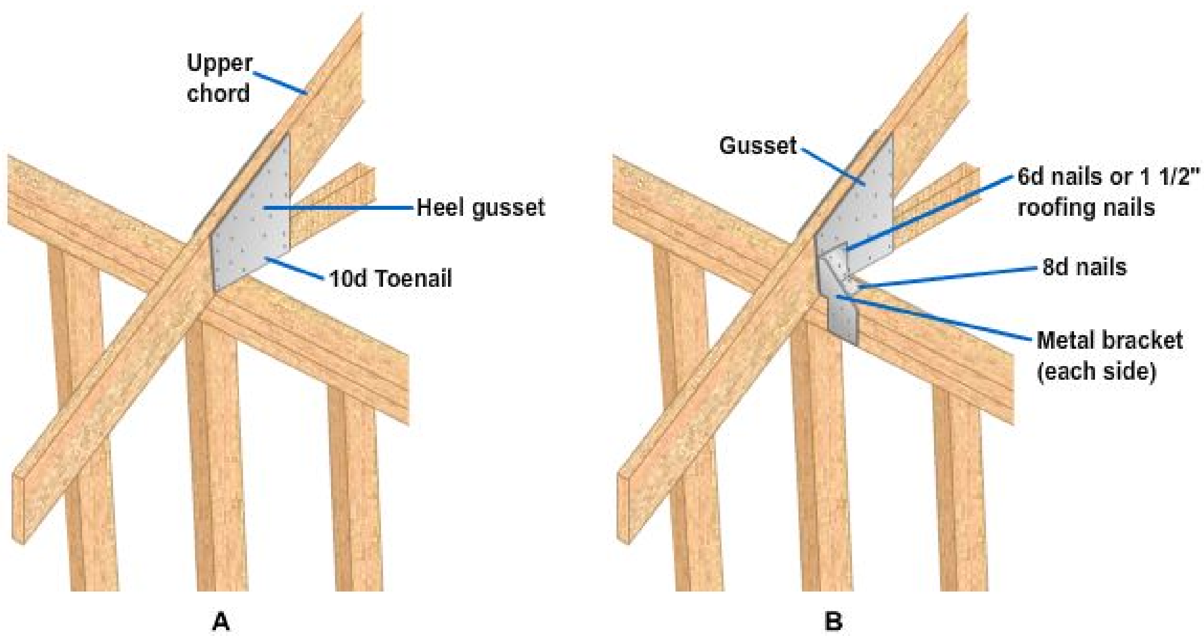


Figure 10-142 – Fastening trusses to the plate
A. Toenailing
B. Metal bracket.

8.5.0 Interior Partition Installation

Where partitions run parallel to, but between, the bottom truss chords, and the partitions are erected before the ceiling finish is applied, install 2 by 4 inch blocking between the lower chords as shown in *Figure 10-143*. Do not space this blocking over 4 feet OC. Nail the blocking to the chords with two 16d nails in each end. To provide nailing for lath or wallboard, nail a 10 by 6 inch or 2 by 6 inch continuous backer to the blocking. Set the bottom face level with the bottom of the lower truss chords.

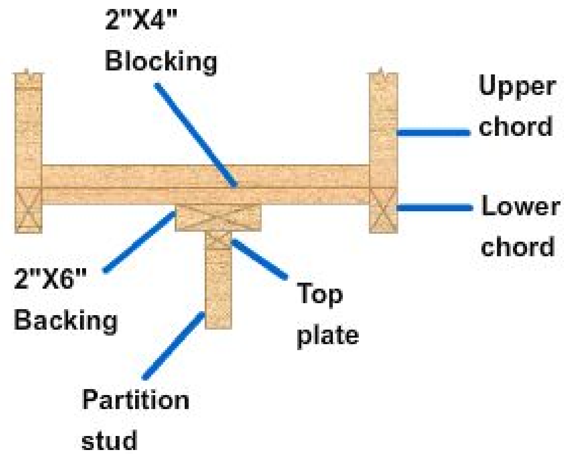


Figure 10-143 – Construction details for partitions that run parallel to the bottom truss chords.

When erecting partitions before the ceiling finish is applied, set 2 by 4 inch blocking with the bottom edge level with the bottom of the truss chords. Nail the blocking with two 16d nails in each end.

If the partitions run at right angles to the bottom of the truss chords, nail the partitions directly to lower chord members. For applying ceiling finish, nail 2 by 6 inch blocking on top of the partition plates between the trusses as shown in *Figure 10-144*.

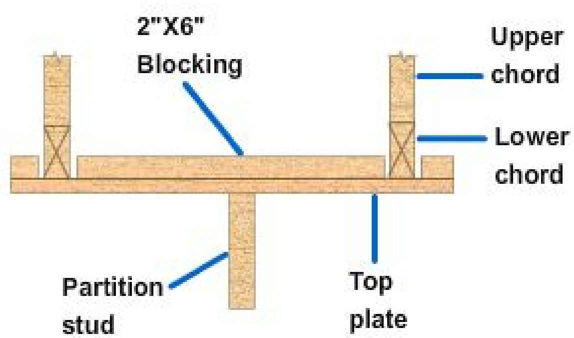


Figure 10-144 – Construction details for partitions that run at right angles to the bottom of the truss chords.

Test your Knowledge

15. Which of the following features is used to support loads over a long span without intermediate support or supports?

    A. Dormer
    B. Valley rafter
    C. Roof truss
    D. Common rafter

9.0.0 FRAMING STAIRS

There are many different kinds of interior and exterior stairs, each serving the same purpose, the movement of personnel and products from one floor to another. All stairs have two main parts, called treads and stringers. The underside of a simple stairway, consisting only of stringers and treads, is shown in *Figure 10-145, view A*. Treads of the type shown are called plank treads. This simple type of stairway is called a cleat stairway because of the cleats attached to the stringers to support the treads.

A more finished type of stairway has the treads mounted on two or more sawtooth-edged stringers, and includes risers, as shown in *Figure 10-145, view B*. The stringers shown are cut from solid pieces of dimensional lumber, usually 2 by 12s, and are called cutout, or sawed, stringers.

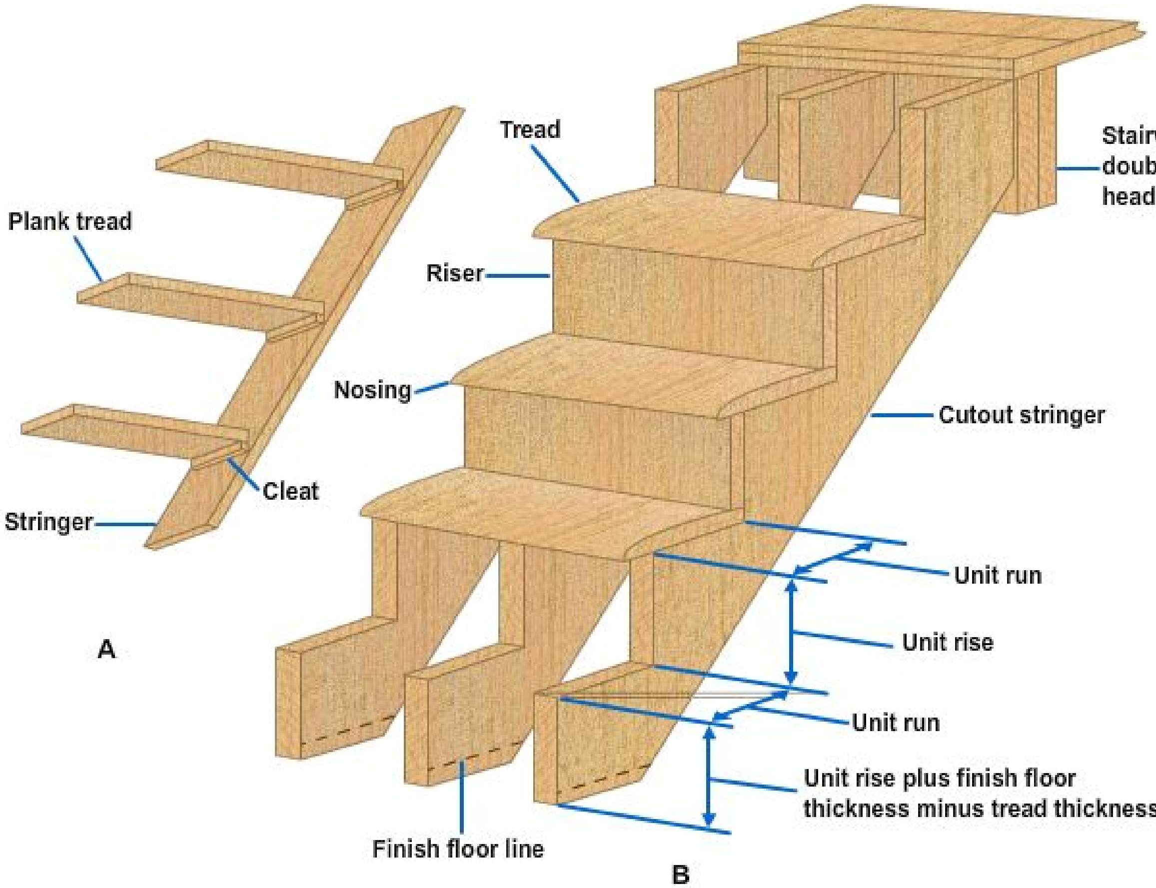


Figure 10-145 – Stairways.

9.1.0 Stairway Layout

The first step in stairway layout is to determine the unit rise and unit run as shown in *Figure 10-145, view B*. The unit rise is calculated on the basis of the total rise of the stairway, and the fact that the customary unit rise for stairs is 7 inches.

The total rise is the vertical distance between the lower finish floor level and the upper finish floor level. This may be shown in the elevations. Since the actual vertical distance as constructed may vary slightly from that shown in the plans, the distance should be measured.

At the time stairs are laid out, only the subflooring is installed. If both the lower and the upper floors are to be covered with finish flooring of the same thickness, the measured vertical distance from the lower subfloor surface to the upper subfloor surface will be the same as the eventual distance between the finish floor surfaces. The distance is equal to the total rise of the stairway. But if you are measuring up from a finish floor, such as a concrete basement floor, then you must add to the measured distance the thickness of the upper finish flooring to get the total rise of the stairway. If the upper and lower finish floors will be of different thickness, then you must add the difference in thickness to the measured distance between subfloor surfaces to get the rise of the stairway. To measure the vertical distance, use a straight piece of lumber plumbed in the stair opening with a spirit level.

Assume that the total rise measures 8 feet 11 inches, as shown in *Figure 10-146*. Knowing this, you can determine the unit rise as follows:

1. Reduce the total rise to inches; in this case it comes to 107 inches.
2. Divide the total rise in inches by the average unit rise, which is 7 inches. The result, disregarding any fraction, is the number of risers the stairway will have, in this case, 107/7 or 15.
3. Divide the total rise in inches by the number of risers, in this case, 107/15, or nearly 7 1/8 inches. This is the unit rise, as shown in *Figure 10-146*.

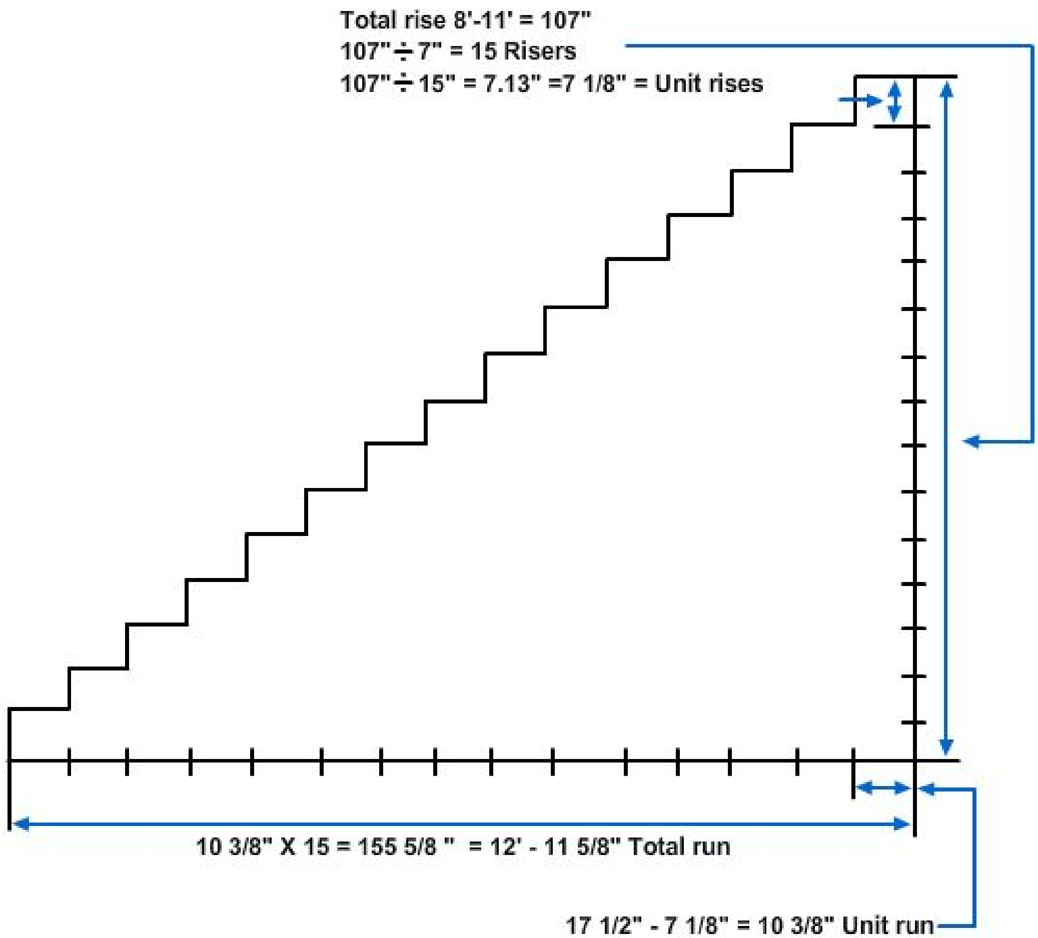


Figure 10-146 – Unit rise and run.

The unit run is calculated on the basis of the unit rise and a general architect's rule that the sum of the unit run and unit rise should be 17 1/2 inches. By this rule, the unit run is 17 1/2 inches minus 7 1/8 inches or 10 3/8 inches.

You can now calculate the total run of the stairway. The total run is the unit run multiplied by the total number of treads in the stairway. The total number of treads depends upon the manner in which the upper end of the stairway will be anchored to the header.

Figure 10-147 shows three methods of anchoring the upper end of a stairway. In *view A*, there is a complete tread at the top of the stairway. This means the number of complete treads is the same as the number of risers. For the stairway shown in *Figure*

10-146, there are 15 risers and 15 complete treads. The total run of the stairway is equal to the unit run times 15, or 12 feet 11 5/8 inches.

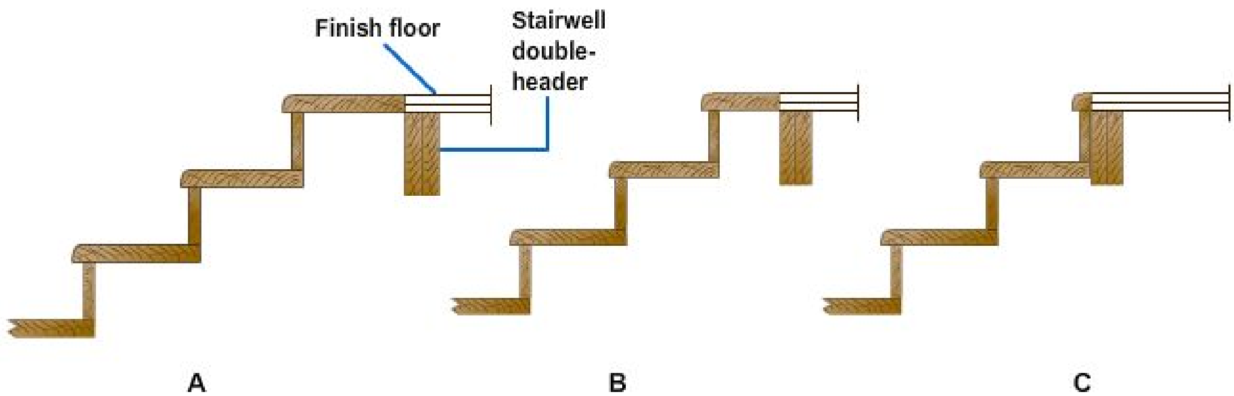


Figure 10-147 – Anchoring upper end of a stairway.

In *view B*, only part of a tread is at the top of the stairway. If this method were used for the stairway shown in *Figure 10-146*, the number of complete treads would be one less than the number of risers, or 14. The total run of the stairway would be the product of 14 multiplied by 10 3/8, plus the run of the partial tread at the top. Where this run is 7 inches, for example, the total run equals 152 1/4 inches, or 12 feet 8 1/4 inches.

In *view C*, there is no tread at all at the top of the stairway. The upper finish flooring serves as the top tread. In this case, the total number of complete treads is again 14, but since there is no additional partial tread, the total run of the stairway is 14 times 10 3/8 inches, or 145 1/4 inches, or 12 feet 1 1/4 inches.

When you have calculated the total run of the stairway, drop a plumb bob from the header to the floor below and measure off the total run from the plumb bob. This locates the anchoring point for the lower end of the stairway.

As mentioned earlier, cutout stringers for main stairways are usually made from 2 by 12 stock. Before cutting the stringer, first solve for the length of stock you need.

Assume that you are to use the method of upper end anchorage shown in *view A* of *Figure 10-147* to lay out a stringer for the stairway shown in *Figure 10-146*. This stairway has a total rise of 8 feet 11 inches and a total run of 12 feet 11 5/8 inches. The stringer must be long enough to form the hypotenuse of a triangle with sides of those two lengths. For an approximate length estimate, call the sides 9 and 13 feet long. Then the length of the hypotenuse will equal the square root of 92 plus 132. This is the square root of 250, about 15.8 feet or 15 feet 9 1/2 inches.

Extreme accuracy is required in laying out the stringers. Be sure to use a sharp pencil or awl and make the lines meet on the edge of the stringer material.

Figure 10-148 shows the layout at the lower end of the stringer. Set the framing square to the unit run on the tongue and the unit rise on the blade, and draw the line AB. This line represents the bottom tread. Then, draw AD perpendicular to AB. Its length should be equal to the unit rise. This line represents the bottom riser in the stairway. You may have noticed that the thickness of a tread in the stairway has been ignored. This thickness is now about to be accounted for by making an allowance in the height of this first riser. This process is called dropping the stringer.

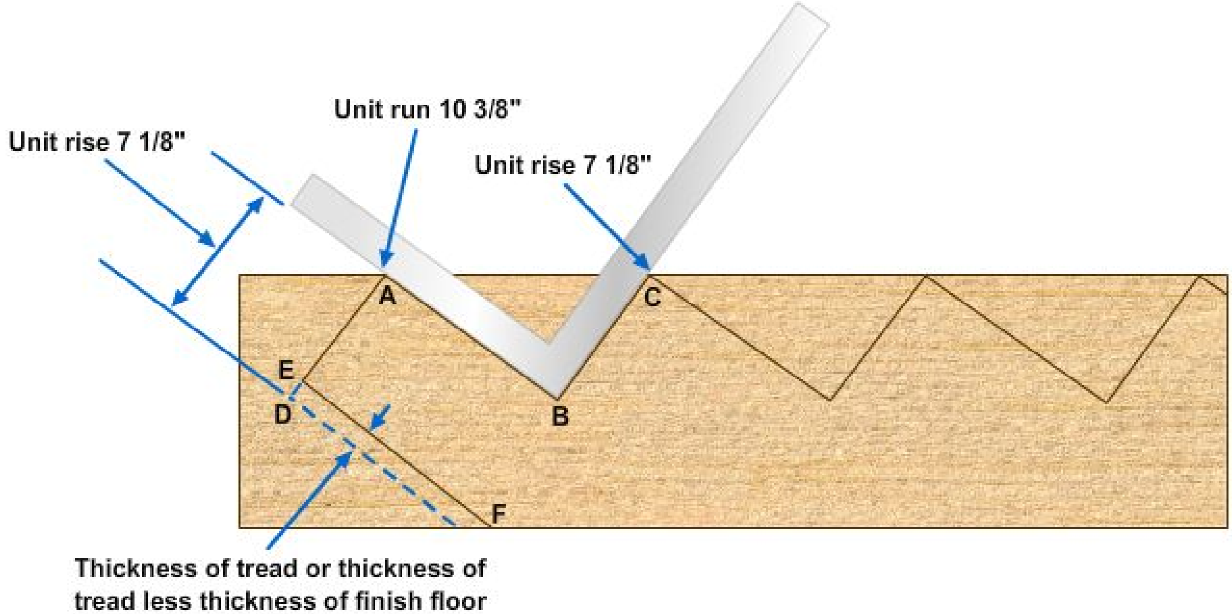


Figure 10-148 – Layout of lower end of cutout stringer.

As you can see in *Figure 10-145, view B*, the unit rise is measured from the top of one tread to the top of the next for all risers except the bottom one. For the bottom riser, unit rise is measured from the finished floor surface to the surface of the first tread. If AD were cut to the unit rise, the actual rise of the first step would be the sum of the unit rise plus the thickness of a tread. Therefore, the length of AD is shortened by the thickness of a tread, as shown in *Figure 10-148*, or by the thickness of a tread less the thickness of the finish flooring. The first is done if the stringer rests on a finish floor, such as a concrete basement floor. The second is done where the stringer rests on subflooring.

When you have shortened AD to AE, draw EF parallel to AB. This line represents the bottom horizontal anchor edge of the stringer. Then proceed to lay off the remaining risers and treads to the unit rise and unit run until you have laid off 15 risers and 15 treads. *Figure 10-149* shows the layout at the upper end of the stringer. The line AB represents the top, the 15th tread. BC, drawn perpendicular to AB, represents the upper vertical anchor edge of the stringer. This edge butts against the stairwell header.

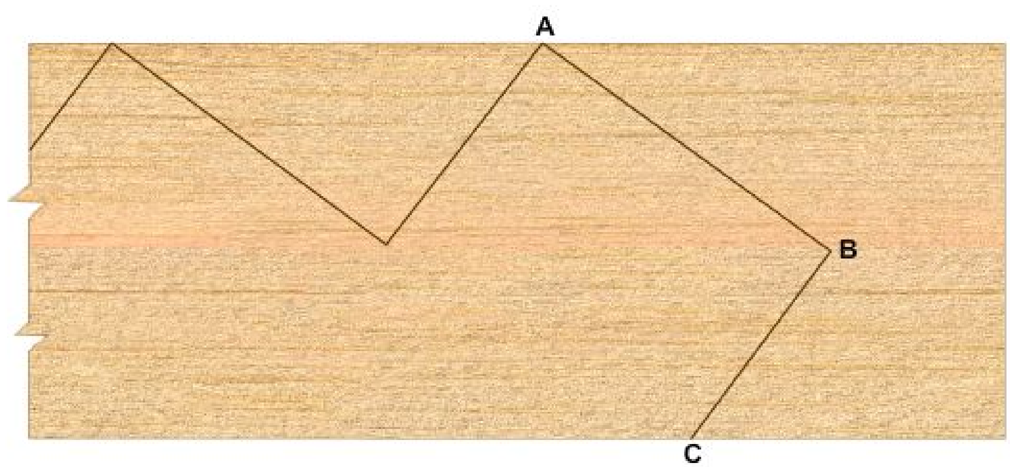


Figure 10-149 – Layout of upper end of cutout stringer.

In a given run of stairs, be sure to make all the risers the same height and treads the same width. An unequal riser, especially one that is too high, is dangerous.

9.2.0 Stairway Construction

We have been dealing with a common straight flight stairway, meaning one which follows the same direction throughout. When floor space is not extensive enough to permit construction of a straight flight stairway, a change stairway is installed, meaning one which changes direction one or more times. The most common types of these are a 90° change and a 180° change. These are usually platform stairways, successive straight flight lengths, connecting platforms at which the direction changes 90° or doubles back 180°. Such a stairway is laid out simply as a succession of straight flight stairways.

When dealing with stairs, it is vitally important to remember the allowable head room. Head room is defined as the minimum vertical clearance required from any tread on the stairway to any part of the ceiling structure above the stairway. In most areas, the local building codes specify a height of 6 feet 8 inches for main stairs, and 6 feet 4 inches for basement stairs.

The stairs in a structure are broadly divided into principal stairs and service stairs. Service stairs are porch, basement, and attic stairs. Some of these may be simple cleat stairways, others may be open riser stairways. An open riser stairway has treads anchored on cutout stringers or stair block stringers, but no risers. The lower ends of the stringers on porch, basement, and other stairs anchored on concrete are fastened with a kickplate as shown in *Figure 10-150*.

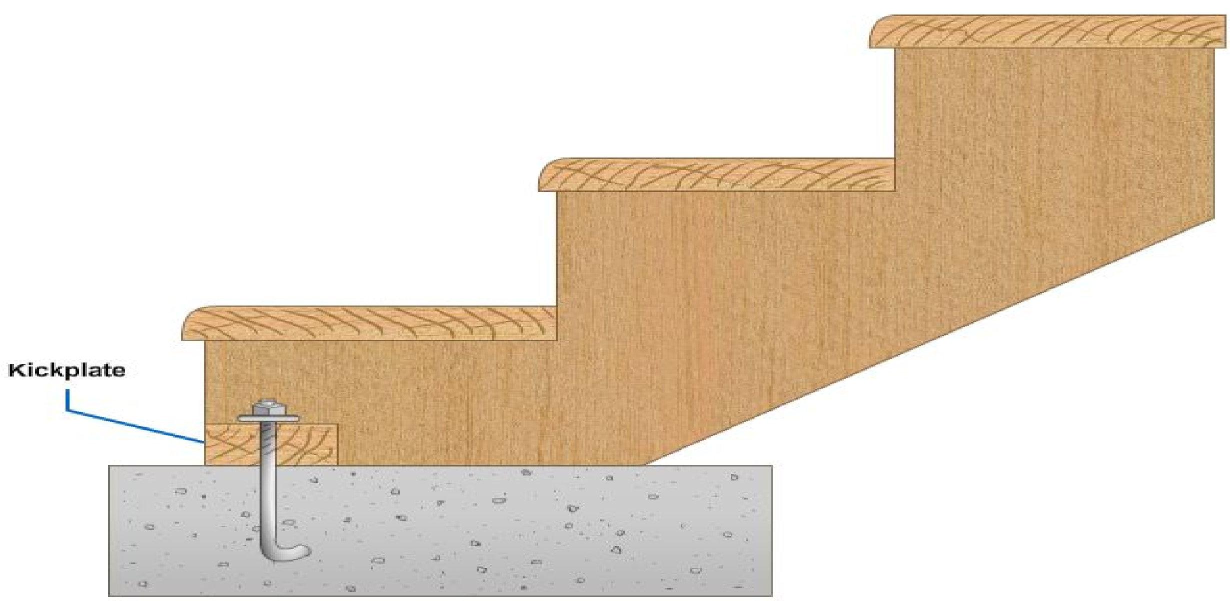


Figure 10-150 – Kickplate for anchoring stairs to concrete.

A principal stairway usually has a finished appearance. Rough cutout stringers are concealed by finish stringers as shown in *Figure 10-151*.

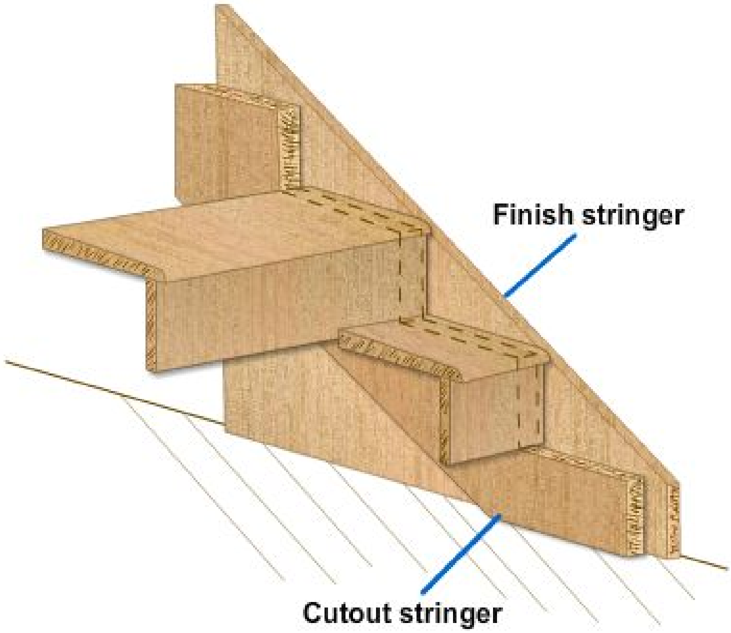


Figure 10-151 – Finish stringer.

Treads and risers are often rabbet jointed as in *Figure 10-152*.

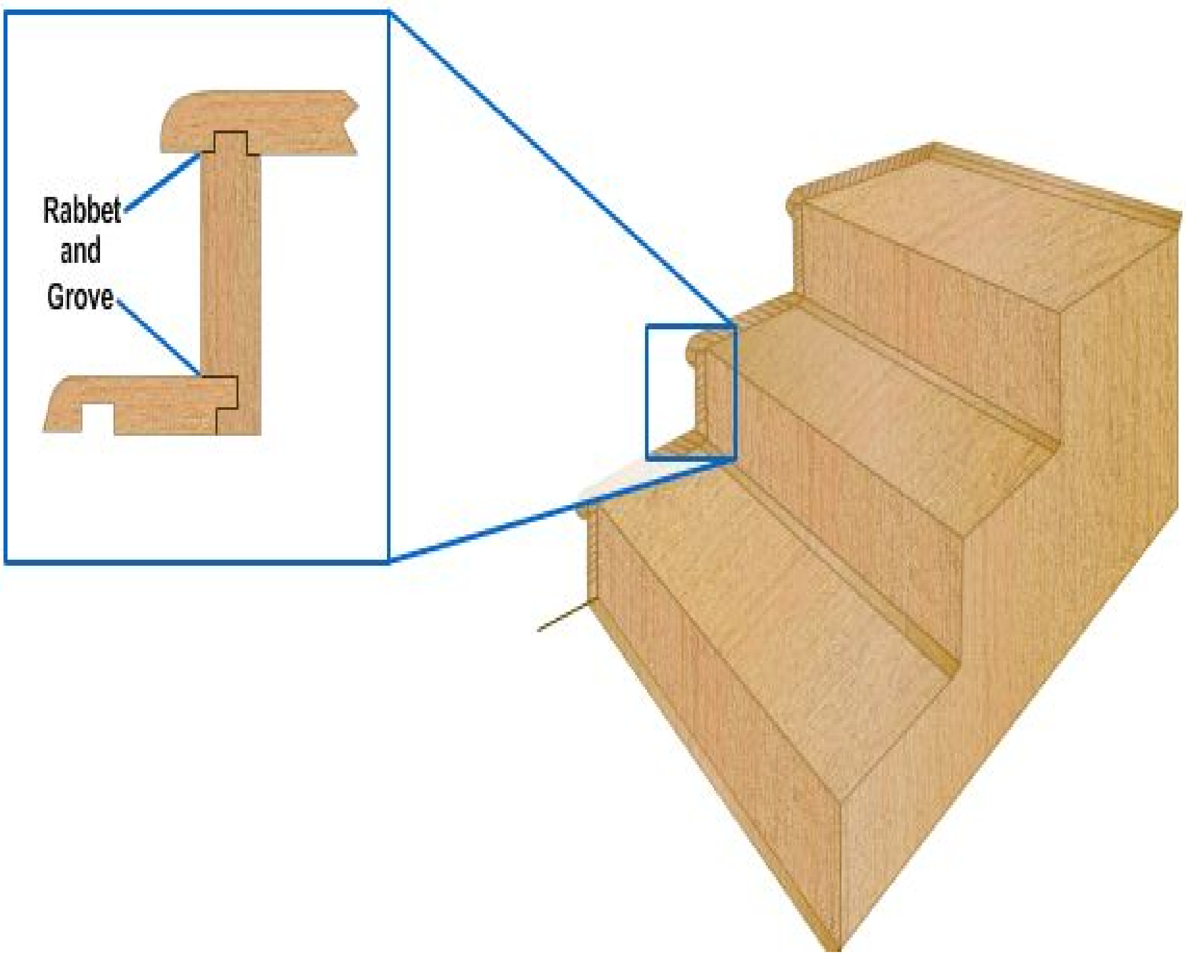


Figure 10-152 – Rabbet-and-groove-jointed treads and risers.

Vertical members that support a stairway handrail are called balusters. *Figure 10-153* shows a method of joining balusters to treads. Dowels shaped on the lower ends of the balusters are glued into holes bored in the treads.

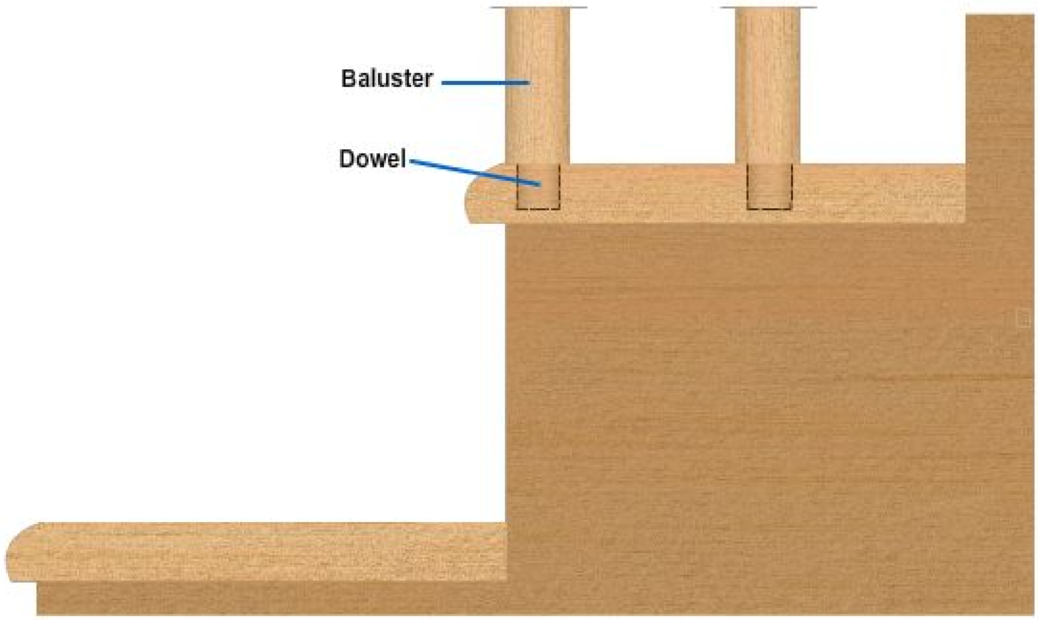


Figure 10-153 – Joining a baluster to the tread.

Stringers should be toenailed to stairwell double headers with 10d nails, three to each side of the stringer. Those which face against trimmer joists should each be nailed to the joists with at least three 16d nails. At the bottom, a stringer should be toenailed with 10d nails, four to each side, driven into the subflooring and, if possible, into a joist below.

Treads and risers should be nailed to stringers with 6d, 8d, or 10d finish nails, depending on the thickness of the stock.

Summary

In this chapter you learned about framing the various components of a building. You learned that sill framing is placed on the foundation, and floor framing is placed after the sill framing. Wall framing is built on top of the floor framing, then raised and aligned. Once the wall framing is in place, you construct and place the ceiling framing, which can also be the bottom of the roof framing. You learned how to use the framing square to calculate and measure cuts for the roof framing. Roof framing and/or roof trusses are the last main part of framing a building. Framing stairs is important in buildings with more than one floor.

Review Questions (Select the Correct Response)

1. The edge of a sill is usually set back from the outside edge of the foundation by what distance?

   A. The thickness of the sheathing
   B. The thickness of the header joist
   C. The thickness of the siding
   D. Twice the thickness of the sheathing

2. After bolt holes are drilled and the sill properly fitted, what is normally the next step?

   A. Install the header joist.
   B. Place the sill sealer.
   C. Install the floor joists.
   D. Install the washers and nuts.

3. **(True or False)** When information is not provided in the specifications, anchor bolt spacing is normally 6 feet.

   A. True
   B. False

4. Which of the following items is/are considered a dead load?

   A. Furniture
   B. Floor joists
   C. Appliances
   D. People

5. **(True or False)** Header joists prevent common joists from rolling or tipping.

   A. True
   B. False

6. Which of the following joist types is used when a joist projects out over the wall below?

   A. Common
   B. Trimmer
   C. Cantilevered
   D. Cripple

7. Which of the following joist spans requires more than one row of bridging?

   A. 16 feet
   B. 14 feet
   C. 12 feet
   D. 10 feet

8. When installed in a straight line, which of the following bridging types provides an additional nailing base for the subfloor?

   A. Diagonal
   B. Heringbone
   C. Solid
   D. Cross

9. **(True or False)** Floor joists are always placed 16 inches OC.

   A. True
   B. False

10. When joists are laid out 16 inches OC, the distance from the edge of the building to the first joist should be

    A. 14 1/2 inches
    B. 15 1/4 inches
    C. 16 inches
    D. 16 3/4 inches

11. A pair of joists placed at each end of an opening and supporting a header is called what type of joist?

    A. Trimmer
    B. Double
    C. Tail
    D. Common

12. When placing a joist, the crown should be turned in what direction?

    A. Left
    B. Right
    C. Down
    D. Up

13. **(True or False)** Any board can be used as a joist regardless of the size of the crown.

    A. True
    B. False

14. Plywood subflooring with an index mark of 32/16 can be used over what maximum OC joist spacing?

    A. 48 inches
    B. 32 inches
    C. 24 inches
    D. 16 inches

15. A header is supported by which of the following studs?

    A. Trimmer
    B. Cripple
    C. Common
    D. Header

16. What is the standard wall height in wood framed construction?

    A. 7 feet 10 inches
    B. 8 feet
    C. 8 feet 1 inch
    D. 8 feet 6 inches

17. What type of wall strength is increased by diagonal bracing?

    A. Lateral
    B. Compressive
    C. Tensile
    D. Flexural

18. Which of the following is the strongest type of diagonal bracing?

    A. Cut-in bracing
    B. Let-in bracing
    C. Diagonal sheathing
    D. Horizontal bracing

19. Diagonal bracing is most effective when installed at which of the following angles?

    A. 25º to 35º
    B. 45º to 60º
    C. 65º to 75º
    D. 80º to 90º

20. What is/are the main purpose(s) of a fire stop in a wall?

    A. Slow the travel of fire inside a wall only
    B. Provide additional backing for nailing the edges of dry wall or plywood only
    C. Both A and B above
    D. Stop a fire inside a wall

21. The locations of walls constructed in the horizontal plate layout method are found in which of the following sources?

    A. Floor plans
    B. Specifications
    C. Table of measures
    D. Measurement-conversion chart

22. When laying out studs 16 inches OC, why should you place the first stud 15 1/4 inches from the corner?

    A. To allow for the corner post
    B. To provide additional nailing surface for sheathing
    C. To allow for 3/4 inch error when laying off the remaining studs
    D. To allow for the sheathing edges to fall on the centers of the studs

23. To determine the lengths of studs, cripples, and trimmers, you should use which of the following layouts?

    A. Vertical
    B. Horizontal
    C. Wall
    D. Top plate

24. The measurement from the subfloor to the bottom of the door header can also be used to establish which of the following measurements?

    A. Rough opening width for door openings
    B. Rough opening height for windowsills
    C. Rough opening height for window openings
    D. Overall wall height

25. Which way should the crown of a stud be turned on an exterior wall?

    A. Up
    B. Down
    C. Side

26. The minimum distance between butt joints in the top plate and the double top plate should be

    A. 24 inches
    B. 32 inches
    C. 48 inches
    D. 96 inches

27. What is the recommended order in raising walls?

    A. Long exterior, short exterior, partitions
    B. Partitions, long exterior, short exterior
    C. Short exterior, long exterior, partitions
    D. Long exterior, partitions, short exterior

28. To accurately plumb a wall, you need which of the following tools?

    A. Straightedge only
    B. Level only
    C. Straightedge and level
    D. Plumb

29. What size nail is recommended for installing 5/8 inch sheathing?

A. 4d
B. 6d
C. 8d
D. 10d

30. **(True or False)** When nailing plywood panels in place, you should leave gaps at the joints to allow for expansion.

A. True
B. False

31. What type of wall is usually constructed when large pipes must pass vertically through it?

A. Reinforced
B. Bearing
C. Partition
D. Chase

32. The size of a ceiling joist is determined by what two factors?

A. Height of walls and span from wall to wall
B. Weight it must carry and span from wall to wall
C. Height of bearing wall and OC spacing
D. OC spacing and span from wall to wall

33. **(True or False)** All joists must run in the same direction.

A. True
B. False

34. Ceiling joists supported by a bearing partition should overlap what minimum distance?

A. 16 inches
B. 12 inches
C. 8 inches
D. 4 inches

35. Double joists and headers are required when an attic scuttle is larger than what minimum size?

A. 5 feet by 5 feet
B. 2 feet by 2 feet
C. 3 feet by 3 feet
D. 4 feet by 4 feet

36. **(True or False)** When placing anchor bolts in a reinforced concrete wall, the bolt should be embedded at least 7 inches.

A. True
B. False

37. Which of the following statements is generally true of wood posts?

A. They are placed directly below wood girders.
B. The width of the post should be equal to the girder it supports.
C. They are always embedded in concrete.

38. The crawl space for a structure should have what minimum distance between the ground and the bottom of the girder?

A. 24 inches
B. 18 inches
C. 16 inches
D. 12 inches

39. In platform framing, a floor joist rests directly on which of the following components?

A. Top plate only
B. Sill plate only
C. Either A or B above
D. Exterior foundation

40. What is the recommended method for connecting header and floor joists?

A. Face-nailing with 12d nails
B. Face-nailing with 16d nails 16 inches OC
C. Face-nailing with 10d nails 16 inches OC
D. End nailing with 16d nails

41. What is the correct sequence for securing a subfloor and cross bridging to the floor joists?

A. Nail the subfloor, then the top and bottom of the bridging.
B. Nail the top of the bridging, then the subfloor, and finally the bottom of the bridging.
C. Nail the top and bottom of the bridging, then the subfloor.
D. Nail the bottom of the bridging, then the subfloor, and finally the top of the bridging.

42. Bottom plate layout should include marks for which of the following framing members?

A. Floor joists only
B. Corner posts only
C. Header joists only
D. All of the above

43. Temporary bracing used for wall alignment should be removed at what point during construction?

A. After wall alignment is completed
B. After exterior sheathing is completed
C. Before the ceiling joists are placed
D. After all framing and sheathing are completed

44. What is the main structural function of a ceiling frame?

A. Support the finished ceiling
B. Support the top of nonbearing partitions walls
C. Tie the exterior walls together
D. Support the weight of the rafters

45. To align ceiling joists in an unfinished attic, what type of structural member should you use?

A. Ribbon board
B. Ledger
C. Strongback
D. Ridge beam

46. Which of the following types of roof is the most commonly used in the Navy?

A. Shed
B. Hip
C. Gable
D. Gable and valley

47. Which of the following types of roof is considered strongest?

A. Shed
B. Hip
C. Gable
D. Gable and valley

48. A roof having only one slope is considered what type?

A. Shed
B. Hip
C. Gable
D. Gable and valley

49. In roof construction, the ratio of unit of rise to unit of span is known by what term?

A. Total run
B. Line length
C. Total rise
D. Pitch

50. In roof construction, the hypotenuse of a triangle whose base altitude equals the total rise is known by what term?

A. Total run
B. Line length
C. Total rise
D. Span

51. What members make up the main body of a roof framework?

A. Double top plates
B. Joists
C. Ceiling framework
D. Rafters

52. **(True or False)** Rafters are a functional part of both walls and roof.

A. True
B. False

53. What type of rafter does not extend the full distance from the plate to the ridgeboard?

A. Jack
B. Valley
C. Hip
D. Common

54. What type of jack is nailed between hip and valley rafters?

A. Valley
B. Cripple
C. Hip
D. Eave

55. Which of the following terms describe(s) that portion of a rafter extending beyond the outer edge of the plate?

A. Eave only
B. Tail only
C. Overhang only
D. All of the above

56. **(True or False)** The hypotenuse is the longest side of a right triangle.

A. True
B. False

57. Which of the following framing square scales is NOT used in roof framing?

A. Octagon
B. Hundredths
C. Tenths
D. Twelfths

58. On a framing square, the longest lines on the hundredths scale indicate how many hundredths of an inch?

A. 5
B. 10
C. 25
D. 50

59. How many tables does a framing square have?

A. One
B. Two
C. Three
D. Four

60. Which of the following framing square features is primarily used for estimating board feet?

A. Brace table
B. Essex-board table
C. Rafter table
D. Octagon scale

61. On a framing square, where is the brace table located?

A. Back of the blade
B. Face of the blade
C. Face of the tongue
D. Back of the tongue

62. Which of the following scales on a framing square is graduated in inches and provides various shortcuts in problem solving?

A. Tenths
B. Twelfths
C. Hundredths
D. Octagon

63. The run of the overhang should be measured between what two points?

A. From the top plate to the bottom of the ridgeboard
B. From the building line to the plumb line of the ridgeboard
C. From the building line to the tail cut on the rafter
D. From the ridgeboard to the tail cut on the rafter

64. The length of a rafter from the heel plumb line to the shortened plumb line is known as what type?

A. Actual
B. Theoretical
C. Line
D. Common

65. What angle should a hip rafter form with the building line?

A. 90º
B. 60º
C. 45º
D. 30º

66. **(True or False)** The unit of rise is always the same for hip and common rafters, but the unit of run for a hip rafter is different.

A. True
B. False

67. With a hip rafter framed against a common rafter, the shortening allowance should be what dimension?

A. One half of the 45º thickness of the ridge
B. One fourth of the 45º thickness of a common rafter
C. One half of the 45º thickness of a common rafter
D. One half of the thickness of the ridge

68. What feature is required when a hip rafter joins the ridge or the ridge ends at other than 90º?

A. Bird's-mouth
B. Angle cut
C. Tail cut
D. Side cut

69. What procedure should you use on a hip rafter to keep it level with a common rafter?

A. Plane the top of the hip rafter
B. Bevel the top edges only
C. Deepen the bird's-mouth only
D. Either B or C above

70. On a gable and valley roof, the area where two or more sloped roof sections intersect is known by what term?

A. Valley
B. Ridge
C. Hip
D. Gable

71. Which of the following features can run from valley rafters to both ridges?

A. Hip jack
B. Valley jack
C. Supporting valley
D. Hip

72. Which of the following features can run at a 45º angle to the exterior walls?

A. Valley rafter
B. Hip jack
C. Supporting valley
D. Hip

73. Which of the following techniques should be used in constructing a gable and valley roof that has one long and one short valley rafter?

A. Frame both valley rafters up against the main ridge.
B. Frame both valley rafters against the instersecting ridge.
C. Frame the long valley rafter up against the intersecting ridge and the short valley rafter up against the main ridge.
D. Frame the long valley rafter up against the main ridge and the short valley rafter up against the long valley rafter.

74. What is the shortening allowance of a valley rafter when a dormer without sidewalls is framed between double headers with a combined actual thickness of 3 1/4 inches?

A. One half of the 45º thickness of the inside upper double header only
B. One half of the 45º thickness of the common rafter only
C. Both A and B above
D. One half of the total thickness of the upper and lower double headers

75. **(True or False)** In an equal pitch framing situation, the unit of rise of a jack rafter is always the same as the unit of rise of a common rafter.

A. True
B. False

76. Which of the following jack rafter types extends from a hip rafter to a valley rafter?

A. Valley
B. Cripple
C. Valley cripple
D. Hip valley cripple

77. When erecting a gable roof, what components are constructed first?

A. Cripple and jack rafters
B. Gable end rafters and the ridge
C. Hip rafters
D. Valley rafters

78. In a gable roof, why is a ridgeboard placed at the peak of the roof?

A. Provide a nailing surface for the top ends of the common rafter
B. Provide a nailing surface for one end of the common rafter
C. Provide a starting point for the peak of the roof
D. Provide the starting point for roof sheathing

79. **(True or False)** All common rafters for a gable roof are the same length.

A. True
B. False

80. Which of the following terms is another name for the notch formed by the seat and heel cut?

A. Overhang
B. Projection
C. Bird's-mouth
D. Eave

81. When installing a roof where the ridgeboard is longer than one piece, where should the break between the boards occur?

A. Between the rafters
B. Center of a rafter
C. Center of the roof
D. At the end of a rafter

82. When working with gable or double-pitch roofs which of the following is/are normally considered for additional horizontal reinforcement?

A. Ceiling joists
B. Gable studs
C. Collar ties
D. Ridgeboard

83. When framing a roof, the scaffold should be set no lower than what distance below the level of the main roof ridge?

A. 1 foot
B. 2 feet
C. 3 feet
D. 4 feet

84. Which of the following structural members connects the joints on roof trusses?

A. Gussets
B. Templates
C. Collar ties
D. Truss ties

85. **(True or False)** When working with roof trusses, double top and bottom plates on interior partitions can be eliminated.

A. True
B. False

86. What is the estimated material savings when using roof trusses?

A. 10%
B. 20%
C. 30%
D. 40%

87. Which of the following truss components acts as a ceiling joist?

A. Gusset
B. Top chord
C. Bottom chord
D. Web

88. Which of the following structural components is eliminated because trusses are self-supporting?

A. Interior bearing partitions
B. Gussets
C. Double top plates
D. Floor joists

89. In frame construction, what truss type(s) is/are most commonly used?

A. King post only
B. W-type only
C. Scissors and W-types only
D. All of the above

90. The load carried by a roof truss is directly transferred to what other structural components?

A. Floor
B. Foundation
C. Outside walls
D. Interior walls

91. Which of the following items is/are not consideration(s) in truss design?

A. Materials
B. Snow and wind loads
C. Weight of roof itself
D. Slope of roof

92. Each part of a truss is in a state of compression or tension. Which of the following states, if any, describe(s) the pushing-together force?

A. State of tension only
B. State of compression only
C. All of the above
D. None of the above

93. In what positions should trusses be (a) handled and (b) stored?

A. (a) Horizontal (b) Horizontal
B. (a) Horizontal (b) Vertical
C. (a) Vertical (b) Horizontal
D. (a) Vertical (b) Vertical

94. Which of the following features is/are necessary to resist wind uplift force?

A. Temporary bracing
B. Gussets
C. Trusses anchored to outside walls
D. Blocking at lower chords

95. **(True or False)** Toenailing is the most satisfactory method of securing a truss to an outside wall.

A. True
B. False

96. A partition can be nailed directly to the lower chord under which of the following conditions, if any?

A. A partition runs at right angles to the bottom of the truss chord
B. Partitions are erected after ceiling finish is applied
C. A partition runs parallel with the bottom chord
D. None of the above

97. What piece of a stairway, when cut from solid pieces of dimensional lumber, is called cutout, or sawed?

A. Rise
B. Run
C. Stringer
D. Tread

Trade Terms Introduced in this Chapter

Batts	Bundles of insulating material.
Bird's-mouth	A notch cut in the lower edge of a rafter to fit over the top wall plate. Formed by a level line and a plumb cut.
Bridging	Crossed or solid supports installed between joists to help evenly distribute load and brace the joists against side sway.
Cantilevered	A projecting beam supported only at one end.
Chase	A vertical recess in a wall for pipes.
Cripple	Any frame member shorter than a regular member.
Crown	The outside curve of a twisted, bowed, or cupped board.
Essex board measure	A method for rapidly calculating board feet.
Girders	Supporting beams laid crosswise to the building; long trusses.
Gussets	Plates connecting members of a truss together.
Joists	Heavy pieces of lumber laid on edge horizontally to form the floor and ceiling support system.
Pitch	The angle or inclination of a roof, expressed as a ratio of rise per run.
Racking	Being forced out of shape or out of plumb.
Rafters	Sloping roof members supporting the roof covering and extending from the ridge or the hip of the roof to the eaves.
Ridge	The long joining members placed at the angle where two slopes of a roof meet at the peak.
Rise	In a roof, the vertical distance between the plate and the ridge. In a stair, the total height of the stair.
Run	The horizontal distance between the outer face of the wall and the roof ridge.
Span	The horizontal distance between supports.
Specifications	Written instructions containing information about the materials, style, workmanship, and finish for the job.
Studs	The vertical members of wooden forms or frames.
Toenailed	A nail driven at an angle.
Trusses	A combination of members, such as beams, bars, and ties; usually arranged in triangular units to form a rigid framework for supporting loads over a span.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Basic Roof Framing, Benjamin Barnow, Tab Books, Inc., Blue Ridge Summit, Pa., 1987.

Carpentry, Leonard Koel, American Technical Publishers, Alsip, Ill., 1985.

Design of Wood Frame Structures for Permanence, National Forest Products Association, Washington, D.C., 1988.

Facilities Planning Guide, NAVFAC P-437, Naval Facilities Engineering Command, Alexandria, Va., 1982.

Means Illustrated Construction Dictionary, Smit, Kornelis & Chandler, Howard M., R. S. Means Company, Inc., Kingston, MA, 1991.

Modern Carpentry, Willis H. Wagner, Goodheart-Wilcox Co., South Holland, Ill., 1983.

Operations Officer's Handbook, COMCBPAC/COMCBLANTINST 5200.2A, Commander, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, and Commander, Naval Construction Battalions, U.S. Atlantic Fleet, Norfolk, Va., 1988.

Seabee Planner's and Estimator's Handbook, NAVFAC P-405, Chapter 5, Naval Facilities Engineering Command, Alexandria, Va., 1983.

Wood Frame House Construction, L.O. Anderson, Forest Products Laboratory, U.S. Forest Service, U.S. Department of Agriculture, Washington, D.C., 1975.

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Chapter 11

Finish Carpentry

Topics

1.0.0 Interior Door Finishes

2.0.0 Window Casing

3.0.0 Moldings

4.0.0 Millwork

To hear audio, click on the box.

Overview

Woodworking, especially finish carpentry, is one of the most visible of the Builder's trades. Quality woodworking shows in the installation of trim, casing, and molding and in cabinets and built-in furniture.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Identify interior door finish components and explain layout and installation procedures for these elements in building construction.
2. Identify window casing components and explain layout and installation for these elements in building construction.
3. Identify the types of moldings and explain layout and installation procedures for these elements.
4. Identify the types of millwork and explain layout and installation procedures for these elements.

Prerequisites

None

This course map shows all of the chapters in Builder Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.