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Structural Journeyman

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Author: MSgt Joshua Horton
366th Training Squadron
366 TRS/TRR
727 Missile Rd
Sheppard AFB, TX 76311
DSN: 736-5816
E-mail address: joshua.horton@us.af.mil

Instructional Systems Specialist: Steve McCarver

Editor: Elizabeth S. Melton

Air Force Career Development Academy (AFCDA)
The Air University (AETC)
Maxwell-Gunter Air Force Base, Alabama 36118–5643

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IN THIS VOLUME you will study carpentry related information that you will use in your future work on the job. Unit 1 addresses floor, wall, ceiling and stair construction, and inspection and repair. Unit 2 covers roof construction, inspection and repair. Unit 3 focuses on installation and maintenance of doors and windows. Unit 4 explains installing and applying energy conserving materials.

A glossary is included for your use.

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This volume is valued at 18 hours and 6 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Unit 1. Floor, Wall, Ceiling, and Stair Framing

THE STRUCTURAL CAREER field requires high skill in framing and construction. Once the foundation work is complete, the normal construction sequence is to frame the floors, walls, roof, and stairs. Except for roofs, this unit discusses the construction process for each of these. We will discuss the construction, inspection, and repair procedures for the most commonly encountered types of framing.

Framing construction includes floors, walls, ceilings, and stairs; they usually follow the foundation construction. In the following lessons, we explain the platform frame construction method for floor and wall framing members. We also provide an explanation of subflooring installation, rough openings for doors and windows, interior partitions, and exterior sheathing. Then we'll turn our attention to ceiling framing, followed by stair construction and conclude the unit with a lesson on inspection and repair.

601. Floor framing

The platform frame construction method for floors and walls begins with the sill plate, often called a *mudsill*. The sill plate is the lowest framing member that rests on the building's foundation. For some areas the sill must be made from decay resistant wood such as redwood, cedar, or pressure treated lumber. The sill plate provides a nailing base for floor joists and can be a single 2 × 6, 4 × 6, or a doubled 2 × 6. Your work in this area is critical because it affects how you install the rest of the framing.

Layout

The box sill (fig. 1–1) layout is used in most platform frame construction. It consists of a sill plate and joist header anchored to a masonry foundation. It is the framing member that supports and holds the floor joists in position. You can place insulation material and metal termite shields under the sill if you desire or when the blueprints specify.

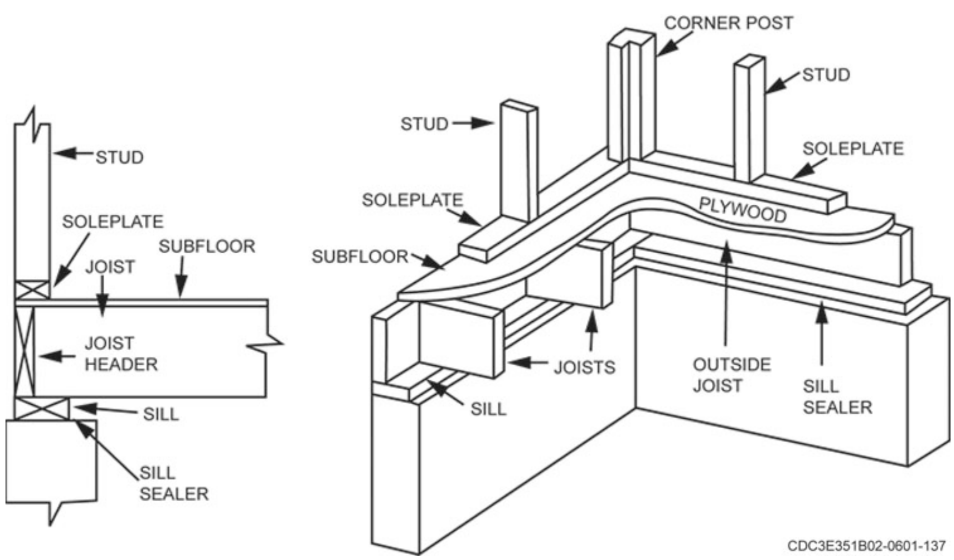


Figure 1–1. Box sill assembly.

With the box sill layout method, you must know what is planned for the exterior wall *before* installing the sill plate. You will need to determine if the sill plate will be set flush with the outside wall, set back to the exterior sheathing's thickness, or further back for brick veneer.

Another consideration is how to layout the sill plate corner joints. When laying out single sills, you can make a satisfactory connection with a butt joint. If you want greater strength, cut wood from each sill end to make a half lap joint that interlocks the corners.

If a single sill is not long enough to make it from corner to corner, you can use a butt joint to continue the length. You may need additional anchor bolts or other fastening methods to secure the sill to the masonry foundation. One option is to make a two-foot-long half lap joint in the two sill ends. You then place the two sills in position and anchor them to the masonry foundation.

The typical way to anchor sills to the foundation is with anchor bolts. You can lay out the anchor bolt hole locations by following the steps in the table below.

Laying Out Anchor Bolt Hole Locations	
Step	**Action**
1	Establish the building line points at each foundation corner.
2	Snap a chalk line at these established building line points for the sill location.
3	Square the sill plate ends. (Sill plate material received at job sites is not necessarily squared at both ends.)
4	Place the sill on edge and mark the anchor bolt locations.
5	Extend these marks with a square across the sill's width.

After you mark all the hole locations, bore the holes. Each hole should be about one-fourth (¼) inch larger than the bolt diameter to allow some adjustment for exact sill plate placement. As you bore each section, position that section over the bolts.

When all sill sections are fitted, remove them from the anchor bolts. If a termite shield is required, place it directly onto the foundation. Then, apply a sill sealer to the termite shield on the side that meets the sill. Make the termite shield from metal that is at least 26 gauge. You can make it from aluminum, copper, or galvanized sheet metal. Bend the outer edges down slightly. If no termite shield is required, apply the sealer directly to the foundation where the sill plate makes contact. The sealer can be compound based and applied with a caulking gun, but most new construction uses thin

Styrofoam insulation that is sold in rolls to match the sill plate width. (Either type fills in foundation irregularities, stops drafts, and reduces heat loss). With the sealer in place, install the sills and tighten them onto the anchor bolts with washers and nuts. As you tighten the nuts, make sure the sill stays aligned. Also, check the distance from the sill edge to the outside wall face of the foundation. The sill must be level and in alignment with the foundation. You can shim low spots with wooden wedges, but it is better to use grout or mortar.

Fastening sills to foundation walls

The recommended way to fasten most wood sills to concrete foundations is with one-half (½) inch diameter anchor bolts. You can find the anchor bolt length in the project's specifications; the project's drawings will show the spacing and location of the bolts. If this information is not specified in the blueprints, your anchor bolt spacing should *not exceed* 6 feet on center (OC). Also, you must place a bolt within 1 foot of the foundation's outside edge. These are the basic rules for fastening sills (fig. 1–2).The rules vary depending on your base's location (stateside or overseas). For specific guidance, see your supervisor.

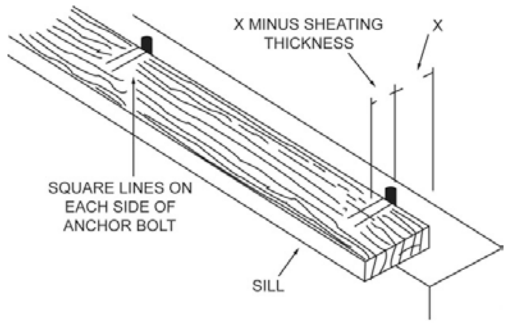


Figure 1–2. Anchor bolt layout.

Floor framing

Floor framing consists of the posts, girders, joists, and subfloor. When assembled, they form a level anchored platform for wall and other construction.

Posts

Wood or steel posts and girders support floor joists and the subfloor. Sizes depend on the loads to be carried. The project's foundation plans show the dimensions and locations. When required, posts give central support to girders that cover long spans. Make sure you have at least 18 inches of 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.

Floor Framing Posts	
Type	**Description**
Wood	You can place wood posts directly below wood girders to help support the load. As a general rule, make the width of the wood post equal to the width of the girder it supports. For example, a four-inch-wide girder requires a 4 × 4 inch or 4 × 6 inch wood post. You can secure a wood post to a concrete pier in several ways: • Nailed to a wooden pier block at the top of a concrete pier. • Placed over an existing one-inch steel dowel in the concrete pier. • Placed into a metal base set into the concrete pier at the time of the pour. When using the dowel method, you must ensure the dowel extends at least 3 inches into the concrete and the post. A metal base embedded in the concrete is the preferred method since nothing else is needed to secure the base. Like the bottom of the post, you must secure the top to the girder. Do this by using angle iron brackets or metal plates.
Steel	Steel pipe 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. You must bolt the steel post base to the pier top or to anchor bolts.

NOTE: If you use anchor bolts, be sure to install them when the concrete is being poured.

Girders

Girders are placed at right angles to joists to help distribute the live and dead load.

- The *dead load* is material that is a permanent part of the building structure.
- The *live load* is material that can be moved in and out of the structure and includes such items as furniture, appliances, and people.

Girders can be made from solid wood, built up from three or more two-inch-thick planks, laminated veneer lumber, glulam beams, or made from steel I-beams.

Types of Girders	
Type	**Description**
Wood	Wood girders cost less than steel and are easier to fabricate. In a built-up girder, 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 into the ends of the planks and stagger other nails every 32 inches OC. Make sure the top of the girder is flush with the top sill plate. When space for heat ducts is required in a partition supported on a girder, a spaced wood girder 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. A wood girder's ends often rest in pockets prepared in a concrete wall. Here the girder ends must bear at least 4 inches on the wall. Make the pocket large enough to provide a one-inch air space around the sides and end of the girder. We usually treat the girder ends with a preservative. As a further precaution, line the pockets with metal.
Steel	We most often use S-beams (standard) or W-beams (wide flange) 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 bearing post length under the girder is correct to ensure the girder is properly supported.

Placing posts and girders

Cut posts to length and set them up before you install the girders. The girders' upper surface may be in line with the foundation plate sill or its ends may rest on the wall top. Place long girders in sections. Measure and cut solid wood girders so that the ends fall over the center of a post. Center the outside joints of built-up girders over the posts.

Floor joists

In platform framing, one floor joist end rests directly on the sill plate of the exterior foundation wall or on the top plate of a framed outside wall. The opposite end of the joist laps over or butts into an interior girder or wall. Choose the joist material (2 × 6, 2 × 10, 2 × 12 inches, etc.) with consideration for the span and the load to be carried. The foundation plan usually specifies the joist size, the spacing between joists, and the direction the joists are to travel.

The usual floor joist spacing is 16 inches OC. Floor joists are supported and held in position over exterior walls by joist headers or by solid blocking between the joists. Mostly we use the joist header system. The following table describes the different floor joists that can be used.

Floor Joists	
Type	**Description**
Joist headers	Joist headers run along the outside walls. They are also referred to as *band joists*, *rim joists* or *box headers*. Drive three 16d nails through the joist headers into the ends of the common joists. Toenail the joist headers and floor joists to the sill with 16d nails. The joist headers prevent the floor joists from rolling or tipping. They also help support the wall above and fill in the spaces between the floor joists.
Header joists	Header joists are used to frame in floor openings.

Floor Joists	
Type	**Description**
	They are usually doubled (double headers) and run perpendicular to the floor joists.
Tail joists	Tail joists are the shortened floor joists at the ends of a floor opening. They are capped with the headers.
Lapped	We often lap joists over a girder that runs down the center of a building. The lapped ends may also be supported by an interior foundation or framed wall. Joists are usually lapped the full width of the girder or wall. The *minimum lap* should be 4 inches. If using a steel girder, bolt a 2 × 4 inch board to the top of the girder so the floor joist can be toe nailed to it. You can install solid blocking between the lapped ends after you nail down all the joists. Another system is to put in the wood blocks at the time you place the joists.
Double	Double joists under partitions that will run 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 such objects.
Cantilevered	Use cantilevered joists when a floor or balcony of a building is to project past an outside wall. Nail a header piece to the joist ends. When floor joists run parallel to the intended overhang, fasten the inside ends of the cantilevered joists to a pair of double joists. Nail through the first floor joist into the ends of the cantilevered joists. Framing anchors are strongly recommended and often required by the specifications. Nail a header piece to the outside ends of the cantilevered joists.
Butted over a girder	You can butt joist ends (rather than lap) over a girder. Cleat the joists together with a metal plate or wooden cleat. You can leave these out if the line of panels from the plywood subfloor straddles the butt joints.
Butted against a girder	Butting joists against (rather than over) a girder allows more headroom below the girder. When the underside of the girder is required to be flush with the joists to provide an unbroken ceiling surface, support the joists with joist hangers.
Blocking between joists	Solid wooden blocks placed between joist ends help distribute the load and prevent joist shifting along the outside walls.

Interior support

Floor joists usually run across the building's full width. However, because extremely long joists are expensive and difficult to handle we usually use two or more shorter joists. You can support the ends of these joists by lapping or butting them over a girder, butting them against a girder, or lapping them over a wall.

Steel beam

The joists may rest on top of the steel beam or you can butt them (and notch them to fit) against the sides of the beam. If the joists rest on top of a steel beam, fasten a plate to the beam and toenail the joists into the plate. When notching joists to fit against the beam sides, you must make an allowance for the wooden joist's shrinkage whereas a steel beam does *not* need a shrinkage allowance. For average work with a 2 × 10 inch wood joist, an allowance of three-eighths ($^3/_8$) inch above the top flange of the steel beam is usually sufficient.

Another method of attaching butted wood joists to a steel girder is to allow a three-eighths ($^3/_8$) inch space above the beam for shrinkage. Notching the joists so they rest on the lower flange of a steel beam is *not* recommended; the flange surface does not provide sufficient bearing surface. You can bolt or weld a wide plate to the bottom of the steel beam to provide better support. You can place wooden blocks at the bottoms of the joists to help keep them in position. A wide-flanged beam, however, does provide sufficient support surface for this construction method.

Bridging between joists

Floor plans or specifications usually call for cross-bridging or solid bridging between the joists. Both types hold the joists in line and help distribute the load carried by the floor. Bridging 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 span center. For longer spans, two rows of bridging spaced 6 feet apart are required.

Cross bridging

Cross bridging, also known as herringbone bridging, usually consists of 1 × 3 inch or 2 × 3 inch wood (fig. 1–3). Toenail cross bridging at each end with 6d or 8d nails. Bridging pieces are usually precut on a radial-arm saw. Start your nails at each end before you place the cross bridging between the joists. The usual procedure is to fasten only the top end of the cross bridging. Don’t drive in the nails at the bottom end until you place the subfloor. Otherwise, you could push the joist out of line when you nail in the bridging. The steps in the table below are an efficient method for the initial placement of cross bridging.

Initial Placement of Cross Bridging	
Step	**Action**
1	Snap a chalk line where you are to nail the bridging between the joists.
2	Moving in one direction, stagger and nail the bridging tops.
3	Reverse direction and nail the tops on the opposite side.
4	Metal cross bridging is also available for 12, 16, and 24 inch joist spacing. It is usually made of 18–gauge steel and is three-fourths (¾) inch wide. Install this type of bridging in same manner as wood cross bridging.

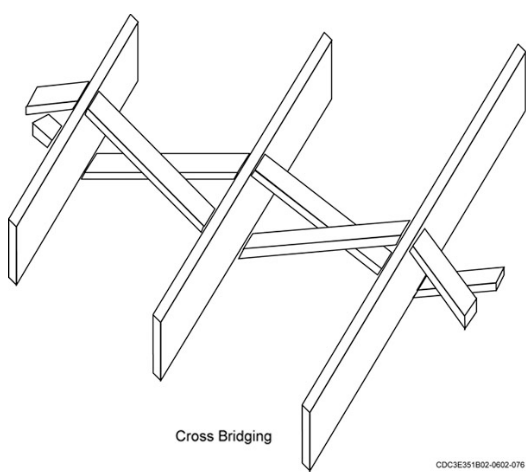


Figure 1–3. Cross bridging.

Solid bridging

Solid bridging, also known as solid blocking, is another method we use to hold the joists in line and help distribute the load carried by the floor. Cut the solid bridging pieces from lumber that is the same width as the joist material. To install solid bridging follow the steps in the table below.

Installing Solid Bridging	
Step	**Action**
1	Snap a chalk line at the appropriate interval.
2	Install the bridging pieces in a straight line in every other joist. Nail through the joists into the ends of the blocking. Be sure that the top edges of the blocking are flush with the floor joists.
3	Install the blocking on the other side of the chalk line (staggered).

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 (fig. 1–4).

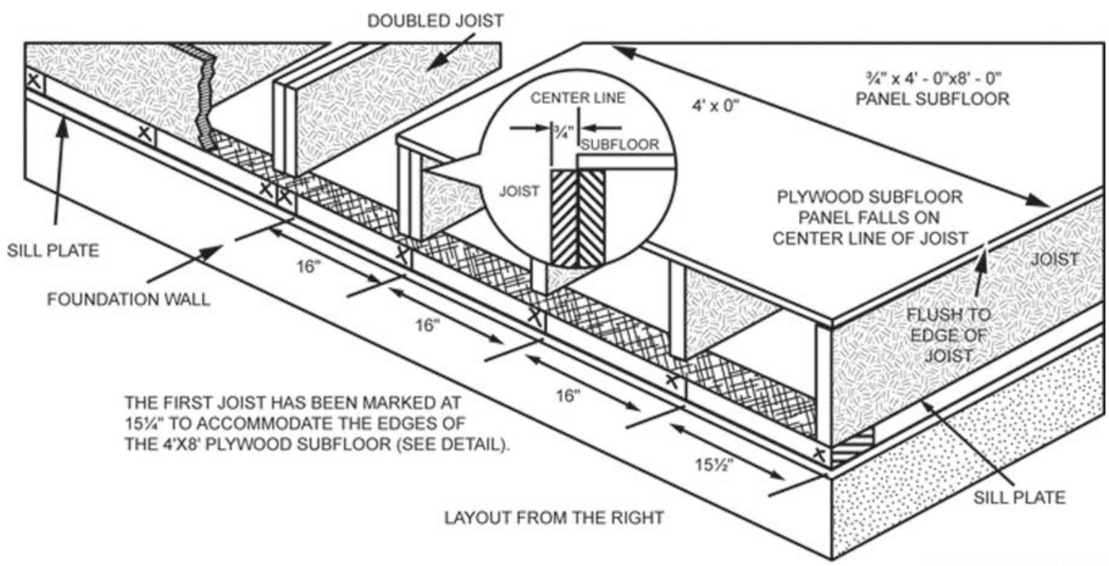


Figure 1–4. Floor joist assembly.

For joists resting directly on foundation walls, place layout marks on the sill plates or the joist headers. Mark lines on top of the girders or walls over which the joists lap. If framed walls are below the floor unit, lay 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. Mark floor openings for stairwells, too.

Layout joists so that the edges of standard-size subfloor panels break over the joist centers. This layout eliminates additional panel cutting. One method of laying out joists this way is given in the following table.

Joist Layout Method	
Step	**Action**
1	Mark the first joists 15¼ inches from the building edge.
2	The second and remaining joists follow 16 inches OC layout pattern.

Joist Layout Method	
Step	**Action**
3	Since many joists are the same size, you can cut them and the bracing at the same time for efficiency. The distance between joists is usually 14½ inches for joists spaced 16 inches OC.
4	Cut blocking for odd spaces as needed.

Framing floor openings

Floor openings, where stairs rise through a wood framed floor or where large air ducts pass through, require special framing. When you cut the joists for such openings, there is a loss of strength in those joists. Install additional wood (trimmers, headers, and tail joists) to build a frame that restores strength to the joists. A good method is described in the following table.

Framing Floor Openings	
Step	**Action**
1	Measure and mark the trimmer positions 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 headers 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 must follow the regular joist layout).
4	Fasten the tail joists to the outside headers with three 16d nails driven through the headers into the tail joist ends.
5	Double the header by driving three 16d nails through the trimmer joists into the double header ends. Nail the doubled header to each other with 16d nails staggered 16 inches OC.
6	Double the trimmer joists and fasten them together with 16d nails you stagger 16 inches OC.

Place the trimmers at each joist side 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 trimmers into the header ends. Tail joists (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 can use various metal anchors to strengthen framed floor openings.

Crowns

Most joists have a crown (a bow shape) on one side. Sight each joist before you nail it in place to make certain you turn the crown up. The joist will later settle from the weight of the floor and straighten out. Pay attention to detail when you sight the crown.

Subfloor

Nail the subfloor, also known as *rough flooring*, to the floor joists (floor frame). It strengthens the entire floor and serves as a base for the finish floor. You can make a subfloor from board lumber or from 4 × 8 foot sheets of oriented strand board (OSB), plywood, particleboard, or composite board. Usually we use the sheets because installing them is less labor intensive than board lumber.

Plywood subfloors are often installed at most Air Force bases. It is available in multiple grades to meet many uses. First, determine if the subfloor will be exposed to moisture, in a bathroom for example. In this situation, select plywood made with waterproof glue.

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 (panel). These markings indicate the allowance spacing needed for plywood that is used as roof sheathing or subflooring. For example, an index mark of 32/16 inches indicates the plywood panel is suitable for a maximum spacing of 32 inches for rafters and 16 inches for floor joists. No strength difference problems between wood species are involved, as the correct identification is shown for each panel.

To install plywood panels follow the steps in the table below.

Installing Plywood Panels	
Step	**Action**
1	Begin installation from the corner in which the floor joists were laid out.
2	Snap a chalk line across the tops of the floor joists the width of the panel. If a four-foot panel is used, snap a chalk line along the tops at 4 feet. **NOTE:** Many types of tongue and groove plywood are only 47½ inches wide.
3	Install plywood with the face grain at right angles to the joists. Begin with a full panel and align it to the chalk line. Be sure to align each joist to the correct spacing before nailing the panel in place. Leave a one-sixteeth ($^{1}/_{16}$) inch gap along the panel ends.
4	Stagger panels so that end joints in adjacent panels break over different joists. Start the next row with a half panel.
5	Continue for successive rows being sure each row is staggered.

The nailing schedule for most subfloor panels requires 6d common nails for materials up to seven-eighths ($^{7}/_{8}$) inch thick and 8d nails for heavier panels up to one and one-eighths (1 $^{1}/_{8}$)inches thick. Deformed-shank nails are strongly recommended for better holding power. You will usually space them 6 inches OC along the panel edges and 10 inches OC over intermediate joists.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

601. Floor framing

1. What component do you start with in platform frame construction?

2. What does an exterior wall have to do with sill placement?

3. How is the size of wooden floor joists determined?

4. What do you install between the floor joists to hold them in line and help distribute the load the floor carries?

5. How do you place the crown for a floor joist?

602. Wall framing

Wall framing begins after the subfloor is nailed in place. You need to know how to correctly layout the walls and erect them. The quality of your finish work depends on the quality of your rough work. In this lesson, we discuss how to layout and erect wood and metal framed walls.

General information

You lay out the walls, frame, and raise them into place on top of the subfloor. There are two basic wall types—exterior (outside) and interior (inside) walls. The exterior walls usually have door and window openings (fig. 1–5) and are load bearing. An interior wall (partition wall) divides a building's inside area into separate rooms. Although most interior walls are usually non-load bearing some can be load bearing. In general, load bearing interior walls run perpendicular to floor joists or ceiling joists while non-load bearing interior walls run in the same direction as the joists and, therefore, carry little weight from the floor or ceiling above.

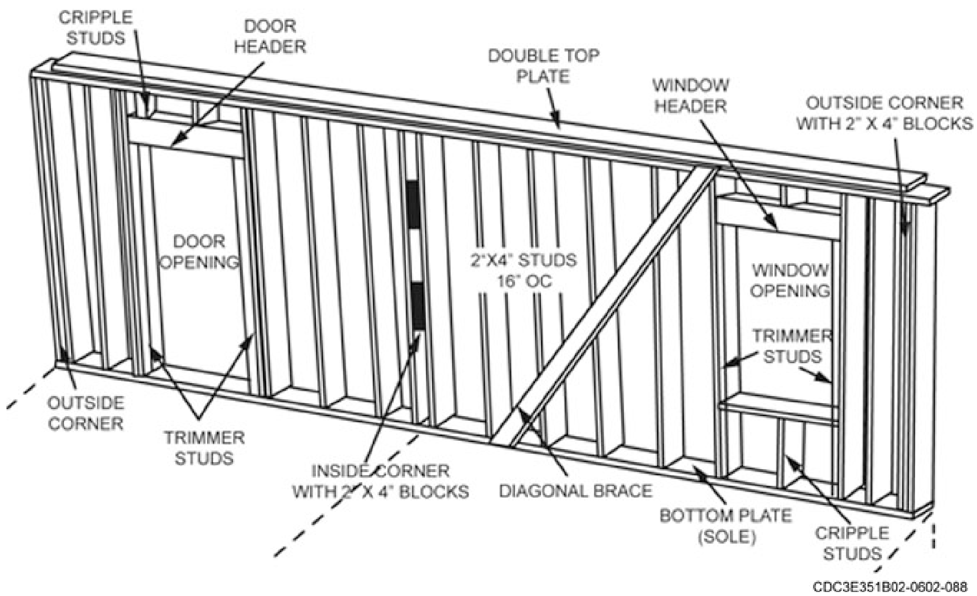


Figure 1–5. Typical exterior wall.

CAUTION: Never remove a load bearing wall without first supporting the load that it is carrying with the proper bracing material. To be safe, always check with your supervisor.

Traditionally we use 2 × 4 inch structural lumber to construct walls in single story buildings. Multi-story buildings may require heavier structural lumber on the lower levels to support the weight of the floors above.

Structural parts

A wood-framed wall consists of structural parts we refer to as “wall components” or “framing members.” The components typically include plates, studs, headers, trimmers, cripples, sills, corner posts, and diagonal braces. Each component is essential to wall structure integrity. The following table provides a closer look at these wall structural parts.

Structural Parts	
Part	**Description**
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*. We normally use a double top plate to strengthen the upper wall section and to help carry the load from the joists and roof rafters. Since we nail top and bottom plates into all the vertical wall members, they help frame the entire wall together.
Studs	Studs are upright (vertical) framing members running between the top and bottom plates. We usually space studs 16 inches OC, but job specifications sometimes call for 12 and 24 inch OC stud spacing.
Corner posts	Construct corner posts where a wall ties into another wall. • Outside corners are at the ends of a wall. • Inside corners occur where a partition (interior wall) ties into a wall at some point between the ends of the wall. There are three typical designs for corner assemblies: • The outside corner construction using only three studs. • An outside corner construction using two studs with short blocks between them at the center and ends. • An inside corner construction using a block laid flat. **NOTE:** You must construct all corner assemblies from straight stud material.
Fire stops	Most local building codes require fire stops (also known as *fire blocks*) in walls over eight-foot one-inch (8’ 1”) high. Fire stops slow down fire travel inside walls. You can nail them between the studs before or after the wall is raised. Fire stops can be nailed in a straight line or staggered for easier nailing. Nailing fire stops at the midpoint of the wall is not necessary. You can position them to provide additional backing for nailing the edges of drywall or plywood.

Rough door and window openings

For a proper fit, you must frame in a rough opening first. In new construction, the blueprint’s door and window schedule gives the details. The rough opening dimensions must allow for the final frame size and for the required clearance around the frame. The rough opening for a typical door includes headers, trimmer studs, and cripple studs. A typical rough window opening includes the same members plus a rough windowsill. Calculate the rough opening dimensions based on width, finish frame thickness, and add one-half-inch (½”) clearance for shim material on the frame sides.

Place a header at the top of the rough opening. It must be strong enough to carry the weight bearing down from above. The header may be solid or built up of two pieces of two-by-lumber with a one-half (½) inch spacer (usually plywood). The spacer is needed to bring the width of the header to three and one-half (3½) inches. This is the actual width of a nominal 2 × 4 inch stud. A built-up header is usually as strong as or stronger than solid lumber. To support each end of the header, nail a trimmer stud onto each rough opening side from the sole plate to just below the header end. Drive nails through the rough opening studs into the ends of the header.

Determine the header type and size by the opening width and how much weight is bearing down from above. You will find this information in the blueprints.

The door and window opening tops are usually in line with each other. Therefore, all headers are usually the same height from the floor. The standard wall height in most wood-framed buildings is either 8 feet ¾ inch (8’ ¾”) or 8 feet one 1 (8’ 1”) from the sub floor to the ceiling joists. The standard door height is 6 feet 8 inches (6’ 8”).

When the wall is assembled, cripple studs are placed between the header and the double top plate. These help carry the weight from the top plate to the header. Cripple studs follow the same spacing as the full-length studs.

A rough opening for a metal window often requires a one-half (½) inch clearance around the entire frame. When the measurements are not given in the window schedule, use the manufacturer’s installation instructions that are supplied with the windows. A rough windowsill is added to the bottom of the rough window opening. The sill provides support for the finished window and frame to be placed in the wall. Determine the distance between the sill and the header by the window dimensions, window frame, and the necessary clearances at the window top and bottom. When the wall is assembled, cripple studs are placed between the sill and soleplate following the same on center spacing as the studs.

NOTE: You can place additional cripple studs under each sill end.

Wall framing layout

Before you begin to layout the wall, you should determine whether or not it is load-bearing. Depending on this information, the layout is a little different. Load-bearing walls support the roof and ceiling joists; whereas, non-load-bearing walls are end walls with the joists running parallel to them. Load-bearing partitions (interior walls) run perpendicular to the joist; whereas, non-load-bearing partitions run parallel to the joists. The table below shows the difference in layout.

Wall type	Measure from	Measure to opening centerlines from
Load-bearing wall	the end of the plate	the end of the plate
Non-load-bearing wall	the exterior of the abutting wall and include the thickness of the exterior sheathing	the outside of the abutting wall
Load-bearing interior wall (partition)	the exterior of the abutting wall	the outside of the abutting wall
Non-load-bearing interior wall (partition)	the end of the plate	the outside of the abutting wall

Construction plans are usually designed so that the layouts for the framing members (floor joists, exterior walls, ceiling joists, and rafters) all begin at the same end of the building. This design keeps the load-bearing studs on top of the joists. While you are not required to follow the steps below in sequence, it’s good advice. Begin layout on the plate using the steps in the table below.

Plate Layout	
Step	**Action**
1	Determine all rough opening centerline locations. Mark the centerlines on the soleplate.
2	Measure one-half the rough opening in each direction from the centerline and mark a line. Place a “T” for trimmer on the other side of the line away from the center.

Plate Layout	
Step	**Action**
3	From those lines, measure away from the center the thickness of a stud—one and one-half (1½) inches. Place an X (X is for full length stud) on the side of the lines away from the center.
4	If there are any intersecting partitions, mark their locations next. Most plans usually dimension partitions to their centerline. Measure and mark to the partition centerline. From that mark, measure one-half the partition stud thickness in each direction. Square mark these locations and place Xs on the sides of the line away from the center.
5	Begin laying out full length and cripple studs after all rough openings and partitions have been marked. Mark the plate at 15¼ inches from the end of the corner for the first stud and place an X away from the end. This places the first stud 16 inches OC.
6	Place the tape on that line and lay out the remaining studs at 16 inches OC. Place an X on the side of the line away from the measuring end (where the stud will be placed). If a stud location falls in an opening, mark the location and write a C in place of an X. This indicates that a cripple stud will be placed there.
7	Once one plate is laid out, transfer the measurements to the other plate.

NOTE: Framing members are only laid out in increments of 4 feet (48 inches), such as 12, 16, and 24 inches. This layout minimizes cutting of 4 × 8 foot wall coverings. For example, you can install a four-foot-wide gypsum board with one edge flush in a corner over a stud with the other edge falling on the center of a different stud.

Assembly

When it comes to the sequence used to assemble a wall worker generally develop their own style. Use the method that works best for you. In the following table we describe a common framing method using 16d common nails.

Common Framing with 16d Common Nails	
Step	**Action**
1	Precut all full-length studs, trimmers, headers, and rough sills.
2	Assemble all corner posts (inside partition and outside) using full-length studs and short blocks.
3	Assemble the rough opening units. • For *door* units, nail the trimmer studs to full-length studs. Place a header on top of the trimmers and fasten through the full-length studs into the ends of the header with two 16d nails. • For *window* units, measure down from the top of the trimmer the height of the opening and mark the location for the rough sills onto the trimmer studs. Fasten through the trimmers into the ends of the sills with two 16d nails. This will look like an H. Fasten the full-length studs to the trimmers ensuring the bottoms are flush. Place the header above the trimmers and fasten through the studs into the ends of the header with two 16d nails.
4	Place the top and bottom plates on the subfloor at a distance slightly greater than the length of the studs.

Common Framing with 16d Common Nails	
Step	**Action**
	Position the full-length studs, corner posts and rough opening units between the plates according to the plate layout. Place studs in position with the crown side up.
5	Fasten through the plates into the ends of these members with two 16d nails.
6	Cut and install all cripple studs where needed.

Squaring walls and placing braces

We often square a completely framed wall while it is still lying on the subfloor In this way, we can nail bracing, plywood, or other exterior wall covering before we raise the wall. When diagonal measurements are equal, the wall is square. Bracing provides lateral strength to walls. In the following table cover three methods of squaring walls and placing braces: let-in bracing, cut-in bracing, and plywood sheathing.

NOTE: *If the floor is not level, the walls will not be plumb.*

Squaring Walls and Placing Braces	
Method	**Description**
Let-in bracing	Let-in bracing for an eight-foot-high wall uses 1 × 4 inch lumber that usually extends diagonally (45 degrees to 60 degrees angle is best) from the outside corner post to the soleplate. Notch the studs so that the 1 × 4 inch lumber fits flush with the surface of the studs. **NOTE:** Notching the studs is much easier if you do it before you raise the wall into position. Nail the brace into each notch with two 8d common nails. When an opening interferes with the bracing, you need to install the two braces. • The *first brace* extends diagonally from just below the mid-point to the soleplate. • The *second brace* extends from just above the mid-point on the cornerpost to the top plate (fig. 1–6).
Cut-in bracing	Cut-in bracing is another type of diagonal bracing. It usually consists of 2 × 4s cut at an angle and toenailed between studs diagonally from the top of a corner post down to the soleplate (fig. 1–7).
Plywood sheathing	Plywood sheathing provides enough lateral strength to eliminate the need for any additional diagonal bracing. It also provides rigidity and insulation to the wall. Nail it as exterior sheathing on all outside walls (fig. 1–8).

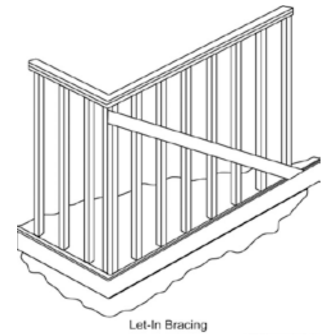


Figure 1–6. Let-in bracing.

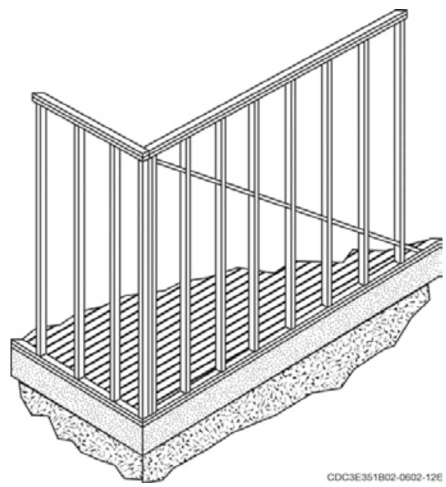


Figure 1–7. Cut-in bracing.

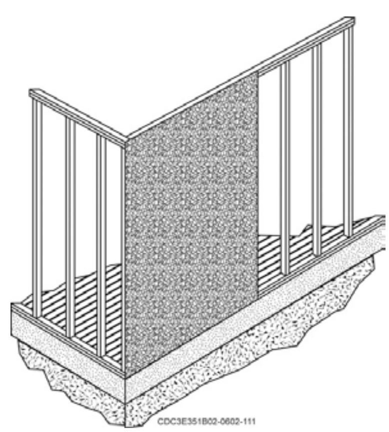


Figure 1–8. Plywood sheathing.

Raising

You can raise most walls by hand if enough help is available. For the lifting operation it is advisable to have one person for every 10 feet of wall. The order in which you frame and raise walls may vary from job to job. Generally you raise the longer exterior walls first. Then raise the shorter exterior walls and nail the corners together.

After you raise a wall, you must nail its soleplate securely to the floor. With the wall in position on a wood subfloor, drive 16d nails through the soleplate and on into the floor joists below the subfloor if possible.

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. Nail blocks that are three-fourths (¾) inch thick to each end of the straightedge. The blocks will rest at the top and bottom of the wall making it possible to accurately plumb the wall from the soleplate to the top plate.

Plumbing corners requires two people working together—one working the bottom brace and the other watching the level. Renail the bottom brace when the level shows a plumb wall.

Placing the double top plate

The double top plate adds strength to a wall. It is usually made from the same lumber that is used to make the wall. You can install the double plates with 16d nails while the wall is still on the subfloor or after you raise it into position. Nail the double top plate to the upper side of the first top plate. Make sure to overlap the second top plate in the corners to help tie in the wall. Use butt joints to join the second top plate ends together but make sure that at least 4 feet separates each joint between the two plates.

Intersecting walls

You must leave space for any intersecting walls. This allows the partition's double top plate to lap the exterior walls top plate. This ties the walls together and makes the structure more rigid.

Straightening the walls

Straighten the tops of the walls (aligned or lined up) after you plumb all the corners. Prior to nailing the floor or ceiling joists to the tops of the walls, make sure the walls are aligned. The table below shows how.

Straightening Walls

Step	Action
1	Cut three small blocks from 1 × 2 inch lumber. Fasten two blocks to the inside of the top plate at each end of the wall.
2	Stretch a string line between these blocks. Make sure the line is held tightly to the blocks.
3	Use the third block as a gauge to check the wall at 6 or 8 foot intervals. Adjust the wall so that the string is barely touching the gauge block.
4	At each checkpoint, fasten a temporary brace to a wall stud. Nail the other brace end to a short 2 × 4 inch block fastened to the subfloor. Do not remove these temporary braces until you complete the framing and sheathing for the entire building.

Framing over concrete slabs

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

Sheathing the walls

Wall sheathing is the material you use to cover the exterior walls. In older facilities, nominal 1 inch thick boards were nailed to the wall horizontally or at a 45 degrees angle for sheathing. Today we use sheathing such as plywood, waferboard, oriented strand board (OSB), fiberboard, or rigid insulated panels. You can install any of these panels more quickly than 1-inch thick boards. Generally wall sheathing does not have a surface that can withstand prolonged exposure to weathering. You usually cover it with siding, shingles, stucco, or brick veneer.

Plywood

Plywood used for sheathing adds considerable strength and eliminates the need for diagonal bracing in exterior walls. The panels range in size from 4 × 8 feet to 4 × 12 feet. We recommend you use panels that are at least three-eighths ($^3/_8$) inch thick when they will be covered with an additional covering such as siding. If the panels are to serve as the final covering, then panels need to be greater than three-eighths ($^3/_8$) inch thick. The required thickness is usually set by the codes of the area where your base is located. You can place the panels with the grain running vertically or horizontally. Specifications may require blocking along the long edges of horizontally placed panels.

Typical nailing specifications for panels that are one-half (½) inch or less in thickness require 6d nails. Panels that are more than one-half (½) inch thick require 8d nails. Space the nails 6 inches apart along the panel edges and 12 inches apart at the intermediate studs.

When nailing the panels, leave a one-eighth ($^1/_8$) inch gap between the horizontal edges of the panels and a one-sixteeth ($^1/_{16}$) inch gap between the vertical edges. These gaps allow for expansion caused by moisture and prevent panels from buckling.

> **NOTE:** You can apply plywood sheathing when the squared wall is still lying on the subfloor. However, problems can occur after the wall is raised if the floor is not level. For this reason, *it's best to install the plywood after the entire building is framed.*

Waferboard and oriented strand board

Waferboard and OSB are nonveneered (reconstituted wood) panels that are lower in price than other types such as plywood. These panels provide a good nailing surface for siding and other finish materials. Like plywood, these panels resist cracking. However where maximum shear strength is required, most experts still recommend conventional plywood panels. Installing waferboard and OSB is similar to installing plywood. Nailing schedules usually call for 6d common nails to be spaced 6 inches OC above the panel edges and 12 inches OC when you nail into the intermediate studs.

Fiberboard

Fiberboard is made from a soft, synthetic material. Most fiberboard panels have a waterproof coating applied to allow them to temporarily protect the outside walls until you install a finished wall covering over it. The panels also provide insulation, reduce noise, and reduce dust infiltration. Install the panels with roofing nails spaced 3 inches along the edges and 6 inches apart along the center. Keep the fasteners at least three-eighths ($^3/_8$) inch from the edges.

Metal framing

Metal is an alternative to wood framing. Many buildings are framed entirely of metal, whereas some buildings are framed in a combination of metal and wood. The metal framing members are usually cold-formed steel that has been electro-galvanized to resist corrosion. The metal studs and runners do not shrink, swell, twist, or warp. Termites cannot affect them, nor are they susceptible to dry rot. Also when combined with proper covering material, such as gypsum board, they have a high fire-resistance rating.

Studs

Studs used for interior, non-load bearing walls range in size from 25 (the lightest) to 20 gauge and various lengths. Most metal studs have notches at each end and knockouts located about 24 inches OC through which you can route pipe, conduit, or other items. The knockout size, not the stud size, determines the maximum pipe size or other items that can be drilled through the member horizontally. Studs are generally available in widths of 1⅝, 2½, 3⅝, 4, 6, and 10 inches, with a leg thickness of one and one-quarter (1¼) inch.

Track

What we called top and bottom plate for wood-framed walls is referred to as *track or runners* on metal-framed walls. The metal runners are manufactured in specified gauges, widths, and leg thicknesses to match the studs. They are available in a standard 10 foot length.

Construction sequence

There are various ways to install metal framing components. Each manufacturer has instructions that are designed for installing the framing quickly and safely. Some systems can be disassembled and reassembled for easy modification while others are made for permanent installation. Assemble the framing members with a power screwdriver using self-drilling, self-tapping screws; however, metals 18 gauge and thicker may be welded.

NOTE: You must prime all welds if welding metal framing members.

Metal framing members may be preassembled into panels prior to erection (same as wood-framing) or assembled in place. There is less chance of the wall being distorted when the wall components are assembled in place—especially when the top track is fastened. Refer to the manufacturer's instructions and job specifications for the correct assembly method. Since you already know how to assemble a wall prior to erection, we'll discuss how to assemble a wall in place.

Commercial framers often use the construction sequence in the table below when installing members in place.

Commercial Framing Sequence for Installing Members	
Step	**Action**
1	Establish reference lines on the floor, plumb up from floor lines and snap lines on the ceiling where the wall will be placed. You can use a plumb bob or laser level.
2	Layout the bottom track for the studs and openings (some framers prefer to mark the locations directly on the floor). **NOTE:** The top track is laid out *after* the first stud is plumbed and fastened. Keep in mind the thickness of the studs when laying out the tracks. If the stud is one and one-fourth (1¼) inch thick, the first mark is placed at 15⅜ inch instead of 15¼ inch.
3	Unless specifications require a different spacing, fasten the tracks to the floor and ceiling using approved fasteners placed 2 inches from each end and spaced 24 inches on center staggered from side to side.
4	Cut studs to size (usually one-fourth (¼) inch short).
5	Place first stud in from the corner (open side of the stud facing inwards) and fasten it to the bottom track with three-eighths (3/8) inch self-drilling pan head screws or use a metal stud-crimping tool.
6	Plumb the stud, clamp it to the top track and fasten in place.

Commercial Framing Sequence for Installing Members	
Step	**Action**
	NOTE: Only one fastener per side is required.
7	From this stud, layout the stud spacing on the top track.
8	Install all full-length studs with the open side facing the same direction and all knockouts aligned. Fasten all in place except for the studs on each side of a door opening. **NOTE:** The studs on each side of the opening are placed into the track with the open side facing away from the door opening.

Door and window openings

The way you frame a door opening depends on the type of doorframe. Some frames assemble (three-piece frame) for installation after a wall is in place and other types (one-piece) are designed to be installed as the wall is built. We'll cover both types.

Three-piece frame

When installing a three-piece frame, fasten the studs next to the rough opening to the top and bottom tracks. Cut a piece of track 6 inches longer than the opening for the header. To fabricate the header, cut the flanges 3 inches on each end and bend the track back 90 degrees to fit over the studs on each side of the opening. Fasten the header in place and install cripples above it.

NOTE: This procedure is used for windows except that a rough windowsill is installed at the bottom of the opening.

One-piece frame

When installing a one-piece frame, place the studs on each side of the opening but do *not* fasten in place. Set the doorframe in place and install according to the manufacturer's instructions. The typical sequence is shown in the table below.

Installing One-Piece Frame	
Step	**Action**
1	Level the doorframe header.
2	Fasten the bottom of the doorjamb to the floors.
3	Fasten the studs to the doorjambs.
4	Fasten the studs to the bottom track, ensure plumb and fasten to the top track.
5	Install the header and cripples, as previously described.

NOTE: For heavy doors *larger than* two feet eight inches (2' 8") wide, you may have to double the studs next to the door or use 20 gauge steel members.

Corners and intersecting walls

Refer to the manufacturer's or job specifications for the recommended way to construct corners and intersecting walls. The three most common methods are butting, lapping, and sliding. The first two methods are self-explanatory; the adjoining wall tracks are either butted or lapped together.

The sliding method is unique. The adjoining wall track is placed three-fourths (¾) inch away from the other wall. The drywall is then slid behind the gap. With the drywall in place, a slap stud (slider) is installed in the adjoining wall. Push it up tight against the drywall and screw in place using one of the following methods:

- Screw from the backside (brown side) of the drywall into the slider. Space screws 16 inches apart.
- Screw through the slider into the drywall. You must drive the screws at an angle (up and down) alternating from side to side. The angle of the screws keeps the slider tight against the drywall.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

602. Wall framing

1. How do you determine if an interior wall is load bearing?

2. What framing members are necessary for constructing a wood-framed wall?

3. How do you raise most walls into position?

4. Name two advantages of using plywood sheathing in an exterior wall.

5. What are the advantages of metal stud framing?

603. Ceiling framing

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. In this lesson, we will discuss the basic procedures for framing a ceiling.

Ceiling frame functions

One of the main structural functions of a ceiling frame is to tie together the outside walls. When located under a pitched roof, the ceiling frame also resists the outward pressure placed on the walls by the roof rafters. 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.

Joists

Joists are the most important framing members of the ceiling. Their size, spacing, and direction are specified on the plans. The spacing between ceiling joists is usually 16 inches OC; however, 24 inches OC is sometimes used. The size of a ceiling joist is determined by the weight it carries and the span it covers from wall to wall. Although it is more convenient to have all the joists running in the same direction, plans sometimes call for different sets of joists running at right angles to each other.

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 three-fourths (¾) inch thick plywood board, 24 inches long, or an 18 gauge metal strap, 18 inches long.

NOTE: Ceiling joists may also butt against a girder and be supported with joist hangers in the same manner as floor joists.

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 strengthens the tie between the outside walls of the building.

If the building is designed so that the ceiling joists do *not* run parallel to the roof rafters, the rafters will push out on the walls that are not tied together with ceiling joists. In this situation, you should install 2 × 4 pieces in the same direction as the rafters. Nail the 2 × 4s to the top of each ceiling joist and to the heels of the rafters or blocking on the outside walls. Use two 16d nails at each end and space the 2 × 4 pieces *no more than* 4 feet apart.

Roof slope

When ceiling joists run in the same direction as the roof rafters, the outside ends must be cut to the slope of the roof. Ceiling frames are sometimes constructed with stub joists (fig. 1–9). Stub joists are necessary when rafters and ceiling joists do *not* run in the same direction in certain sections of the roof. For example, a low-pitched hip roof requires stub joists in the hip section of the roof.

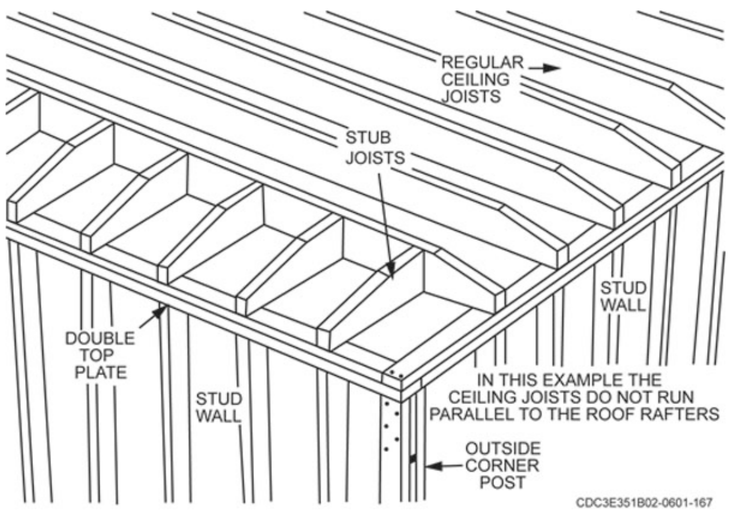


Figure 1–9. Stub joists.

Ribbands and strongbacks

Ceiling joists that do *not* support an above floor do *not* require a header joists or blocking. However, without the additional header joists, the ceiling joists may twist or bow at the center of their span. To help prevent this, nail a 1 × 4 piece called a ribband at the center of the spans. The ribband is laid flat and fastened to the top of each joist with two 8d nails. The end of each ribband is secured to the outside walls of the building.

A more effective method of preventing twisting or bowing of the ceiling joists is to use a strongback. A *strongback* is made of 2 × 6 or 2 × 8 material nailed to the side of a 2 × 4 piece. The 2 × 4 piece is fastened with two 16d nails to the top of each ceiling joist (fig. 1–10). The strongbacks are blocked up and supported 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.

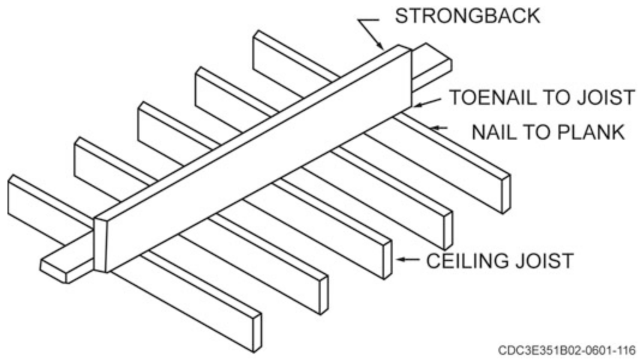


Figure 1–10. Strongback.

Layout

If the joists are placed 16 inches OC, mark the first joist location at 15 ¼ inches and then at every 16 inches from the first mark. If the joists are laid out 24 inches OC, mark the first joist at 23¼ inches and then at every 24 inches OC.

Mark the positions of the roof rafters at the time the ceiling joists are being laid out. If the spacing between the ceiling joists is the same as between the roof rafters, 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. Therefore, every other rafter can be placed next to a ceiling joist.

Backing

Walls running in the same direction as the ceiling joists require backing. Backing is one (1) inch or two (2) inch boards nailed to the top plates to provide a nailing surface for the edges of the finish ceiling material. Fasten the backing to the top plates with 16d nails spaced 16 inches OC.

Frame

Cut all the joists for the ceiling frame to length *before* they are placed on top of the walls. On structures with pitched roofs, the outside ends of the joists should also be trimmed for the roof slope. Be sure to cut this angle on the crown (top) side of the joist. Once the joists are cut to size, hand them up to workers on top of the walls. Spread the joists in a flat position along the walls, close to where they will be nailed. One sequence used to frame a ceiling is described in the table below.

Framing a Ceiling	
Step	**Action**
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 × 4 blocks flat between joists where needed to fasten the tops of inside walls running parallel to the joists.
6	Place strongbacks at the center of the spans.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

603. Ceiling framing

1. What is one of the main structural functions of a ceiling frame?

2. Where can you find the size, spacing, and direction for joists?

3. How is the size of a ceiling joist determined?

604. Stair construction

Stairs (also called *staircases* or *stairways*) consist of steps leading from one level of a structure to another. This lesson covers the different stair types and how to design and construct them. Some of the common terms for stair layout are illustrated in figure 1–11.

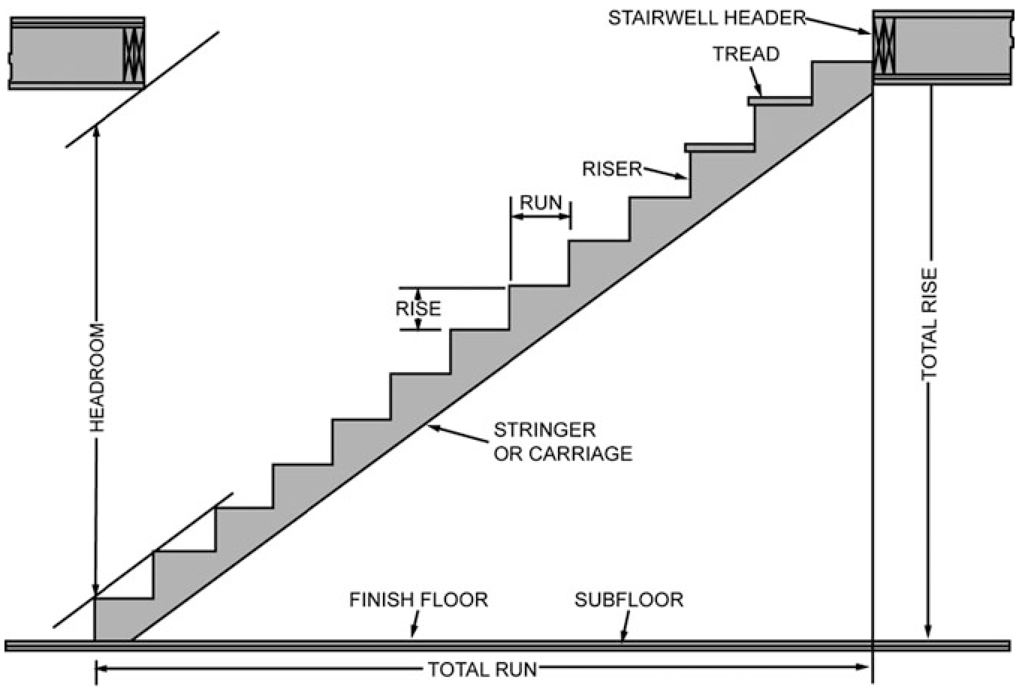


Figure 1–11. Stair layout terms.

General information

The two main stair types are principal and service. *Principal* stairs are designed to provide ease and comfort and are often a construction design feature. *Service* stairs, which lead to the basement or attic, are usually somewhat steeper and are made of less expensive materials. You may build stairs on the job or assemble prefabricated ones.

Stairways may have a straight, continuous run with or without an intermediate landing (figures 1–12 and 1–13). They may also consist of two or more runs at angles to one another.

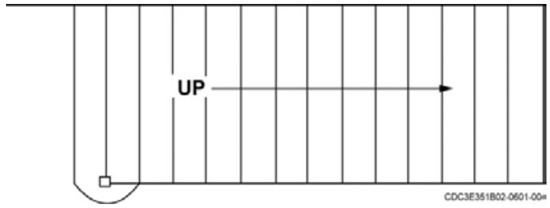


Figure 1–12. Straight flight stairway.

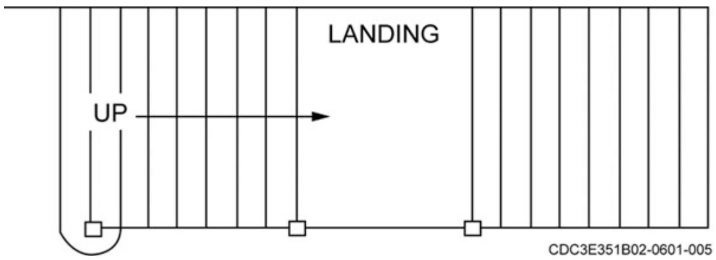


Figure 1–13. Straight flight stairway with landing.

You may make turns by having landings and right angles on straight stairs (fig, 1–14), or by radiating treads called winders that make circular-type stairs. In some stairways, the treads and risers are supported on triangular stair blocks nailed to the upper edges of straight-edged stringers.

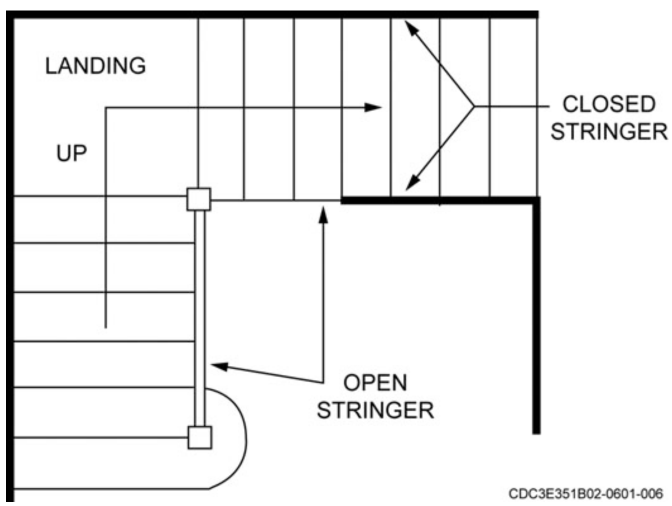


Figure 1–14. Stairway with a 90-degree landing.

While there are many types of stairs all have two main parts in common: the treads people walk on and the stringers that support the treads. A more finished stairway has the treads mounted on two or more sawtooth-edged stringers. Stringers are cut out of solid dimensional lumber (usually 2 × 12 inches). A *straight* stairway is is continuous from one level to the other without landings or turns. *Platform* stairs include a landing when the stair direction changes. Landings are preferred over winders because they are safer, and they provide a break in ascending the stairs. *Winding* stairs gradually change direction as they ascend from one level to another.

Designing stairways

Stairways are designed, arranged, and installed for safety, adequate headroom, and space for the passage of furniture. There are three important considerations in designing stairways: the stair width, the headroom, and the relationship between the riser height and the tread width. Staircases should be wide enough for two people to pass comfortably and for furniture to be carried up or down. The *minimum* width should be 3 feet. *Headroom* is the distance above a stair. We measure it from the outside tread corner to the lowest ceiling point (fig. 1–15). The desired height (headroom) is 7 feet or more; however, refer to your local building codes for height and length requirements. Most building codes require at least 6 feet 8 inches (6' 8") of headroom.

Risers and treads

It's very important that the stairway has the proper rise and tread run. The relationship between the riser height and the tread width determines the ascending or descending ease. If the combination of rise and run is too great, the steps are tiring; this strains the leg muscles and heart. If the combination is too short, the foot may kick the riser at each step. Although there are many rules that can be applied to determine riser height and tread width, we recommend the *sum of one riser and one tread* be 17 to 18 inches (7½ + 10 = 17½ inches).

Laying out stringers

The first step in stairway layout is to determine the exact unit of rise (height of one riser). You calculate it from the stairway's total rise and the fact that the customary unit of rise for stairs is 7 inches. The *total rise* is the vertical distance between the lower finished floor level and the upper finished floor level. It's given on the elevations and wall sections in the blueprints, but the actual distance may vary from that slightly. *Always measure the actual distance.* If the lower and upper floors will have the same finished flooring material, then the measured distance between subfloors will be the same as the distance between the finished floors.

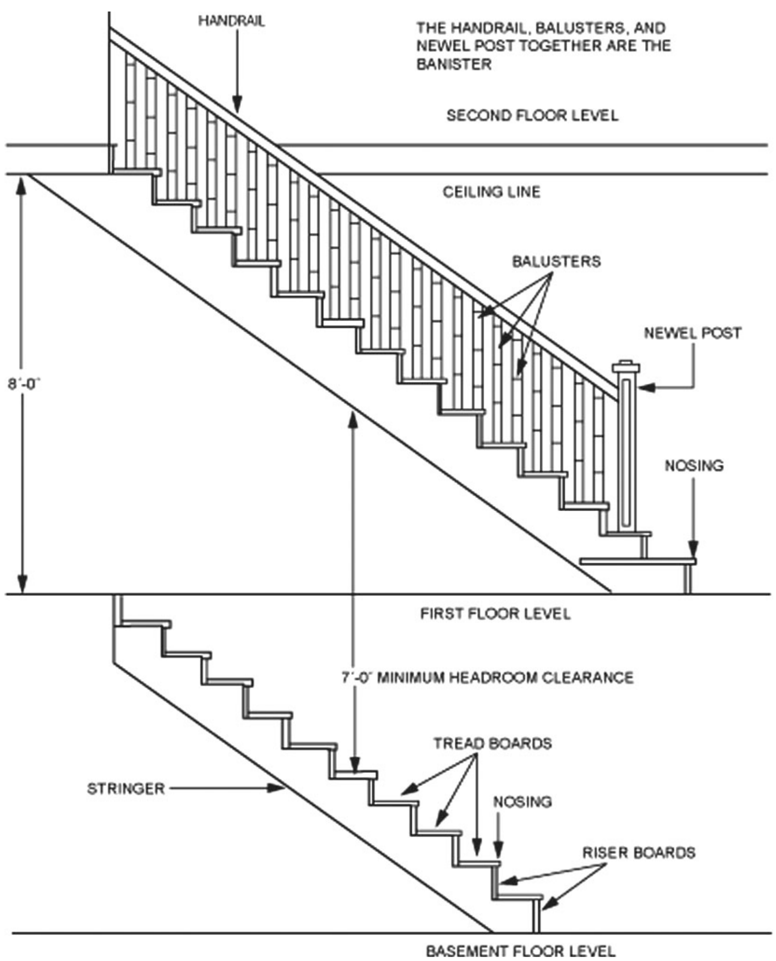


Figure 1–15. Stairway headroom.

If you're measuring from a finished floor, such as a concrete basement floor to a floor that will be covered with finished flooring, you'll have to add that (upper floor) flooring thickness to the vertical distance. 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.

Let's say the total rise between finished floors is 8 feet, 11 inches. You can calculate the rise by following the steps in the table below.

Calculating Rise	
Step	**Action**
1	Convert feet to inches to get a total rise of 107 inches.
2	You divide this total rise by 7inches (average unit rise). The result, disregarding any fraction, is the number of risers the stairway will have—in this case, 107 ÷ 7 is 15.29. Rounding to the nearest whole number, you need to lay out 15 risers on the stringer (see fig. 1–16,a).
3	Now you figure the actual unit of rise, as laid out on the stringer. To do this, you divide the total number of risers into the total rise: 107 ÷ 15 = 7.13 (see fig. 1–16,b).
4	You round this number to the nearest one-sixteeth ($^{1}/_{16}$) inch by taking .13 and multiplying it by 16 (.13 ×16 = 2.08 rounded to the nearest whole number) to get two-sixteeth ($^{2}/_{16}$) or one-eighth ($^{1}/_{8}$) inches. Thus your unit of rise is seven and one-eighth (7 $^{1}/_{8}$) inches.
5	Subtract the unit of rise (7 $^{1}/_{8}$ inches) from the total allowed tread width (18 inches) to find the unit of run—10⅞ inches.

NOTE: You can vary your tread width (within range of the formula) to adjust for the facility. For example, if you take seven and one-eighth (7 $^{1}/_{8}$) from 17, you would have a tread width of nine and seven-eighth (9 $^{7}/_{8}$) inches. That reduces your total run by more than 1 foot.

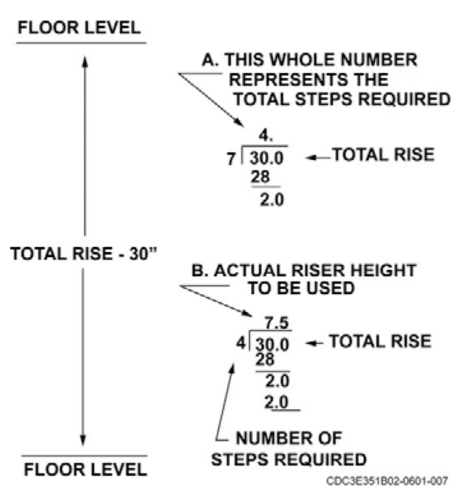


Figure 1–16. Determining riser height.

Calculating rough stringer length

As mentioned earlier, cutout stringers for main stairways are usually made from 2 × 12 stock. Before cutting the stringer, you first need to figure out what length of stock you need.

A simple method to use is the Pythagorean Theorem ($a^2 + b^2 = c^2$). Let's imagine that the 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 9^2 plus 13^2 (9^2 [81] + 13^2 [169] = 250). The square root of 250, about 15.81 feet or 15 feet 9 ¾ inches, means you'll need at least a 16 foot length of stock.

Stringer step off

Now you are ready to use the framing square to step off the stringer. Figure 1–17 shows the first framing square position on the stringer. Set the framing square to the unit of run on the blade and the unit of rise on the tongue, and draw the tread and riser lines. Repeat the process for the second step (fig. 1–18) and the third step (fig. 1–19).

> **NOTE:** Some carpenters prefer to use the tongue for the unit of run and the blade for the unit of rise. The end result is the same.

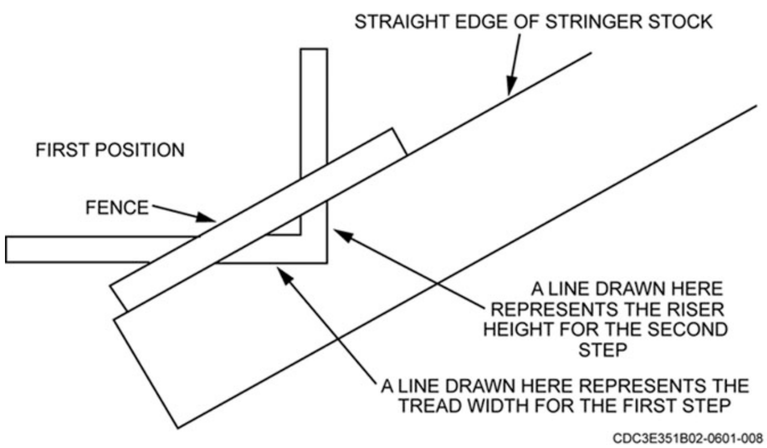


Figure 1–17. First position of framing square on a stringer.

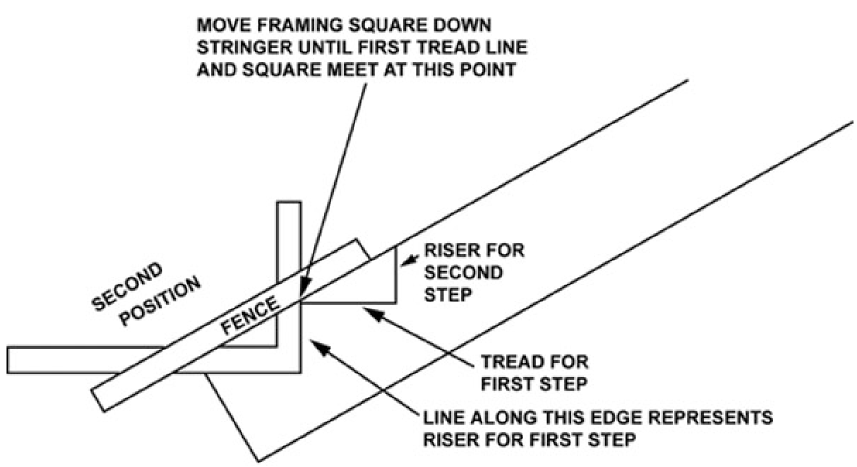


Figure 1–18. Second position of framing square on a stringer.

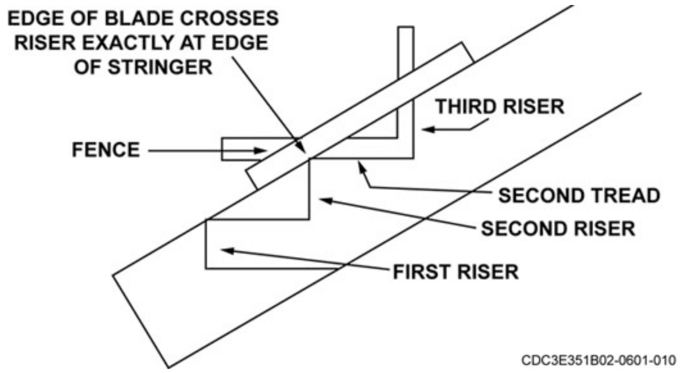


Figure 1–19. Third position of framing square on a stringer.

Dropping the stringer

This is a very simple but important task. You subtract one tread thickness from the stringer's bottom end. The reason you drop the stringer is to make the bottom riser the same height as the other risers and the top tread flush with the upper finished floor.

Installing stringers

The methods we use in framing stairways and securing stringers vary for different Air Force bases. Regardless of the method, the object is to build a structurally strong and safe stairway. Here are a few suggested ways to secure stringers. Figure 1–20, view B shows that the stringers are hung by a metal supporting strap. Figure 1–20, view A shows the stringer notched out for the stairwell header and supported by a ledger board. This method slightly reduces headroom. Figure 1–20, view C requires a larger stairwell opening and is not often used, yet it offers the full bearing of the rough stringer against the stairwell header. The support is a ledger board.

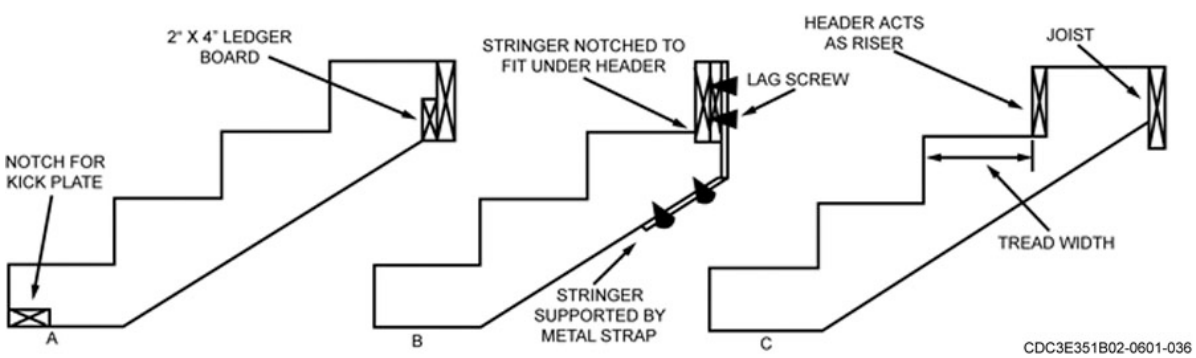


Figure 1–20. Anchoring stringers.

Constructing the stairway

The rough stringers are the first interior stairway members you erect except when a stairway butts against a wall; in which case, you must nail the wall (finish) stringer on first. Temporarily nail the rough stringers in place. Check each stringer for plumb by holding a level vertically against a riser cut. Then check the stringers for level with each other by setting a level across the stringers on the tread cuts. Spike a stringer which lies against a trimmer joist to the joist with at least three 16d nails. Install a center stringer by toenailing to the wall header, three nails to each side of the stringer. Toenail the bottom of a stringer that's anchored on subfloor with 16d nails, four to each side if possible. Drive them into the subfloor and, if possible, into a joist below. After you mount the stringers to the wall, cut the riser trim and tread boards to length.

NOTE: Exterior stairs do *not* usually have riser trim.

The following table describes a basic way to install them starting at the bottom of the stairs.

Installing Stairs (Starting at the Bottom)	
Step	**Action**
1	Nail the riser trim to the stringers with two 6d or 8d nails (depends on trim thickness).
2	Nail a tread board to the stringers with two 10d or 12d finish nails (depends on tread thickness).
3	Nail the same tread board to the riser trim below with at least two 10d finish nails.
4	Proceed up the stairs in the same manner.

Figure 1–21 shows the riser and tread types used on a typical interior staircase on the left and an exterior staircase on the left.

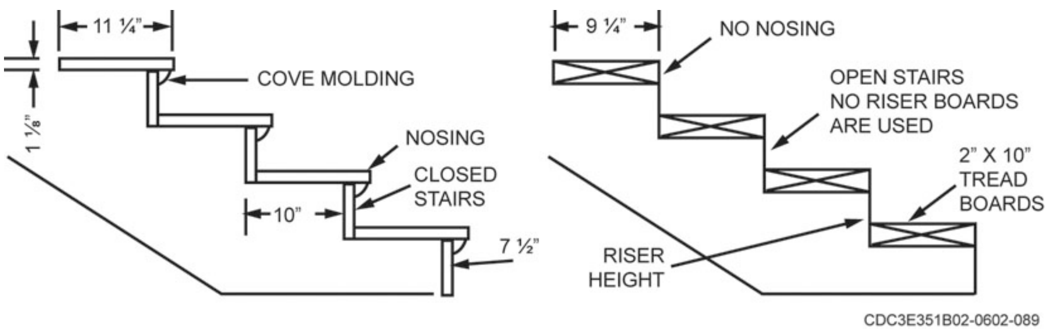


Figure 1–21. Riser and tread types.

Railings

As previously mentioned, you need to refer to your local building codes for the staircase safety requirements. Some codes require the handrails to be placed from 30 to 34 inches *above the nosing* (outside edge of the tread beyond the riser) and landings, while others require 34 to 38 inches. The handrails should extend past the bottom and top risers by at least 12 inches. They should also provide a gripping surface of 1¼ to 2 inches with at least a 1½ inch finger clearance between the wall and the handrail.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

604. Stair construction

1. What factors do you consider in designing a stairway, and why is each factor important?

2. The vertical distance between the upper and lower levels of a stairwell is 8 feet, 4 inches measured from the subfloor of both levels. The upper level is to have a ¾ inch finished floor and the lower level is to have a concrete finished floor. The finished tread is 1½ inches.

   a. What is the *total rise* of the stairway?

   b. What is the *unit of rise*?

c. What is the *unit of run*?

d. How much *drop* will there be in the stringer?

605. Inspection and repair

Many of our jobs deal with repairing or replacing structural components. You've learned how to construct floors, walls, ceilings, and stairs. In this lesson we'll discuss what to look for during and after construction and some basic repair methods.

We focus on wood and metal framing. We'll discuss inspection procedures that occur during the construction process, as it's not practical to inspect framing members after they are covered with sheathing. Let's begin with wood framing.

Wood-framed construction

In light-frame construction, buildings are constructed according to local building codes. You must be familiar with these codes and regulations. In some areas of the country, buildings must be constructed with special resistance to wind and rain. In other locations, buildings are constructed according to codes designed with for other disaster problems such as earthquakes, cold climates, snow loads, and humidity. All require quality construction and special designs. Structures should be built to reduce the effects of shrinkage, warping, and resistance to fire hazards.

We will not cover all aspects of inspecting light-framed construction; however as an inspector or crew leader, you need to be knowledgeable about what to look for when inspecting this type of construction.

Metal-framed walls

When inspecting metal-framed walls, make sure the proper self-drilling screws are used, check for tolerance and gauge of metal, and be sure the top and bottom tracks are securely fastened. Also ensure the knockouts are aligned properly for easier runs for the electrical and mechanical lines. When you cut or scratch metal it tends to oxidize which results in the creation of rust. How fast the oxidation occurs depends upon the climate. To prevent oxidation, paint the cut ends with a galvanized paint or a primer.

Wood floors

As the inspector, you must ensure:

- That all lumber is of the specified grade and type according to specifications.
- That all beams are true.
- That flooring material is resting squarely on the joist.
- That floor joists are the correct size and overall length, and are sound and free from excessive warp.
- That the floor joists are installed bearing on sills or beams or supported by straps or hangers, and are braced with cross bridging and/or with solid bridging, as specified.
- That the tops of the floor joists are brought to a true, level plane.
- That subflooring of the specified kind, grade, and size is installed, made tight, and thoroughly nailed.
- That building paper is laid, if prescribed.

Wood floors are frequently installed on steel framing, particularly in light industrial buildings where steel bar joists are used. You must make sure that all materials and workmanship conform to the requirements of the specifications and that the floor is finished smooth and even.

Wood-framed walls

You must familiarize yourself fully with the drawings and specifications and the standard specifications used for references. Make sure the framing material is of the specified grade, size, and the surface has been inspected and grade marked. You must make certain that the nails, bolts, screws, connector rings, and other fastening devices conform to the requirements for type and size. Also ensure that metal ties, straps, hangers, stirrups, joist hangers, and similar accessories are suitable and used correctly. Where long bolts hold numerous plies of lumber together, you should recheck the tightness of the nuts before the project is finally accepted because shrinkage of the lumber may have caused them to loosen.

Make sure that the wall material conforms to the specifications as to the kind of wood, grade, and manufacture or has been inspected or grade flashed as necessary for weather tightness. Also make certain that siding is applied carefully so that the lines are straight and true and that laps and exposed faces are correct. In addition, make sure that nails are the specified kind and weight, are driven flush, recessed, or blind, as specified; and that, if recessed, they are filled over with a suitable plastic wood putty.

In most cases, wood partitions are composed of 2 × 4 inch wood studs with sills and plates of the same material. Studs are doubled at openings, and the top plates are usually doubled to provide strong splices.

Headers, encountered in light-frame construction, are required at all openings of load bearing and non-load bearing walls. Remember non-load bearing headers run parallel with the joists; load bearing headers run perpendicular to the joists and carry the load immediately above the openings. If the opening is more than 3 feet in width, the header will need additional strength to carry the load imposed upon it from above. Check the local building codes, plans, and specifications for more information on headers.

Partitions

Wood partitions to be finished on both sides are covered with wood lath, metal lath, plasterboard, or some other base or may be covered in drywall construction with wallboard of various types. Paneling is frequently used to cover wood partitions in offices. This type of construction uses studs spaced fairly wide (2 feet) apart with tongue-and-groove panels, wallboard, or some other material used for wall coverings. Such partitions frequently extend only part way to the ceiling.

When inspecting, you must ensure:

- All partitions are adequately anchored to the floor, the walls, and the ceiling as specified, and are adequately braced and stiffened at all splices and corners.
- Studs are set truly plumb and in line, and are well nailed to sills and plates.
- Plaster base or other surfacing or panels and trim are carefully and accurately installed so that a neat, workmanlike finish is obtained.
- When necessary, that all fastenings are completely concealed behind the trim and that the trim is nailed with finished brads.

Wood exteriors

Regularly inspect wood exteriors for damage from wear, accidents, and the elements. Tap the wood with a hard object to inspect for insect damage. A dull or hollow sound is an indication of damaged wood, which may be the result of insects. Inspect painting and surface treatments for deterioration; inspect exteriors for loose, warped, cracked, or broken boards or shingles.

Moisture is the most prevalent cause of exterior wall failure. Stains, paint deterioration, and rot are usual signs of moisture damage. Condensation within and behind walls is a less obvious but equally damaging factor. Insufficient, loose, or displaced nailing produces, separations, and cracks that admit moisture, reducing the stability of wood walls.

Foundation settlement or displacement may cause misaligned framing members and damage the walls, including cracks in siding and broken or displaced boards or shingles. Carefully check to determine that existing structural, functional, and material conditions warrant repair to the existing wall, rather than complete residing, insulating, or other overall repair or rehabilitation. Replace damaged material with like material. Cut back sufficient areas beyond the damaged part to obtain good jointing and sound nailing. Make sure that the material that you nail into is sound and true. Cover replacement wood with treatment and/or paint to match the rest of the wall.

Review “as-built” plans, if available, to ensure that out-of-sight construction and utilities will not be damaged. Periodically check panel siding for looseness and faulty caulking. Replace damaged or deteriorated panels rather than attempting to patch. It is usually more economical and satisfactory.

Wood decay

Wood-rotting fungi grows in damp wood and results in wood decay. Fungi attack wood members in contact with damp masonry foundations, moist ground or standing water, and water pipes on which moisture condenses. Poor ventilation around the wood hastens the process of decay.

Wood decay may be indicated by:

- A damp, musty odor.
- Opening or crumbling of the wood.
- The presence of fine, dusty, reddish-brown powder under the building.
- A hollow sound when the timber is tapped.
- Easy penetration of timber by a sharp-pointed tool.

Corrective actions taken to alleviate wood decay include:

- Removing fungus-infested lumber.
- Spraying infested areas with wood preservative.
- Eliminating the source of moisture.
- Adding fill around masonry and grade swales to lead water away from the foundation. Where land contours do not promote water runoff, install drain tiles around the foundation, and lead them to a storm drain.
- Providing ventilation to affected areas.
- Replacing infested lumber with wood preservative treated lumber.

Girders and floor/ceiling joists

Like the other basic supporting members, periodic inspection and timely repair of girders and joists are important to the general maintenance of a structure.

It is normal to expect shrinkage, splits, and checks in wood joists and girders because they are not easily dried (seasoned) due to their size.

Carefully record size, location, and depth of checks and splits. If records indicate increase in length or depth, then you may have to install stitch bolts.

Stitch bolts are required in all structural members that have deep checks or splits $^{3}/_{8}$ inch or greater in width and/or have slope of grain greater in width than 1 inch in 14 inches.

In the event of a structural failure, make an engineering study to determine whether the failure can be properly patched or if the entire girder or joist must be replaced. There are many methods used to reinforce girders and joists. However, the method selected should be determined by the loads to be carried, the cost, and clearance and accessibility.

When either a permanent or temporary post is placed under a failed girder or joist, you must first consider the size of the post and the cap, as well as adequacy of base support under the post. Joist repair can be facilitated if the new member is sized one dimension smaller than the original member. Replace any bridging that was removed with solid bridging.

Stairways

Periodically inspect stairways for adequacy of support and safe condition of components (some organizations suggest quarterly). A good stairway inspection includes a check for the following conditions:

- Cracked, weathered, or rotted wood framing.
- Settled, cracked, or spalled concrete.
- Rusted or loose metal supports.
- Inspect treads for loose or broken tread nosing; excessive wear; paint or tread covering deterioration; and loose, eroded, or slippery tread surfaces. Slope or drill exterior treads to drain properly.
- Inspect handrails for loose fastenings and material deterioration.
- Check newel posts and balusters for looseness and missing parts.

Maintenance

Maintenance on interior wood stairs usually involves treads. Squeaks indicate loose treads that you can correct by driving finishing nails through the treads into the riser or carriages or by removing the molding under the tread overhang, driving wood wedges between the tread and riser, renailing the tread tightly, and replacing the molding. In open-string stairs, a tread that is worn but not split or broken may be removed and reversed. Replace split, broken, or otherwise seriously damaged treads with new boards. Repair treads that cannot be removed by leveling the worn surface with asphaltic mastic or other suitable plastic materials and cover the tread with a suitable floor covering. Plain and nonslip nosing of steel, brass, bronze, aluminum, and molded hard rubber is commercially available and should be applied according to the manufacturer’s recommendations.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

605. Inspection and repair

1. What do you check for when inspecting metal-framed walls?

2. When you inspect wood-framed walls what do you check for?

3. How do you fix squeeking stair treads?

Answers to Self-Test Questions

601

1. The sill plate or (mudsill).
2. You must know what is planned for the exterior wall before installing the sill. The exterior wall affects where you place the sill on the foundation. For example, some sheathing may require the sill to be set back to its thickness while brick veneer can require much more.
3. By the span and the amount of load to be carried.
4. (1) Cross-bridging.
   (2) Solid bridging.
5. Sight each joist before you nail it in place to make certain you turn the crown up.

602

1. Load bearing walls are usually installed *perpendicular* to the ceiling joists. If it is installed *parallel* to the ceiling joists, it probably is not load bearing.
2. Studs, plates, headers, trimmers, cripples, sills, corner posts, and diagonal braces.
3. By hand if enough help is available. It is advisable to have one person for every 10 feet of wall for the lifting operation.
4. (1) Plywood sheathing adds considerable strength.
   (2) Often eliminates the need for diagonal bracing.
5. (1) The metal studs and runners do not shrink, swell, twist, or warp.
   (2) Termites can't affect them nor are they susceptible to dry rot.
   (3) When combined with proper covering material, they have a high fire-resistance rating.

603

1. To tie together the outside walls.
2. On the plans.
3. By the weight it carries and the span it covers from wall to wall.

604

1. (1) Width, so two people can pass one another going in opposite directions.
   (2) Distance between the tread and the lowest point in the ceiling, to allow for proper head room.
   (3) Riser height and tread width, to ascend and descend the stairs comfortably.
2. (a) 8 feet, 4 ¾ inches.
   (b) 7 $^{1}/_{8}$ inches.
   (c) 10 ⅞–inches.
   (d) ¾ inch.

605

1. (1) Proper self-drilling screws are used.
   (2) Check for tolerance and gauge of metal.
   (3) Ensure top and bottom tracks are securely fastened.
   (4) Check knockouts and ensure they are aligned properly for easier runs of the electrical and mechanical lines.
2. (1) Framing material is of the specified grade, size, and the surface has been inspected and grade marked.
   (2) Make certain nails, bolts, screws, connector rings and other fastening devices conform to the requirements in type and size.
   (3) Ensure metal ties, straps, hangers, stirrups, joist hangers, and similar accessories are suitable and correctly used.

3. (1) Drive finishing nails through the treads into the riser or carriages or remove the molding under the tread overhang.
   (2) Drive wood wedges between the tread and riser.
   (3) Renail the tread tightly.
   (4) Replace molding.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (601) In platform frame construction, what floor frame member do you install *first*?
   a. Joist.
   b. Subfloor.
   c. Sill plate.
   d. Sole plate.

2. (601) What determines the size of wooden floor joists?
   a. Live and dead loads.
   b. Span and height of the building.
   c. Span and amount of load to be carried.
   d. Height of the building and load to be carried.

3. (601) Which floor joists are used when a floor or balcony extends past the building’s outside wall?
   a. Butted.
   b. Lapped.
   c. Doubled.
   d. Cantilevered.

4. (601) Which type of *bridging* usually consists of 1 × 3 inch or 2 × 3 inch wood?
   a. Cross.
   b. Solid.
   c. Inline.
   d. Staggered.

5. (601) A floor joist’s *crown* is installed turned
   a. up.
   b. down.
   c. to the left.
   d. to the right.

6. (602) What precautions are necessary for *removing a load-bearing wall*?
   a. Nothing.
   b. Remove the wall, then brace it.
   c. Nothing, brace the wall as you are removing it.
   d. Support the load it is carrying before removing the wall.

7. (602) Load bearing partitions (interior walls) run what direction to the floor joists?
   a. Vertical.
   b. Parallel.
   c. Horizontal.
   d. Perpendicular.

8. (602) According to recommendations how many people are needed to raise a 30 foot wall?
   a. 1.
   b. 2.
   c. 3.
   d. 4.

9. (602) Which type of panel do most experts still recommend when *maximum shear strengt*h is required?
   a. Oriented strand board (OSB).
   b. Conventional Plywood.
   c. Fiberboard.
   d. Waferboard.

10. (602) How are metal framing members *thinner* than 18 gauge assembled?
    a. Welded.
    b. Lag screw.
    c. Machine screw.
    d. Self-drilling, self-tapping screws.

11. (603) What determines the size of a *ceiling joist*?
    a. Weight it carries and roof slope.
    b. Height and span from wall to wall.
    c. Roof slope and span from wall to wall.
    d. Weight it carries and span from wall to wall.

12. (604) The *preferred* construction method to make stairway turns is to use
    a. winders, because they are safer.
    b. landings, because they are safer.
    c. winders, because they are more appealing to the eye.
    d. landings, because they are cheaper and easier to construct.

13. (604) The recommended sum of one riser and one tread is
    a. 15 to 16 inches.
    b. 16 to 17 inches.
    c. 17 to 18 inches.
    d. 18 to 19 inches.

14. (604) To drop the stringer to make the bottom riser the same height as the other risers and the top tread flush with the upper finished floor you subtract one tread thickness
    a. from the stringer's top end.
    b. from the stringer's bottom end.
    c. from the stringer's top and bottom end.
    d. and one riser from the stringer's bottom end.

15. (604) How do you check *stair stringers* to make sure they are plumb?
    a. Place a level on the tread cut.
    b. Use any horizontal support member.
    c. Hold a level vertically against the riser cut.
    d. Level the top of the stringer with the finished floor.

16. (605) When inspecting metal-framed walls, make sure the knockouts are aligned properly for
    a. structural integrity
    b. installing gypsum board.
    c. attaching bottom and top tracks.
    d. easier runs for the electrical and mechanical lines.

17. (605) To prevent oxidation when you cut or scratch metal frame wall members you should paint them with
    a. flat latex paint or primer.
    b. flat enamel paint or primer.
    c. a fast drying paint or primer.
    d. a galvanized paint or a primer.

18. (605) When inspecting wood framed walls where long bolts hold numerous plies of lumber together, you should recheck the tightness of the nuts because
    a. expansion of the lumber may have caused them to over-tighten.
    b. shrinkage of the lumber may have caused them to over-tighten.
    c. shrinkage of the lumber may have caused them to loosen.
    d. expansion of the lumber may have caused them loosen.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Roof Construction

THIS UNIT HIGHLIGHTS the fundamentals of roof design and construction. As a structural journeyman you will very likely have to design some type of roof during your career—maybe not at your permanent duty station but at a forward location. Your ability to accomplish this task successfully depends upon your ability to design and calculate roof-framing members.

Before you can begin constructing a roof, you need to be familiar with different types of roofs and the terms used for the roof components. The most common types of pitched roofs are the gable, hip, intersecting, and the shed (or lean-to). However, in this unit we only discuss construction techniques for the gable and hip roofs.

The *intersecting 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 degree angle. This type of roof is more complicated than the other types and requires more time and labor to construct.

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. Walls or posts hold up the roof and one side is at a higher level than the opposite side.

Now that we have reviewed the basic roof types let's take a look at what is involved in framing two different roof types in the following lessons. First up is the gable roof. However, before we discuss the actual process we'll make a quick review of terms you need to know.

606. Gable roof framing

In this lesson, we discuss how to construct a gable roof. A gable roof has a ridge at the center and slopes in two directions. It is simple in design, economical to construct, and can be used on any type of structure.

Framing terms and rafters

Before we begin our discussion on gable roofs, let's go over some common framing terms and different types of rafters that are common to all roof types. Most of the terms are shown in figure 2–1.

Framing terms

You must know the basic vocabulary to understand the whole concept of roof framing. The following table identifies the basic terms that you need to know.

Roof Framing Terms	
Term	**Explanation**
Span	The horizontal distance measured between the outsides of the top plates.
Unit of run	A fixed horizontal measurement used to calculate rafter length. On a common rafter the unit of run is 12 inches. On a hip or valley rafter, it is 16.97 inches or 17 inches.
Unit of rise	The distance the rafter rises per foot of run.
Unit of span	Fixed measurement; *always 24 inches.*

Roof Framing Terms	
Term	**Explanation**
Total run	A horizontal measurement that is equal to half of the span.
Total rise	The vertical distance from the top plate to the top of the ridge.
Slope	The angle that the roof surface makes with a horizontal plane; usually expressed as a fraction with the unit of rise as the numerator and the unit of run (12) as the denominator.
Pitch	The ratio of unit of rise to the unit of span. The amount of roof incline expressed as a fraction by dividing the total rise by the span.
Line length	Line length of a rafter is the hypotenuse of a triangle whose base equals the total run and whose altitude 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	The hypotenuse of the triangle with the unit of run for the base and unit of rise for the altitude.

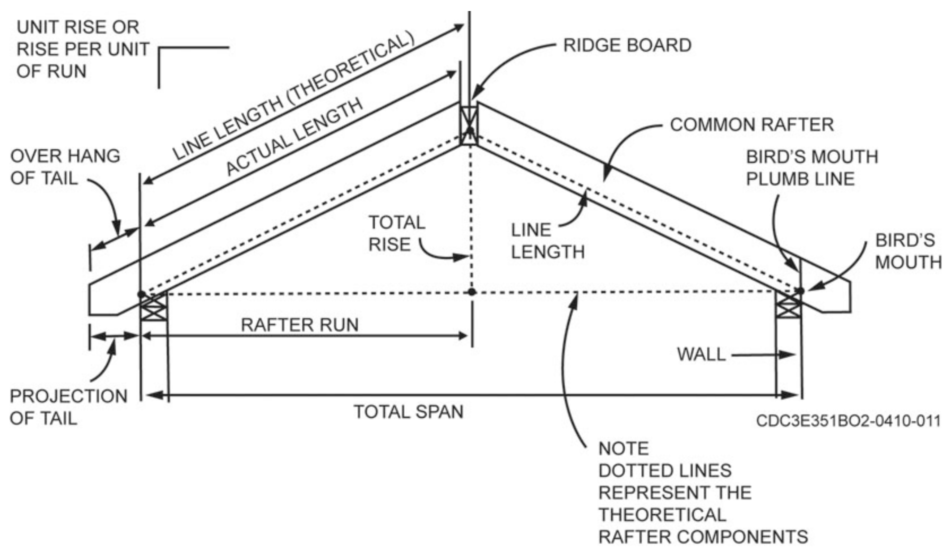


Figure 2–1. Roof framing terms and components.

Rafter types

Rafters make up the main body of the roof framework. The four rafter types used in roof framing are the common, hip, valley, and jack rafters described below and shown in figure 2–2.

Rafter Types	
Type	**Description**
Common	Extends at a right angle from the top plate to the ridgeboard. Used as the basis for laying out other rafter types.
Hip	Extends diagonally from the plate corner to the ridgeboard.
Valley	Extends diagonally from the plate to the ridgeboard at the line of intersection of two-roof surfaces. The valley rafter lies where adjacent roof slopes meet to form a valley.
Jack rafter	Runs parallel to a common rafter but does not touch the ridge or the rafter plate.

The hip jack, valley jack, and cripple jack are rafters that are required for structural support on certain roof types. The *hip jack rafter* extends from the plate to the hip rafter, whereas the *valley jack rafter* extends from the ridge to the valley rafter. A *cripple jack rafter* extends from a hip to a valley rafter.

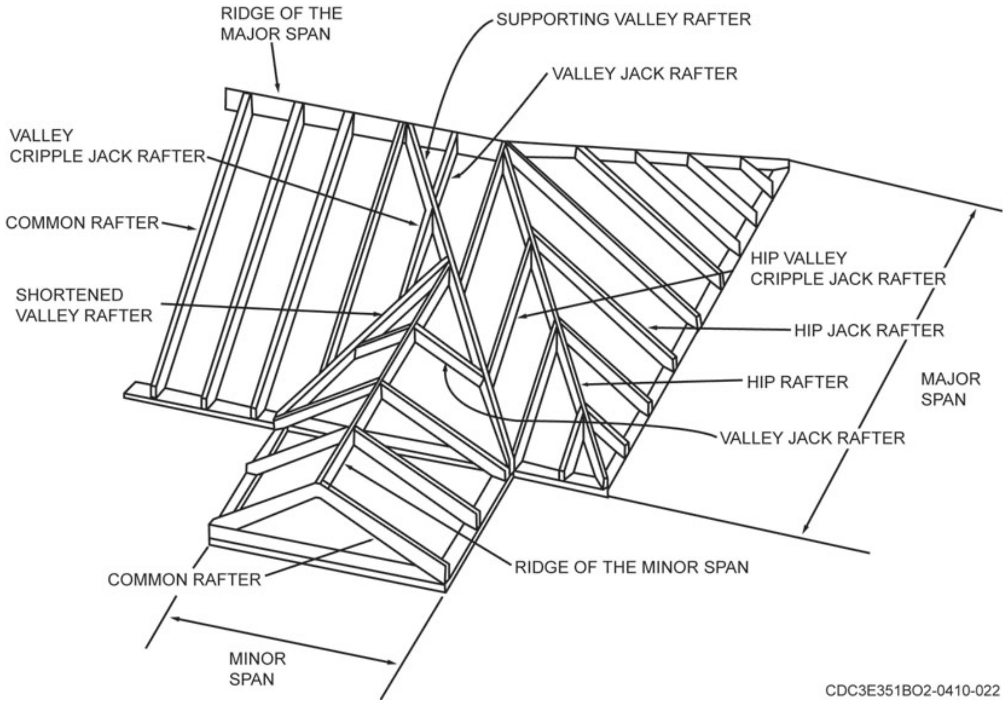


Figure 2–2. Roof framing members.

Gable roof description

The gable roof is one of the simplest types of roofs to build because it slopes in only two directions. The basic structural members of the gable roof are the ridgeboard, common rafters, and the gable-end studs.

- The *ridgeboard* is placed 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.

Common rafter layout

There are several ways to layout rafters to determine the exact length needed. We will discuss the framing square table method, basic triangle (bridge measure) method, and the framing square step-off method. If you know another way that gets correct results and is easier for you, don’t hesitate to use it. Your main objective is to construct an attractive roof that protects the facility from bad weather. Figure 2–3 shows a common rafter.

To calculate the length of a common rafter, you need to know the unit of rise and the total run of the roof. With this information, you can use a framing square to lay out rafters for the building. The rafter stock must be long enough to cut the rafter from it. Use a framing square to lay out the plumb and horizontal rafter cuts.

NOTE: The rafter length found by any of the methods we will discuss is the measurement from the heel plumb line (outside top plate) to the center of the ridge. This is known as the theoretical length of the rafter.

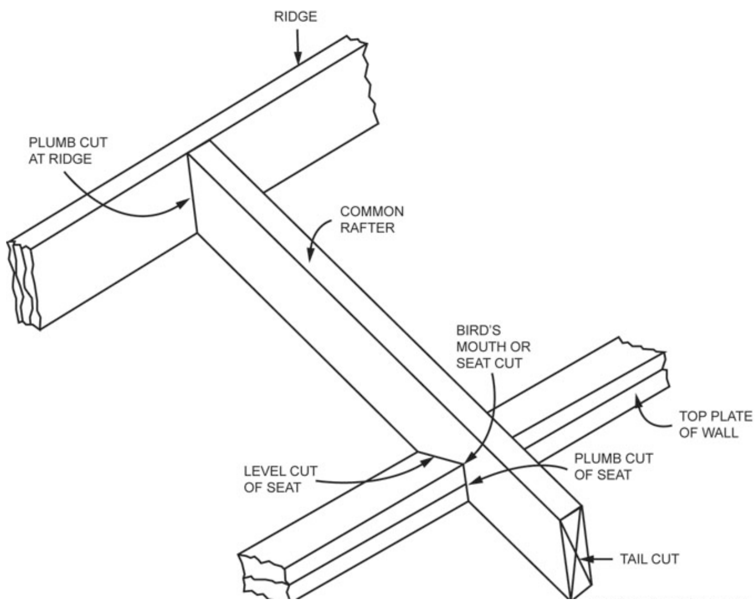


Figure 2–3. Common rafter.

One-half of the ridgeboard must be deducted from each rafter. This calculation is known as *shortening the rafter*. It is done 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.

Framing square table method

This is probably the simplest way to compute rafter lengths. To use it, you need to know how to use the framing square table. Many framing squares have a rafter table on the blade, laid out like the tables for board measure on the opposite side of the blade (fig. 2–4). First, find the section labeled “length common rafters per foot run.” One foot (12 inches) of run is assumed, so all you need is the rise to find the rafter length. Deduct half the ridgeboard thickness to for the actual rafter line length.

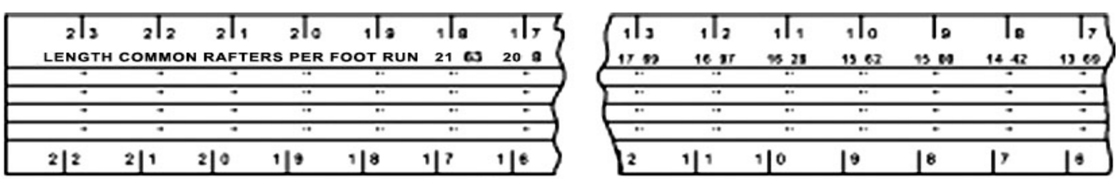


Figure 2–4. Framing square rafter table.

If the rise is 10 inches per foot of run and the total run is 6 feet, first find the 10–inch mark, representing 10 inches per foot of rise. Just below the number 10, the number 15.62 is shown. In this case, the .62 indicates hundredths of an inch. The number 15.62 represents a common rafter length, and is the bridge measure of a 10–inch rise and a 1-foot run. All you need to do is multiply 15.62 inches by the total run. The answer is 15.62 × 6 = 93.72, or about 7 feet 9 and ¾ inches (7’ 9¾”).

NOTE: Books are available that list the rafter tables.

Basic triangle (bridge measure) method

If a framing square is not available, you can find the bridge measure using the Pythagorean theorem (fig. 2–5).

- The *vertical side* is the *rise*.
- The *horizontal side* is the *run*.
- The *hypotenuse (bridge measure)* is the *rafter length*.

Let's say that the roof in figure 2–5 has a 9-inch unit of rise and a 12–foot total run. Using the Pythagorean theorem (A squared + B squared = C squared), you can compute the rafter length as illustrated in the following table.

Computing Rafter Length	
Step	**Action**
1	Square the unit of rise (9 × 9 = 81).
2	Square the unit of run (12 × 12 = 144).
3	Add the squared unit of rise and the squared unit of run (81 + 144 = 225).
4	Find the square root of 225 (15). The bridge measure equals 15.
5	Multiply the bridge measure by the total run to determine the total rafter line length with no overhang (15 × 12 = 180 or 15 feet).
6	Deduct half of the ridge board thickness from the 15 feet to get the actual rafter length.

NOTE: To save time, you can also apply this method using the total rise and total run.

For example, suppose you have roof with a 5-inch unit of rise, and the total rise of 6 feet 3 inches and a total run of 15 feet. Use the same steps as above:

6.25 feet squared [39.06] plus 15 feet squared [225] = 264.06

The square root of 264.06 is 16.25. The rafter line length is 16 feet 3 inches. This is the same answer that you would get if you computed the bridge measure for a 5-inch unit of rise and multiplied it by the total run.

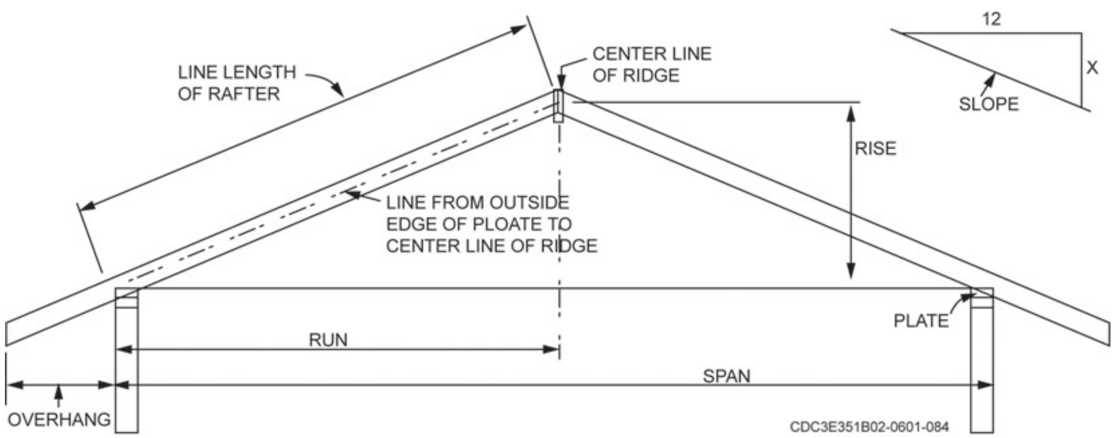


Figure 2–5. Right triangle.

Common rafter layout using framing square table and bridge measure methods

Before you 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. We will discuss how the angles are laid out with the use of a framing square; however, you can also use a speed square. If square gauges are available, place one square gauge on the tongue of the square next to the number that is the same as the unit of rise—we'll use 6 inches for this example. Attach 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). When the square is placed on the rafter stock, the plumb cut is marked along the tongue (unit of rise) side of the square. The seat cut is marked 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 (fig. 2–6). Overhang, or tail line length, is rarely given and must be calculated 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 (in inches) times projection (in feet) equals tail line length in inches.

Determine the bridge measure by using the rafter table on the framing square or calculate it by using the Pythagorean theorem. There are four basic steps remaining which are described in the table below.

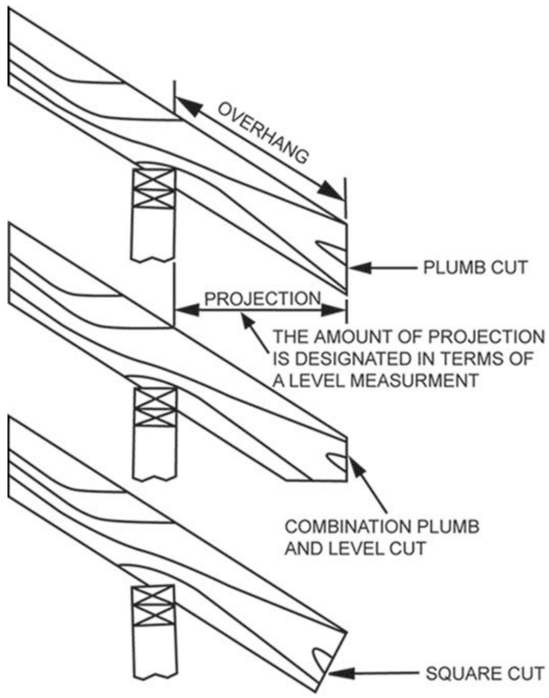


Figure 2–6. Rafter overhang.

Four Basic Steps for Rafter Layout	
Step	**Description**
1	*Lay out the rafter line length*. Hold the framing square with the tongue in your right hand, the blade in the 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 centerline 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 six 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 one and one-half (1½) inches along the heel plumb line up from the bottom of the rafter.

Four Basic Steps for Rafter Layout	
Step	**Description**
	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 (fig. 2–7). (This is the ridgeboard shortening allowance.) Strike a plumb line at this point. This line represents the plumb cut of the ridgeboard.

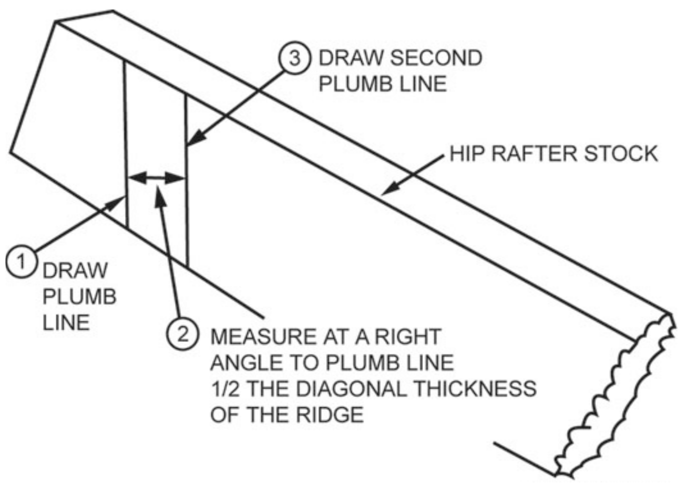


Figure 2–7. Shortening allowance.

Framing square step-off method

In this method, you use the rise (in inches) on the tongue and the run (12 inches) on the blade of the framing square. It is best to use the measurements on the outside of the blade and tongue. In any case, make sure you *take both measurements from the same side* (inside or outside) of the framing square. Once again, if you have square gauges, attach them to the tongue and blade to indicate the applicable numbers when you move the square from step to step along the rafter length. The steps in this method are described in the following table.

Framing Square Step-Off Method	
Step	**Action**
1	After you've found the marks on the square, hold the framing square with the tongue in your right hand, the blade in the left, and the heel away from your body. Mark the ridge plumb line along the tongue. Assuming that the desired roof slope is 5:12 and that the run is 6 feet, you place the square near the end of the rafter. The 5-inch mark on the tongue and the 12–inch mark on the blade are on the rafter's lower edge. A mark along the tongue's outer edge lays out the roof centerline.

Framing Square Step-Off Method	
Step	**Action**
	NOTE: All *marks along the tongue indicate plumb lines*, and all *marks along the blade indicate horizontal lines* as viewed after the rafter is raised into position. Make a thin mark or knife cut on the rafter where the blade's outer edge meets the material.
2	Slide the square along the rafter's edge until the 5-inch mark on the tongue meets the rafter's edge at the point marked in the first step along the blade. Mark the rafter where the 12–inch mark on the blade meets the rafter's lower edge. This completes step 2 (since this is a 6-foot run, you need to step it off six times).
3	Repeat step 2 at positions until you have stepped off the rafter six times. You'll need to position the framing square at the last mark and strike the heel plumb line. **NOTE:** If your total run is 6 feet 9 inches, add 9 inches to the last mark and then strike the heel plumb line.
4	Follow the same procedures as previously mentioned to lay out the shortening allowance, bird's mouth, and tail line length.

Collar ties

Horizontal members called *collar ties* are often used to reinforce gable roof rafters. In a finished attic, these ties may function as ceiling joists.

To find the line length of a collar tie, times the drop in inches by two and divide by the unit of rise of the common rafter. The formula is as follows:

Drop in inches × 2 ÷ unit of rise = the length in feet.

The collar tie lengths vary from roof to roof, but they are usually about one-third ($^{1}/_{3}$) to one-half (½) of the span. 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.

Methods of ridge board assembly

There are several different methods for setting up the ridgeboard and attaching the rafters to it. When only a few helpers 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 supports. Then nail the rafters to the ridgeboard and the top wall plates.

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

Common rafter overhang can be laid out and cut before the rafters are set in place. However, many craftsmen prefer to cut the overhang after the rafters are fastened to the ridgeboard and wall plates. To do this, you snap a line from one end of the building to the other, and then mark the tail plumb line with a sliding T-bevel or a level (fig. 2–8). Next, 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.

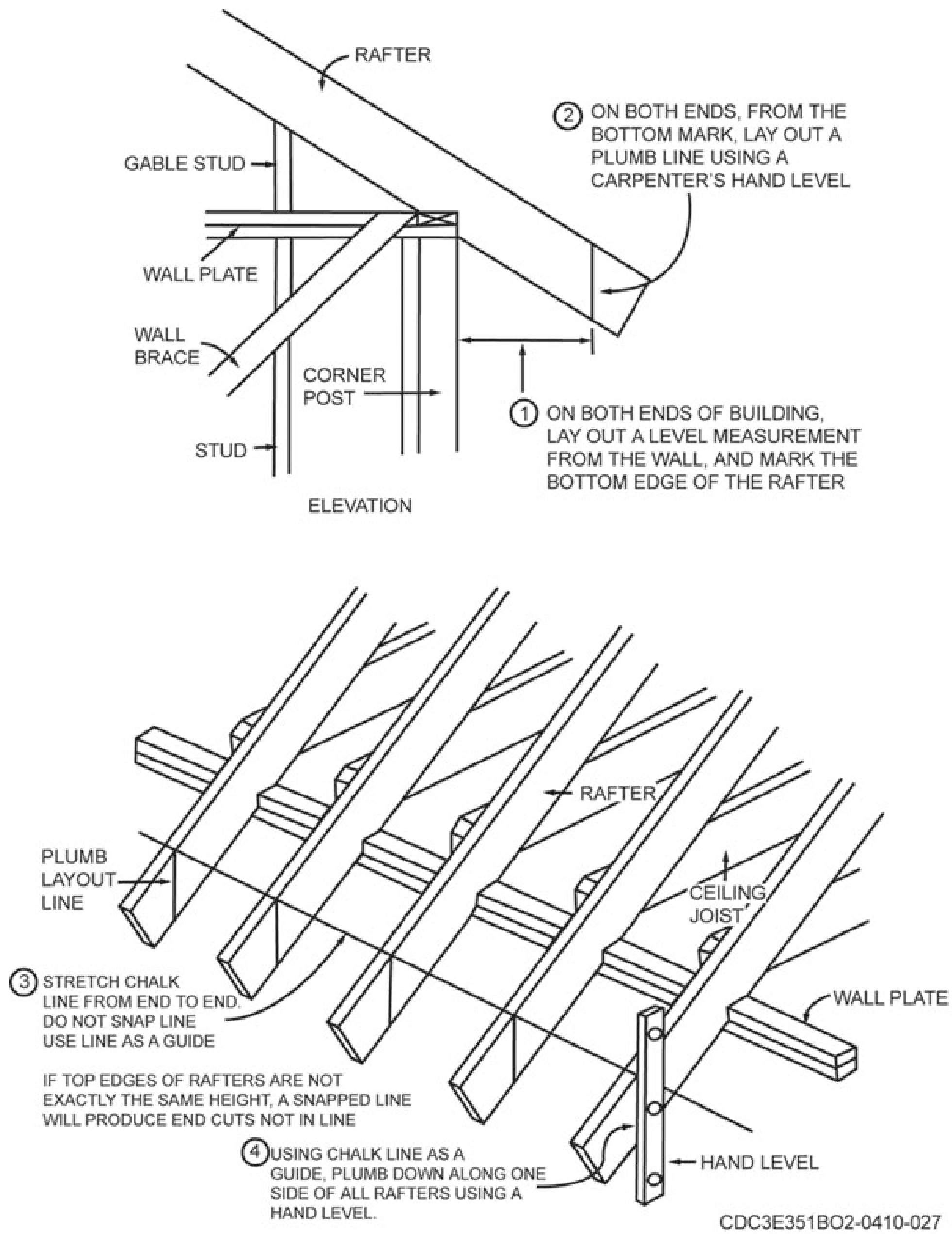


Figure 2–8. Marking rafter overhang.

Rake overhang

Over each gable end of the building, another overhang can be framed. If required, you must install horizontal structural members called *lookouts* to support the rake (fly) rafters. Tie fly rafters 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.

Figure 2–9 shows different methods used to frame the gable-end overhang. In one method, you nail the fly rafter to the ridgeboard and the fascia board. Rest the lookouts on the end wall and nail them between the fly rafter and the rafter next to it. This section of the roof is further strengthened when the roof sheathing is nailed to it. In the next method, you place two common rafters directly over the gable ends of the building. Place the fly rafters between the ridgeboard and the fascia boards. You cut the gable studs to fit against the rafter above, which is also notched to receive the lookouts.

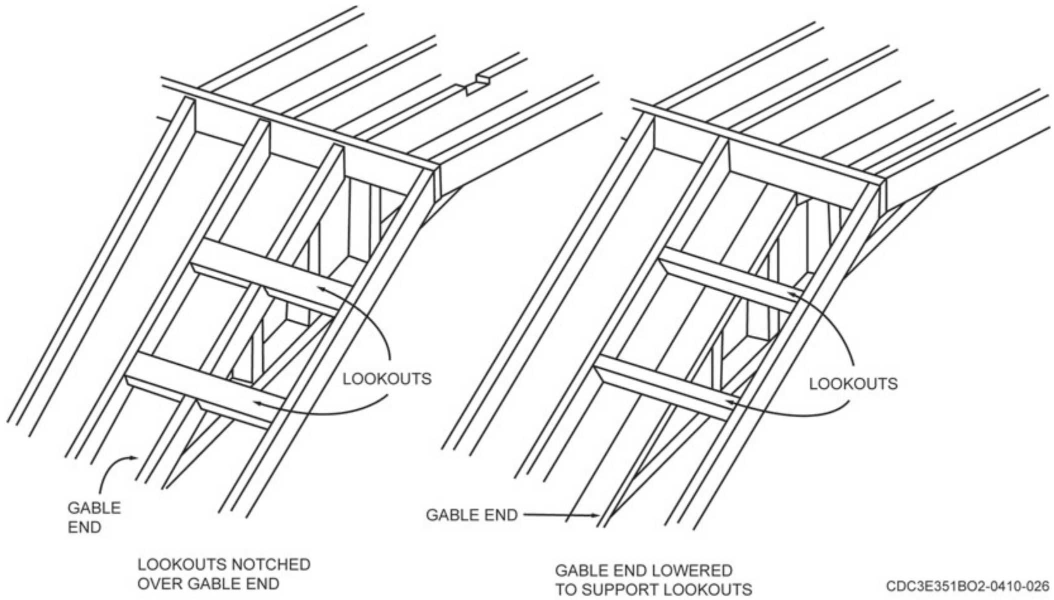


Figure 2–9. Rake overhang methods.

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 (fig. 2–10).

Place the gable end studs directly above the studs in the end wall. This allows you to install wall sheathing easier. The position of the gable-end stud is located by squaring a line up from the wall studs over to the top of the plate. Then use a level to plumb these lines up to the end rafters.

Once the studs are cut, toenail the studs to the plate with two 8d nails in each side. As the studs are nailed in place, take care not to force a crown into the top of the rafter.

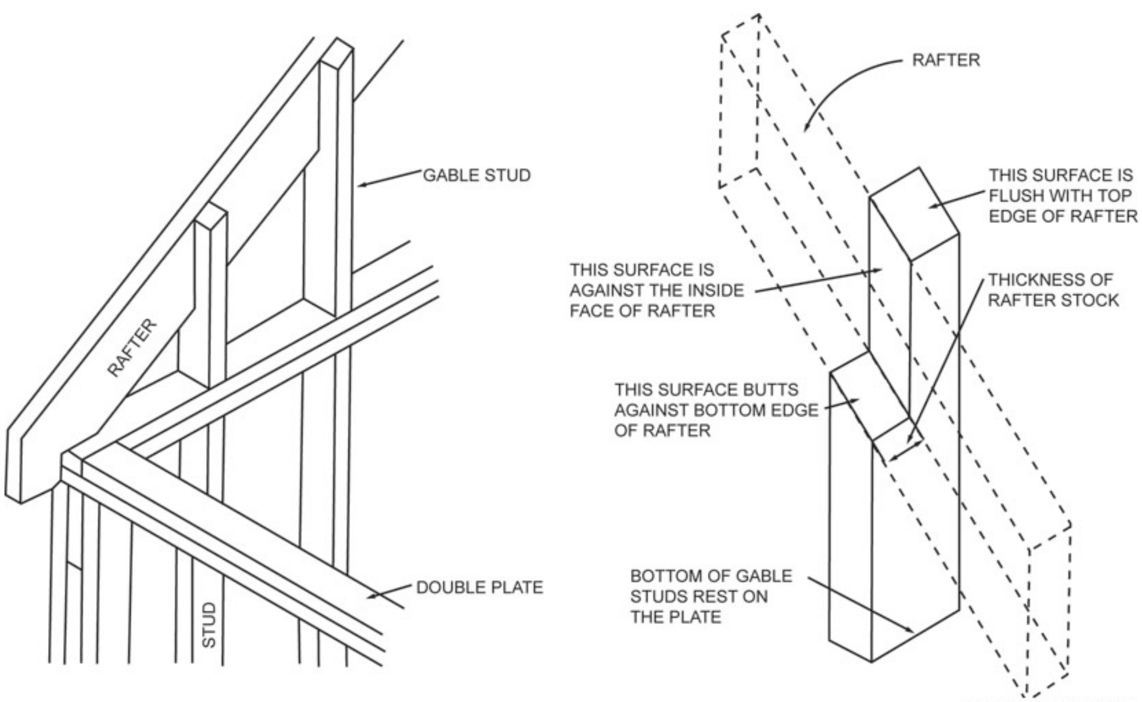


Figure 2–10. Gable end studs.

Gable end stud layout

To find the length of the gable end stud, the easiest method is to stand the stud in place and mark it along the top and bottom edge of the rafter. Next, you should mark the depth of cut (thickness of rafter). Repeat this for the remaining studs.

The common difference in the length of the gable studs may be figured by the following method:

multiply the spacing in units of run (in feet) by the unit of rise

If the studs are spaced 16 inches on center and you have a 6-inch unit of rise, change 16 inches into feet (16 ÷ 12 = 1.33 feet). Then multiply 1.33 by 6 (unit of rise); the result indicates that the common difference between gable end studs is 8 inches.

To find the length of the first stud, stand it in place as previously described. Then you can figure the common difference for each successive stud.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

606. Gable roof framing

1. What does the term *unit of run* mean in roof framing?

2. Briefly describe a *valley rafter*.

3. What are the three *jack rafters*?

4. What two things must you know to lay out and cut common rafters?

5. Identify three methods used for rafter layout.

6. Which method is the *simplest* way to compute rafter lengths?

7. A squared + B squared = C squared is used in which rafter layout method?

8. What bird’s mouth part rests on the top plate?

9. When you’re using the framing square step-off method to layout a rafter, which part indicates the vertical and horizontal lines?

10. When you’re using the framing square step-off method to layout a rafter, what is the *last step*?

607. Hip roof framing

So far, we've discussed common rafters. This information can also be applied to hip rafter layout. The hip roof has four sloping sides. It is the strongest type of roof because four hip rafters brace it. These hip rafters run at a 45-degree angle from each corner of the building to the ridge. A hip roof is more difficult to construct than a gable roof. Most hip roofs are equal-pitch hip roofs, which means the slope angles on the roof ends and sides are the same. Unequal-pitch hip roofs exist, but they're rare. In this lesson, we'll focus on the equal-pitch hip roof.

Hip rafter length

The hip rafter length, like the common rafter length, is calculated on the rise times the unit of run. You can apply any layout method for a common rafter to the hip rafter, but some basic data is different. There is usually a roof-framing plan included in the working drawings; if not, you should lay one out. First, lay out the building lines to scale. You can figure the building's span and length on the working drawings.

The lines that indicate the hip rafters form 45 degree angles with the building lines. The points at which they meet the centerline are, in theory, the ridge ends. The ridge end common rafters join the ridge at the same points (fig. 2–11).

A line indicating a rafter in the roof-framing plan must be in scale to the rafter's total run. The total run of a hip rafter is the right triangle's hypotenuse and each of the shorter sides is equal to a common rafter's total run.

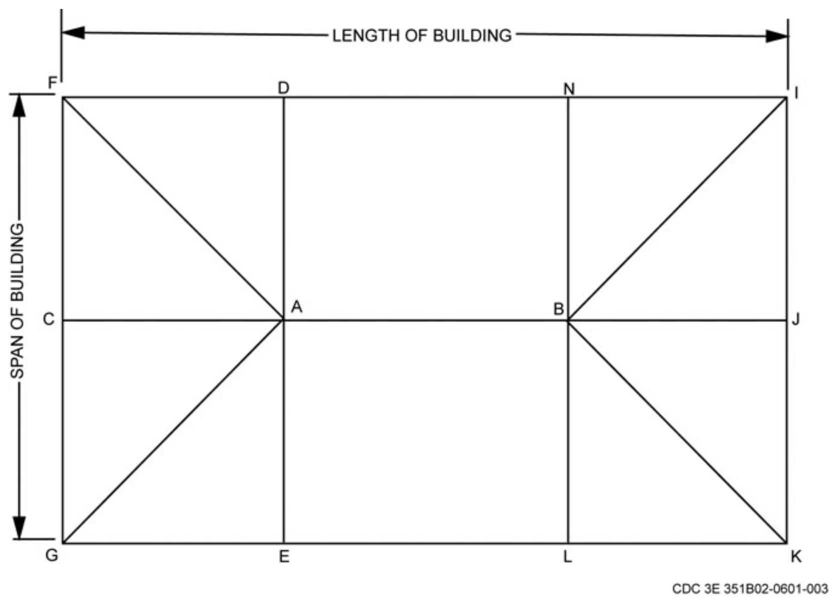


Figure 2–11. Equal pitch hip roof framing diagram.

Computing hip rafter layout

You can use the same methods used for common rafters as you can for hip rafters. The only exception is that you use 16.97 or 17 inches as the unit of run instead of 12 inches. The three methods are repeated below for clarification.

Framing square table method

A simple way to compute a hip rafter length is to use the framing square table method. The second line in the table is labeled "hip length" or "valley length." The measurement shown is equal to one unit of rise and one unit of run. It provides the length of the hip rafter in inches for every foot of run for the common rafter. All you need to do is multiply this measurement by the total run to determine the hip rafter length.

Basic triangle (bridge measure) method

To find the length of a hip rafter on the basis of bridge measure, you must first determine the bridge measure. Like 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 16.97.

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 the square root of $12^2 + 12^2$, which equals 16.97.

If the unit of run of a hip rafter is 16.97 and the unit of rise is 8, the bridge measure of the hip rafter is calculated using the formula $A^2 + B^2 = C^2$ (round to the nearest hundredths):

$$16.97^2 + 8^2 = 18.76$$

This means that for every unit of run (16.97 inches) the rafter has a line length of 18.76 inches for a roof with an 8-inch unit of rise. The last step is to multiply 18.76 by the total run (15 feet).

$$18.76 \times 15 = 281.4 \text{ or } 23 \text{ feet } 5\tfrac{3}{8} \text{ inches.}$$

Framing square step-off method

If you can’t remember the other two methods, this method is probably the easiest way to compute hip or valley rafter length. This method is similar to stepping off a common rafter, except you must use 17 inches as the unit of run. Since 16.97 inches is very close to 17.00, setting the square to a 17–inch unit of run is close enough for most practical purposes. Bear in mind that, for any plumb cut line on an equal-pitch hip roof rafter, you must set the square to the common rafter’s unit rise and to a 17–inch unit run.

To begin, you’ll step off once for each foot in the common rafter’s total run; only the size of each step is different. That is, for every 12–inch step in a common rafter, a hip rafter has a 17–inch step. For example, you can use the framing square to lay out a hip rafter on a 6:12 slope roof with a 22–foot span. Set the tongue at the 6-inch mark (unit of rise) and the blade at the 17–inch mark (unit of run) and step off the rafter 11 times.

Rafter Shortening Allowance

Like 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. The ridge end of the hip rafter can be framed against the ridgeboard or against the ridge-end common rafters (fig. 2–12). To calculate the actual length, deduct one-half (½) the 45-degree thickness of the ridge piece that fits between the rafters from the theoretical length.

When no common rafters are placed at the ends of the ridgeboard, you will place the hip rafters directly against the ridgeboard. You must shorten them one-half (½) the length of the 45 degree line (that is, one-half (½) the thickness of the ridgeboard). When you place common rafters at the ends of the ridgeboard, the hip rafter will fit between the common rafters. You must shorten the hip rafter one-half (½) the length of the 45 degree line (that is, one-half (½) the thickness of the common rafter).

If you frame the hip rafter against the ridge piece, the shortening allowance is one-half (½) of the 45-degree thickness of the ridge piece. The 45-degree thickness of stock is the length of a line laid at 45 degrees across the thickness dimension of the stock. If you frame the hip rafter against the common rafter, the shortening allowance is one-half (½) of the 45-degree thickness of a common rafter.

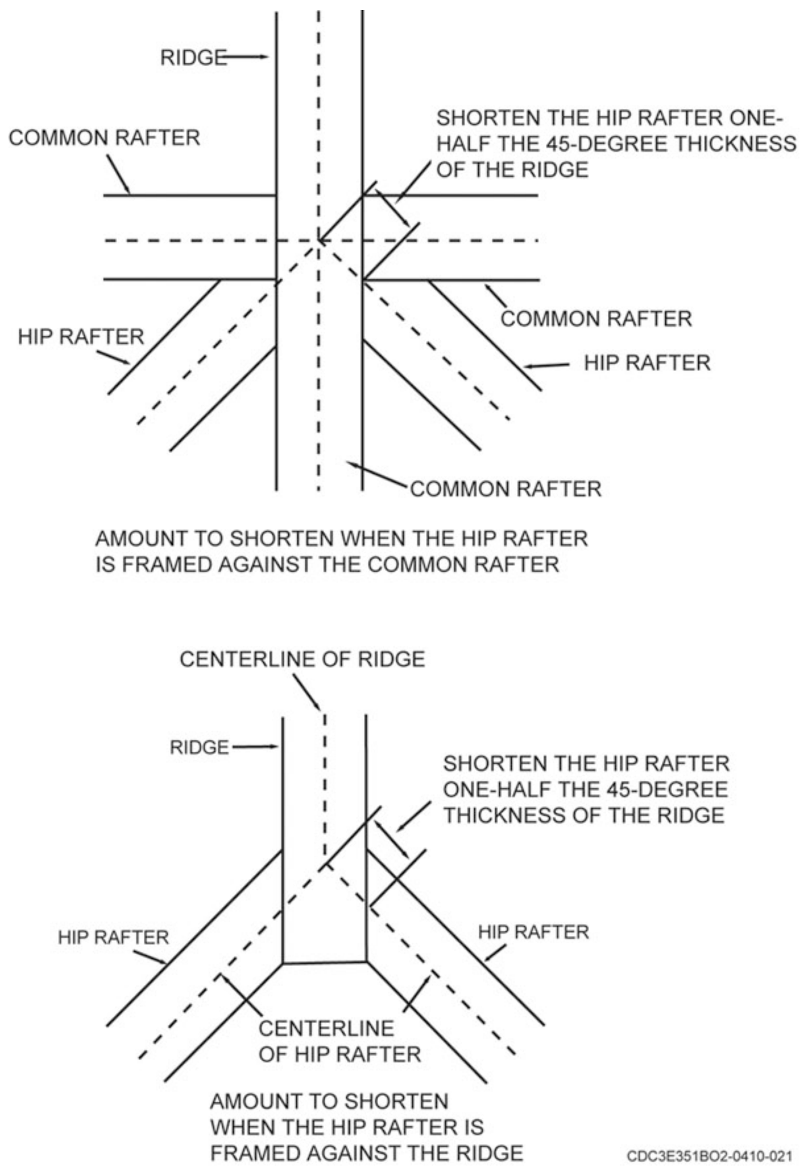


Figure 2–12. Hip rafter shortening allowance.

To lay out the shortening allowance, you mark the plumb line at the ridge. Hold the square with the tongue to the rise and the blade to the run. Measure at right angles from the ridge plumb line one-half (½) the diagonal thickness of the ridge and draw a second plumb line.

> **NOTE:** To find the 45-degree thickness of a piece of lumber, draw a 45 degree line across the edge, and measure the length of the line and divide by 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. If the run of the common rafter overhang is 18 inches for a roof with an 8-inch unit of rise, the length of the hip or valley rafter tail is figured as shown in the following table.

Calculating Rafter Projection	
Step	**Action**
1	Find the bridge measure of the hip or valley rafter on the framing square. It's 18.76 for an 8-inch unit of rise.
2	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 × 1.5 feet (projection of common rafter) = 28.14 or 28⅛ inches.
3	Add this product to the theoretical rafter length.

You can also step off the overhang as described earlier for a common rafter. When you step 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.

Rafter side (cheek) cuts

Since a common rafter runs at 90 degrees to the ridge, you must cut the ridge end square, or at 90 degrees to the lengthwise line. A hip rafter, however, joins the ridge or the common rafter's ridge ends at an angle, so you must cut its ridge end to a corresponding angle called a *side cut*. The side cut angle is more acute for a high unit rise than it is for a low one.

Lay out the side cut angle as shown in figure 2–13. Place the framing square's tongue along the ridge cut line as shown and measure off one-half (½) the hip rafter thickness along the blade. Shift the tongue to the mark, set the square to the cut position (8 inches and 17 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 side cut angle as indicated (fig. 2–13, lower view). A hip rafter that's framed against the ridge has only a single side cut as indicated by the dotted line; one that's framed against the common rafter's ridge ends has a double side cut as shown. The rafter tail must have a double side cut at the same angle, but in the reverse direction.

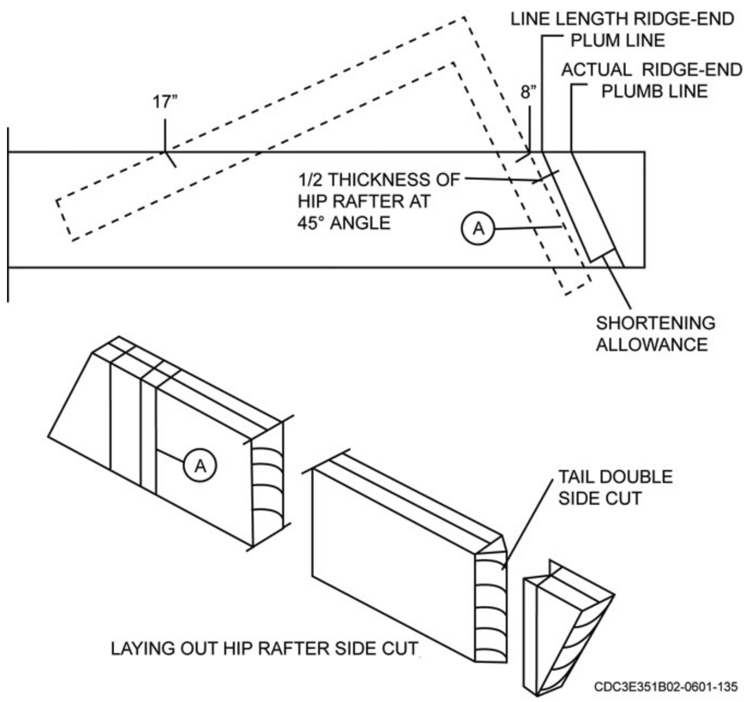


Figure 2–13. Laying out a hip rafter side cut.

NOTE: The side cuts may also be laid out using the unit length rafter table on the framing square.

Bird's mouth

Laying out the bird's mouth for a hip rafter is much the same as for a common rafter; however, 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.
- When you lay out the depth of the heel for the bird's mouth, remember that the height above the bird's mouth on a hip rafter must be the same as the height above the bird's mouth on the common rafter.

When determining where the seat cut is placed, you 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. Next, you must consider *dropping the hip* rafter.

Backing or dropping a hip 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. You can correct this by either backing or dropping the hip rafter.

- *Backing* means to bevel the hip rafter's upper edge (fig. 2–14). The backing amount is removed at a right angle to the roof surface or the hip rafter's top edge.
- *Dropping* means to deepen the bird's mouth to bring the hip rafter's top edge down to the level of the jack rafter's upper ends. The drop amount is removed from the seat cut line. Dropping is faster and much easier.

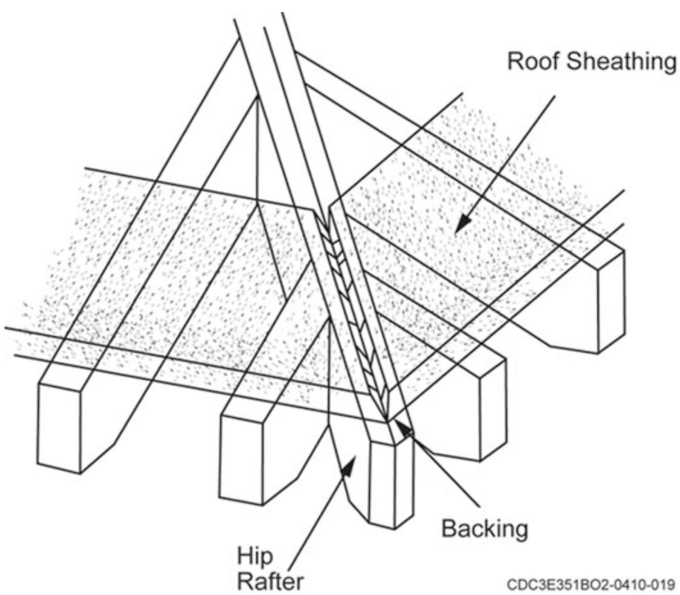


Figure 2–14. Backing a hip rafter.

You can determine the amount of drop as shown in figure 2–15. If you decide to back the hip, be sure to leave the same amount of stock above the seat cut on the hip, as there is stock above the seat cut on the common rafters.

NOTE: Never cut the bird's mouth more than half of the rafter's depth.

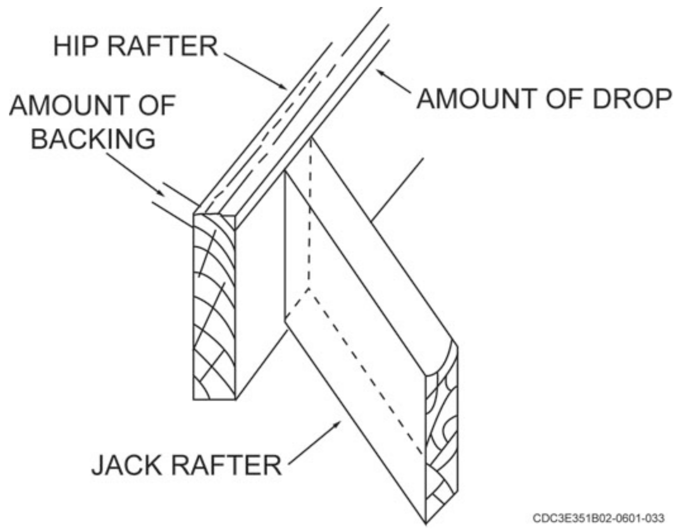


Figure 2–15. Dropping a hip rafter.

Hip jack rafters

Hip jack rafters take the place of common rafters where the hip rafter begins. They run in the same direction and are spaced the same distance apart as common rafters. If the common rafters are spaced 2 feet on center, then the hip jacks are spaced 2 feet on center (fig. 2–16).

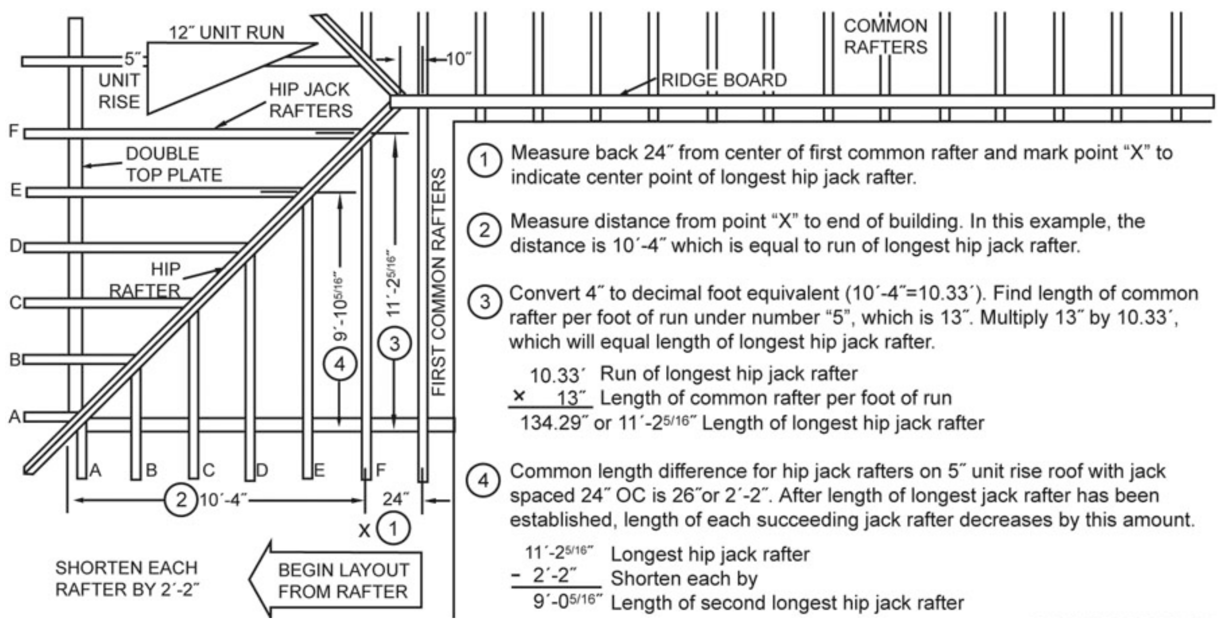


Figure 2–16. Hip jack rafter layout.

Hip jacks are framed in pairs on each side of the hip rafter. Thus, they become smaller and smaller the closer they get to the top plate. Like gable-end studs, hip jacks have a common difference between the pairs. You can find the common difference of the hip jacks on the framing square's rafter table (fig. 2–17). Once you find the length of the longest hip jack, you make each other set shorter by the common difference. Lay out the seat and tail cuts the same as you would for a common rafter.

Shortening the hip jack rafter

You will have to shorten the rafter where it meets the hip rafter. This is a 45–degree angle and it must be shortened one-half of the 45–degree angle thickness of the hip rafter.

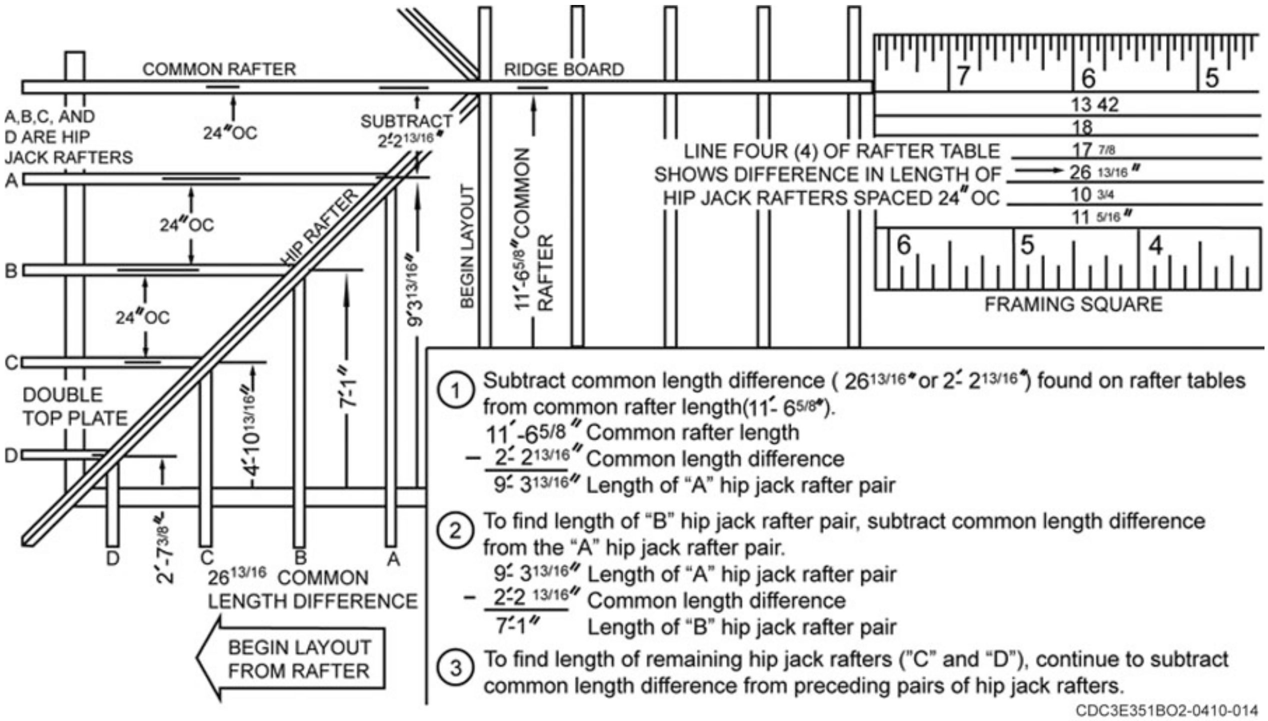


Figure 2–17. Common difference in length of hip jack rafters.

Hip roof construction

Once you cut all the main supporting members, you're ready to begin assembly (fig. 2–18). The procedure in the following table is one of many different ways you can assemble the rafters.

Assembling the Rafters	
Step	**Action**
1	Install the ridge board with at least two common rafters (at a 90 degree angle to the ridge) at each end. **NOTE:** Some craftsmen also nail common rafters to the very ends of the ridge board.
2	Install the hip rafters.
3	Install remaining common rafters, in pairs.
4	Install the hip jack rafters in pairs.

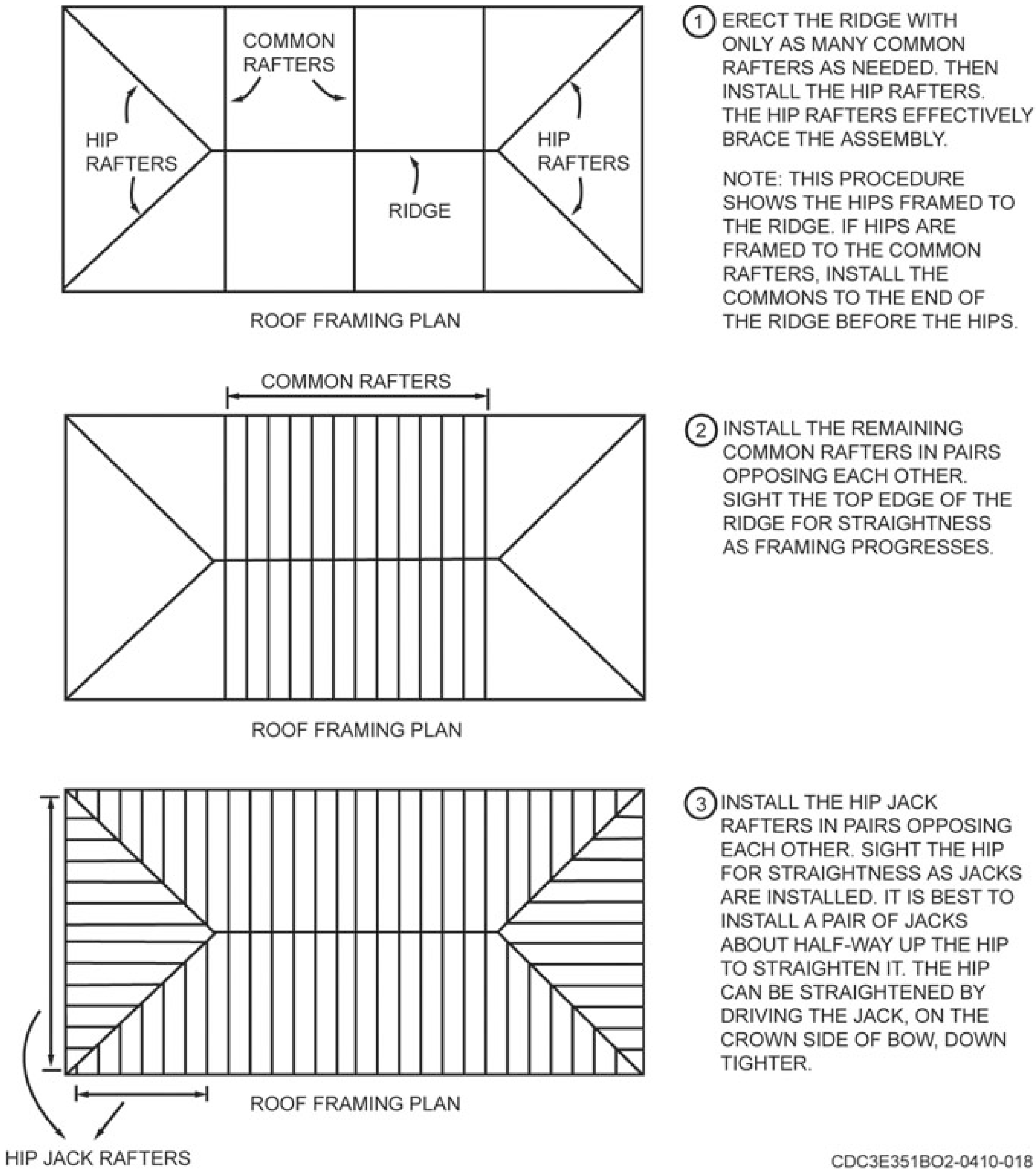


Figure 2–18. Hip roof construction.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

607. Hip roof framing

1. What is a *hip rafter's unit of run*?

2. What does *backing and dropping a hip rafter* mean?

3. What is the *maximum depth* of the *bird's mouth*?

608. Truss fabrication and erection

Many facilities are built using a truss type roof frame system to span the distance between outside walls, and to support and distribute the roof load in an efficient manner. When you finish this lesson, you should understand how trusses are made and installed.

Trussed framing

Trussed framing is generally heavier than rafters and is used over long spans. Some common truss types are shown in figure 2–19. All truss framing is designed with consideration for wind pressure and snow loads, evidenced by the braces (webs) used in their construction.

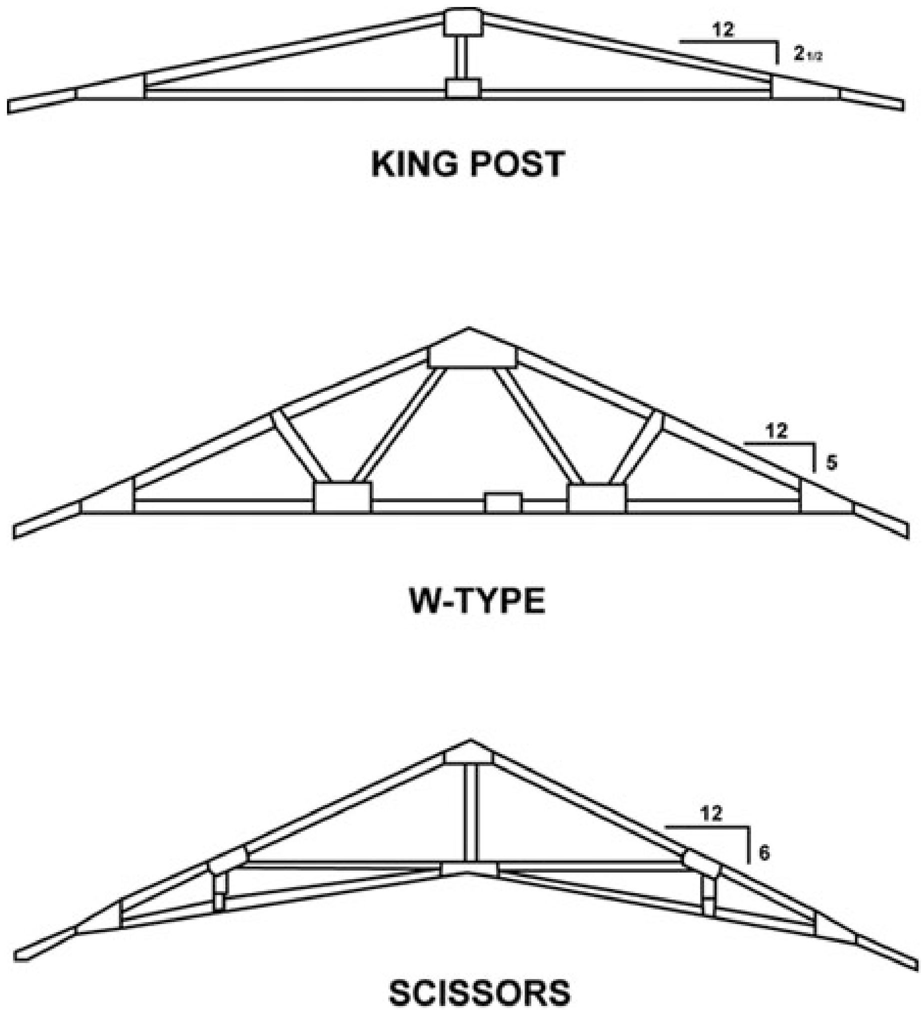


Figure 2–19. Truss types.

Truss parts

Truss parts usually include an upper chord, lower chord (horizontal supports), and tension and compression webs (between chords). The wood members for heavy-duty trusses (fig. 2–20) are fastened together with bolts. Timber connects, like those in figure 2–21, are seated between the framing members. A hole saw is used to seat the splitting connector into the face of a chord or web. Trusses for residential structures are fastened together with gang nail (connector) plates or plywood gussets (fig. 2–22).

NOTE: Gang nail plates and plywood gussets are placed on both sides of a joint.

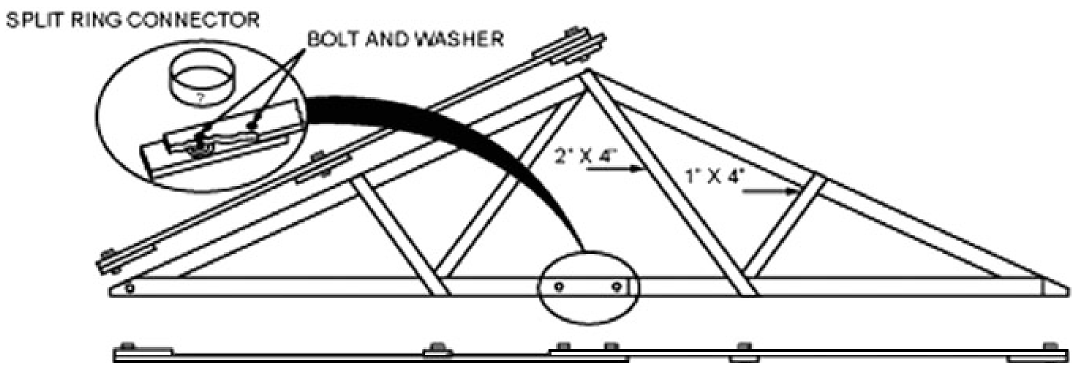


Figure 2–20. Warehouse truss.

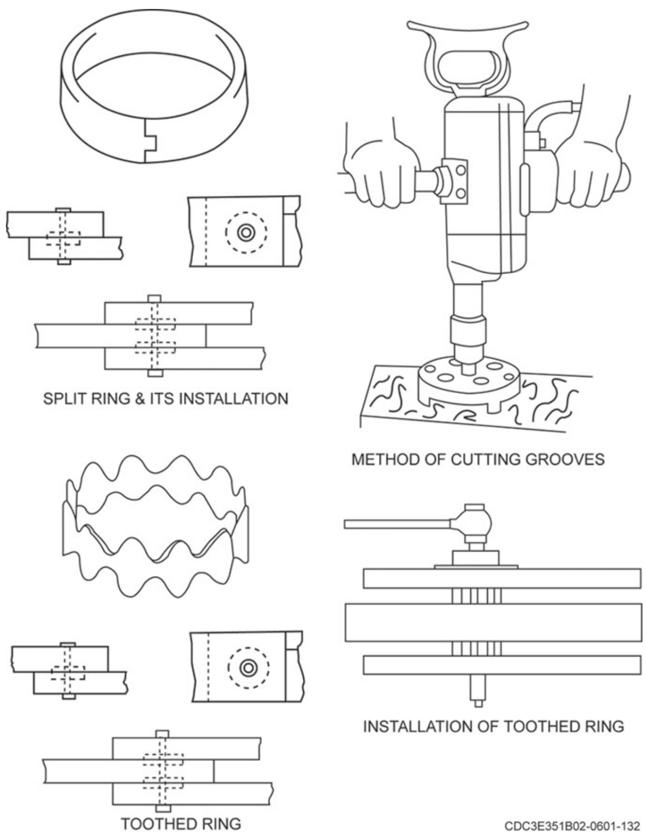


Figure 2–21. Timber connector.

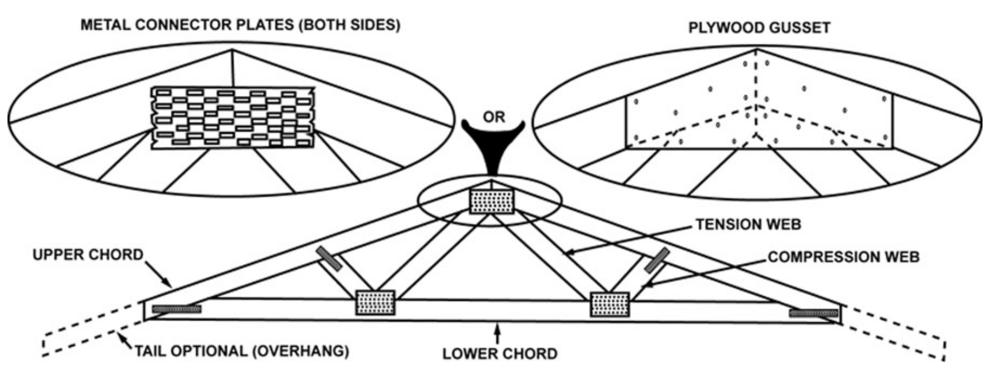


Figure 2–22. Truss connectors.

Truss fabrication

You normally order trusses from a truss manufacturer for a specific job. However, there may be times when you must fabricate them such as in a deployed location. The first thing you should do is set up an assembling table as shown in figure 2–23. You can construct one by whatever means best suits your situation. The end result is a level table that is large enough to lay out and assemble the size trusses needed.

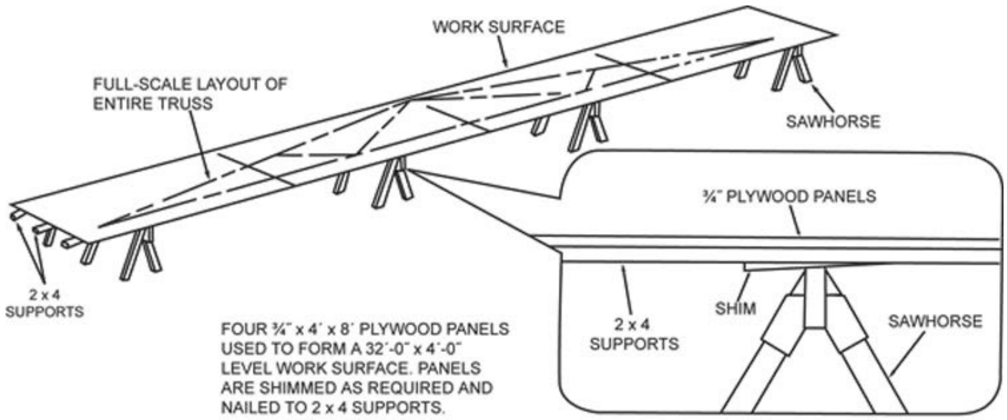


Figure 2–23. Truss assembling table.

Truss layout

Once the table is constructed, lay out the truss on it. The following table describes one method (fig. 2–24) used to lay out job-built trusses.

Laying Out Job-Built Trusses	
Step	**Action**
1	Snap a line representing the bottom chord. Establish center location on this line. Measure one-half the span in each direction from this point and place marks on the line. From the two outside marks, draw lines down at a 90 degree angle. From the center mark, draw a line up at a 90 degree angle and mark the total rise.
2	Snap lines from the total rise to the two outside marks. Snap the lines past the outside marks to allow for an overhang. Your pattern should now resemble a triangle.
3	Mark the widths for the top and bottom chords. You can use a 2 × 4 inch block as a guide. Once again, snap lines on these marks.
4	To locate the web centers, divide the total span into thirds and place marks on the bottom chord. Divide the total truss span into fourths and use a square (and straightedge) and transfer these marks onto the top chord. Figure 2–25 shows the web spacing.
5	Snap lines from the bottom chord to the top chord to represent the centers of the web members. Once the lay out is complete, measure and cut a complete set of truss components and verify the size. If the sizes are correct, use them as a pattern for additional trusses.

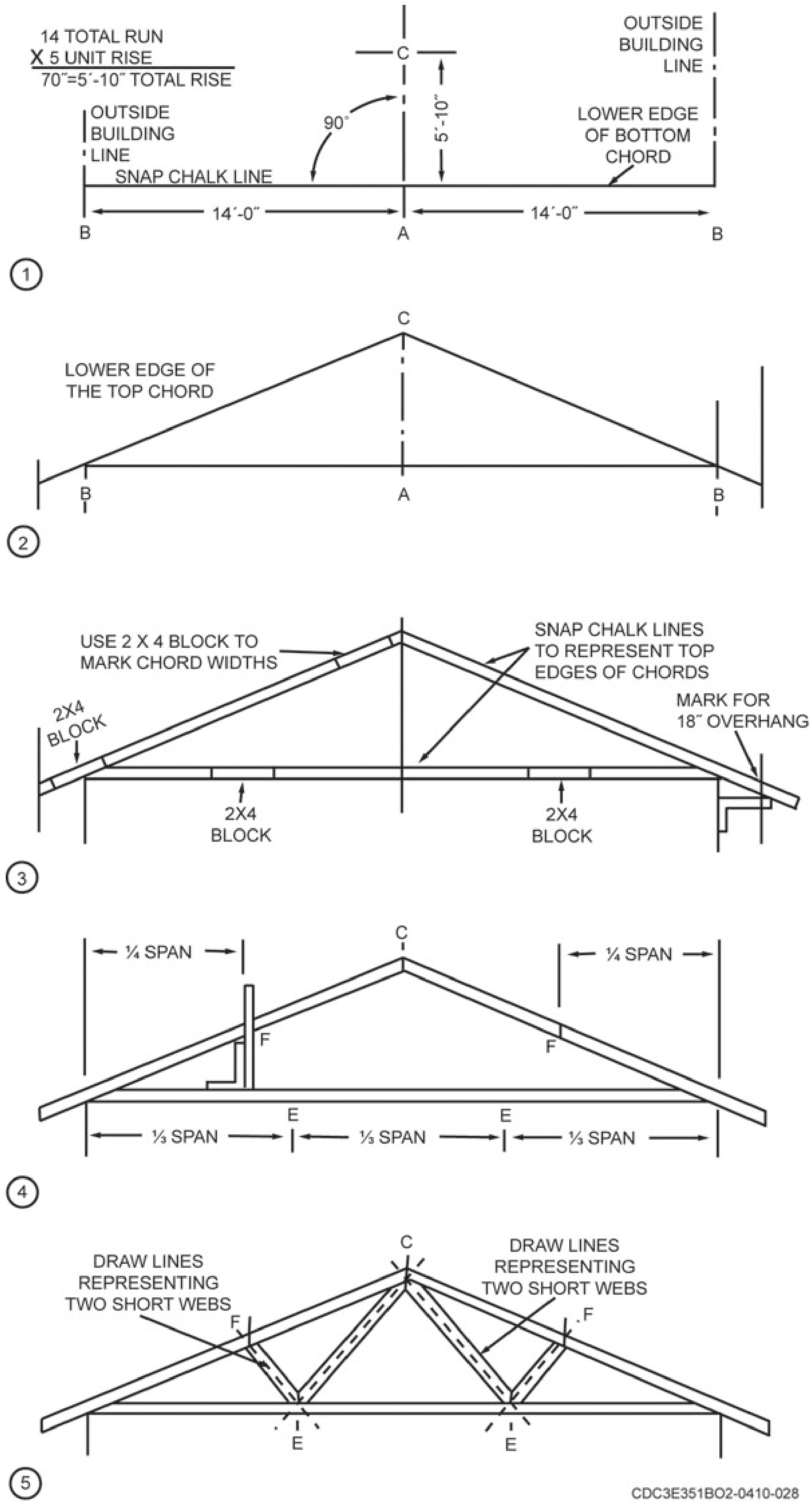


Figure 2–24. Truss layout.

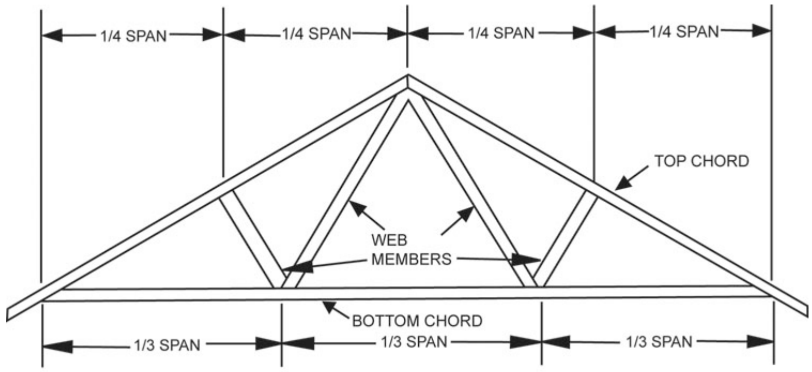


Figure 2–25. Web spacing.

Truss assembly

To assemble the truss components together, you should use guide blocks, wedge blocks, and wedges in conjunction with the assembling table (fig. 2–26). Guide blocks are used to hold the top and bottom chords in position. Place wedge blocks away from the truss members. This allows you to drive wedges between the wedge blocks and the truss members to get a tight joint.

When assembling the pieces, arch the bottom chord slightly upwards in the center. This helps prevent sagging when the truss is erected. Once all the components are fit tightly together, fasten the connector plates or plywood gussets to all the joints on one side. Next, flip the truss over and nail plates to the other side.

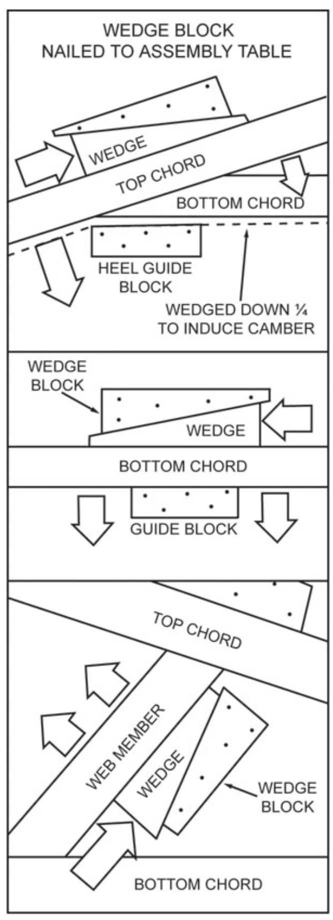


Figure 2–26. Wedge and guide blocks.

Truss erection

Most trusses used in residential construction don't require special equipment for placement. You simply place the truss upside down with its ends supported by the outside building walls. Position the ends as near the desired location as possible. This saves you time and effort when you slide or shift the truss into its permanent position. Once you have the truss supported by the outside walls, turn the truss peak upward. You can fabricate lifting poles to make the erection easier. Lifting poles are long poles with a V-shape on the lifting end. If you use two lifting poles, place them close to the quarter points of the span on the truss. If you are using one lifting pole, place it the peak.

> **NOTE:** Placing the lifting pole(s) at these locations allows you to erect the truss without placing added strain on the joints.

Erection sequence

You begin with erecting an end truss. Once the end truss is in the right position, toenail it to the top plate and check it for plumb. Since all other trusses are tied to the first truss, you must ensure the first truss is securely braced. One method is to nail temporary bracing from the truss to stakes driven into the ground. Ensure that the ground stakes are placed in line with the lateral bracing that is used to brace truss-to-truss (fig. 2–27).

Set the remaining trusses in place and toenail them to the top plate. You should use 2 × 4 inch lumber for the lateral bracing. Use the longest lengths possible, ensuring they are not shorter than 8 feet. Fasten the lateral bracing at every intersection with two 16d duplex nails. You must ensure the trusses are accurately spaced as the bracing is installed—usually 24 inches on center.

> **NOTE:** Temporary bracing is installed at three different places on the trusses—top chord, bottom chord, and vertical web plane at right angles to the truss.

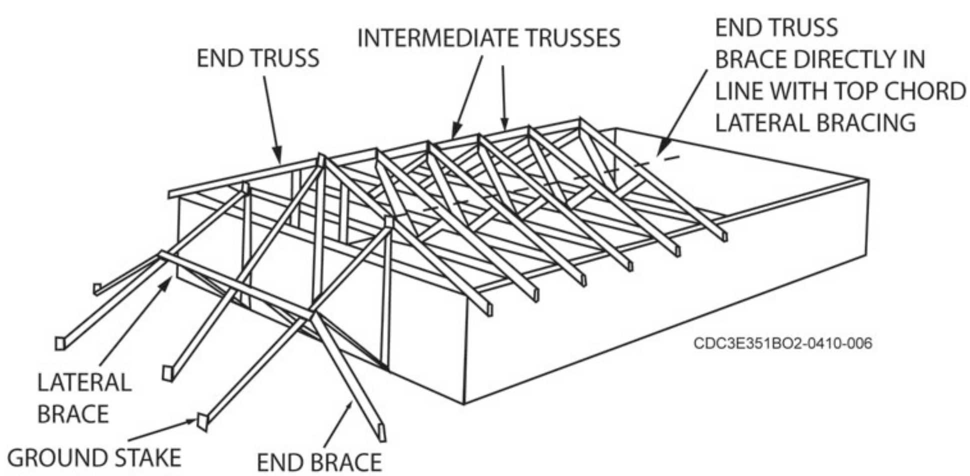


Figure 2–27. Temporary bracing of end truss.

The following table provides additional information on the elements used in temporary truss bracing.

Temporary Truss Bracing	
Type	**Description**
Top chord	Install lateral bracing on the top chord within 6 inches of the ridge, then at 8 to 10–foot intervals between the ridge and the top plate. You then install diagonal bracing between the rows of lateral bracing starting at the end and then spaced every 30 feet (fig. 2–28).

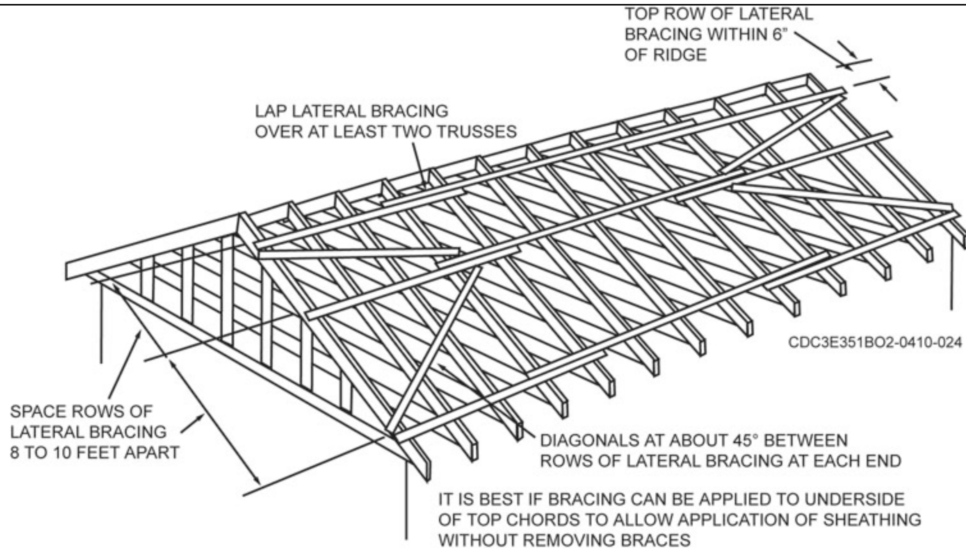
<table>
<tr><th colspan="2">Temporary Truss Bracing</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td></td><td>

Figure 2–28. Top chord bracing.</td></tr>
<tr><td>Bottom chord</td><td>You must nail bracing to the top of the bottom chord and ensure it is nailed at no greater than 8 to 10–foot intervals.

You then place diagonal bracing between rows of lateral bracing on the bottom chord; usually only on the ends (fig. 2–29).

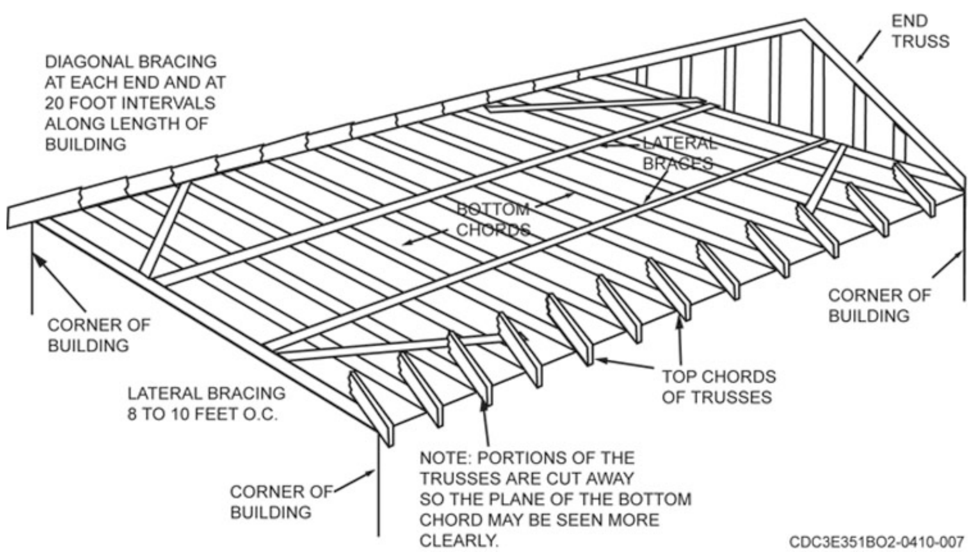
In most cases, you leave the temporary bracing on the bottom chord in place.


Figure 2–29. Bottom chord bracing.</td></tr>
<tr><td>Vertical web plane</td><td>This bracing runs at right angles to the trusses from the top chords to the bottom chords.

They are usually left in place (fig. 2–30).</td></tr>
</table>

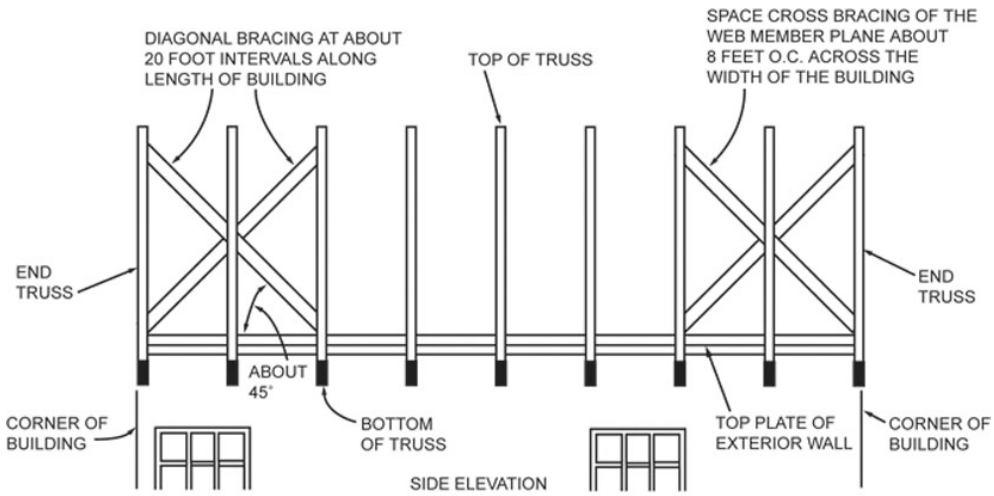
<table>
<tr><th colspan="2">Temporary Truss Bracing</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td></td><td>

Figure 2–30. Vertical web plane bracing.</td></tr>
</table>

Roof sheathing

Once the frame is complete on either rafters or trusses, it's time to install roof sheathing. You can install plywood or some other rated panel. They are installed with the face grain running perpendicular to the rafters or trusses. Like floors, the end joints of successive rows are staggered. Always refer to the job specifications for fastening; however, most specifications require nails to be placed 6 inches apart on the ends and 12 inches apart on intermediate supports.

Whenever the distance between rafters or trusses exceed the value of the sheathing used, you must take adequate measures to prevent sag. Edge support includes blocking, tongue and grooved edges, and panel ("H") clips. H-clips are used most often. As the name implies, they are small metal clips that are shaped like the capital letter "H." You place them between the plywood edges centered between two rafters or trusses. If the span between trusses is greater than 48 inches, you must use two clips spaced evenly between.

It's allowable to let the ends of the sheathing overhang the rakes until all of the sheathing is installed. You can then snap a chalkline between the ridge and the eave at each end and trim off the excess with a circular saw.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

608. Truss fabrication and erection

1. Label items 1 through 8 in figure 2–31 with the letters of these terms:

   a. Slope.

   b. Overhang.

   c. Run.

   d. Upper cord.

   e. Tension web.

f. Compression web.

g. Lower cord.

h. Span.

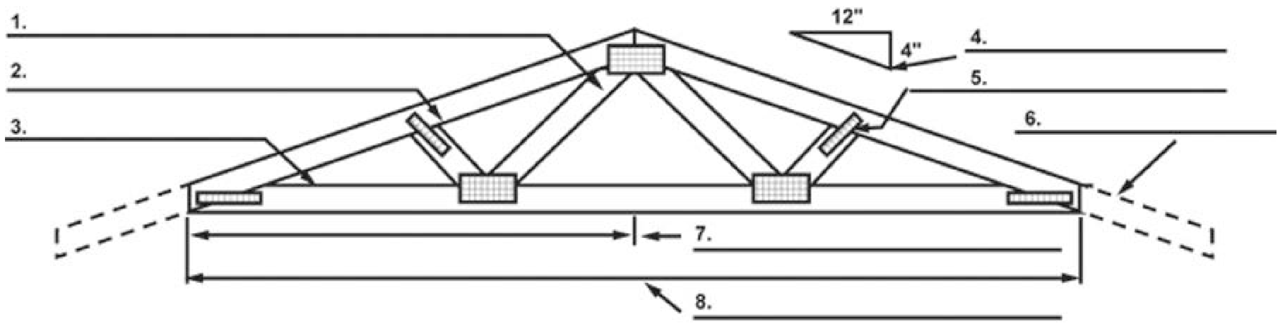


Figure 2–31. Truss diagram.

2. How are *residential trusses* fastened together?

3. Where do you install *temporary bracing* on trusses?

609. Inspection and Repair

Even if a roof is constructed properly, there may come a time when a member fails. Extreme loads of snow or high wind pressure may cause some members to crack or break. As a building settles, it may place pressure on structural components as well resulting in stress cracks. This lesson covers some of the more common repair methods for structural roof framing components.

Roof inspections reveal what maintenance and repair work is needed for trusses and other roof-framing members. In the following paragraphs, we explain what you should inspect and how you can make repairs.

Inspecting trusses

Truss inspections are usually scheduled and made by a civil engineer planning technician. Although it may not be your job to make the initial inspection, you'll more than likely be on the crew that does the preventive maintenance or repair work. Inspect trusses once a year to look for the following problems:

- Failure in the upper and lower chord or web members.
- Bowing or over-stressed compression members.
- Separation at joints due to shrinkage.
- Splits along bolt lines.
- Splits in web member ends and chord splices.
- Sagging trusses.
- Decayed truss components.
- Loose nuts and bolts.

Maintaining and repairing trusses

Check trusses immediately after installation to find loose bolts—bolts that are too long, too short, or too small. You must also check for bolts smaller in diameter than the holes drilled, and for bolts that were never installed in drilled holes. In both cases, you must install the correct size bolt.

Replacing short bolts

Where installed bolts were too short, the bolt head and the washer may have been recessed into the wooden truss member. This reduces the truss's load carrying capacity. To correct it:

- Install the correct size bolt.
- Use larger diameter washers and tighten the bolt and nut without recessing the washer into the wood.

Replacing overlength bolts

When bolts are too long, you can't draw the nut up tight for a firm connection. Installing additional washers takes up the space and lets you tighten the bolt tightly without embedding the washer into the truss.

> **NOTE:** Always provide support under a chord when you must loosen or remove bolts.

Periodic tightening

It's important that all truss connections be tightened periodically until the lumber's moisture content is equal to the surrounding air. During the first year after construction, you'll need to tighten the bolts frequently to keep the connections from getting too loose. Loose members may result in truss settlement, excessive checking, and splitting.

During routine bolt tightening, check the bolts to be sure there's enough thread to draw the nut up tight. Also, check the washer diameter; if they're so small that you can't draw the truss members together without embedding the washer, replace them with larger ones. Where it's impractical to remove the bolt to replace the washer under the bolthead, you can insert a square slotted washer between the existing washer and the wood. Drive a nail beside the washer to keep it from turning and sliding off the bolt. The washer should be at least one-fourth (¼) inch thick and at least 2 inches square. In tightening a nut, strike the bolthead a sharp blow with a hammer to force the bolt through the truss member and break any adhesion between the bolt and member resulting from corrosion.

Your inspection may show that bolt tightening is necessary because members have shrunk. As a general rule, bolts should be tightened if the average take-up on bolts is more than two turns. This depends on bolt size.

> **NOTE:** It is very important that you keep the bolts tight to keep the truss from working loose and coming apart. Such separation can lead to a roof section *collapse*. Design values depend on tight connections, and the full truss strength can't be realized unless the bolts are kept tight.

Truss repair/replacement

You may be assigned to a work crew that must repair or replace a truss. To do the job, the crew must use equipment and other materials to support the roof or truss. Never try to repair or replace a truss that is not properly supported. After you are sure that you have proper support, you are ready to make repairs. A typical way to repair a truss is to install splices and clamps, so let's have a closer look at truss framing.

On wood trusses that are less than 2 inches thick, the common repair method is to install steel plates on each side and fasten them together with bolts that extend along the sides of the wood. On trusses that are 2 inches thick or greater, a different method is used. One recommended method of repair for trusses 2 inches or greater is shown in figure 2–32, which shows a truss with a broken lower chord. You'll need one-half (½) inch and three-fourths (¾) inch stitch bolts, washers, and lumber. Stitch bolts are threaded on each end. The wood splice plates must be good quality with straight-grain. You must make sure that your wood splice material is the same size as the original truss. You can use this method to repair truss members that are 2 inches or more in thickness. A suggested way to repair the split lower cord (fig. 2–32) is given in the table below.

Repairing Split Lower Chord on Trusses	
Step	**Action**
1	Drill a small hole ahead of the split to stop further splitting.
2	Temporarily install a clamp or clamps to draw the split back together.
3	Drill one-half (½) inch diameter holes for the stitch bolts.
4	Install the stitch bolts with washers and draw them up tight.
5	Measure for two wood splice plates to be installed (one on each side). **NOTE:** the outside plate must extend past the nearest joint (webs and chord) to develop full strength.
6	Cut the two wood splice plates to size.
7	Temporarily clamp the splice plates in place.
8	Select a bolt-spacing pattern for the three-fourths (¾) inch stitch bolts (fig. 2–33).
9	Install the stitch bolts with washers and draw them up tight.
10	Remove all clamps.

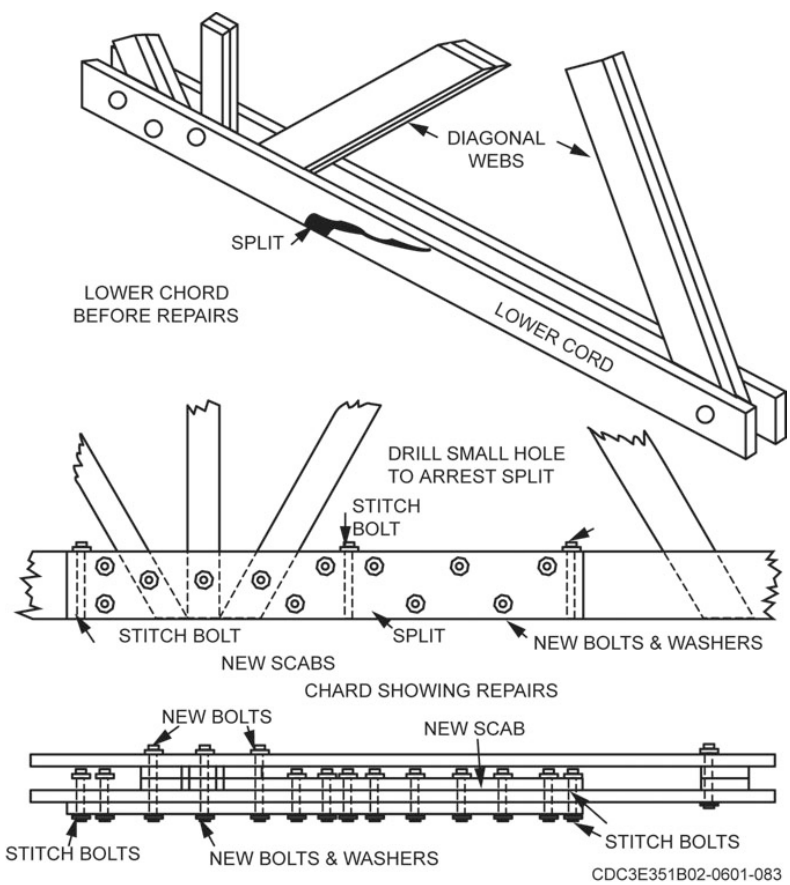


Figure 2–32. Truss repair method.

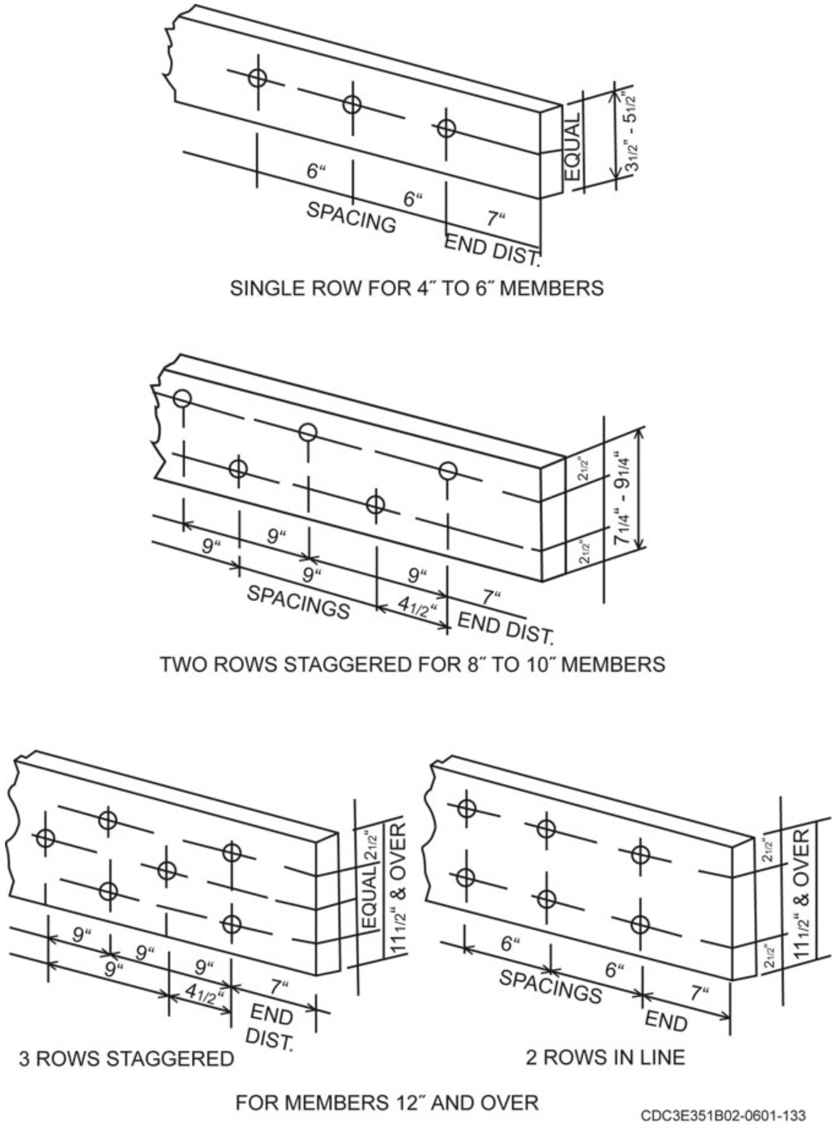


Figure 2–33. Minimum bolt spacing for truss repair.

Some truss repairs may require different methods or larger diameter bolts be used for greater strength and durability. If you need any help concerning truss repair, see your supervisor. It may be necessary to have a structural engineer design a repair or replacement method.

The basic methods that you use to repair trusses can also be used on other structural framing such as girders, beams, and columns.

Rafter repair and replacement

Warped, twisted, or broken rafters must be repaired or replaced. Sometimes you can straighten a warped or twisted rafter by adding solid bridging between it and the rafters next to it. If the rafter is broken, you can usually repair it by nailing scabs along its sides. In some cases you may need to install additional support under them, extending from a top plate to the rafter and set at a right angle to the rafter’s underside.

When you must repair or replace rafters, you can usually copy the angles from the old rafter by using a T-bevel square. Rafters, sheathing, and other roof-framing members that are decay damaged must be replaced. A prevalent cause of the need for extensive roof maintenance is failure of the roof covering. Leaky roofs no longer protect the framing, thus allowing weathering and eventual decay.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

609. Inspecting and repairing trusses and rafters

1. Select the repair method in column B for each problem situation in column A. The items in column B are used only once or not at all.

Column A	*Column B*
____ (1) Trusses with loose bolts that are too long.	a. Use stitch bolts and a splice plate on each side.
____ (2) When you tighten nuts and bolts, the washer starts to embed into the wood and you can easily remove the bolt.	b. Install more washers to let the bolts tighten correctly.
____ (3) You need a washer under a bolthead, but it's impractical to remove the bolt.	c. Insert a square-slotted washer at least one-fourths (¼) inch thick.
____ (4) A split develops in a two-inch thick lower chord member.	d. Use a steel plate on each side fastened with bolts.
____ (5) A split develops in a one-inch thick lower chord member.	e. Insert a larger diameter washer.
	f. Insert a larger diameter bolt.
	g. Use a one-fourths (¼) inch thick plywood strip and fasten with wood screws.

Answers to Self-Test Questions

606

1. A fixed horizontal measure used to calculate rafter length.
2. The valley rafter extends diagonally from the top plate to the ridgeboard at the line of intersection of two roof surfaces.
3. (1) Hip.
   (2) Valley.
   (3) Cripple.
4. (1) Unit of rise.
   (2) Total run of the roof.
5. (1) Framing square table method.
   (2) Basic triangle (bridge measure) method.
   (3) Framing square step-off method.
6. Framing square table method.
7. Basic triangle (bridge measure) method.
8. Seat.
9. All marks along the framing square's tongue indicate vertical lines (rise), and all marks along the blade indicate horizontal lines (run).
10. Step 4. Follow the same procedures as previously mentioned to lay out the shortening allowance, bird's mouth, and tail line length.

607

1. 17 inches.

2. *Backing* means to bevel the hip rafter's upper edge. The backing amount is removed at a right angle to the roof surface or the hip rafter's top edge. *Dropping* means to deepen the bird's mouth to bring the hip rafter's top edge down to the level of the jack rafter's upper ends.
3. Never cut the bird's mouth more than half of the rafter's depth.

608

1. (1) e.
   (2) d.
   (3) g.
   (4) a.
   (5) f.
   (6) b.
   (7) c.
   (8) h.
2. With gang nail plates or plywood gussets placed on both sides of the joint.
3. Top chord, bottom cord, and vertical web plane at right angles to the truss.

609

1. (1) b.
   (2) e.
   (3) c.
   (4) a.
   (5) d.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

19. (606) In roof construction, the term *total run* refers to the
    a. vertical distance the rafter rises per foot of run.
    b. diagonal measurement used to calculate rafter length.
    c. horizontal measurement that is equal to half of the span.
    d. horizontal distance between one outside top plate to the opposite outside plate.

20. (606) The *vertical distance* from the top plate to the top of the ridge is called the
    a. total run.
    b. total rise.
    c. unit of run.
    d. unit of rise.

21. (606) Which *rafter extends at a right angle* from the plate line to the ridgeboard?
    a. Hip.
    b. Jack.
    c. Valley.
    d. Common.

22. (606) Which *rafter extends diagonally* from the plate to the ridge board at the line of intersection of two roof surfaces?
    a. Hip.
    b. Jack.
    c. Valley.
    d. Diagonal.

23. (606) When you are computing rafter length, you must deduct how much of the ridge board thickness from each rafter?
    a. Two-thirds ($^{2}/_{3}$).
    b. One-fourth (¼).
    c. One-third ($^{1}/_{3}$).
    d. One-half (½).

24. (606) To figure common rafter length with the framing square step-off method, how is the *framing square* used to represent the unit of rise and the unit of run?
    a. The tongue (unit of rise in feet) and the blade (unit of run at 17 inches).
    b. The tongue (unit of rise in inches) and the blade (unit of run at 12 inches).
    c. The tongue (unit of rise at 12 inches) and the blade (unit of run at 17 inches).
    d. The tongue (unit of rise at 17 inches) and the blade (unit of run at 12 inches).

25. (607) The *standard unit of run* for a *hip rafter* is
    a. 12 inches.
    b. 17 inches.
    c. half the span.
    d. double the span.

26. (607) What is the *maximum depth* of the bird's mouth?
    a. Same as the rafter's depth.
    b. More than the rafter's depth.
    c. More than half the rafter's depth.
    d. Not more than half of the rafter's depth.

27. (608) Residential truss-framing members are fastened together with
    a. nuts, bolts and lock washers.
    b. self-drilling sheet metal screws.
    c. gang nail plates attached to one side.
    d. gang nail plates or plywood gussets attached on both sides.

28. (609) What should you do when a *truss inspection* shows that an installed bolt is *too long*?
    a. Cut to size.
    b. Remove the bolt.
    c. Replace the bolt with a smaller diameter one.
    d. Install additional washers to take up the space.

29. (609) The recommended repair method for wood trusses that are less than two inches thick is to use
    a. stitch bolts and a splice plate on each side.
    b. a steel plate on each side fastened with bolts.
    c. a one-fourth plywood strip and fasten with wood screws.
    d. a wood splice same size as the original truss material and stitch bolts.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Doors and Windows

THIS UNIT DEALS with installing and maintaining exterior and interior doors and windows. Thus far you've learned to be accurate and neat with your work. Starting now, you must place even more emphasis on detailed accuracy and neatness. Those almost-square joints and those occasional hammer marks were allowed in the rough framework because the outer finish would cover them. In finish construction, a thirty-second-of-an-inch ($^{1}/_{32}$) error could very well make the difference between a joint that's well fitted and one that's poorly fitted. A few hammer marks here and there may identify you as uncaring or having a bad attitude toward your work. On the other hand, your care and attention to fine detail can identify you as a skilled craftsman. With this in mind, let's start our discussion with exterior doors and windows.

3–1. Doors, Windows, and Accessories

Once you've installed the subsiding and sheathing paper (if required), go back and check the window and door schedule. Look for the different door and window types and how they will be installed. Find out if they are to be installed before or after the finish siding. For example, most aluminum and wood window units are installed before you apply the finished siding, while some units (especially some local shop-built units) are installed after you apply the finish siding. Always follow your drawings closely to prevent errors in construction. Since we install most doors, windows, and ventilators before the finish siding, we'll discuss them first.

610. Installing doorframes and doors

You'll probably spend more time installing and maintaining exterior doors than any other building part. Most exterior doors are exposed to the sun, rain, wind, and ice—which causes them to deteriorate. This deterioration is one reason for door maintenance. Another is the wear resulting from day-after-day use and misuse. You must thoroughly know the different methods of installing, adjusting, and repairing these doors. Even though there are many types, an important goal is to make sure they are installed and functioning properly to prevent premature wear and to reduce the need for repairs. In addition to the satisfaction given a building's users, a properly functioning door reduces heating and cooling costs.

Types of doors

There are many exterior door types. They are classified according to the way they open and close, such as swinging or sliding doors. They are also classified by construction feature types such as batten, panel, or flush. These types have many variations based on size, strength, and ornamental requirements. Doors are also classified as permanent, which means they are used for houses, offices, and other structures where we need to control temperature, humidity, or air cleanliness. We use the flush, or panel type, doors in these areas. Mortised hinges are best here, as they allow a close fit of the door to the frame. We also use locks and latches for the various types. Because there are many different door types, we focus on the most common doors used by the Air Force in the table below.

<table>
<tr><th colspan="2">Common Doors Used by the Air Force</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td>Batten</td><td>Batten doors are used for sheds or other temporary storage buildings.

We usually make them from sheathing boards that are held together with two or three batten strips and one or two diagonal braces placed on one side (fig. 3–1). These diagonal braces help keep the door from sagging.

While batten doors are usually made with wider tolerances because a close fit is not required, we make them accurately to show our good craftsmanship.

These doors are usually installed with strap hinges or T-hinges that are either nailed or screwed on.

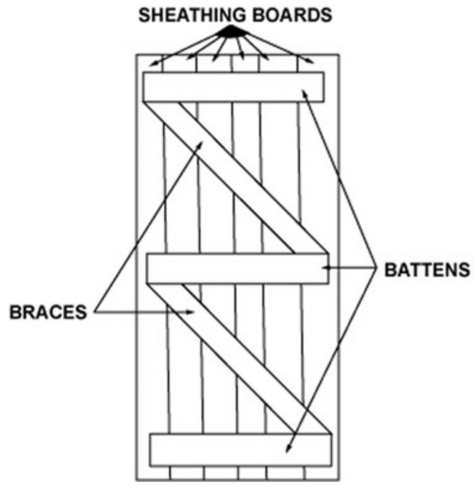


Figure 3–1. Batten door.</td></tr>
<tr><td>Panel</td><td>Panel doors are constructed of stiles (vertical members), rails (cross members), and panels.

The panel number and shape vary considerably (fig. 3–2).

The panels may be of either wood or glass.

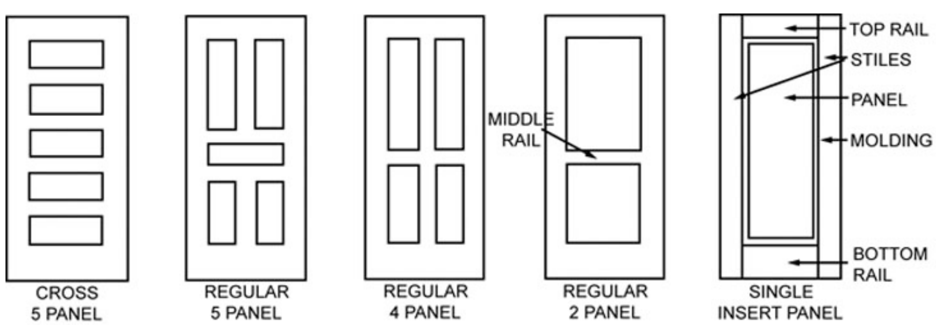
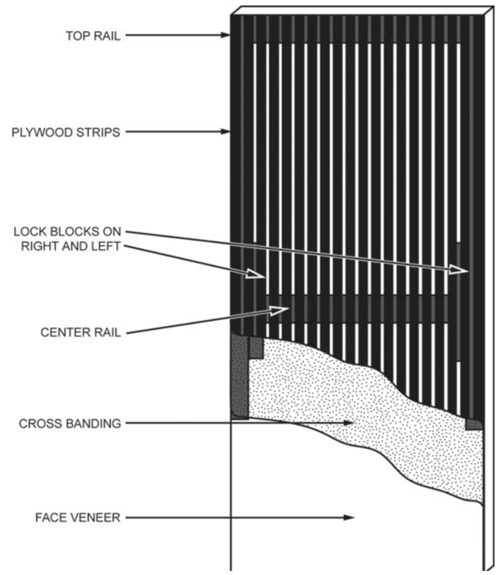


Figure 3–2. Panel doors.</td></tr>
<tr><td>Flush</td><td>Flush doors are probably the most common type used by the Air Force.

They have either a solid core of softwood or a hollow core made of grids (fig. 3–3).

The core usually has stiles and rails like those in a panel door. Manufacturers lay plywood over the core to provide a smooth surface on each side and cover the edges with the same wood type.

These doors may be economically made to resemble more expensive and massive doors, but they’re relatively lightweight.</td></tr>
</table>

Common Doors Used by the Air Force	
Type	**Description**
	 **Figure 3–3. Flush door.**

Installing exterior doorframes and doors

Before you install exterior doors, you should apply a coat of primer since they could be exposed to rain or moisture. After priming, you must paint or seal the door to weatherproof it. Check the doorframe squareness. Even a commercially built frame squared at the factory may have braces shifted during handling.

After squaring the frame, proceed with the installation. Compare the doorframe dimensions with the rough opening dimensions. A typical way to install an exterior doorframe is outlined in the table below.

Installing an Exterior Doorframe	
Step	**Action**
1	Tack a strip of 15-pound asphalt coated felt, 10 to 12 inches wide, against the sheathing around the rough wall opening to act as a vapor barrier. **NOTE:** This step is *not needed if house wrap was used*.
2	Set the frame in the center of the opening and brace it temporarily to keep it from falling out while you're plumbing and leveling it. Ensure the sill is set on the subfloor.
3	Level the sill by placing a wooden wedge (use a type that is resistant to weathering, if they're available) under the side jamb you need to raise. The top of the sill must be level with the finished floor when it's installed (fig. 3–4). **NOTE:** The sill on an exterior doorframe is the first member you must level.
4	Place two wedges between each of the two side jambs near the sill (keep the jamb centered). Tack the lower ends of each side casing to the rough frame (trimmer) with a 16d casing nail.
5	Check to make sure both side jambs are plumb and the head jamb is level.

Installing an Exterior Doorframe	
Step	**Action**
	If the sides are plumb and the top is level, the jamb should be square.
6	Place additional wedges behind the hinges, latch location, and any other location where the jamb is subject to bowing or needs to be plumbed (fig. 3–5). Adjust the wedges until the side jambs are well supported and straight (plumb).
7	At each wedge location, drive two 16d casing nails through the jamb, wedges, and into the rough frame. Space these nails three-fourths (¾) inch in from the outer edge of the casing. **NOTE:** Some craftsmen do not drive the nails flush until after they install all wedges and make a final plumb check. This practice makes it much easier if readjustment is necessary.

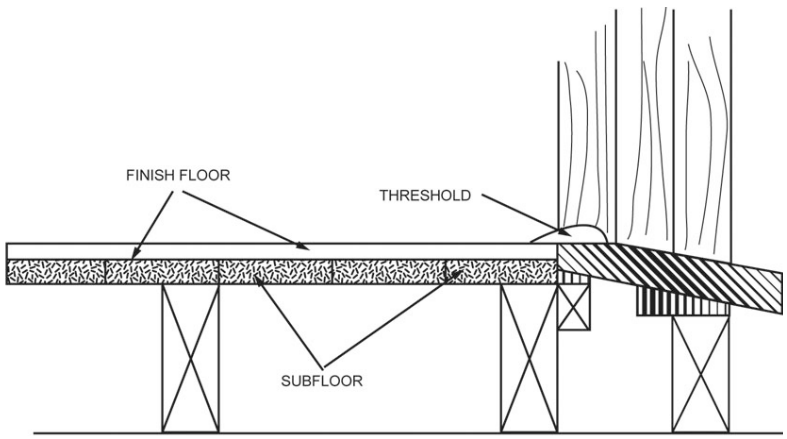


Figure 3–4. Adjusting a doorsill.

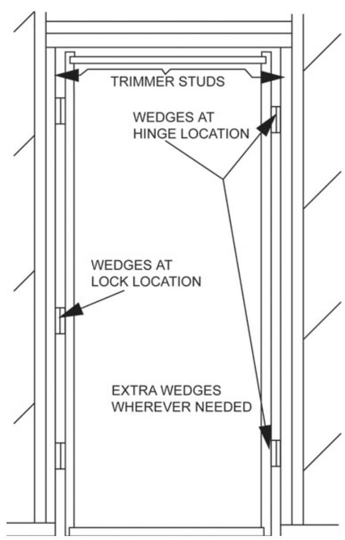


Figure 3–5. Placing wedges in a doorframe.

Installing prehung wood door units

A variety of prehung exterior door units are available including single doors, double doors, and doors with sidelights. The door's manufacturer provides detailed instructions for installing their products. The following table discusses general guidelines to follow when installing prehung wood door units.

Installing Prehung Wood Door Units	
Step	**Action**
1	Check the rough opening. Make sure the size is correct and that it is plumb, square, and level.
2	Apply a double bead of caulking compound to the bottom of the opening, and set the unit in place. Do *not* remove spacer shims, located between the frame and door, until the frame is firmly attached to the rough opening.
3	Insert shims between the side jambs and trimmer studs. They should be located at the top, bottom, and midpoint of the door.
4	Drive 16d finishing nails through the jambs, shims, and into the structural frame members. Manufacturers usually recommend that at least two of the screws in the top hinge be replaced with 2¼ inch screws.
5	Adjust the threshold so that it makes smooth contact with the bottom edge of the door.

After installing a prehung exterior door unit, remove the door from the hinges and carefully store it. A temporary door can be used until final project completion.

Installing interior doors and doorframes

In the following paragraphs we discuss the general procedures used for installing an interior doorframe. While installing doors and doorframes in a facility's interior is similar to installing them on the exterior, there are a few differences that we'll cover.

An interior door can be basically installed the same way that you install an exterior door. The main difference is that interior doorframes do *not* have sills, so we start leveling at the head jamb rather than at the sill. If you know how to set an exterior doorframe, setting an interior doorframe and door is easy.

Installing the doorjamb

The interior doorjamb that you install may be prehung or or be one you built in the structural shop. There are several ways to install it into the rough frame. We suggest that you start the installation with a doorjamb that has the side jambs nailed onto the head jamb and then follow the procedures in the following table.

Installing A Doorjamb	
Step	**Action**
1	Place the doorjamb in the rough opening.
2	Level the head jamb.
3	Install a 1 × 6 inch temporary spreader board between the side jambs near floor level.
4	Center and plumb the doorjamb in the rough opening with a carpenter's level. Use wooden wedges placed between the doorframe and the rough frame near the head jamb and at the spreader board (use two wedges at each location) to hold the doorjamb in place (fig. 3–6).
5	Drive two 8d finish nails through the jamb, wedges, and into the rough frame. Place these nails so that they will be covered by the doorstop.
6	Place additional wedges at the following locations: • Hinges. • Midway between the two hinges.

Installing A Doorjamb	
Step	**Action**
	• Latch location. • Midway between the latch and the head jamb. As you install each wedge, plumb and secure them with two 8d casing or finish nails. Again, place the nails so that they will be covered by the doorstop. **NOTE:** Some craftsmen do not drive the nails completely into the wood until after they install all wedges and make a final plumb check. This practice makes it much easier if readjustment is necessary.

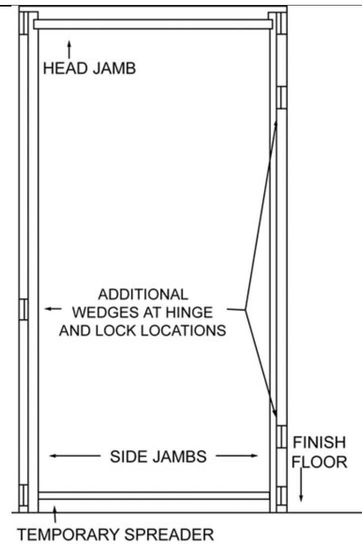


Figure 3–6. Setting an interior doorframe.

Fitting interior wood doors

Before you install a new interior wood door, check the door schedule in the blueprints for type and door swing. To avoid confusion, temporarily mark the jamb edge where the door hinges are to be mounted. Doors must fit into the doorframe for it to open and close properly. Sometimes a door may be too wide or long and you must cut it to size. Some paneled wood doors also have two long stiles (lugs) that project beyond the rails; you must cut them off even with the rail. These lugs help protect the door prior to installation (fig. 3–7, view A and B).

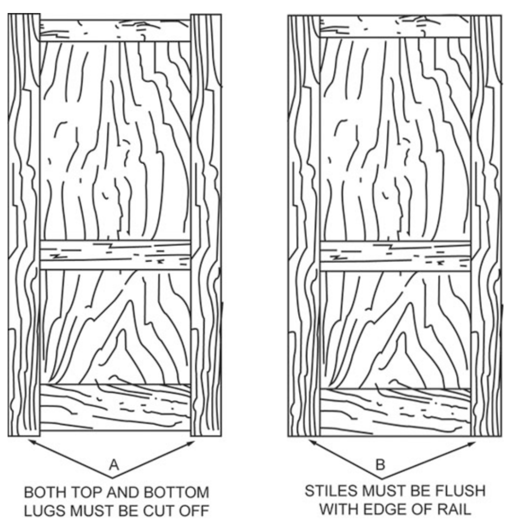


Figure 3–7. Lugs on a new panel door.

If the door is still too long to fit into the doorframe, trim the bottom edge. If you need to trim off more than 1 inch, take equal amounts from the top and the bottom to keep both rails close to the same size.

NOTE: Do this procedure *before you mortise in the hinges*.

All paneled doors have two stiles—one is the hinge stile and the other is the lock stile. Select the stile with the straightest grain for the lock, especially if you'll be installing a mortise lock. When the door is cut to the correct height, position it in the opening and check it for width (fig. 3–8). It may be necessary to plane down or cut the stile to allow for the proper clearance. You can do this by scribing a line on the stile and use a jackplane or portable power planer to plane down to the scribed line. Another option is to use a table saw.

We recommend that you use the following space allowances between an interior door and doorframe:

- Hinge stile, one-sixteenth ($^{1}/_{16}$) inch.
- Top rail, one-eighth ($^{1}/_{8}$) inch.
- Lock stile, one-eighth ($^{1}/_{8}$) inch.
- Bottom rail, one-half (½) inch.

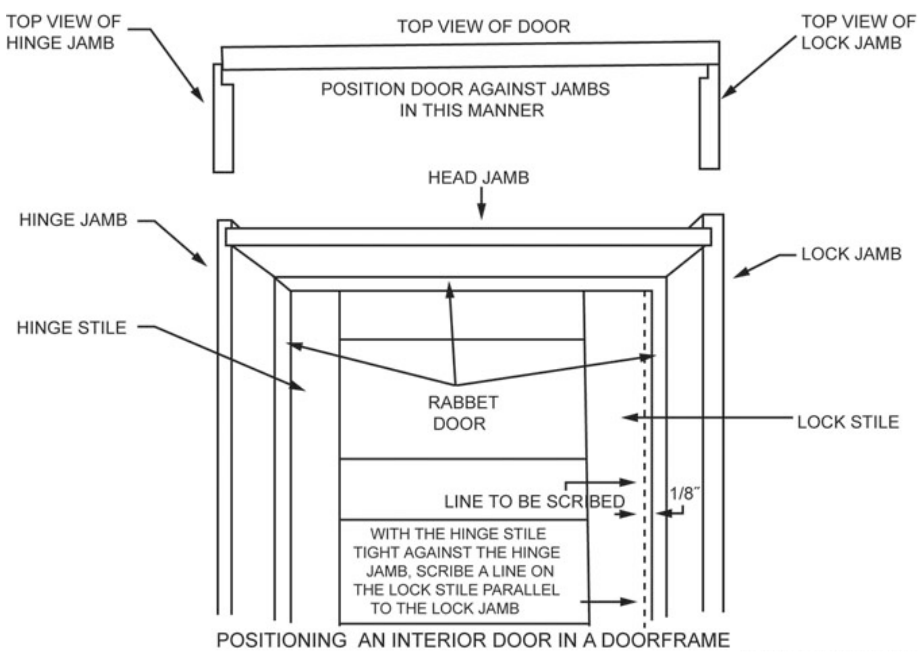


Figure 3–8. Positioning an interior door in a doorframe.

If flooring material, such as carpet, changes the gap allowance of the bottom rail, add its thickness to the one-half (½) inch space allowance.

To adjust the space between the door and the doorframe, you place wooden wedges between the rough opening and doorframe. Place these wedges (two at each location) at the hinge and latch locations first. Place additional wedges where needed to set the desired space around the door. An easy way to maintain the spacing at the top is to place two 4d casing or finish nails between the head jamb and the door's top rail (fig. 3–9). Put a single wedge near the center of the bottom rail to hold the door in place. The nails you've placed on the top rail will let you shift the door if necessary.

When you have the door properly positioned, wedge it firmly and mark the hinge locations on the stile and the jamb 7 inches from the top of the door and 11 inches from the bottom of the door rail (fig. 3–9). Most interior doors use butt hinges (fig. 3–10), which require a mortise (gain) for both hinge leaves.

Figure 3–11 shows using a wood chisel to mortise a door for butt hinges. Layout and chisel the mortise carefully so that the hinge fits perfectly (fig. 3–12). An incorrect hinge mortise may keep the door from closing and make it swing improperly. A must for metal doorjambs, whether the door is wood or metal, is that the door's mortised hinges must match the factory mortise on the jamb.

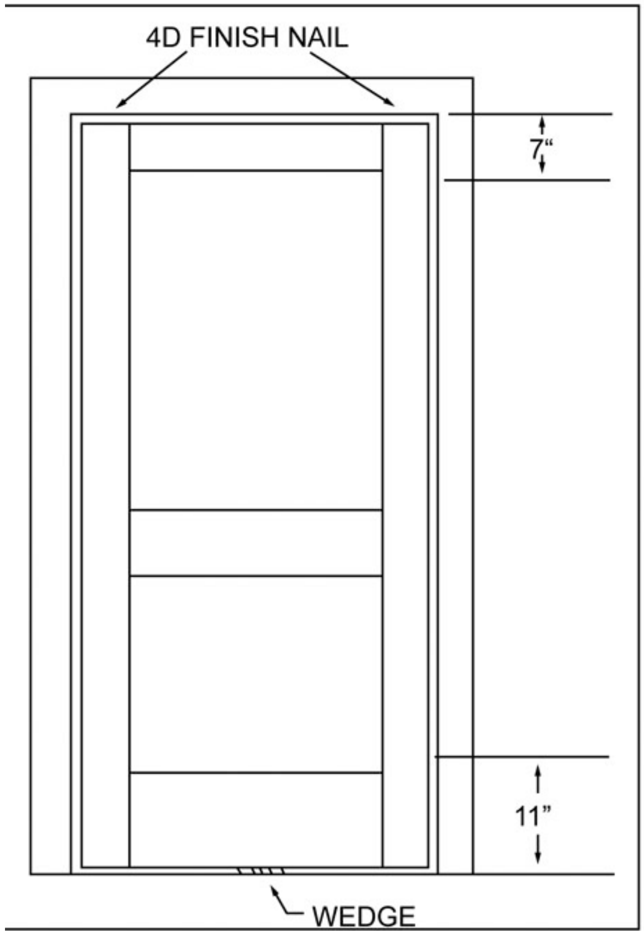


Figure 3–9. Setting the space between the door and doorframe.

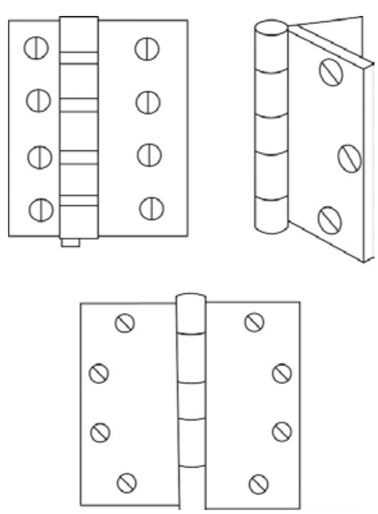


Figure 3–10. Hinges.

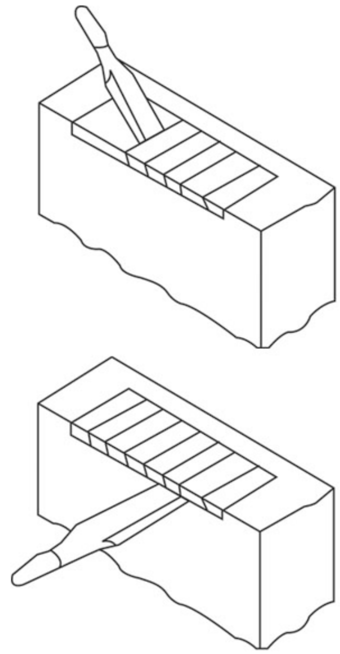


Figure 3–11. Mortising a door for a butt hinge.

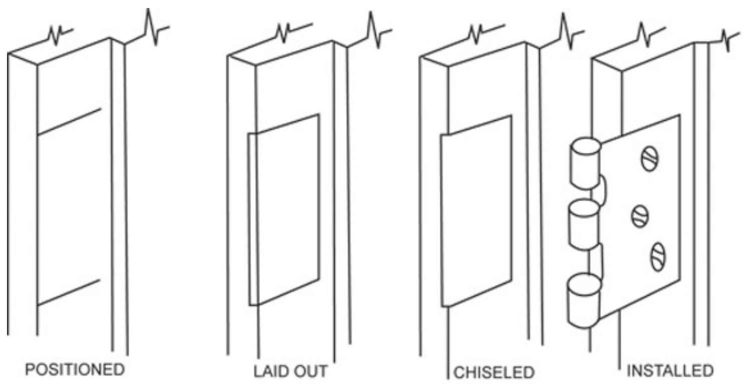


Figure 3–12. Steps for mortising a butt hinge.

611. Installing metal doorframes

Wood, metal, and glass doors are installed on wood or metal frames; however, metal frames are becoming increasingly popular—especially with metal and glass doors. This lesson covers some of the various ways of installing metal doorframes. Different doorframe manufacturers may have different methods, but the installation concept is relatively the same.

> **NOTE:** Although this information is in the exterior door section, the methods discussed here apply to interior metal doorframes as well.

Metal doors and doorframes

Standard metal jambs are available in various widths for plaster, concrete block, brick veneer, and drywall construction. The sill is usually made of oak for wear resistance. When wood is used for the sill, a metal nosing and wear strips are generally included. The brick mold or outside casings are designed and installed to serve as stops for the screen or combination door.

Doorframes can be purchased knocked down (KD) (fig 3-13) or preassembled with just the exterior casing or brick mold applied. In some cases, they come preassembled with the door hung in the opening. Exterior doors are 1¾ inches thick and not less than 6 feet 8 inches high. The main entrance door is 3 feet wide, and the side or rear service door is 2 feet 8 inches wide. A hardwood or metal threshold covers the joint between the sill and the finished floor.

The bottom of an exterior door may be equipped with a length of hooked metal that engages with a specially shaped threshold to provide a weatherproof seal. Wood and metal thresholds with flexible synthetic rubber tubes that press tightly against the bottom of the door to seal out water and cold or hot air are available.

NOTE: The information presented here also applies to glass doors. Most glass doors are simply metal-framed with glass panels or inserts and are installed in a metal frame.

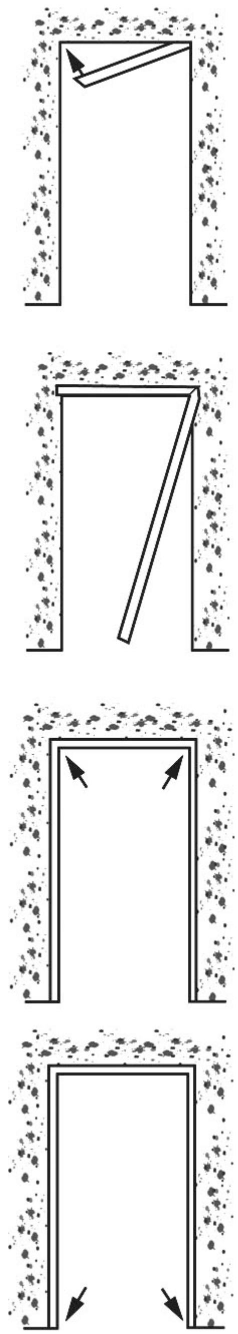


Figure 3–13. Knock down frame installation.

General information

Welded metal doorframes are assembled at the factory and checked to ensure that they are square and straight. Then temporary spreader bars are attached to the base of the jamb to help minimize any misalignment or other damage during shipment. The spreader bar is for shipping purposes only and must be removed before installing the frame.

You must always follow the manufacturer's instructions when using knockdown frames. You must make sure that the frames are square and in true alignment. These type frames usually assemble with bendable tabs, screws, or bolt fasteners. Knockdown frames are not usually recommended for doors wider than 3 feet 6 inches or weighing more than 100 pounds.

Jamb anchors

The frame must be properly anchored for the door to function as designed. There are a variety of jamb wall anchors available to accommodate the various types of wall construction. We'll discss three types: masonry, miscellaneous, and floor anchors.

Masonry anchors

Figure 3–14 shows some types of masonry anchors used for metal frames. The first three types are used for new construction—either masonry or poured concrete. The *T-strap, strap,* and *stirrup* type provide sufficient adjustment for the block courses as well as providing access to grout the jambs. An *expansion bolt anchor* is a hole that is punched and dimpled through the doorframe that allows for a three-eighths ($^3/_8$) inch flat head machine bolt with an expansion shield. It also comes with a crush proof tube and strap anchor welded to the back. This type anchor is used in existing masonry and concrete openings. Regardless the type used, it is very important that you ensure that one anchor is placed near the top and bottom of each jamb.

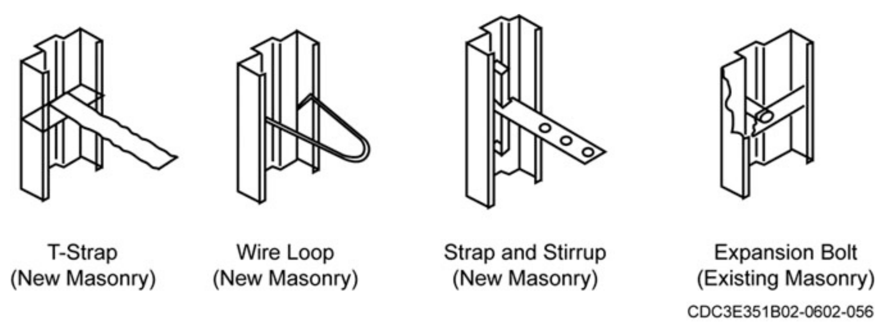


Figure 3–14. Masonry anchors.

Miscellaneous anchors

Figure 3–15 shows anchors that you may use with either metal or wood studs.

- *Steel stud anchors* are welded to the back of the jambs and are used on custom frames.
- The *wood stud and wood stud zee anchors* are welded to the back of the jamb; loose twist-in anchors are not as strong, thus most contractors do not recommended their use.
- A *slip-on drywall base anchor* has a strap of metal welded on each side of the jamb at the bottom with holes punched for nails or screws.
- A *compression anchor* uses an adjustable compression device that is located near the top of each jamb. It is used with slip-on drywall base connectors for slip-on drywall frames.

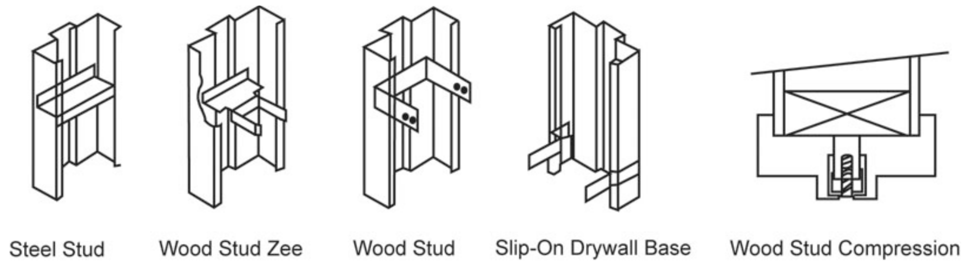


Figure 3–15. Miscellaneous anchors.

Floor anchors

The standard floor and adjustable floor anchors are shown in figure 3–16. They are secured to the floor with expansion shield fasteners to provide solid anchorage. The *standard floor anchor* cannot be adjusted and you must shim it if the floor is not level. On the other hand, the *adjustable floor anchor* is used when the floor is unlevel or to accommodate special floor coverings, such as terrazzo. Both types cannot be used in existing masonry, pre-framed stud walls, or on slip-on dry-wall frames, since it doesn't allow access to anchorage it.

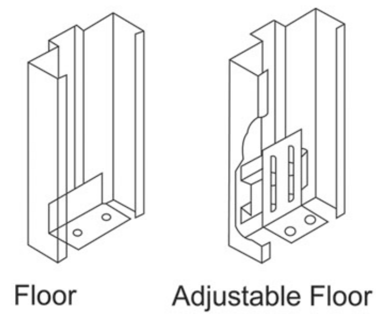


Figure 3-16. Floor anchors.

Anchor spacing

You must always follow the manufacturer's specifications for the jamb anchor spacing requirements. The suggested spacing requirements for most systems are given in the table below.

Suggested Anchor Spacing	
System	**Spacing**
Masonry walls	When using expansion bolt anchors, they are typically spaced a maximum of 6 inches from the top and bottom with intermediate spacing at a maximum 26 inches on center.
Stud partitions	When installing the frames with steel or wood stud anchors, place the anchors near the hinges and directly opposite on the strike jamb.

Masonry wall installation

The following table is a suggested way to install a metal jamb (frame) for new masonry construction.

Installing a Metal Jamb in New Masonry Construction	
Process	**Description**
Bracing	To install the frame, you'll need to brace the frame in the desired position (fig. 3–17). You need to be sure that your bracing extends perpendicular to the frame (do not brace inline with the wall), so that it doesn't interfere with wall construction.

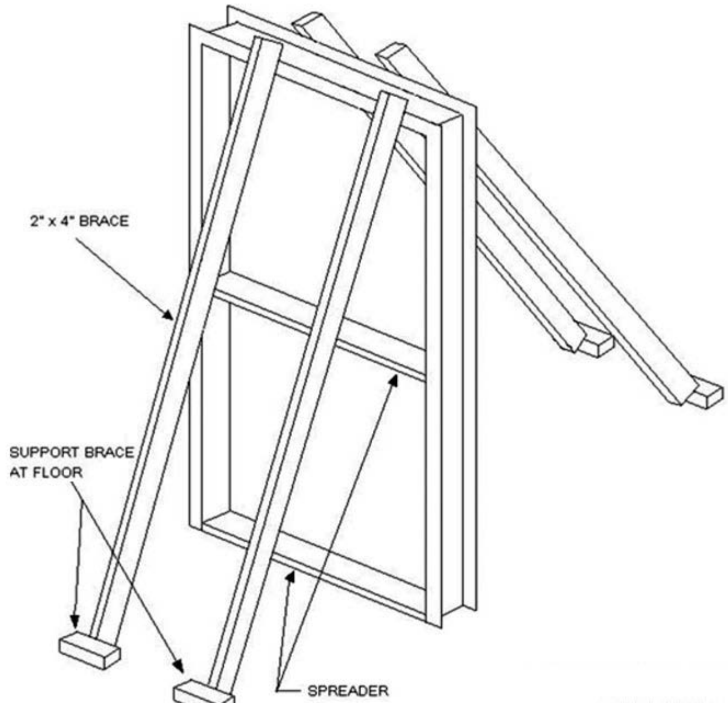
<table>
<tr><th colspan="2">Installing a Metal Jamb in New Masonry Construction</th></tr>
<tr><th>Process</th><th>Description</th></tr>
<tr><td></td><td>

Figure 3–17. Metal frame bracing.</td></tr>
<tr><td>Plumbing</td><td>You should use a level, square, and spreader when plumbing the frame.

Set the frame in the desired location and then:
Level the header. If necessary, you may have to place a shim under the jamb floor anchor.
Once you get the frame in position, set the spreader at the base of the frame and fasten the jamb to the floor through the floor anchors.
Place a second wood spreader at the mid or strike point on the frame. This second spreader must be used with the spreader at the base of the frame to prevent the jambs from bowing making the door opening too small.

NOTE: Don’t rely on the temporary spreaders that are usually attached to the bottom of the frames. They are only there to prevent shipping damage—not to aid installation.</td></tr>
<tr><td>Anchoring</td><td>As the wall is constructed, place anchors at the hinges on the hinge jamb and at the same position on the strike jamb.
Follow the manufacturer’s specifications for any additional anchor locations.
The frame must be fully grouted as the wall is built around the frame.
Continue to check plumb and square and twist in the jamb during the entire wall construction.</td></tr>
</table>

Metal stud installation

This method applies to installing a metal jamb into a steel-stud wall as the wall is built—new construction. Use the techniques for bracing, plumbing, and spreader as mentioned above. Place anchors at the hinges on the hinge jamb and at the same position on the strike jamb. Follow the manufacturer’s specifications for any additional anchor locations.

Metal Stud Installation	
Process	**Description**
Securing the jamb	Your first step is to attach the jambs to the floor through the floor anchors. You will need to center the studs in the frame. Then attach the steel studs to the floor and ceiling runners. You can either weld or screw the steel studs to the anchors. Be sure to continually check the frame for plumb, square, and twisting as the wall progresses.
Wall construction	Like most things we do, it is very important that you refer to the steel stud manufacturer's recommendation on thickness and general construction techniques. You want to ensure that the wall opening is solid and stable.

Wood stud installation

When framing the rough opening for a metal frame, the opening's width is usually the overall frame width plus one-half (½) inch and the height is usually the frame height plus one-fourth (¼) inch. Refer to the manufacturer's specifications on the number of wall anchors required. Frames over 60 inches high usually require four anchors per jamb. Place the anchors immediately above and below the hinges and as close as possible to the bottom of the jamb. Place the anchors in the corresponding locations on the opposite jamb. The following table covers suggested steps to complete the frame installation.

Completing Frame Installation in Wood Studs	
Step	**Action**
1	Once the anchors are in place, set the frame into the rough opening and bend the anchor tabs around the studs. Be sure to leave the required amount of clearance between the frame and stud to allow space for the finished wall material, such as gypsum board.
2	Use the spreader to set and level the frame. Be sure to check for any twists and install shims, as needed.
3	Ensure the frame is square at the corner and nail the top anchors to the studs. Nail one jamb and recheck for plumb, square, and twists. Then continue to nail the remaining anchors to the studs.
4	Repeat the above step for the opposite jamb.

Knockdown frame installation

Many of your projects may involve installing a metal frame into an existing drywall. You'll need to refer to the manufacturer's instructions for specific information. The steps listed in the following table are what is typically done. Refer back to figure 3–13.

Knockdown Frame Installation	
Step	**Action**
1	Ensure rough opening is the specified size.
2	Slide the header jamb in place over the wall.
3	Install one side jamb in place.

Knockdown Frame Installation	
Step	**Action**
	Start at the top and push the bottom in until it is vertical.
4	Repeat the above step for the other side jamb.
5	Join the header jamb to the side jambs using the specified fasteners and/or procedures.
6	Plumb and square the opening and attach the base anchor, then the other anchors.

NOTE: For security purposes, the wall sections behind the middle hinge and the strike locations must be reinforced with blocking.

Completed masonry and wall jamb installation

The table below discusses suggested steps for installing a metal frame into an existing masonry or concrete opening.

Installing Metal Frame Into Existing Masonry or Concrete Opening	
Step	**Action**
1	Install a minimum of four anchors per jamb. Place the anchors as close to the bottom in the hinge jamb and in a corresponding position in the strike jamb. It's recommended to use five anchors on frames over 7 feet 6 inches in height.
2	Place the frame in the existing wall opening, checking for squareness. Mark the wall through the holes in the jamb at the anchor points, drill the holes at the marks, and install the sleeve anchors.
3	Insert the flathead bolts through the frame into the expansion shields. You may have to shim behind the anchors above the bolts to ensure the frame is plumb. Use the plumbing methods previously discussed with the spreader and tighten the screws. As before, continually check plumb, square, and twist in the jamb as you tighten the screws.
4	Caulk or grout any clearance between the frame and wall.

Door installation

Your experience and care are essential when hanging metal doors. You may have to use metal hinge shims to provide uniform clearance around the door and eliminate "hinge bind."

Edge clearances

The Hollow Metal Manufacturers Association recommends the following edge clearances:

- Between door and frame at head and jamb: ⅛ inch $\pm$ $^{1}/_{16}$ inch.
- Between edges of pairs of doors: ⅛ inch $\pm$ $^{1}/_{16}$ inch.
- Where a threshold is used ⅛ inch maximum from bottom of door to top of threshold.
- Where no threshold is used ¾ inch maximum from bottom of door to the finish floor.

NOTE: There are different clearance requirements for fire rated doors. Always refer to your local building codes for the construction project you are working on.

612. Locking devices and door accessories

There are numerous types of locking devices that are used on interior and exterior doors. Due to the variety of lock types and numerous manufacturers, you must follow the installation instructions provided with the lock. This lesson serves as a guide and specifies common procedures for cylinder locks, mortise locks, cipher locks, and panic hardware installation and maintenance. The material referenced in this lesson is not intended to replace the manufacturer's instructions.

Cylinder locks

Cylinder locks are actually called *key-in-knob* locks. Most people refer to them as cylinder locks because they have a pin tumbler cylinder in the knob. Install the lock so that the center of the doorknob is anywhere from 36 to 40 inches above the floor. Most sets come with paper templates, for marking the location of the lock and latch bolt and indicate the size of the holes to be drilled. Be sure you read the manufacturer's installation instructions carefully. Recheck your layout measurements before you drill any holes.

The parts of an ordinary cylinder lock for a door are shown in figure 3–18. The procedure for installing a lock of this type is as shown in the table below.

Installing a Cylinder Lock

Step	Action
1	Open the door to a convenient working position and check it in place with wedges under the bottom near the outer edge.
2	Measure up the required distance from the floor (the usual knob height), and square a line across the face and edge of the lock stile.
3	Place the template, which is usually supplied with a cylinder lock, on the face of the door at the proper height and alignment with layout lines and mark the centers of the holes to be drilled.
4	First drill the holes through the face of the door and then the hole through the edge to receive the latch bolt. It should be slightly deeper than the length of the bolt.
5	Rout for the latch-bolt mounting plate ensuring that the plate is *flush* with the door edge, and install the latch unit.
6	Install the interior and exterior knobs.
7	Find the position of the strike plate and install it in the jamb.

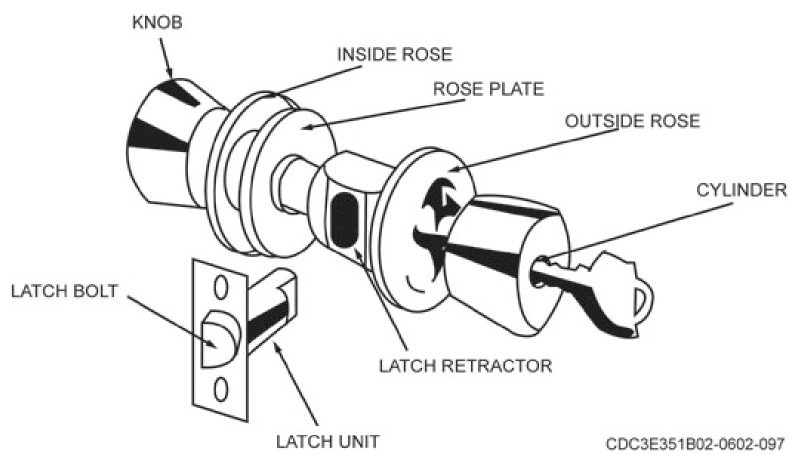


Figure 3–18. Parts of an ordinary cylinder lock.

Strike Plates

The strike plate, which you route into the doorjamb, holds the door in place by contact with the latch. To install, mark the location of the latch bolt on the doorjamb and locate the position of the strike plate by outlining it. Rout out the marked outline with a chisel and rout for the latch bolt. The strike plate should be flush with or slightly below the face of the doorjamb. When the door is latched, the door face should be flush with the edge of the jamb.

Mortise locks

Mortise locks are installed in a pocket or mortised hole. The basic installation sequence (assuming knob and cylinder holes are already drilled) are in the following table.

Installing Mortise Locks	
Step	**Action**
1	Ensure the mortised hole (pocket) in the door is clean.
2	Insert the mortise lockbody into the pocket, ensure proper fit and secure screws (do not fully tighten the screws).
3	Install the outside plate cover (escutcheon assembly). Hold the outside lever in the horizontal position and insert the mounting posts through the door into the lockbody. The spindle must be engaged in the lock with the outside escutcheon assembly flush with the door surface.
4	Install inside adapter and plate assembly and secure screws.
5	Install inside escutcheon assembly.
6	Screw cylinder into lockbody and secure with the cylinder retainer and tighten the lockbody screws.
7	Install the inside lever in the horizontal position and approximately one-sixteenth ($^{1}/_{16}$) inch from the inside escutcheon face and secure the setscrew.

NOTE: The installation sequence is the same regardless if knobs or levers are used.

Cipher locks

Cipher locks are commonly referred to as access control devices or push button locks. There are electronic and mechanical. We limit our discussion to mechanical cipher locks. The following table contains general procedures for installing common mechanical cipher locks.

Installing Cipher Locks	
Step	**Action**
1	Tape the mounting template to the door at the correct height. The template should have a fold line that that aligns with the edge of the door. Mark the centers of all holes with a center punch.
2	Drill holes using recommended drill size and depth.
3	To drill the large holes, drill from the both the outside and inside surfaces to keep from damaging the door face.
4	Slide the lock housing into the holes and screw it to the door.
5	Place the holding bracket onto the front door surface and fasten with screws.
6	Remove the lock housing from the door.

Installing Cipher Locks	
Step	**Action**
7	Slide the holding edges of the faceplate behind the holding bracket. The faceplate must be held securely on both sides.
8	Replace the lock housing while holding the control knob in the correct position. You must rotate the knob to ensure that it engages properly and then fasten the lock housing to the door.

NOTE: Try the combination three or more times before locking the door to ensure that everything is operational.

Panic hardware

Another locking device is panic hardware or an exit device. You see it on public building exits (fig. 3–19). Panic hardware acts more as an unlocking device than a locking one. The name comes from the fact that people in crowds are likely to panic in an emergency, and not take time or get a chance to operate regular doorknobs before the pressure from behind makes it impossible to do so. Panic hardware operates on a very simple principle: any outward pressure on the horizontal bar releases the lock and opens the door. Even an unconscious person falling against the door will open it and free the following crowd. There are different types available, such as rim and vertical rod exit devices. Panic hardware varies widely among manufacturers, so always follow the installation instructions carefully.

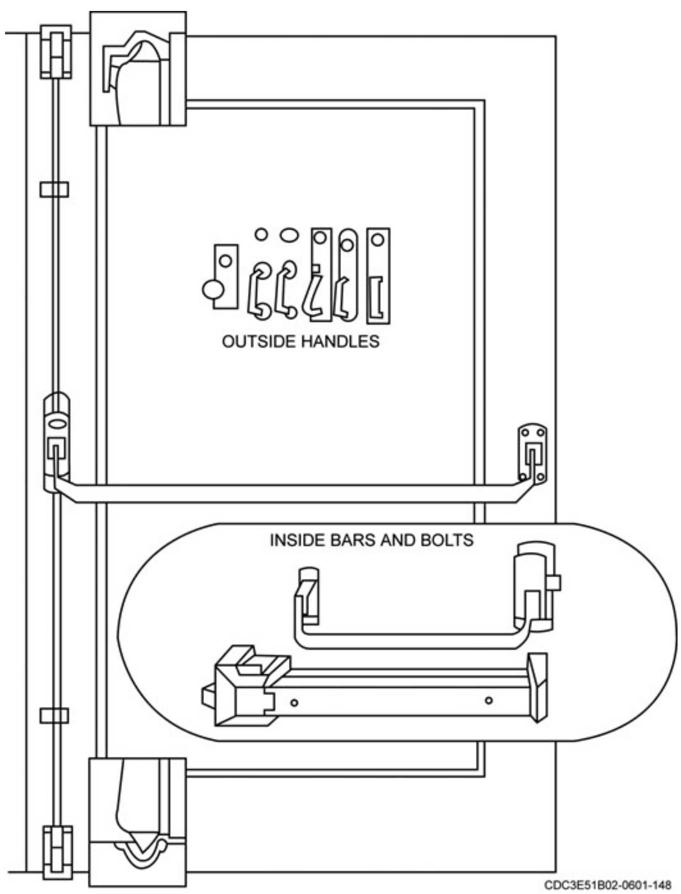


Figure 3–19. Panic hardware.

There are basic procedures to follow when you install any panic hardware. They are described in the table below.

Installing Panic Hardware	
Step	**Action**
1	Establish the centerline for the hardware on the door and doorstop. If you are installing a vertical rod type, you will also need to establish the vertical centerline on the inside of the door.
2	Use the manufacturer’s template that comes with the hardware. The template will line up with your centerline marks and provide you with all bracket and hole locations.
3	Drill and cut the holes per the template.
4	Mount the hardware according to the manufacturer’s specification.
5	After the installation is complete, perform an operational check to make sure the hardware opens and closes properly.

Maintenance and repair

There will come a time when you will be called to a job where the lockset is not working right. Before you assume there’s something wrong with the lockset, you should rule out other possible problems. Ask yourself the following questions:

- Is the door locked?
- Is this the right key?
- Is the bolt or strike misaligned?
- Is the door warped?
- Are the hinges bound?
- Have the hinge screws loosened?
- Is the door sagging?

If the answer to any of these is yes, the problem is probably not the lock. Try to resolve these issues before tearing apart or replacing a lockset.

Cylinder locks

We’ll cover some of the more common problems with cylinder locks that you may encounter.

Cylinder Lock Problems	
Problem	**Solution**
Latchbolt will not deadlock	Latchbolts have a little latch on the backside called a deadlocking latch. Whenever this latch is depressed, it prevents someone from trying to slip an object in front of the latch bolt and pry the door open. Whenever the latchbolt doesn’t deadlock, the deadlocking latch going into the strike is usually the cause. This strike may be out of line or the gap between the door and jamb may be excessive. You will have to realign the strike or shim it out.
Key is difficult to use (insert/turn)	You will have to lubricate the keyway periodically to keep it working properly. Do not use petroleum products such as a lightweight oil or penetrating oil;

Cylinder Lock Problems	
Problem	**Solution**
	instead, use a spray powdered graphite, lead pencil shavings, silicon or Teflon spray. Then slide the key back and forth in the keyway.

Mortise locksets

In addition to the problems mentioned above, you may encounter the following problems with Mortise locks.

Mortise Lockset Problems	
Problem	**Solution**
Latchbolt doesn't extend or retract freely	Check for binding. Loosen the faceplate (trim/rose) and handle. If the binding stops, you'll have to realign the trim. If the lockset still does not operate properly, you'll need to remove it from the door and check for operation. If it operates properly outside of the door, you'll need to enlarge the mortise to allow the lockset to slide into it freely.
Latchbolt gets stuck (stubs) on edge of strike plate	If this happens you can either bend the strike slightly towards the jamb or apply some wax or paraffin to help the latchbolt slide over the strike.
Deadbolt doesn't slide into the strike	The most common cause for this is misalignment of the strike and bolt. You can correct this with one of two methods: • File the strike. • Reposition the strike.
Broken key in lock	You'll need to remove the cylinder from the lock and insert a thin long pin or wire into the back end. Keep moving the wire or pin back and forth until the broken piece comes out the front. Then clean out the cylinder with ethyl acetate and lubricate it with products listed above before you reinstall it.

Cipher locks

The most common service call you may receive is to help the customer reset the combination. This is where the manufacturer's instructions come in handy. Each make and model has it's own tools and procedures. The following is one method for some mechanical cipher locks.

Resetting Cipher Lock Combination	
Step	**Action**
1	Open the door and enter the current combination with the lock in the locked position.
2	Remove screw at the top of the lock housing.
3	Insert Allen wrench into screw hole and depress the reset button.
4	Turn front control knob to the left to remove current combination.
5	Enter new combination and turn front control knob to the right.

Resetting Cipher Lock Combination	
Step	**Action**
6	Operate lock several times before closing the door.

Panic hardware

When it comes to panic hardware, the concealed vertical rod type is more pleasing to the eye but more difficult to adjust. Mortise lock and rim devices are considered the best alternative because these are easier to install and maintain properly. The rim series has the least problems, followed by the mortise, then surface-mounted vertical rod and last, the concealed vertical rod series. Rim devices can be used on pairs of doors with either fixed or removable mullions. Rim or mortise devices should be the only series used on single doors.

The most common problem that you might encounter with panic hardware is the latch will not fully extend. To fix this problem, slightly loosen the mounting screws until the latch releases and then lubricate. If the panic hardware will not lock or unlock, remove the panic hardware and check to see if the actuating cam is broken. If it is, you can replace the cam. Check with the manufacturer for the replacement part.

Like all mechanical items, a little preventative maintenance helps prevent problems. Remember to use only those lubricants indicated in this lesson.

Door closers

We use door closers on exterior and interior doors that are likely to be slammed by drafts or people. We also use them where it's desirable to have a door automatically close after it is opened. There are many models that you may have to install, maintain, adjust, or repair. Obviously you'll have to get most of your information from the instructions, but let's take a quick look at a few general principles of pneumatic and hydraulic door closers.

Pneumatic door closers

Lightweight doors, such as storm doors and screen doors normally use surface-mounted pneumatic closers (fig. 3–20). An internal spring provides the force that closes the door. The door closing speed is controlled by air pressure. You can adjust the closing speed by turning a setscrew on the closer.

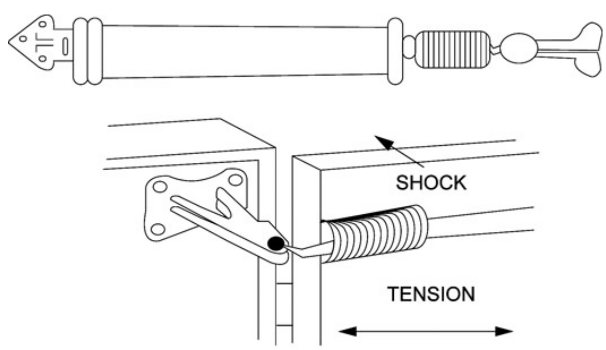


Figure 3–20. Pneumatic door closer.

Hydraulic door closers

Heavy wood or metal doors in public buildings need heavy-duty, hydraulic closers (fig. 3–21). The model needed depends on the application. Some models are universal for left- or right-handed doors. You must be set up closer for the correct hand before installation. Other models come only for left- or right-handed installation and must be ordered for a specific door swing. The door is closed by a spring in the closer, but its hydraulic fluid that controls the speed. An adjustable restrictor controls the hydraulic flow. You can adjust both the spring tension and the hydraulic flow to match the door. In areas of severe weather, especially where there are high winds, you may need to reinforce the door and jamb with metal plates to withstand the extra stress. Most types can be installed three different ways—regular arm, top jamb, and parallel arm installation. Due the variety of types available, it is impossible to describe specifically how to install them; however, we will discuss the basic installation procedures for regular arm installation. Always refer to the manufacturer's installation instructions.

Regular arm installation

Before you begin installing a door closer, open the package and refer to the installation instructions that come with it. The instructions will list all the tools required, the installation sequence, and special precautions to observe. The door closer should also come with a template that provides mounting locations for the closer and arm bracket. The basic installation sequence is given in the table below.

Regular Arm Hydraulic Door Closer Installation	
Step	**Action**
1	Ensure all tools and parts are available.
2	Mark the holes for the closer and the arm bracket. Install the closer and bracket using appropriate fasteners. The closer is usually installed with the adjusting valves placed towards the hinges.
3	Install the arm assembly onto the bracket and closer. The top of closer usually has a square piece with one flat corner that the arm slides over. Mark the arm with different numbers or letters. The installation method chosen will determine which mark is placed next to the flat corner.
4	With the closer and arm mounted, adjust the sweep (closing speed). The sweep should be distinguished with an "S" next to the adjusting valve. Turning the valve clockwise slows the speed and counterclockwise makes it faster. An idea speed is between 3 to 7 seconds when the door is opened to 90 degrees.
5	Adjust the latch speed. The latch speed ("L") controls the door speed the last few inches before the door closes. Clockwise is faster; counterclockwise is slower.
6	Adjust the backcheck ("BC"). This adjusts the opening pressure on a door. In windy areas, you may have to set it stronger by turning it clockwise. In areas with a lot of small children, you may to need to weaken it by turning the valve counterclockwise.
7	Some closers are designed to stay open (hold open) if they are opened past a certain degrees. Set the desired hold open location, if applicable.
8	Install any caps or covers.

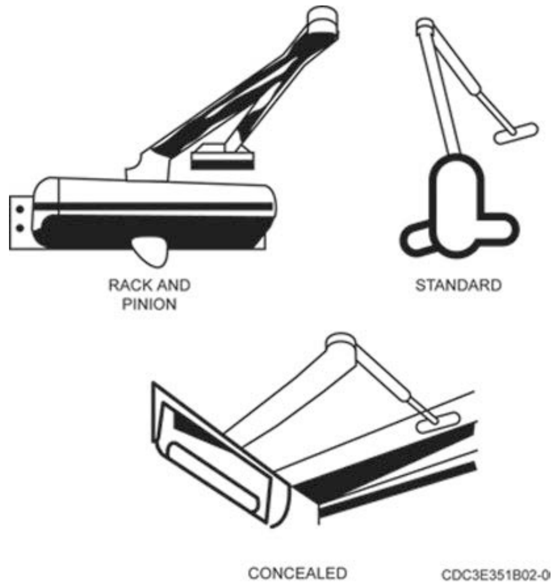


Figure 3–21. Hydraulic door closers.

Maintenance and repair of door closers

Simple pneumatic closers usually need occasional adjustment and lubrication. Check to be sure the attaching screws are secure and the plunger still works. If the plunger is inoperative, no amount of adjusting will control the closing speed. All you can do is discard the unit.

Hydraulic closers are a little more complex. More points require lubrication and adjustments aren't quite as easy. Don't try to adjust them until you read the manufacturer's instructions. Use lubricant sparingly to keep from staining doors, walls, and floors. Hydraulic fluid leaking from the unit is a sure sign that the unit is ready to be replaced.

613. Window types and installation methods

Most windows used today are factory made units that are ready for installation into rough openings. The frames and sashes can be made from wood, metal, vinyl, or other materials along with glass and other items to make a complete unit. In this lesson, we will discuss information common to the different window types and discuss installation and repair methods. Because there are slight variations between window manufacturers, the information presented here is general in nature.

Window types and parts

The three basic window types are sliding, hinged, and stationary (fixed in place). You can open the sliding and hinged types for ventilation; the stationary type you can't. The common window frame parts include the head jamb, side jamb, and sill. The common window parts include the top rail, bottom rail, stiles, and sash. There are additional parts that manufacturers use to make different window types. Figure 3–22 shows two typical window units—the fixed type on the left is wood and the awning type on the right is aluminum. Let's take a more detailed look at some other window types.

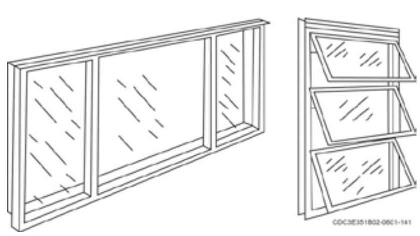


Figure 3–22. Window units.

Sliding windows

Sliding windows operate by sliding, as the name implies. They include the double-hung (vertical) and the horizontal sliding windows.

Double-hung windows

Figure 3–23 shows the double-hung window frame. The jamb is three-fourths (¾) inch thick, with a parting strip to separate the top from the bottom sash. The outside casings are the same thickness and width as door casings. Whether installed separately, in pairs, or in triples, these windows must have space on either side for the sash-balancing mechanism to operate. Asash-balancing device is needed or the upper sash won't normally stay closed and the lower sash won't stay open. The balancing device holds the sashes open, closed, or in any other desired position.

Where wall space is limited, manufacturers use a friction control window-balancing device. These devices fit into a grooved slot made into the sash edge—each window needs two (one for each sash edge along the jamb). A clip or some other method holds the device in position and allows the spring to operate properly. The spring tension holds the sash at the desired height. Figure 3–24 shows one common type, the spring-and-tube-holding device.

Figure 3–25 shows two more devices. These almost never need maintenance or repair unless the aluminum jamb liners get bent or deformed. If this happens, liner replacement is probably in order since you can't repair them easily.

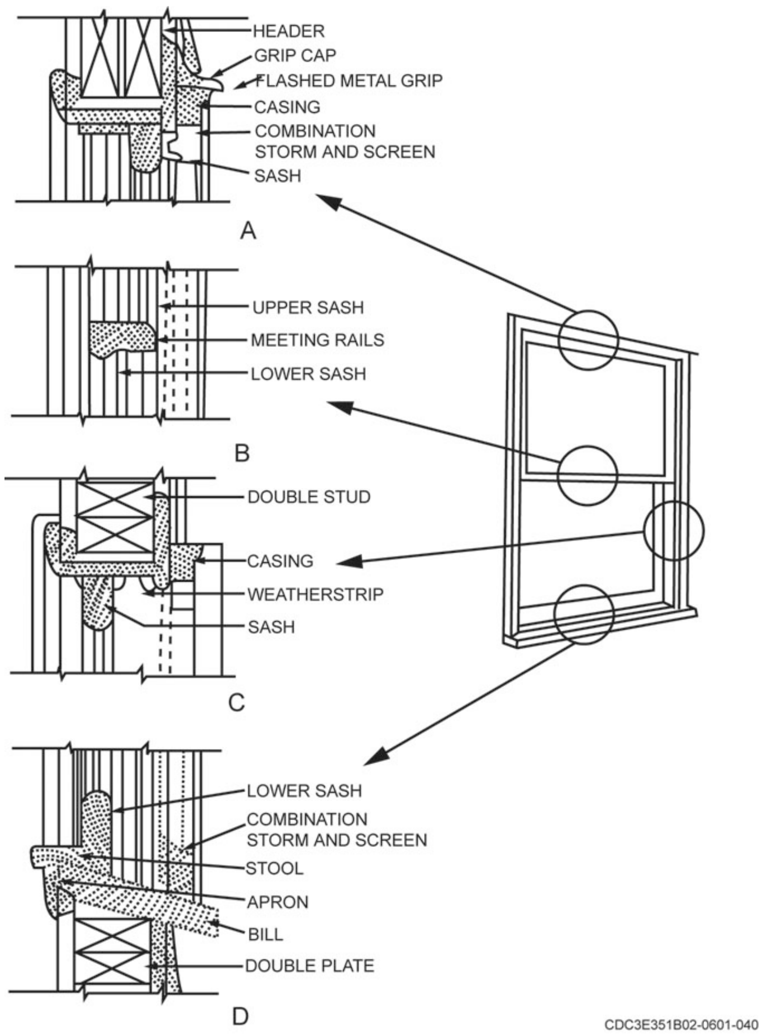


Figure 3–23. Double-hung window frame, detail view.

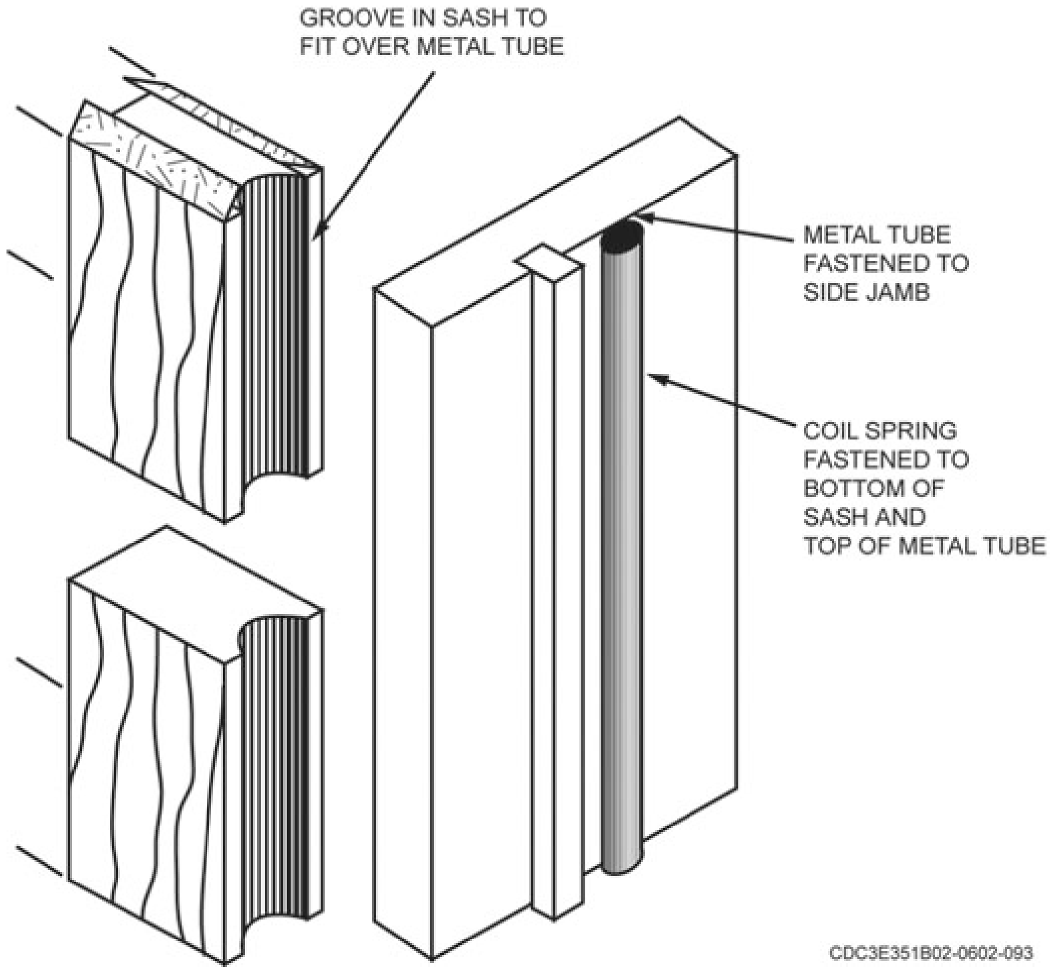


Figure 3–24. Spring and tube holding device.

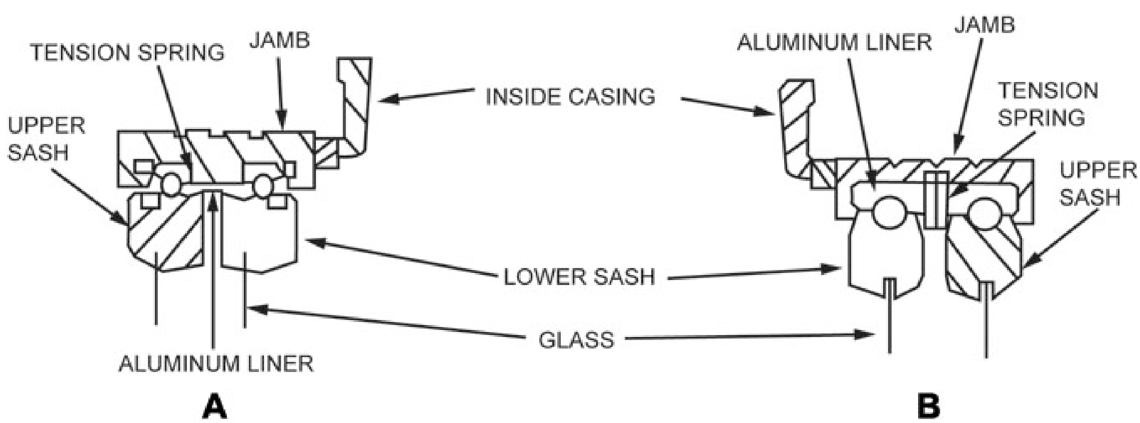


Figure 3–25. Friction holding device on a wood sash.

Horizontal sliding windows

Figure 3–26 shows a typical horizontal sliding window unit—a two-sash frame with both sashes movable. In a three-sash design, the center sash is normally in a fixed position. Notice in the detailed drawing that each sash has an individual track on which it slides. Like the double-hung (vertical) window, manufacturers build the horizontal frame with aluminum jamb liners or wood tracks.

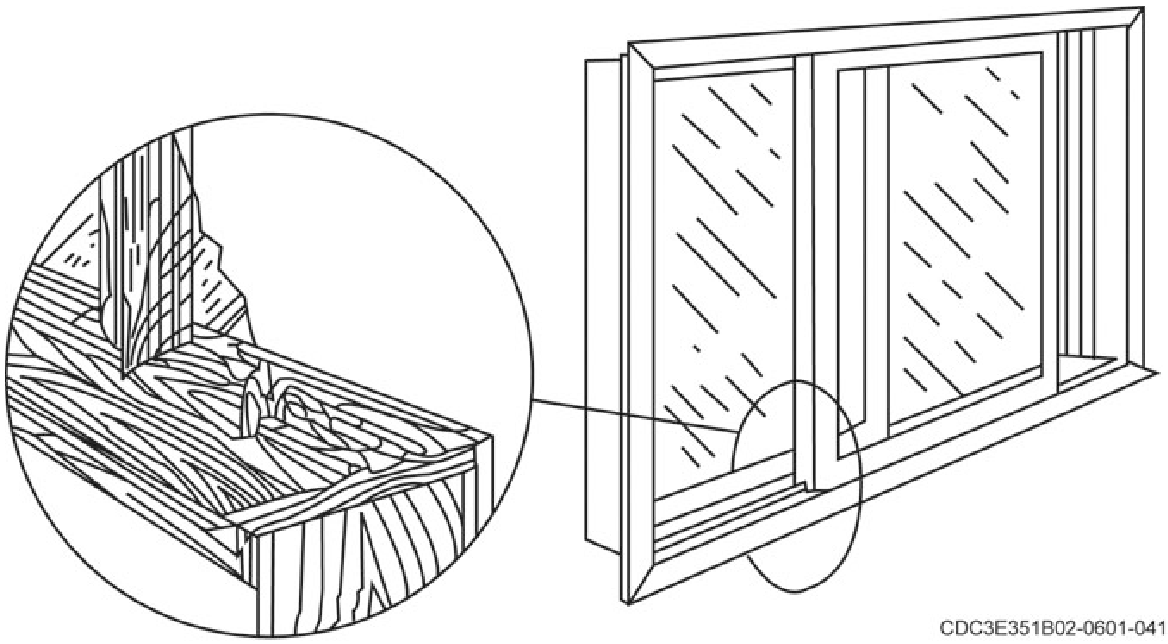
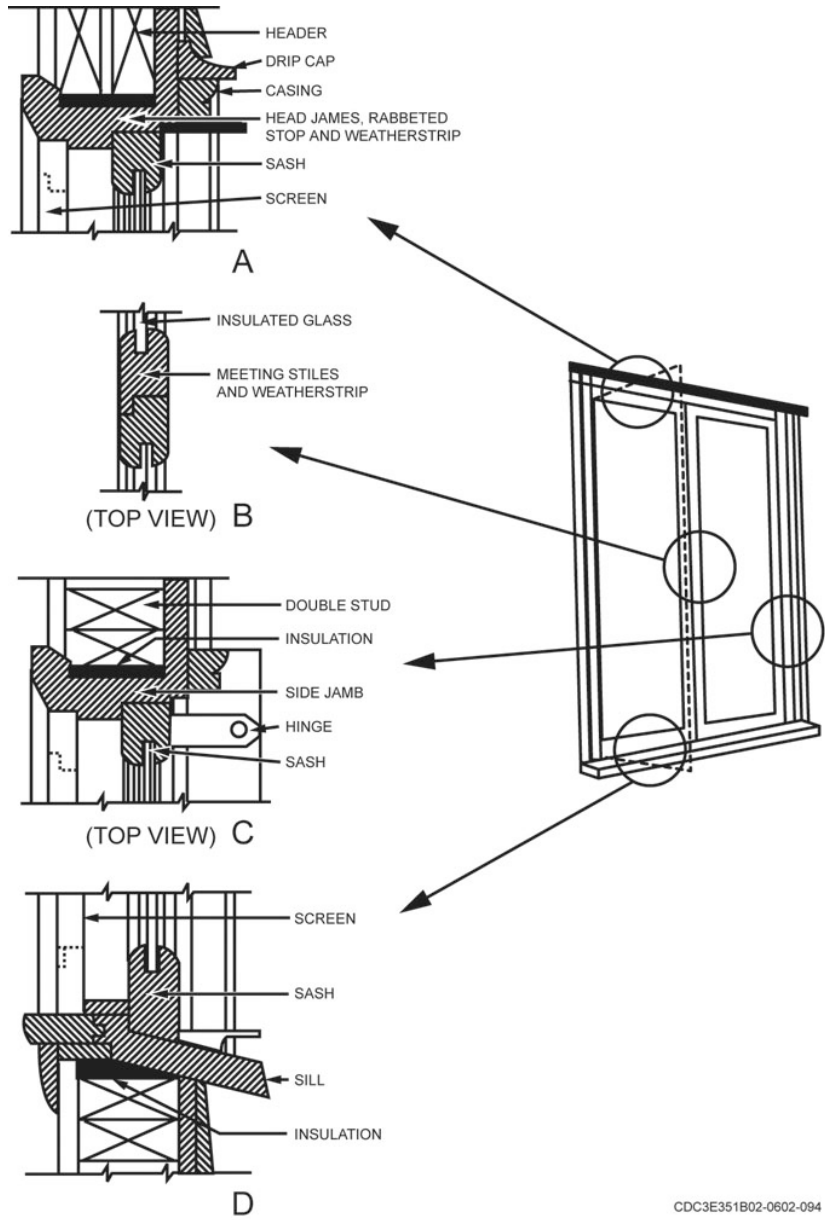


Figure 3–26. Horizontal sliding window.

Hinged windows

Hinged windows are also called *swinging* windows because hinges allow the window to swing open and close. They are available in many styles and shapes. The classifications for them include casement, awning, hopper, and jalousie.

Hinged Windows	
Type	**Description**
Casement-sash	Casement-sash windows are more economical to install than double-hung windows, so we often use them in temporary buildings. The construction methods and material thickness are about the same as for an outside doorframe. The sash hangs on hinges and can swing either inward or outward from the left or right side of the jamb. Because the sash must fit the frame closely, we use mortise-type hinges and locks. To keep the sash in alignment with the wood jamb, use wood strips or a rabbeted jamb. If the window doesn't need to open, you can hold the sash in place with molding rather than with hinges. In many locations, however, casement-sash windows are undesirable because they're hard to keep weather-tight. Another problem involves installing window screens: if the sash swings out, the screen must be inside. Figure 3–27 shows a typical casement-sash window.

Hinged Windows	
Type	**Description**
	 **Figure 3–27. Typical casement-sash window.**
Awning and hopper sashes	Awning and hopper sashes work much like casement sashes. A basic *awning sash* opens outward and hinges at the top of the frame. The *hopper sash* looks the same in detail, except for the hinge positions and the swing direction. It opens to the inside and is hinged at the frame bottom. With a few changes in the hardware locations, you can invert the awning sash and use it as a hopper sash.
Jalousie	Jalousie-type windows are used extensively in the warmer parts of the country because they permit maximum ventilation. They consist of a metal-framed unit with a series of glass slats about one-fourth (¼) inch thick, 3 to 8 inches wide, with ground or polished edges (fig. 3–28).

<table>
<tr><th colspan="2">Hinged Windows</th></tr>
<tr><th>Type</th><th>Description</th></tr>
<tr><td></td><td>Pivoting metal brackets at each end hold the slats horizontally in the frame. Each of these support brackets is also attached to a bar and a cranking device that opens and closes the slats simultaneously.

Jalousies have a disadvantage in that they are not as airtight as most other windows. For this reason, jalousies are seldom used where air conditioning and heating losses are factors.

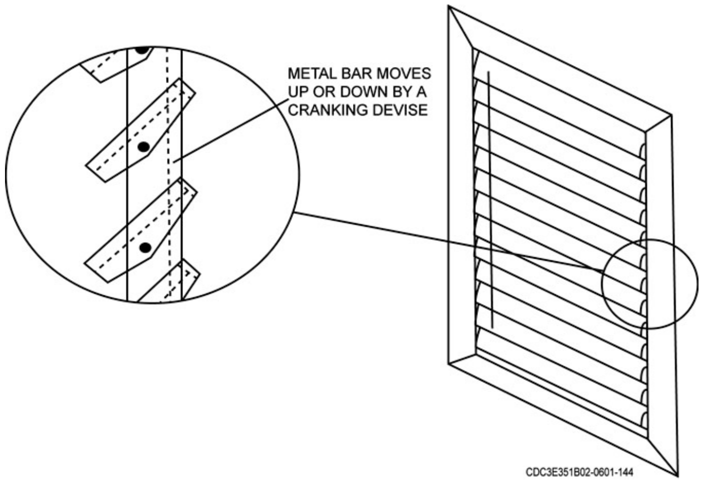


Figure 3–28. Jalousie window.</td></tr>
</table>

Fixed windows

Fixed windows cannot be opened or closed. Their primary purpose is to provide light and, in most applications, a clear view from inside or outside of the room. They are mostly used in combination with other window types. When used alone, the framework that encloses them can be practically any style. When you use fixed windows in combination with other window types, mount the fixed window sashes in frames that match the other window frames (fig. 3–29).

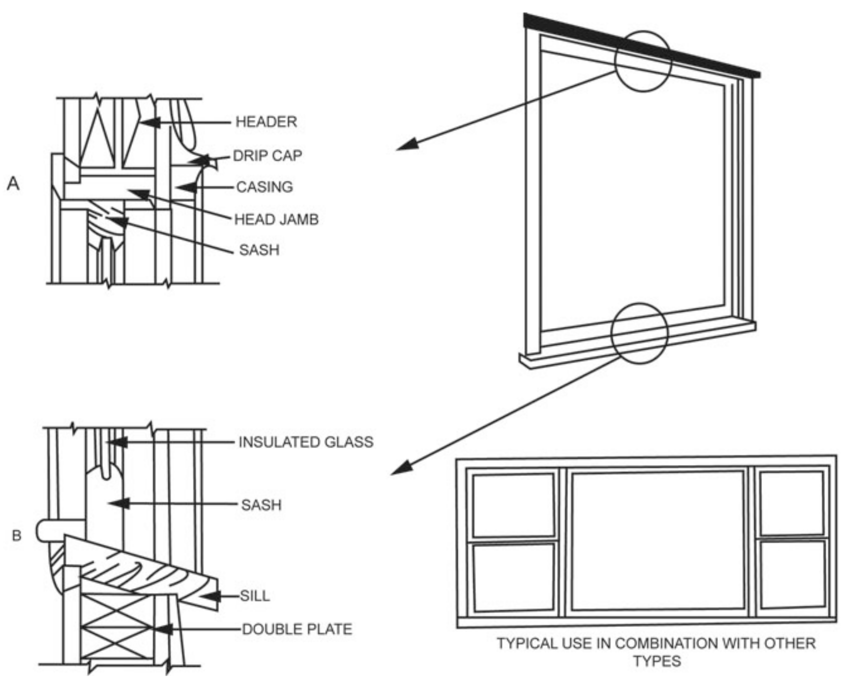


Figure 3–29. Fixed window sash.

Installing wood-framed windows

You use the same methods to install (set) window frames as you do doorframes. If the window frames are wood, consider applying primer to them for rainwater protection before you install them; this makes them weatherproof. If the window frames are commercially made, follow the manufacturer's guide.

Compare the window dimensions with the dimensions of the rough opening. Usually, you need a one-half (½) inch space on each side of the rough opening to allow for plumbing and leveling. Before you install the window, remove all protection blocks and cut off any horns (side jamb extensions above the head jamb and below the sill). If there are any diagonal braces installed on the window, leave them in place. Then complete the installation using the steps in the table below.

Installing Wood-Framed Windows

Step	Action
1	Place a strip of building paper (15-pound asphalt) 10 to 12 inches wide around the rough wall opening to act as a vapor barrier.
2	Set the frame in the center of the rough opening and brace it temporarily to keep it from falling out while you adjust it. Check the head jamb height with a story pole to make sure that all windows are the same height throughout the building.
3	Place wedge-shaped blocks under the sill to adjust the frame's height. You can level off the sill by placing blocks near the outside jambs.
4	Hold the frame in position with nails that you place near the bottom on each side. Check both side jambs with a carpenter's level, then use the level to recheck the whole frame, making sure all sides are plumb and the sill is straight and level.
5	When you're sure the frame is plumb, nail it securely in place against the wall with 8d casing or finish nails spaced 16 inches apart and three-fourths (¾) inch from the outside casing edges.

Installing wood-framed windows with casing

More and more windows are manufactured with the casing already applied. This makes it somewhat easier to install the window frames. If you have this type window, the steps are a little different.

Before you install the window, remove all protection blocks and cut off any horns (side jamb extensions above the head jamb and below the sill). If there are any diagonal braces installed on the window, leave them in place. Then follow the steps in the table below.

Installing Wood-Framed Windows With Casing

Step	Action
1	Place a strip of building paper (15-pound asphalt) 10 to 12 inches wide around the rough wall opening to act as a vapor barrier.
2	Set the frame in the center of the rough opening and brace it temporarily to keep it from falling out while you adjust it. Check the head jamb height with a story pole to make sure that all windows are the same height throughout the building.
3	Place wedge-shaped blocks under the sill to adjust the frame's height. You can level off the sill by placing blocks near the outside jambs.
4	Remove the window and apply caulking to the backside of the casing.
5	Reinstall the window and tack through the lower end of the casing on the high side of the window.

Installing Wood-Framed Windows With Casing	
Step	**Action**
6	Shim and level the low side and tack through the lower end of the casing on that side.
7	Plumb the side jambs and tack the upper ends of the side casing on each side.

You should use galvanized casing nails spaced approximately 16 inches apart. Place the nails about 2 inches from the ends of the casing. This reduces the chance of the casing splitting. When determining the nail length, choose a nail that will penetrate the casing and sheathing plus go into the framing members.

Installing metal-framed windows

There is not much difference between a metal-framed window and the wood-framed window with a casing. In a nutshell, apply caulking under the flanges and set the window unit in place. Ensure the window is plumb/level and screw through the flanges into the wall.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

610. Installing doorframes and doors

1. What three members make up a panel door?

2. When you install a door, the top of the sill must be level with what?

3. Where do you place additional wedges in a jamb that is subject to bowing or needs to be plumbed?

4. What type of nails and spacing must you use to secure a door to the jamb and rough frame?

5. Where do you *level first* when installing a doorjamb?

6. When installing the doorjamb where do you place additional wedges?

7. What are the recommended space allowances between an interior door and doorframe?

611. Installing metal doorframes

1. Name three different ways you can purchase doorframes.

2. Where must you anchor the metal frame in an existing masonry and concrete opening?

3. List three devices used to plumb a doorframe.

4. How much bigger is the rough opening for a metal frame in a wood stud wall?

5. List the four recommended edge clearances for door installation.

612. Locking devices and door accessories

1. Name the four types of locks you install and maintain most often.

2. Which locking device opens the door when any outward pressure is applied to the horizontal bar?

3. What type of closer do you install on lightweight doors such as storm and screen doors?

4. Which direction do you turn the adjustment for faster door speed in the last few inches before the door closes?

5. What do you do when a hydraulic door closer is leaking hydraulic fluid?

613. Window types and installation methods

1. Name the three basic types of windows and explain each.

2. What are the advantages of friction control window balancing devices that manufacturers often use in double-hung windows? Explain how they operate.

3. What type of window may swing either in or out from either side of the jamb? What type of hinges do you use on this type of window? Why?

4. What type of window is often used in warm climates? What are its advantages and disadvantages?

5. In installing preassembled window frames, why do you leave at least one-half (½) inch on each side of the frame between the jamb and the stud of the rough opening?

6. What tool do you use to check the height of all head jambs throughout the building?

3–2. Door and Window Maintenance and Repair

This sections deals with door and window maintenance and repair. Now that you know how to install doors and windows, we'll cover some of the maintenance and repair functions that you may have to perform. No matter how well something is constructed, there will come a time when it needs some tender loving care.

614. Maintaining doors and doorframes

Maintaining doors and doorframes involves correcting many kinds of malfunctions. We'll discuss only the ones you are most likely to have to troubleshoot and correct. Sometimes you will find that you cannot repair some doors and doorframes and must replace them instead.

Determining door swing

When you replace or order components for doors, you must be able to determine the swing (or hand) of the door. The method that we recommend is widely accepted and used by engineers both in and out of the Air Force. The four door swing types are shown in figure 3–30. You always face the outside of the door to determine its swing (or hand). The *outside* is the *street side of an entrance door* or the *corridor side of a room door*.

- A *left-hand* door has the hinges on the left and opens inward (away from you).
- A *right-hand* door has the hinges on the right and opens inward (away from you).
- A *left-hand reverse* door has the hinges on the left and opens outward (towards you).
- A *right-hand reverse* door has the hinges on the right and opens outward (towards you) as you face it from the outside.

On new construction, check the architectural drawings and door schedule to find out which way the doors swing.

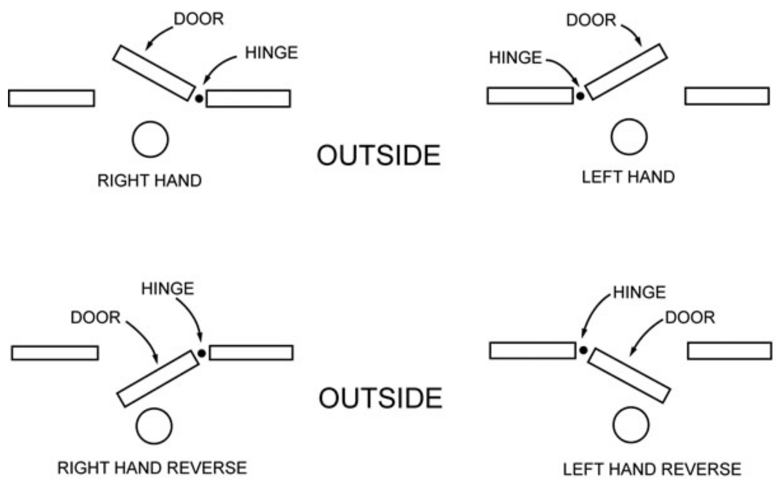


Figure 3–30. Door swing identification guide.

Wood door inspection

Many things can happen to keep doors from operating properly. Wood decay, shrinkage, and exposure to weather or severe temperature changes can cause distortion or failure. Loose door joints or sagging lock stiles can make the door drag or bind. Only frequent and thorough inspections lead you to effective remedies for failing doors. Here are a few points to start with in developing your own checklist for the doors at your base:

- Examine the opening to see that the hinge and the lock side of the jamb are parallel.
- Make sure the header is level.
- Check the jamb's anchorage.
- Check the hinges and other hardware anchorage.
- Make sure the lock faceplates don't project beyond the stile (along the bevel).
- Check all wood members for swelling, shrinking, and warping.
- Check all hardware (hinges, locks, and door closers).

Wood door maintenance

Wood door maintenance starts with a good inspection to determine specific door repairs. If you need to remove a door to repair it, make sure you support it in a woodworker's vise or a shop made support that holds the door on edge.

A popular way to correct minor door maintenance problems is to use shims. These shims can be made from thin cardboard or metal; cut them to fit evenly underneath a hinge leaf. By using them, you change the gap (space) between the door and the doorframe, which often corrects many of the following door maintenance problems:

- Door latching.
- Frame shifting.
- Door shrinkage.
- Door binding.

A door that doesn't latch can have different causes. For example, if a doorframe shifts (usually the result of foundation settling) the doorframe may spread apart, widening it enough to keep the bolt from reaching the striker plate and latching. You repair it by placing shims under two or more hinge leaves to shift the door toward the lock. If the spreading is severe, you may need to replumb the doorframe or install a wood strip on the lock stile (fig. 3–31). Of course, you'll have to cut a hole in the strip and reset the striker plate. An alternative way to get the same effect is to remove the hinges and attach a full-length wood strip to the door.

When a door shrinks, it can have the same problem of not latching. To correct this problem, add as many shims as needed to allow the door to latch properly. Another latch problem is caused by door sag. The lock stile usually sags lower than the hinge stile. You can usually see this when the door is closed. Look for a wide gap at the bottom and a narrow gap at the top on the latch stile. You can restore the door to level by first checking to see if the screws in the top hinge are tight. Next, check the frame for plumb. If it is plumb, you can install a shim under the bottom hinge leaf. If the problem is too severe, replumb the frame.

Perhaps the most annoying latch problem is a door that rattles when closed. This problem is usually caused by too much space between the door and the doorstop. The easiest repair is to move the striker plate toward the stop. An alternate method for a removable doorstop is to move it toward the latch.

Binding is a common door problem. Sometimes it is due to improper hinge installation. For example, cutting the mortise too deep into the door for the hinge leaf can cause the hinge to bind along the hinge stile. The binding can cause the screws to work loose, which can result in a door that won't close. To correct this problem, install cardboard shims behind the hinge leaf on the door side.

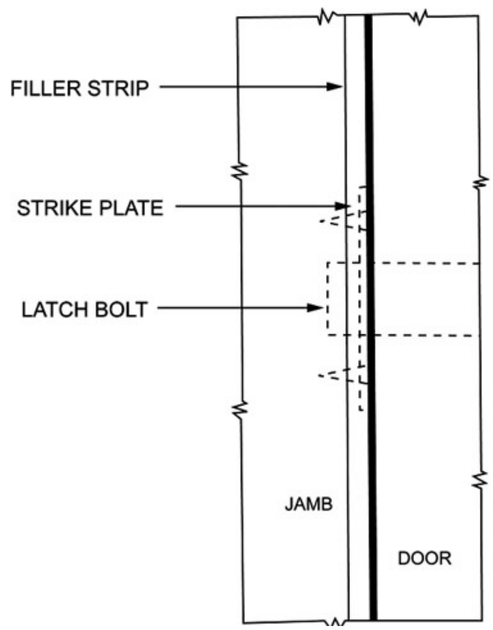


Figure 3–31. Doorjamb section with a filler strip.

Another binding problem is when a door seems to be too big for its frame. Many times this happens just after a rainstorm. What happens is the wood door absorbs the humid air and swells up. If possible, wait until after the door returns to its normal size and then apply a sealer coat, such as polyurethane or primer/sealer and paint to prevent this from happening again.

NOTE: For safety or security reasons, you can trim the door to fit. Just remember that after the door shrinks back to normal, it may fit too loosely and need further adjustments.

A binding problem that happens to doors with only two hinges is the door bulging inward or outward between the two hinges. This condition makes it impossible to close the door without applying pressure against the bulging part. You can eliminate the bulging by placing another hinge midway between the first two. If you can't get another hinge, make temporary repairs by shifting the hinges outward on the doorjamb (fig. 3–32).

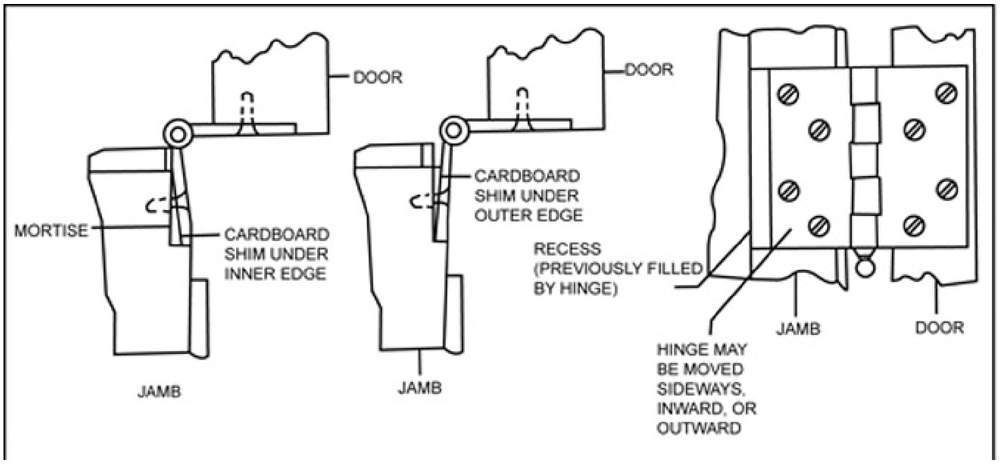


Figure 3–32. Shifting the hinges on the doorjamb.

You usually replace broken wooden panels in panel doors with wood that matches the existing door, but you may want to modify some panel doors by removing a panel and installing louvers, screen, or glass. You can use a wood chisel to remove the wood molding from around the panel. After you remove the molding, the panel should fall out. Use the old panel as a template or measure the panel opening and deduct one-eighth ($^1/_8$) inch from its width and length. Use this measurement to cut your replacement panel. Your replacement panel should match the remaining panels. Now you are ready to place the panel in position and install the molding. Often, you must replace the original molding; plan for this before you start the repair, if possible. Don't glue or nail the panel to the door or the molding because that can split the door or the panel during shrinkage and expansion cycles. Nail the molding to the door; the panel can still expand and contract but not fall out. If you're installing glass, use glazier points and putty or molding. In either case, use a bed of putty to keep water from getting in the rabbet behind the glass.

Doors

Repairing and replacing doors may seem to be a never-ending maintenance requirement. Whenever a door is broken or decayed beyond reasonable repair, you must install a new one. The replacement process is much like an original installation. Removal of the old door is a simple process of removing screws or bolts and any hinges or locks that may be reusable. Examine the door for style and type of material and measure it for size so that you can build or order the same kind of door (or suitable substitute).

Some doors are repairable. For example, batten doors may require board replacements. Often you can do this at the site, but don't try to repair flush doors or panel doors without a properly equipped woodworking shop. Your first consideration in repairing a warped door is to remove it and lay it on a flat surface. You may have to weigh it down. If it's still warped after a reasonable length of time, screw battens (strips) to the door to help restore it to a true plane. You can also use screw eyes, rods, and turnbuckles to help straighten a door by gradually pulling it into place. Install a diagonal batten from the top of the hinge side to the bottom of the lock stile to permanently repair a sagging door. Make a temporary repair by installing a diagonal wire stay brace with turnbuckles. Many outside doors have glass panels. Replace broken panels the same way you repair broken windows.

Doorframes

Repairs for doorframes deal with repairing or replacing doorjambs that are damaged or decayed. Sometimes the door's weight splits the jamb where the hinges are fastened. The jamb also splits in the area around locks and latches. If the splits aren't too severe and the jamb material isn't badly splintered, you can use the procedures in the following table to repair the damage using wood screws or dowel pins.

Repairing Damaged Doorframes	
Step	**Action**
1	Remove the door casing and door hardware from the damaged jamb.
2	Apply wood glue to the split stock using a small brush.
3	Clamp the split back together with wood clamps.
4	Install screws or dowel pins to strengthen the repair area (fig. 3–33).
5	After you install the screws or dowels, remove the wood clamps.
6	Reinstall the door casing, door, and hardware during the same workday, but try to avoid using the door until the glue has enough time to set. You can repair a split doorjamb on the lock side in the same way.

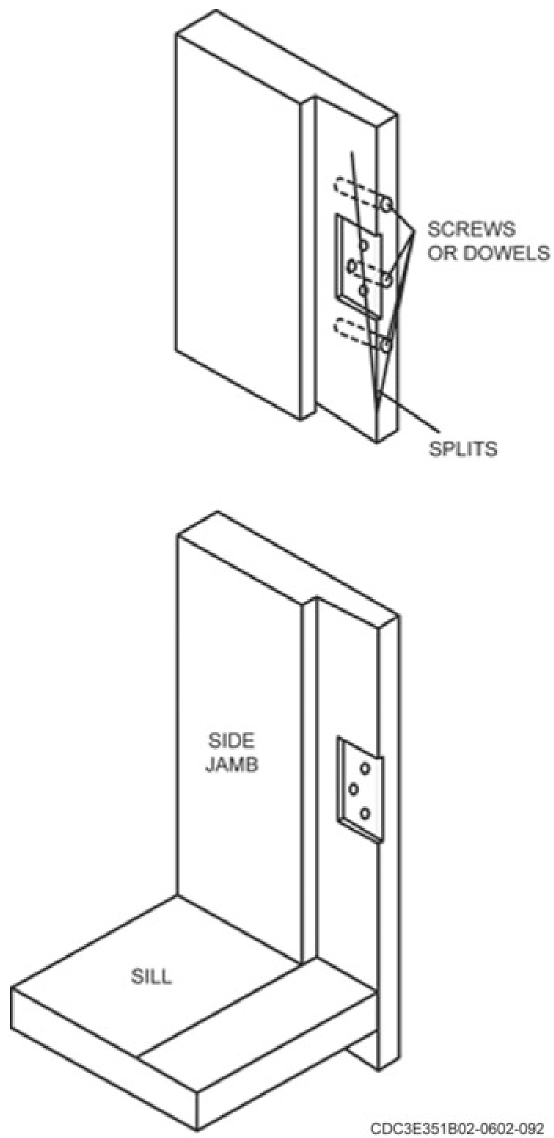


Figure 3–33. Repairing a split doorjamb.

If the split is too severe for economical repair, you must replace the jamb. Measure carefully to be sure that the door will fit the repaired frame. Remember on exterior doors, rabbet the jamb to the thickness of the door for a flush fit. You can fit the frame by using blocks and shims between the jamb and frame.

Sometimes you can make a door seal better at the edges by weather-stripping it during installation, but more often we do this to improve the weatherproofing qualities of older doors. Normally you use weather-stripping made from metal, felt, or rubber (or rubber-like plastic). Install metal weather-stripping on the side of the doorjamb rabbet to form a seal with the edge of the closed door. Fasten the soft, spongy, felt or rubber material to the doorjamb or casing so that the door face closes against it to form an airtight seal.

Metal door maintenance and repair

Metal doors usually require very little maintenance. Most problems involve the door hinges, which in turn affect the door fit. Typically we use machine screws and reinforcement plates on both the door and casing to secure hinges. Over a period of time, these screws may work loose or the spot welds securing the reinforcement plate to the door or casing may break. You may find that the screws have stripped or pulled loose; you will then have to cut new threads into the plate with a tap. A broken door closer may also allow the door to be opened violently by the wind, which can break these plates or screws. A door that is *not* hung properly can cause the hinge to bind and produce enough pressure to damage the plates or screws. A hinge-bound door is hard to close and may spring open. Occasionally the hinge reinforcement is *not* mounted flush with the inside of the jamb or becomes twisted; this causes excess pressure on hinge components.

Before you make any repairs to the door, first determine what caused the damage. It won't help to replace a hinge only to ruin the new one because the hinge plate is twisted. Usually, you can find the problem by visually checking door alignment and operation.

- Check the gap between the door and its casing. If the door fits tighter at one end than it does at the other, perhaps a hinge is bent or sprung.
- If a door tends to spring open, check the hinges for binding or the mounting plates for misalignment or damage.
- If a hinge plate is twisted in its mount, you may be able to straighten it with a simple shop-made tool (fig. 3–34). By fastening the hinge part of the tool to the reinforcement plate with the correct size screw, you can pry it in the direction needed to straighten it.

If the spot welds holding the hinge plate in position are broken, you must reweld them. We recommend that you drill holes through the hinge stile and the hinge reinforcement plate (fig. 3–35). To hold the hinge plate in position, you can use a shop made hinge alignment tool like the one shown in figure 3–34. After you drill the holes, ensure you spot-weld through them. To complete the repair, you grind the welds flush with the hinge stile to allow the door to close without binding.

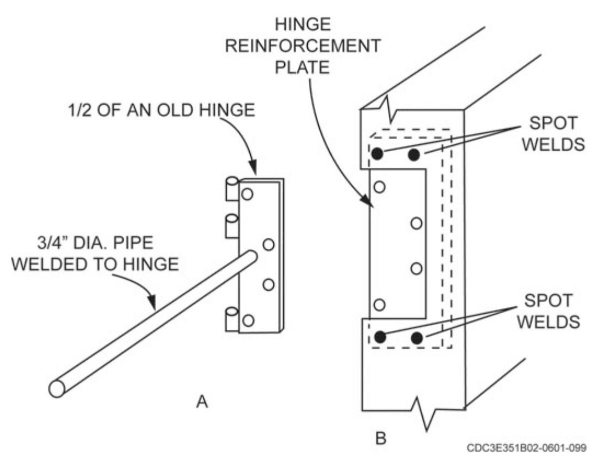


Figure 3–34. Hinge alignment tool.

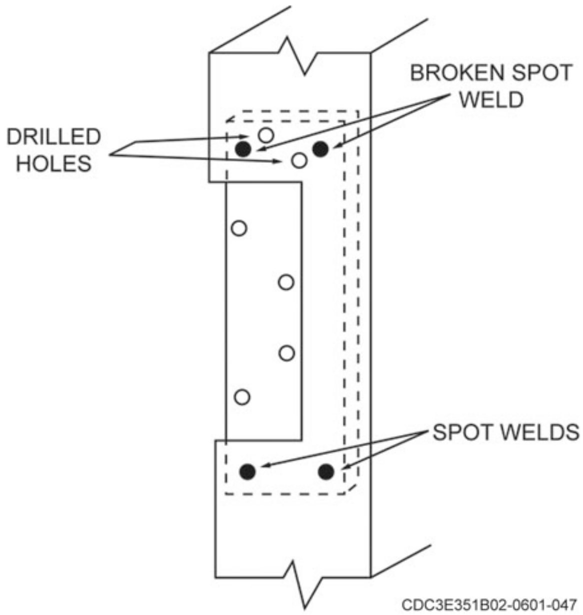


Figure 3–35. Hinge reinforcement plate.

Not all metal doors are of the swinging type. You'll find some doors that slide back and forth on rollers. Normally these doors are at facilities like the hospital or commissary. The maintenance that may be required on these doors is adjusting the rollers to keep the door at the proper height and adjusting the operator. Always follow the manufacturer's instructions in adjusting sliding metal doors.

Normally metal doors don't require much lubrication but if the hinges are corroded, some light lubrication can improve their operation. You could apply a light coat of machine oil to the hinge and hinge pin and remove any excess oil, or you could apply a synthetic spray. The idea is to provide lubrication without attracting dust and dirt.

615. Maintaining windows

If your assignment as a structural journeyman is typical, it's likely that you will spend more time maintaining and repairing windows than installing them. The maintenance and repair knowledge that you gain from this lesson may be very helpful.

Window unit maintenance

The time that you spend on window unit maintenance is usually for adjusting hardware or loosening the sash in the jamb. For example, casement windows may need to have their hinges or barrel bolts lubricated. The jambs, casings, headers, and drip caps of these windows can have the same defects that are found on doors; but double-hung windows may have some quite different problems.

To start with, the double-hung window top and bottom sashes slide up and down between the stops in the jamb. Sometimes you have to loosen the sash from the stops by inserting a putty knife between them before they can function properly. You can use a hammer and block (gently) to loosen the paint if there's not enough room to insert the putty knife. If the sash is old, take extra care to keep from breaking the glass.

Other differences between window units and door units concern the sill, stool, and apron. A window unit has these parts; a door unit does not. When you need to replace a windowsill, you must remove the window as a unit. This action allows you easy access to remove the sill from the side jambs and then to install a new sill. One method of removing a wooden widow as a unit from the outside includes the steps in the table below.

Removing a Wooden Window from the Outside	
Step	**Action**
1	Remove the apron, stool, and inside casing.
2	Check around the rough opening for nails that are holding the jamb and sill in place.
3	Drive through or cut off all nails that are nailed between the rough opening and the jamb/sill.
4	Pry the outside edge of the outside casing loose. This allows the window to be removed as a unit.

Once you pry the outside casing loose, the jamb should be free to fall out of the opening. Sometimes you may find a wooden window unit that did not have any nails driven into the jamb/sill to hold the wedges in place. This method was sometimes used to leave the jamb as free and straight as possible without wedging and nailing; unfortunately, this method could eventually spread the jamb apart at the top and bottom.

After removing the window unit, you can easily replace the sill with a new one. You are now ready to reinstall the window unit. After you place the unit back into the rough opening, you must place wooden wedges around the two side jambs and sill to hold the window plumb and level. We recommend that you use 8d finish nails to secure the wedges in place. Next, reinstall the apron, stool, and the inside and outside casing to complete the job.

Common maintenance requirements

Regardless of the size, location, or the material that we use to construct windows, they all have problems. Let’s begin by discussing some common maintenance requirements.

Common Windows Maintenance	
Problem	**Solution**
Binding sash along stops	If the sash binds along the stops, wax the binding surfaces. If this doesn’t stop the binding on a wood window frame, remove the stop and plane a small amount from the side of contact. (Sanding or scraping may be easier if the binding is not great).
Binding due to swollen sash	If the swelling is from moisture and the sash works right when it’s dry, leave it alone. Don’t plane the sash unless it’s necessary. If the sash is too large to slide properly under normal circumstances, remove it (by removing the stops) and plane it as required. Sometimes applying a coat of paint or sealer after the sash dries can prevent it from swelling again.
Bowing stops	Remove the stop, cut off the end to the proper length, and reinstall.
Malfunctioning springs	Check the attachment of the window balancing control springs or friction devices. These may require reinstallation or replacement. Follow the manufacturer’s instructions for adjusting holders, springs, or other parts. You may need to use a special tool or device that comes with certain windows to make adjustments.
Sticking windows	Some windows are installed in wood jambs with aluminum jamb liners. If the damage is excessive, you may have to replace the complete liner. If the window is sticking because of humid or wet weather conditions, apply a light coat of silicone lubricant directly to the metal liner. *Never try to repair this kind of sticking window by driving nails or screws*

Common Windows Maintenance	
Problem	**Solution**
	through the liners.

Cut and replace glass

Removing or cutting glass for windows and doors is not a difficult job. Doing the job right the first time requires attention to detail and skill. The first thing to remember is to use care in removing the broken glass. Make sure you wear a longed sleeved shirt, leatherwork gloves, and eye protection as safety precautions. Don't take chances!

You can remove a shattered windowpane easily by pulling out one piece at a time. If the glass is only cracked, remove all or most of the putty to pull the pieces of glass out. On many doors, the glass is held in place with thin wood strips, which are attached with small brad nails.

Use a wood chisel or putty knife to remove the putty around the broken glass. Use extreme caution to protect your hands and arms from cuts. Remove all the glazier's points as you remove the putty. Glazier's points are the small metal triangles driven into the frame underneath the putty that hold the glass in place. After you thoroughly clean the area, apply a coat of linseed oil to the wood frame before you apply the putty. This will make the new putty remain pliable and last longer.

Now you're ready to cut the glass to fit the window or door pane. Cut your piece of glass one-eighth ($^1/_8$) inch smaller than the length and width of the window area it is to fill. Use a sharp, lubricated glasscutter and a straightedge. Some structural shops have a specialized tool for holding the glass while glass cutting. If your shop doesn't have one, another way to cut glass is described in the following table.

Method to Cut Glass	
Step	**Action**
1	Start with a sharp, well-lubricated glasscutter and a straightedge.
2	Wear the proper safety equipment to protect yourself from glass fragments.
3	Place the glass on a level surface that can support the glass without scratching or breaking it. **NOTE:** A workbench with a felt or carpet-covered surface works well.
4	Hold the straightedge on the glass firmly enough for it to serve as a guide for the glasscutter but not so firmly that it can break the glass.
5	Score one single line on the glass from end to end. **NOTE:** Additional scoring over the same line usually makes an uneven cut when you snap the glass. It also dulls the glasscutter.
6	Use the glasscutter handle tip (opposite from the cutterhead) to tap lightly on the opposite side of the glass from where you scored it. This action helps the glass break on the line when you snap it.
7	Snap the glass on the line.

You're now ready to place the glass in the window or door pane. Place the glazier's points about every 4 inches and reputty (glaze) the frame. Finish the putty (glazing compound) off with a putty knife or scraper/glazier using long, even strokes.

Cut acrylic sheets

If you replace the piece of glass with an acrylic sheet, remember to cut it one-eighth ($^1/_8$) inch smaller than the length and width of the window frame it is to fill. You can cut the acrylic sheet on the radial arm saw or table saw, but pay special attention to the cut area because the acrylic sheet can melt into the sawdust or burn you. When you cut an acrylic sheet, remember to select the proper blade and watch for kickback while cutting. The teeth should be fine, equal height and evenly spaced. They should also have little or no set. It's best to use hollow ground high-speed blades with no set with at least five teeth per inch.

For the smoothest cuts, use carbide tipped blades with a triple chip tooth. For the best results, keep the manufacturer's paper on the acrylic sheet until you complete all cutting. You can then remove the paper and install it the same as you do glass.

Cutting Acrylic Sheets	
Method	**Description**
Cutting with a knife	You can cut acrylic sheets up to $^3/_{16}$" thick in a method similar to that used to cut glass. Score the sheet 7–8 times with a utility knife ran along a straight edge. Ensure the straightedge is held firmly in place. Clamp the sheet or hold it rigidly under a straight edge with the scribe mark hanging just over the edge of a table. Apply a sharp downward pressure to break the sheet along the scribe line. Scrape the edges to smooth any sharp corners. *Do not use this method for long breaks or thick material.*
Cutting with a power saw	To reduce chipping, set the saw blade height approximately one-eighth ($^1/_8$) inch above the acrylic sheet thickness. You should lubricate the blade with soap or beeswax to minimize gumming from the masking adhesive. Start the saw and ensure it is running at full speed before you start to feed the material into the blade. Feed the sheets slowly.

Replace screen fabric

You occasionally have to replace screen mesh on exterior doors and windows due to damage or deterioration. The two types that most Air Force bases use are fiberglass and aluminum. The fiberglass screen mesh is easier to install, installs tighter, and is just as durable but less expensive than aluminum.

You can follow the suggested steps in the table below when replacing screen fabric.

Replacing Screen Fabric	
Step	**Action**
1	Cut the screen larger than the opening—approximately 2 inches on all sides.
2	Roll the screen into the base strip with the spline and a screening tool. Start rolling at the top horizontal, then roll down the sides and finish with the bottom. **NOTE:** A screening tool with a plastic wheel works the best. Make sure you tightly stretch the screen.

Replacing Screen Fabric	
Step	**Action**
3	Carefully trim all excess screen fabric away with a razor knife.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

614. Maintaining doors and doorframes

1. Where must you stand to determine door swing?

2. Which door swing has the hinges on the right and opens inward (away from you) as you face it from the outside?

3. Match the solutions in column B with the maintenance problem in column A. The solutions in column B may be used once or not at all.

Column A

____ (1) Door can't latch due to an excessive space between the door and the latch site.

____ (2) Hinge stile on the door has warped inward to the extent that the center is binding slightly against the center of the doorstop.

____ (3) Hinge binds along the stile and causes the screws to come loose. An inspection shows that the hinge leaf is cut too deep on the door.

____ (4) Door sticks only during humid conditions, usually after a rain.

____ (5) Door has sagged on the latch side. Inspection shows that the gap between the door and the lock stile is wide at the lower end and narrow at the top.

____ (6) Door rattles when closed because of excessive space between the door and doorstop.

____ (7) Door will not latch. Investigation reveals that the higes are rightly in place, but the door latch is three-eighths ($^3/_8$) inch below the striker plate hole.

____ (8) Door will not latch. Inspection reveals that the hinges are tightly in place, but the door latch is approximately $^1/_{32}$ inch above the strker plate hole.

Column B

a. Place an additional hinge midway between the other two hinges.
b. Trim the door to fit.
c. Wait until the door shrinks and apply a sealer coat.
d. Install a narrower door.
e. Install a wider door.
f. File the striker plate to fit.
g. Move the striker plate toward the doorstop.
h. Move the strker plate away from the doorstop.
i. Raise the striker plate.
j. Lower the striker plate.
k. Place cardboard shims behind the lower hinge learf on the jamb side.
l. Place cardboard shims under the hinge leaf on the door side.
m. Place cardboard shims under all hinges.
n. Place cardboard shims under either or both hings leaves of the lower hinge.

4. When ordering a new door, what information do you need to determine?

5. How may you *temporarily* repair a sagging panel door?

6. Where do splits in a doorjamb often occur, and how can you repair the small splits?

7. What condition indicates that a door is hinge-bound?

8. What is the recommended way to repair broken spot welds?

615. Maintaining windows

1. What must you do to replace a windowsill? Why?

2. In removing windows, why do you often find that once you remove the inside casing, the window is free to fall? What is the positive and negative result?

3. How can you repair a double-hung window when the sash is too large to slide properly under normal circumstances?

4. How do you protect yourself when removing broken glass from a window frame?

5. How much smaller than the opening do you cut a piece of glass for a windowpane?

6. What two screen mesh materials do you use for window screen replacement?

Answers to Self-Test Questions

610

1. (1) Stiles (vertical members).
   (2) Rails (cross members).
   (3) Panels
2. The finished floor.
3. Behind the hinges, latch location, and any other location where the jamb is subject to bowing or needs to be plumbed.
4. At each wedge location, drive two 16d casing nails through the jamb, wedges, and into the rough frame. Space these nails three-fourths (¾) inch in from the outer edge of the casing.
5. The head jamb.
6. Hinges, midway between the two hinges, latch location, and midway between the latch and the head jamb.
7. (1) Hinge stile, one-sixteenth ($^1/_{16}$) inch.
   (2) Top rail, one-eighth ($^1/_8$) inch.
   (3) Lock stile, one-eighth ($^1/_8$) inch.
   (4) Bottom rail, one-half (½) inch.

611

1. (1) KD.
   (2) Preassembled with just the exterior casing or brick molding applied.
   (3) Preassembled with the door hung in the opening.
2. Be sure to place one anchor near the top and bottom of each jamb.
3. (1) A level.
   (2) Square.
   (3) Spreader.
4. The opening's width is usually the overall frame's width plus one-half (½) inch and the height is usually the frame height plus one-fourth (¼) inch.
5. (1) Between door and frame at head and jamb ⅛ inch $\pm$ $^{1}/_{16}$ inch.
   (2) Between edges of pairs of doors ⅛ inch $\pm$ $^{1}/_{16}$ inch.
   (3) Where a threshold is used one-eighth ($^{1}/_{8}$) inch maximum from bottom of door to top of threshold.
   (4) Where no threshold is used three-fourth (¾) inch maximum from bottom of door to the finish floor.

612

1. (1) Cylinder.
   (2) Mortise.
   (3) Cipher.
   (4) Panic hardware.
2. Panic hardware.
3. Pneumatic door closers.
4. Adjust the latch speed (L), clockwise for faster.
5. Replace the unit.

613

1. (1) *Sliding* – May slide vertically (double-hung) or horizontally.
   (2) *Hinged* – Open in or out and include casement, awning, and jalousie.
   (3) *Stationary* – Don't open and are usually combined with another type.
2. They can be used where wall space is limited. They are friction control window balancing devices that fit into a grooved slot made into the sash edge and two are needed (one for each sash edge along the jamb). A clip or some other method holds the device in position and allows the spring to operate properly. It is the spring tension that holds the sash at the desired height.
3. (1) Casement.
   (2) Mortise.
   Because the sash must fit the frame closely.
4. Jalousie; they permit maximum ventilation but aren't energy efficient.
5. To allow room to plumb and level the frame.
6. A story pole.

614

1. On the outside facing the door.
2. Right-hand door.
3. (1) m.
   (2) a.
   (3) l.
   (4) c.
   (5) n.
   (6) g.

(7) i.

(8) f.

4. (1) Door's style.

   (2) Type.

   (3) Materials.

   (4) Size.

5. By installing diagonal wires with turnbuckles.
6. At the hinges and around locks and latches; remove the casing from the damaged jamb's side, apply glue to the split area, draw the split together with clamps, and secure with dowels or screws.
7. It is hard to close and often springs back open when closed.
8. Drill through the casing and plug weld the hinge plate in place.

615

1. Remove the window as a unit by removing the apron, stool, and inside casing; so that you can remove the window unit from the outside.
2. Because no nails were driven into the jamb. It leaves the jamb free and straight without wedging and nailing but it could spread the jamb apart at the top and bottom.
3. Wax the binding surfaces. If this does not stop the binding on a wood window frame, remove the stop and plane a small amount from the side of contact.
4. By being careful and by wearing a long sleeve shirt, leather work gloves, and eye protection.
5. Cut your piece of glass one-eighth ($^1/_8$) inch smaller than the length and width of the window area it is to fill.
6. Fiberglass and aluminum.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

30. (610) Which door is usually built from sheathing boards?
    a. Solid.
    b. Panel.
    c. Flush.
    d. Batten.

31. (610) Which door is economical, lightweight, and can be made to resemble more massive and expensive doors?
    a. Solid.
    b. Panel.
    c. Flush.
    d. Sliding.

32. (610) Which door has a *solid or hollow* core?
    a. Flush.
    b. Panel.
    c. Batten.
    d. Louver.

33. (610) Where do you start to level an *exterior doorframe*?
    a. At the sill.
    b. At the head jamb.
    c. On the trim casing.
    d. On the hinge jamb.

34. (610) Where do you place additional wedges in a jamb that is subject to bowing or needs to be plumbed?
    a. Below the hinges, and above the latch location.
    b. Above the hinges, and below the latch location.
    c. Below and above the hinges and latch location.
    d. Behind the hinges, and latch location.

35. (610) Where do you start to level an *interior doorframe*?
    a. At the sill.
    b. At the head jamb.
    c. On the trim casing.
    d. On the hinge jamb.

36. (610) You install the door lock on the *stile* with the
    a. most grain.
    b. least grain.
    c. straightest grain.
    d. fewest grain defects.

37. (610) The recommended space allowances between an interior door and doorframe are hinge stile, one-sixteenth ($^1/_{16}$) inch;
    a. top rail, one-sixteenth ($^1/_{16}$) inch; lock stile, one-half (½) inch; bottom rail, one-eighth ($^1/_8$) inch.
    b. top rail, one-sixteenth ($^1/_{16}$) inch; lock stile, , one-eighth ($^1/_8$) inch; bottom rail, one-eighth ($^1/_8$) inch.
    c. top rail, one-eighth ($^1/_8$) inch; lock stile, one-eighth ($^1/_8$) inch; bottom rail, one-half (½) inch.
    d. top rail one-eighth ($^1/_8$) inch; lock stile, one-eighth ($^1/_8$) inch; bottom rail one-half (½) inch.

38. (611) What three different ways can you purchase doorframes?
    a. Knocked down (KD), preassembled with just exterior casing, and preassembled with door hung.
    b. KD with exterior casing, preassembled with just interior casing, preassembled with door hung.
    c. KD with interior casing, preassembled with no casing, preassembled with door hung.
    d. KD with door hung, preassembled with no casing, preassembled with door hung.

39. (611) What three devices do you use to *plumb a doorframe*?
    a. Level, square, and spreader.
    b. Level, square, and plumb bob.
    c. Square, plumb bob, and spreader.
    d. Level, plumb bob, and spreader.

40. (612) The four types of locks you will install and maintain most often are cylinder,
    a. mortise, cipher, and panic hardware.
    b. tubular, cipher, and panic hardware.
    c. mortise, tubular, and panic hardware.
    d. tubular, pad, and panic hardware.

41. (612) Which lock is installed in a pocket or mortised hole?
    a. Cipher.
    b. Mortise.
    c. Cylinder.
    d. Panic hardware.

42. (612) What type closer do you install on lightweight doors such as storm and screen doors?
    a. Pneumatic.
    b. Hydraulic.
    c. Spring.
    d. Strut.

43. (612) The three operating adjustments you can make on a hydraulic door closer are closing,
    a. locking, and opening.
    b. latching, and opening.
    c. latchng, and backcheck.
    d. locking, and backcheck.

44. (613) Which window opens outward and is hinged at the top of the frame?
    a. Hopper.
    b. Awning.
    c. Jalousie.
    d. Casement.

45. (613) When installing a window what type and size of paper do you place around the rough wall opening to act as a vapor barrier?
    a. (15-pound asphalt) 6 to 8 inches wide.
    b. (30-pound asphalt) 6 to 8 inches wide.
    c. (15-pound asphalt) 10 to 12 inches wide.
    d. (30-pound asphalt) 10 to 12 inches wide.

46. (614) You can eliminate the bulging on a two-hinge door by placing
    a. two hinges midway between the first two.
    b. another hinge midway between the first two.
    c. another hinge midway between the top hinge and the top of the door.
    d. another hinge midway between the bottom hinge and the bottom of the door.

47. (614) How can you make a *permanent* repair to a sagging door?
    a. Weight it down overnight.
    b. Remove the door and lay it flat.
    c. Install a batten strip diagonally on the door face.
    d. Install a diagonal wire stay brace with turnbuckles.

48. (614) Where do splits in a doorjamb often occur?
    a. At the hinges, around locks, and latches.
    b. Below the hinges, below locks, and below latches.
    c. Above the hinges, above locks, and above latches.
    d. Above the hinges, below locks, and above latches.

49. (614) A door is *hinge-bound* when it is hard to
    a. open and may not latch when closed.
    b. close and may not latch when closed.
    c. open and may spring open when closed.
    d. close and may spring open when closed.

50. (615) When you are repairing a sticking double-hung window with an aluminum jamb liner, you should *never*
    a. replace the liner.
    b. wax the binding surface.
    c. apply a light coat of silicone lubricant.
    d. drive nails or screws through the liner.

51. (615) How many times should a line on a piece of glass be scored with a glasscutter?
    a. One time.
    b. Two times.
    c. At least three times.
    d. As many times as needed.

52. (615) To reduce chipping, you set the saw blade height how far above the acrylic sheet thickness approximately
    a. one-fourth (¼) inch.
    b. one-eighth ($^1/_8$) inch.
    c. one-sixteenth ($^1/_{16}$) inch.
    d. three-sixteenths ($^3/_{16}$) inch.

Please read the unit menu for unit 4 and continue ➔

Unit 4. Energy Conserving Materials

MOST BUILDING materials have some insulating value; however, we usually need to add insulating materials or other products to increase the resistance to temperature changes. As a structural journeyman, you need to know what types of energy conserving materials work best for different areas of the world and how to install them correctly. This unit covers the most common types of materials we use. We start our discussion with thermal insulation and then discuss caulking and weather-stripping materials.

616. Installing thermal insulation

We add thermal insulation to a facility to conserve energy by controlling heat flow. In the winter, insulation keeps the heat in. In the summer, insulation keeps the heat out. In this lesson, we cover the different types of insulation and their installation methods.

General information

The basic concept of how insulation works focuses around air. If air is confined to a small space and kept from moving, it is an efficient insulator. As the spaces become smaller and in number, the insulating ability is more effective.

R-value

You will hear the term R-value at some point in your career. R-value is a number used that measures the insulation's resistance to the flow of heat. A higher number means that the material is more efficient in retarding the passage of heat. Your local climate will determine what R-value is required.

Insulation requirements

Insulation requirements vary according to the average low temperature of the area; the warmer the area, the less insulation required. You install insulation in the ceilings, walls, and floors where basements or crawl spaces are used.

Insulation types

There are various materials we use to provide thermal insulation. Three basic types are flexible (fig. 4–1, A), loose fill (fig. 4–1, B), and rigid (fig. 4–1, C).

Types of Insulation	
Type	**Description**
Flexible	Flexible insulation is available in blanket rolls or batt form. • The *blanket form* comes in a long roll that you cut to length. • The *batt form* comes cut to specific lengths for certain applications. Both forms range from three-fourths (¾) to 12 inches thick and in standard widths to fit between joists and studs. The material manufacturers use to make them are fibers from minerals, vegetables, rock, slag, glass, wood, or cotton. (A popular type used at many Air Force bases is fiberglass.) These blankets or rolls usually have one side that has a paper cover with staple tabs attached along the entire length on each side. Some covers have a bitumen vapor barrier coating added between the insulation and the paper cover. Other types have a reflective coating (usually aluminum foil) added to the paper's outside surface. Selecting the proper insulation thickness is important for efficiency. For example, suppose you need to insulate a stud wall made from 2 × 6s. As you know, this means the depth is

Types of Insulation	
Type	**Description**
	actually 5 ½ inches. For efficiency, select a size that is close to this depth without compressing the insulation. (If insulation is compressed, it reduces the enclosed air spaces within the insulation that lowers insulating quality). You could use 3½ inch thick insulation, but 5½ inches thick is better because it fills the space completely without being compressed. Any thickness greater than 5½ inches is *not* recommended because the insulation would be compressed. Another consideration is to allow a 1½ inch airspace between the insulation and the roof deck for air circulation and to prevent moisture build-up between the rafters.
Loose fill	Manufacturers package loose fill insulation in bags or bales. It is made from fibers of rock, glass, slag, wool, shredded redwood bark, cork, ground wood pulp, vermiculite, perlite, gypsum, sawdust, and wood shavings.
Rigid	Rigid insulation is made into sheets that are usually 2 or 4 feet wide and 8t feet long or longer with a common thickness of ½ to 1 inch. The sheets are made of pulp from wood, cane, or other materials to make them lightweight or low density with good strength and insulating properties.

NOTE: Foamed plastic type (polystyrene and polyurethane) is very good for masonry work because it is waterproof. We use these insulated sheets as roof and wall sheathing, as a surface cover for walls and ceilings, as a base for plaster and stucco, or as insulation strips for foundation walls and slab floors.

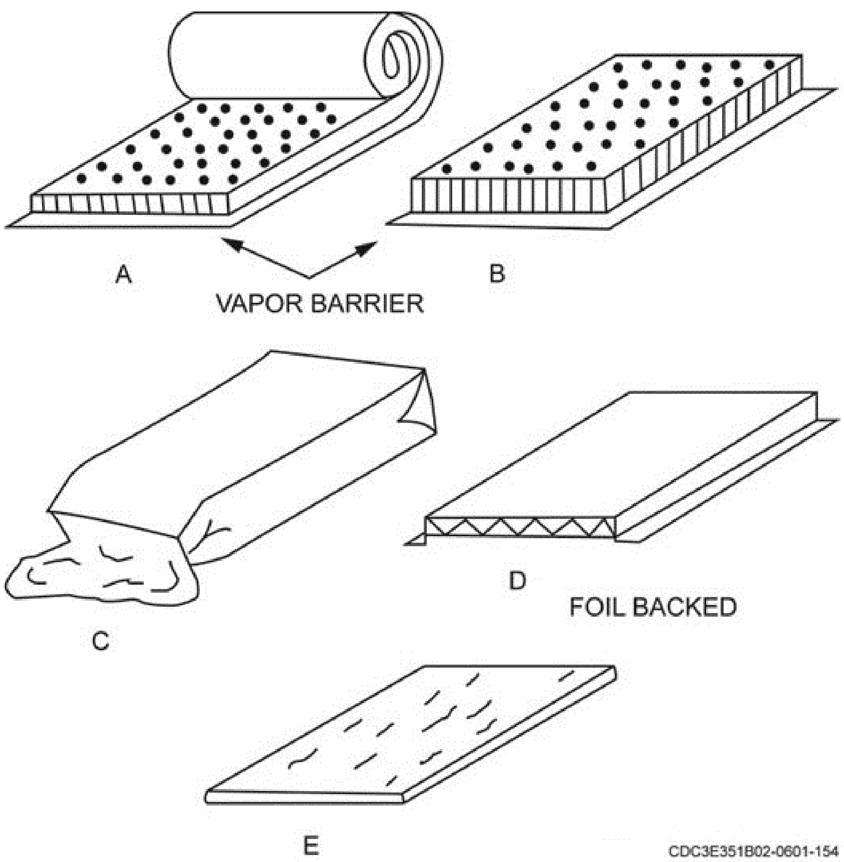


Figure 4–1. Types of insulation.

Installation methods

Installing insulating materials is relatively simple. We will discuss the basic installation procedures for the types of insulation in (fig. 4–2).

Installing flexible insulation

For installing most insulation you will need some common tools including a tape measure, straight edge, utility knife, and a stapler. You can use a utility knife to cut the blankets or batts to size. When you cut the insulation to size, you should add enough material to make stapling flanges at the top and bottom. One method is to measure the needed length and mark a line on the floor. Unroll the insulation on the floor, place a straightedge on the line, compress the insulation, and then cut it with the utility knife.

Installing Flexible Insulation	
Location	**Procedure**
Walls	Once the insulation is cut to size, start installing it in the walls. Place it between the studs and staple the flanges to the sides or to the studs' inside edges and to the top and bottom plates. Fill in small spaces around doors and windows with a can of non-expanding spray-foam and fill the rest of the space up with flexible insulation after the foam cures. Be careful to not compress or squeeze the insulation—this reduces its insulating ability. If the insulation does not have a vapor retarder or stapling tabs (flanges), it is designed to be friction-fitted. If so, simply place the insulation between the framing members.
Ceilings	As mentioned above, you can install insulation in the ceiling joist using staple flanges or friction fitting. Unfaced insulation is usually recommended for ceiling application. When installing the insulation in between the ceiling joists, be sure to extend it over the top plates, but *not* into the eaves. The eaves are usually vented to allow air to come into the attic.
Floors	Two of the most common ways you can install insulation between floor joists are: • Staple wire mesh to the edges of the floor joists. • Use heavy-gauge wire that is placed (wedged) between two joists to support the insulation.

Installing loose-fill insulation

This insulation is usually placed into a machine that blows the material into place. For small projects, it can be poured in place manually. It is usually used in attics between ceiling joists. You may have to level the surface of the insulation to ensure it is at the required depth.

NOTE: You must wear a respirator to prevent fine dust particles from being inhaled.

Installing rigid insulation

Most types of rigid insulation you can easily cut with an "s"-saw or knife. There are various installation methods for this type of insulation. You must refer to the project specifications for the required application method. Such methods include friction-fitted between framing members, fastened over framing members and adhered with special adhesives over masonry surfaces.

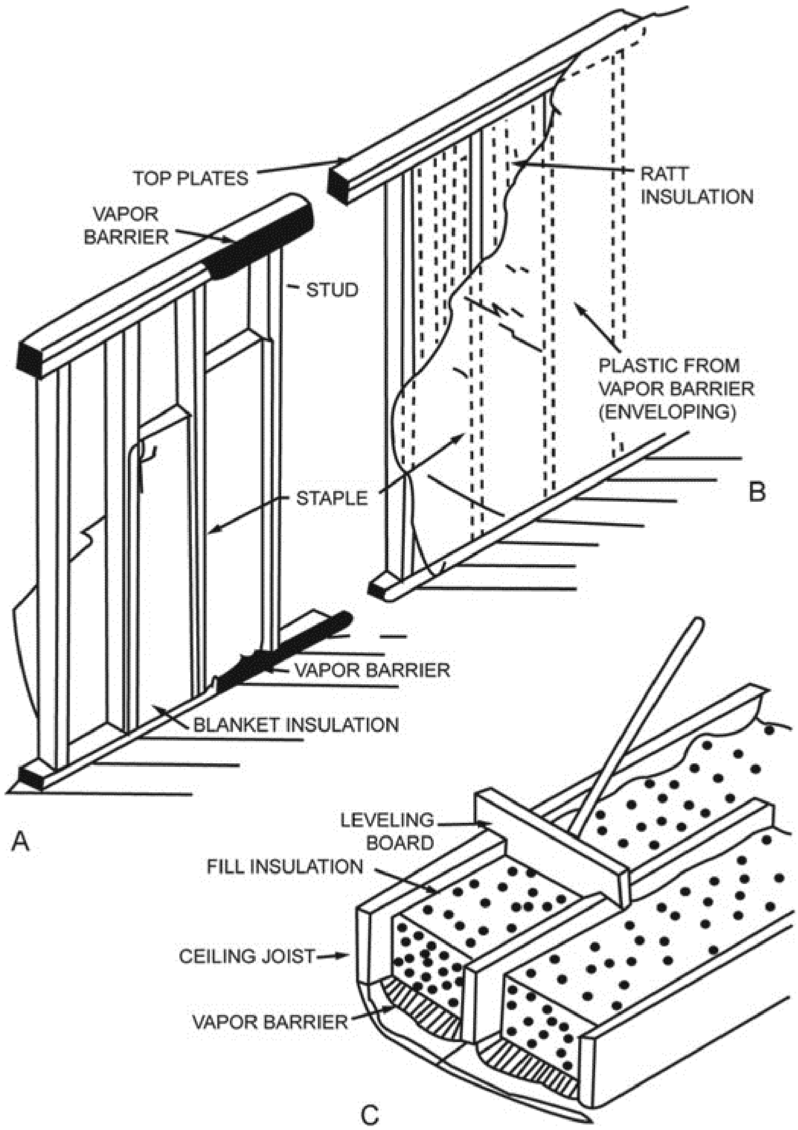


Figure 4–2. Installing insulation.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

616. Installing thermal insulation

1. What function does thermal insulation serve in the summer and winter?

2. What do manufacturers sometimes add to *flexible insulation's* paper cover?

3. Besides providing thermal insulation, for what other purposes do we use *rigid insulation*?

4. What are the common tools used to lay out, cut, and install insulation?

5. What type of insulation would you install *between the joists* in *attics*?

617. Applying caulking compounds and installing weather-stripping

Another means to improve a facility's energy efficiency is to use caulking and weather-stripping. We will discuss some of the most common types of caulking and weather stripping materials available and provide installation procedures in this lesson.

Caulking compounds

Caulk improves efficiency by filling cracks and seams (usually around doors or windows) to stop drafts and prevent moisture from entering. It is available in squeeze tubes and cartridges for use with caulking guns.

Types of caulk

There are many types of caulking compounds available. For the most part, they all install the same. However, some types create more health hazards. Be sure to familiarize yourself with the product's material safety data sheet (MSDS) before use. The following table describes the more common caulking compounds that you will work with.

Caulking Compounds	
Type	**Description**
Latex	Latex caulk is water based and can be painted when dry. You will apply it most often around doors and windows to make a seal. You can also apply it on walls and trim to fill in holes and other imperfections before painting. After the caulk is applied, you can use a putty knife, caulk tooling device, a brush, or a moistened finger to smooth and shape it. Clean up any excess caulk with water before it starts to set.
Acrylic latex	Acrylic caulk is more durable and waterproof than latex caulk. Most acrylic caulk is water based and can be painted when dry. We often apply it around bathtubs, sinks, and other areas subject to occasional water contact. Application and clean up is similar to that of latex caulk.
Silicone	You use silicone caulk to fill exterior surface cracks, splits, holes, or other damage, and to provide a weatherproof seal. It is the most durable and waterproof caulk used In fact, some types can last for 30 years. The drawback is that paint does not stick to silicone caulk very well. It is available in clear, and various colors to match your needs. A carefully applied bead gives the best result. You can work this type with a caulk tooling device or a brush. A brush could smear it onto areas where you don't want the caulking. If so, you may need to remove this excess caulk with solvent. If you have to use solvent, make sure that you are authorized, and have a current MSDS.

Applying caulking compound

Before applying the caulking compound, cut the tip nozzle at an angle for the desired bead width and squeeze the tube or caulking gun trigger. There are different methods used for applying the caulking; some craftsmen prefer to push the tube/cartridge forward and force the caulking into the joint, while others prefer to pull it. Use whichever method you are most comfortable doing. The most important consideration is that the joint is completely filled. A correctly applied bead doesn't require any touch-ups; however, this is not always the case. After the caulk is applied, you can use a putty knife, caulk tooling device, a brush, or a moistened finger to smooth and shape it. Clean up any excess latex caulk with water, and silicone caulk with solvent, before they start to set.

Weather-stripping

Weather stripping around exterior doors and windows adds to energy efficiency by providing a seal that prevents wind and rain from entering. Let's look at some common weather stripping that you can install.

Vinyl-gasket threshold

You can place a vinyl gasket into an aluminum or wood threshold to make a weather resistant seal between the threshold and the door bottom. These gaskets are half-circle shaped on top and flatten out at each edge to fit channels that run down each side of the threshold center (fig. 4–3).You can replace some gaskets without having to remove the entire threshold. Other types require you to temporarily remove the threshold to replace the gasket.

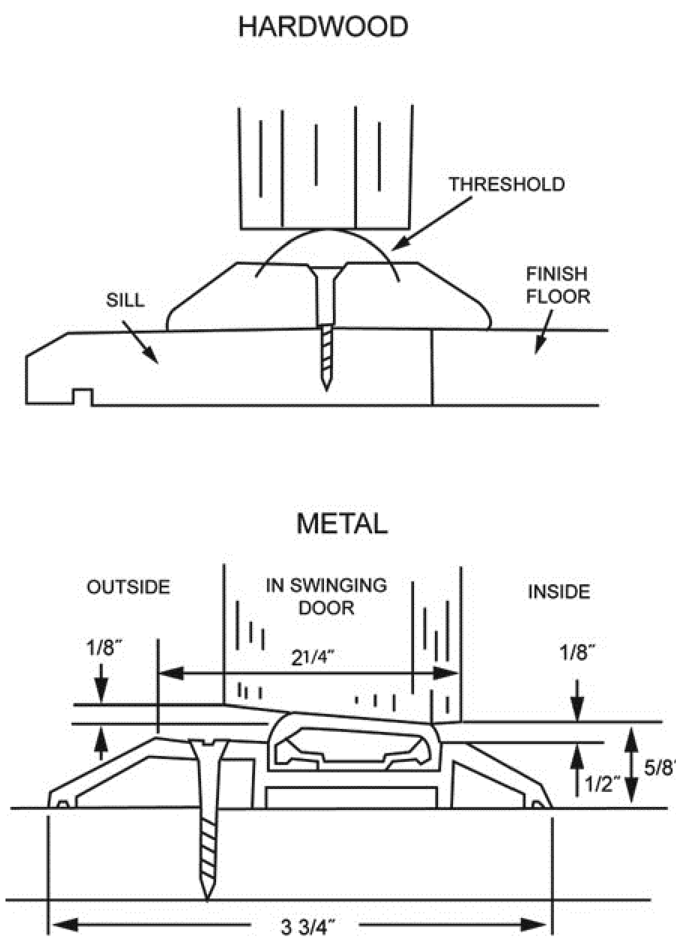


Figure 4–3. Thresholds.

Door sweep

Install a door sweep horizontally on a door face near the door bottom. Its purpose is to reduce heat loss and reduce drafts by covering the airspace between the door bottom and the threshold. Various types are available, including all vinyl with an attached adhesive strip and vinyl attached to a wood or metal strip that is installed with nails or screws. Follow the simple steps in the table below to install a door sweep.

Installing A Door Sweep	
Step	**Action**
1	Determine the type needed.
2	Measure the area at threshold height between the hinge jamb and the lock jamb.
3	Cut the door sweep to length. (It may be necessary to cut more material from the door sweep to allow the door to open and close properly).
4	Place the door sweep so that it covers the space between the bottom of the door and the threshold.
5	Fasten in position. **NOTE:** The method used varies with the door sweep type. Some have adhesive with a non-stick peel away paper strip and others require nails or screws.

Sponge rubber

We sometimes install sponge rubber around doorstop edges. It is sold in rolls that vary in compression resistance, width, and thickness. It usually has one side that has an adhesive with a non-stick peel away paper strip attached. A common way to install it is given in the following table.

Installing Sponge Rubber Weather Stripping	
Step	**Action**
1	Determine sponge rubber width and thickness.
2	Measure the length needed.
3	Make sure the mounting surface is clean and dry.
4	Cut the sponge rubber to length.
5	Peel away the paper strip as you press the sponge rubber into position.
6	Check the door for proper operation.

Spring metal

Spring metal flattens out (springs out) to make an effective seal when you close a door or sliding window. Most spring metal is sold with an adhesive and non-stick peel away paper strip attached. On doors, install it on all three-door jambs (hinge, head, and lock). On windows, snugly fit it onto the frame between the stops on each sash side. An easy way to install spring metal is given in the following table

Gasket weather stripping

You can install gasket weather stripping on doors or windows. The weather stripping type could be foam attached to a wood strip, vinyl attached to a metal strip, vinyl-covered foam, vinyl attached to extruded aluminum, or other types. A common way to install gasket weather stripping is described in the following table.

Installing Spring Metal Weather Stripping	
Step	**Action**
1	Measure the length needed.
2	Cut the spring metal to length.
3	For a door, miter the spring metal corners and install them between the doorstops and the doorjambs. Start with the hinge jamb, move to the head jamb, and finish with the lock jamb. Trim the spring metal around the striker plate.
4	For a sliding window, use square cuts to make a butt joint. **NOTE:** It is sometimes necessary to remove the window sash before you can replace the spring metal weather stripping. Install the spring metal between the window stops so that it runs their length and width.
5	Position the spring metal on the door or window.
6	Remove the paper backing and press the spring metal in position. **NOTE:** Some types may require nails or screws.

Installing Gasket Weather Stripping	
Step	**Action**
1	Determine the gasket weather stripping type.
2	Measure the length needed.
3	Cut the weather stripping to length, starting with the head jamb.
4	Close the door or window to line up the weather stripping to make an effective seal.
5	For a door, position the weather stripping around the doorstop.
6	For most windows (awning, casement, and hinged), position the weather stripping on each inside sash stop.
7	Secure the weather strip in position. The method you use varies according to the gasket weather stripping type and may include adhesive, nails, and screws.
8	Make sure the door or window still opens and closes properly.

Vinyl V-strip

A Vinyl V-strip is designed for sliding windows. Because its function is similar to spring metal, refer to that section for installation information.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

617. Applying caulking compounds and installing weather-stripping

1. What is caulk used for?

2. What steps are needed to apply and smooth out *latex caulk*?

3. What is *silicone caulk* used for?

4. What is the purpose of a door sweep?

5. Where do you sometimes install sponge rubber on a doorframe?

6. What happens to spring metal when you close a door or sliding window?

7. Where do you install *gasket weather stripping* on doors and windows?

Answers to Self-Test Questions

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1. In the summer, it keeps the heat out. In the winter, it keeps the heat in.
2. A bitumen vapor barrier coating to the inside or a reflective coating (usually aluminum foil) to the outside.
3. (1) Roof and wall sheathing.
   (2) Surface cover for walls and ceilings.
   (3) Base for plaster and stucco.
   (4) Insulation strips for foundation walls and slab floors.
4. (1) A tape measure.
   (2) Straight edge.
   (3) Utility knife.
   (4) Stapler.
5. Loose-fill.

617

1. To improve facility efficiency, appearance, or waterproofness.
2. (1) Cut the nozzle at an angle for the desired bead and squeeze the tube or caulking gun trigger.
   (2) Use a putty knife or a moistened finger to smooth and shape the caulk.
   (3) Clean up any excess with water before it starts to set.
3. To fill exterior surface cracks, splits, holes, or other damage to provide a weatherproof seal.
4. To reduce heat loss and reduce drafts by covering the airspace between the door bottom and the threshold.
5. Around the doorstop edges.
6. It flattens out.
7. On the stops.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

53. (616) *Flexible* insulation is available in
    a. sheets or strips.
    b. bags or cartons.
    c. panels or bundles.
    d. blanket rolls or batts.

54. (616) What insulation type is popular for insulating concrete slabs and other masonry products?
    a. Rigid.
    b. Flexible.
    c. Loose fill.
    d. Temperate.

55. (617) Which weather strip item do you use to reduce heat loss and drafts by covering the airspace between the door bottom and the threshold?
    a. V-strip.
    b. Door sweep.
    c. Spring metal.
    d. Sponge rubber.

Glossary of Terms, Abbreviation, and Acronyms

Terms

Anchor bolts—Bolts used to fasten columns, girders, soleplates, or other members to concrete or masonry.

As-built drawings—Drawings made during or after construction, illustrating how various elements of the project were actually installed.

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 line.

Blemish—A flaw that mars the appearance of lumber but has no effect on the utility value.

Bridging—Crossed or solid supports installed between joists (floor or ceiling) to help evenly distribute the load and brace the joists against side sway.

Cantilevered—When a portion of a structure projects outward beyond the structure below.

Casing—The trim around doors and windows.

Chase—Opening in a metal stud through which pipe is routed.

Cornice—The area under the eaves where the roof and sidewalls meet.

Cripple studs—A stud used with wall openings. Its length runs from the top plate to the header (above wall openings) or from the sole plate to the rough sill (below wall openings).

Crown—The outside curve of a twisted, bowed, or cupped board.

Dead load—The material weight used to construct the roof such as rafters, sheathing, insulation, shingles, etc.

Defect—Any flaw in lumber that tends to affect the strength, durability, or utility value of the lumber.

Eave—The part of a roof projecting over the sidewall.

Escutcheon—A protective, often ornamental shield or plate, as that around a keyhole.

Fascia—The flat outside horizontal member of a cornice placed in a vertical position.

Furring—Any extra material added to another piece or member to bring an uneven surface to a true plane and to provide additional nailing surface.

Gang nail plates—Metal plates made with formed metal teeth. During truss construction, they are usually hammered into position at each joint on both truss sides. Are sometimes used instead of plywood gussets.

Girder—A supporting beam laid crosswise to the building; a long truss.

Gusset—A plate connecting members of a truss together.

Jalousie—A window formed of overlapping, horizontal slats, or louvers, of wood, metal, or glass that can be adjusted to regulate the air of light coming in between them.

Joist—Heavy pieces of lumber laid on edge horizontally to form the floor and ceiling support system.

Knocked down—A complete group of parts that is cut to size and sold as a kit that is ready for assembly.

Laminated lumber—Made of several pieces of lumber, either nailed, bolted, or glued together to form a single unit with the grain of all pieces running parallel with each other.

Lateral strength—The ability to withstand side-to-side forces or loads.

Lintel—A support beam place over an opening in a wall.

Live load—Weight from snow, personnel, etc. that a roof is subjected to support.

Lumber––Wood that has been cut and surfaced for use in construction work.

Miter—A kind of joint formed by fitting together two pieces, beveled to a specified angle to form a corner.

Mortise—A hole or recess cut, as in a piece of wood, to receive a projecting part.

Mullion—A slender, vertical dividing bar between the lights of windows, doors, etc.

Muntin—The small members dividing glass panes in a window frame; vertical separators between panels in a panel door.

Parapet—The part of a wall above the roofline.

Purlin—Horizontal members of a roof supporting common rafters. Also, members between trusses supporting sheathing.

Rabbet—A groove or recess cut in the edge of a board, plank, etc.

Rafter—A sloping roof member supporting the roof covering and extending from the ridge or the hip of the roof to the eaves.

Rake—The inclined position of a cornice; also the angle of slope of a roof rafter.

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. Roof angle incline or amount expressed in inches per foot of run. In a stair, the total height of the stair.

Run—Construction term that refers to the horizontal distance covered by a rafter. The run is ½ the span distance.

Sash—The movable part of a window.

Seasoning—The removing (drying) of moisture from the small and large cells of wood. Wood is considered dry enough for most uses when the moisture content is reduced to around 12 to 15 percent.

Sills—The first members of a frame set in place.

Soffit—The underside of a subordinate member of a building.

Soleplate—The lowest horizontal wall-framing member that rests on a subfloor or finish floor. It also provides support to wall studs.

Span—Construction term that refers to the distance from the outside of one double top plate to outside of the opposite double top plate. The span is twice the run distance.

Specifications—Written instructions containing information about the materials, style, workmanship, and finish for the job.

Stitch bolt—Truss repair method where bolts are placed vertically. This method can only be used on two-inch thick or thicker trusses. Always follow engineering guidelines when repairing trusses.

Stud—The vertical members of wooden forms or frames.

Timber—Lumber that is 5 inches or more in both thickness and width.

Trimmer stud—A stud used with wall openings. Its length runs from the sole plate to the bottom of the header. It also runs in parallel contact with a full-length stud.

Truss—A wood framed support system that takes the place of rafters in supporting a roof. A truss can span a wide distance and is built to withstand various conditions including wind and live loads. 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.

Abbreviations and Acronyms

AFI	Air Force instruction
AFMAN	Air Force manual
AFOSH	Air Force Occupational Safety and Health
ANSI	American National Standards Institute
BCE	base civil engineer
d	penny
KD	knocked down
MSDS	material safety data sheet
OC	on center
OSB	oriented strand board
PEB	pre-engineered building
PS	product standard
RPM	revolutions per minute
T&G	tongue and groove

Student Notes

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