

*The roof's main purpose is to keep out the rain, cold, or heat. It must be strong enough to with stand high winds; sloped to shed water; and, in areas of heavy snow, it must be constructed more rigidly to bear the extra weight. This chapter will familiarize carpenters with the most common types of roof construction and materials. This chapter also covers reroofing.*

**ROOF FRAMING**

Roofs for TOs are chosen to suit the building; the climate; the estimated length of time the building will be used; and the material, time, and skill required for construction. TO constraints dictate simple design as shown in Figure 7-1.

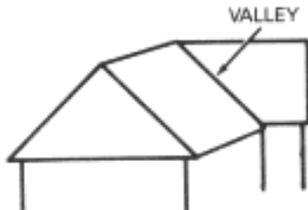
<p>GABLE ROOF. This roof has two roof slopes that meet at the center (ridge), forming a gable. It is the most common roof because it is simple, economical, and may be used on any type of structure.</p>	
<p>LEAN-TO OR SHED ROOF. This roof is used where hasty or temporary construction is needed and where sheds or additions to buildings are erected. The pitch of this roof is in one direction only. The roof is held up by the walls or posts on four sides. One wall, or the posts on one side, is higher than those on the opposite side.</p>	
<p>HIP ROOF. This roof has four sides or slopes running upward toward the center of the building to create a ridge (or peak). Rafters at the corners run diagonally from the bottom edge to meet at the center (ridge). Other rafters are then framed into these.</p>	
<p>VALLEY ROOF. This roof is formed of two intersecting hip or gable roofs. The two roofs meet at a valley. Each roof slants in a different direction. This roof is seldom used, since it is complicated and requires much time and labor.</p>	

Figure 7-1. Types of roofs

## ROOFING TERMS

When framing a roof (Figure 7-2), carpenters must be familiar with commonly used roofing terms (Figures 7-3 and 7-4).

### RAFTERS

Rafters make up the main framework of all roofs. They are inclined members spaced from 16 to 48 inches apart. They vary in size, depending on length and spacing. The tops of inclined rafters are fastened to the ridge or another rafter, depending on the type of roof. Rafters rest on the top wall plate.

Rafters are nailed to the plate, not framed into it. Some are cut to fit the plate, while in hasty construction they are merely laid on top of the plate and nailed in place. They may extend a short distance beyond the wall to form the eaves and protect the sides of the building.

### Types of Rafters

Examples of most types of rafters are shown in Figure 7-3. The four types are—

**Common Rafters.** These are framing members that extend at right angles from the plate line to the roof ridge. They are called common rafters because they are common to all types of roofs and are used as the basis for laying out other types of rafters.

**Hip Rafters.** These are roof members that extend diagonally from the corner of the plate to the ridge.

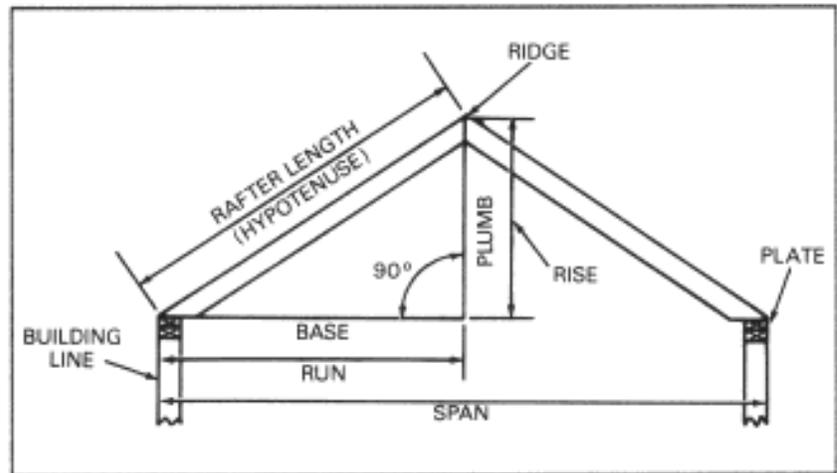


Figure 7-2. Framing a roof

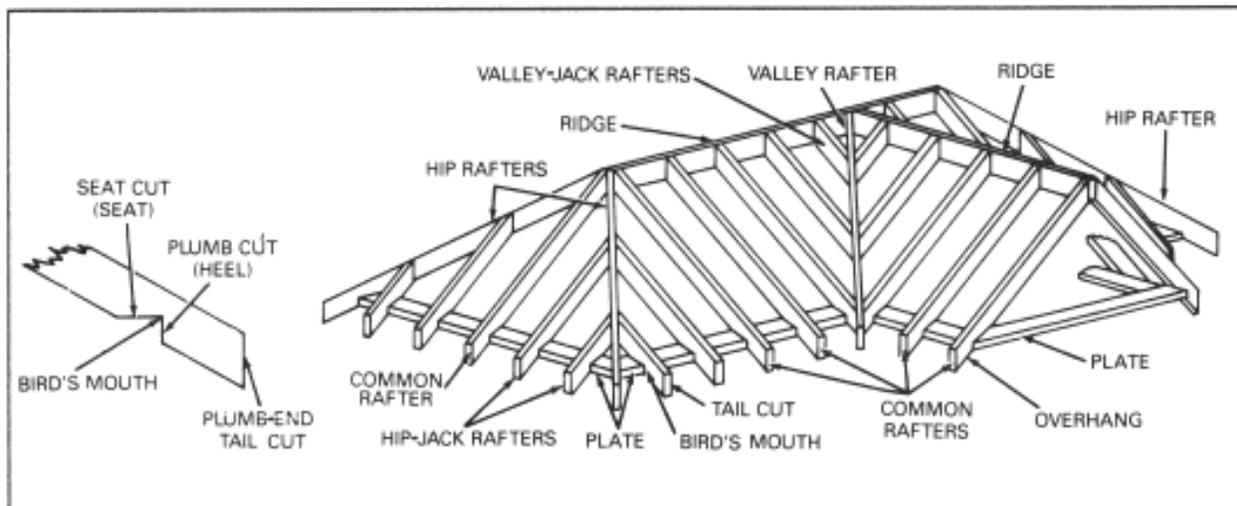


Figure 7-3. Common roof-framing terms

*Basic Triangle.* The basic triangle is the most elementary tool used in roof framing. When framing a roof, the basic right triangle is formed by the horizontal lines (or run), the rise (or altitude), and the length of the rafter (the hypotenuse). Any part of the triangle can be computed if the other two parts are known. Use the following equation:

The square of the hypotenuse of a right triangle is equal to the sum of the squares of the two sides. In roofing terms—

$$\text{Rafter length}^2 = \text{run}^2 + \text{rise}^2$$

*Rise.* The rise of a rafter is the vertical (or plumb) distance that a rafter extends upward from the plate.

*Span of a Roof.* The span of any roof is the shortest distance between the two opposite rafters' seats.

*Cut of a Roof.* The cut of a roof is the rise over the run (such as 4/12 roof) or the pitch of the roof.

*Horizontal Line.* A horizontal line is one level with the building foundation.

*Line Length.* In roof framing, line length is the hypotenuse of a triangle whose base is the run and whose altitude is the total rise.

*Total Rise.* The total rise is the vertical distance from the wall plate to the top of the ridge.

*Run.* Run always refers to the level distance any rafter covers—normally, one-half the span.

*Unit of Run (or unit of measurement).* Unit of measurement, 1 foot (or 12 inches), is the same for the roof as for any other part of the building. Using this common unit of measurement, the framing square is used in laying out large roofs (Figure 7-5, page 7-4).

*Pitch.* Pitch signifies the amount that a roof slants and the ratio of rise (in inches) to run (inches). Using this method, 4, 6, or 8 inches rise per foot of run would give a pitch of 4-12, 6-12, or 8-12. (Figure 7-6, page 7-4, shows how to determine roof pitch.)

*Plumb Line.* The line formed by the cord on which the plumb bob is hung.

*Bird's Mouth.* A cutout, near the bottom of a rafter, that fits over the top plate. The cut that fits the top of the plate is called the seat; the cut for the side of the plate is called the heel.

*Overhang.* The part of a rafter that extends past the outside edge of the walls of a building. When laying out a rafter, this portion is in addition to the length of a rafter and is figured separately. The overhang is often referred to as the tailpiece.

*Plate.* The wall-framing member that rests on the top of the wall studs.

*Ridge.* The highest horizontal roof member. It ties the rafters together at the upper end.

Figure 7-4. Roofing terms

**Valley Rafters.** These rafters extend from the plate to the ridge along the lines where two roofs intersect.

**Jack Rafters.** These are a common rafter. The three kinds of jack rafters are the—

- Hip jack, which extends from the plate to the hip rafter.
- Valley jack, which extends from the ridge of the valley rafter.
- Cripple jack, which is placed between a hip rafter and a valley rafter. The cripple jack rafter is also part of a common rafter, but it touches neither the ridge of the roof nor the rafter plate.

## Collar Tie and Beam

A collar tie or beam (Figure 7-7) is a piece of stock (usually 1 x 4, 1 x 6, 1 x 8, or 2 x 4) fastened in a horizontal position to a pair of rafters between the plate and the ridge of the roof. This type of beam keeps the building from spreading. Most codes and specifications require them to be 5 feet apart or every third rafter, whichever is less. Collar ties are nailed to common rafters with four 8d nails to each end of a 1-inch tie. If 2-inch material is used for the tie, they are nailed with three 16d nails at each end. This type of bracing is used on small roofs where no ceiling joists are used

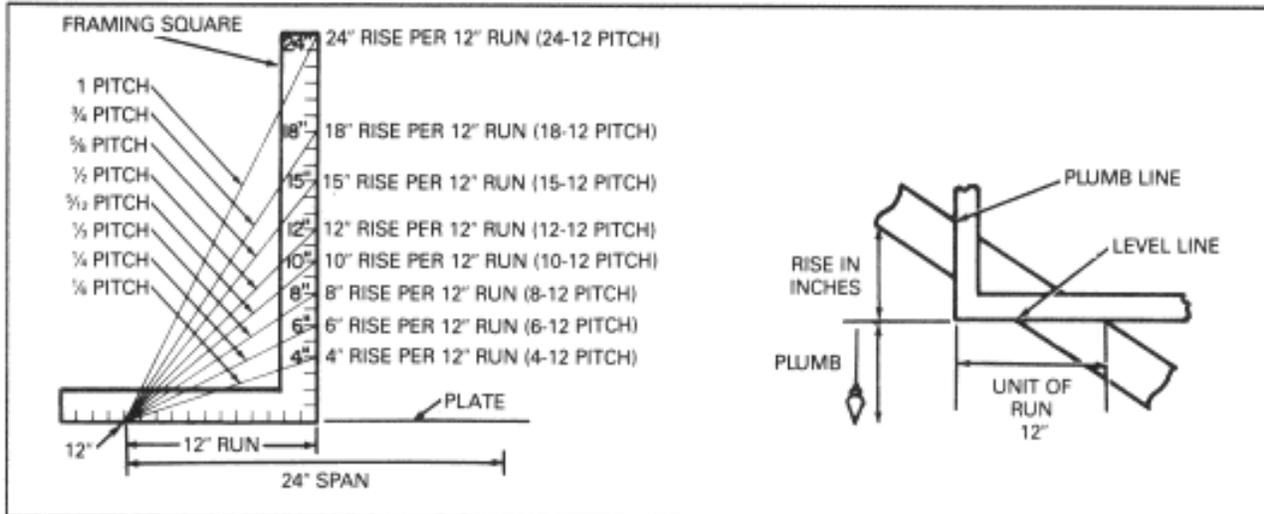


Figure 7-5. Use of framing square

and the building is not wide enough to require a truss.

In small roofs that cover only narrow buildings in which the rafters are short, there is no need for interior support or bracing. In long spans, the roof would sag in the middle if it were not strengthened in some way. To support long rafters, braces or other types of supports must be installed.

## Rafter Layout

Rafters must be laid out and cut with slope, length, and overhang exactly right so that they will fit when placed in the roof.

### Scale or Measurement

**Method.** The carpenter should first determine the length of the rafter and the length of the lumber from which the rafter may be cut. If he is working from a roof plan, he learns the rafter lengths and the width of the building from the plan. If no plans are available, the width of the building must be measured.

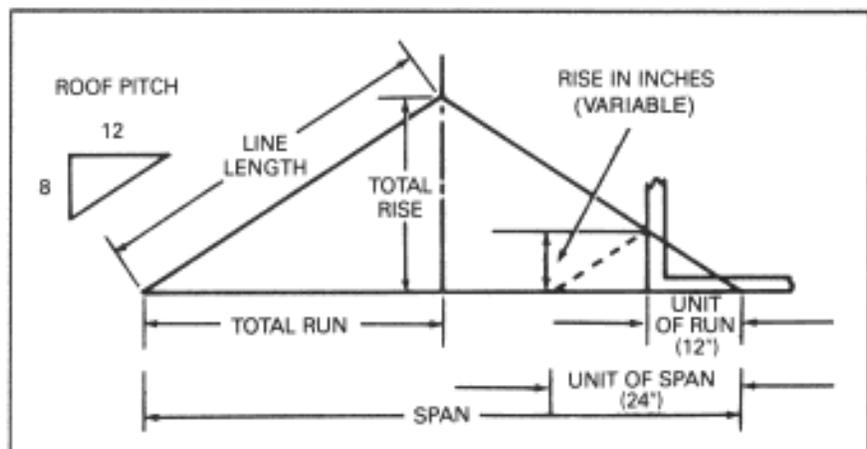


Figure 7-6. Determining roof pitch

*Step 1.* To determine the rafter length, first find one-half of the horizontal distance (total run) of the rafter. The amount of rise per foot will not be considered yet. (For example, if the building is 20 feet wide, half of the span will be 10 feet. See the example below.)

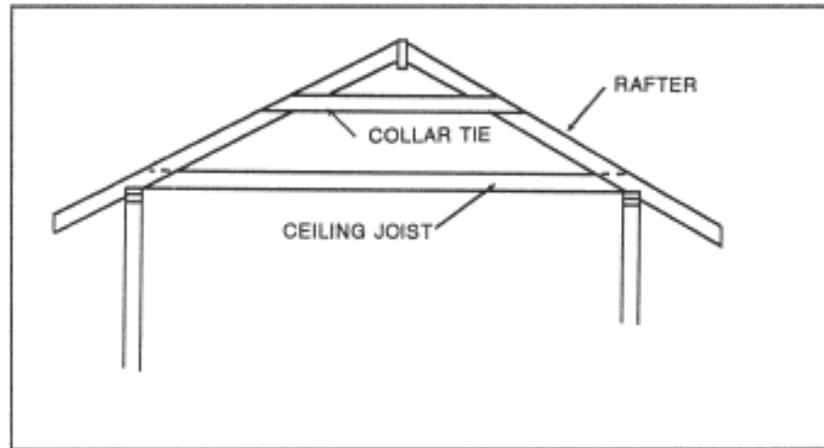


Figure 7-7. Collar tie or beam

*Step 2.* After the length has been determined, lay the timber on sawhorses (saw benches), with the crown or bow (if it has any) as the top side of the rafter. If possible, select a straight piece for the pattern rafter. If a straight piece is not available, have the crown away from the person laying out the rafter.

*Step 3.* Hold the square with the tongue in your left hand, the blade in your right, and the heel toward your body. Place the square as near the upper end of the rafter as possible. (For example, in Figure 7-8, page 7-6 (step 1) the figures 8 on the tongue and 12 on the blade are placed along the timber edge that is to be the top edge of the rafter.)

*Step 4.* Mark along the outside tongue edge of the square, which will be the plumb cut at the ridge. *Step 5.* Since the length of the rafter is known to be 12 feet and 1/6 inch, measure the distance from the top of the plumb cut and mark it on the timber. Hold the square in the same manner with the 8 mark on the tongue directly over the 12-foot 1/6-inch mark. Mark along the tongue of the square to give the plumb cut for the seat (Figure 7-8, step 2).

*Step 6.* Measure off, perpendicular to this mark, the length of overhang along the timber. Make a plumb-cut mark in the same way, keeping the square on the same edge of the timber (Figure 7-8, step 3). This will be the tail cut of the rafter. Often, the tail cut is made square across the timber.

*Step 7.* The level cut or width of the seat is the width of the plate measured perpendicular to the plumb cut, as shown in Figure 7-8, step 4. Using a try square, square the lines down on the sides from all level and plumb-cut lines. Now the rafter is ready to be cut (Figure 7-8, step 5).

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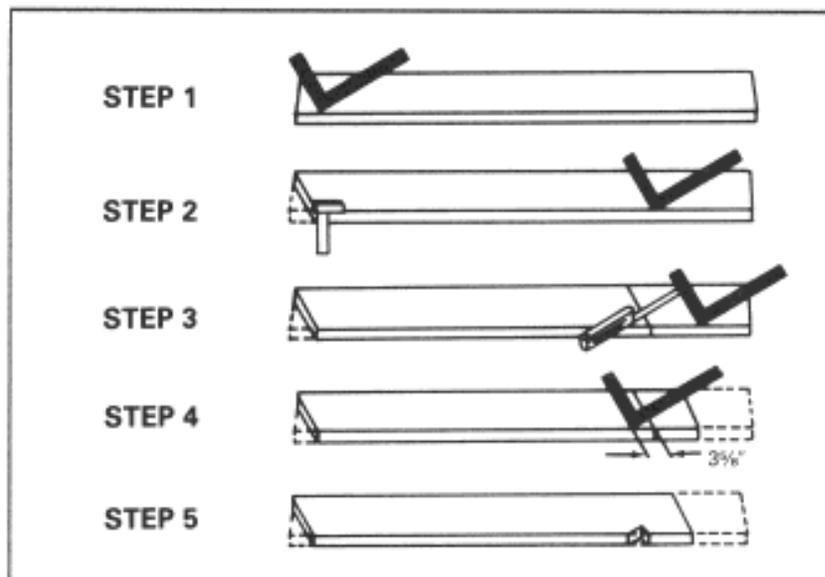


Figure 7-8. Scale or measurement method

### EXAMPLE - Rafter layout, step 1: determine rafter length

As an example, use a rise per foot of 8 inches. To determine the approximate overall length of the rafter, measure on a steel carpenter square the distance between 8 on the tongue and 12 on the blade, because 8 is the rise and 12 is the unit of run. This distance is  $14 \frac{5}{12}$  inches. This represents the line length of a rafter with a total run of 1 foot and a rise of 8 inches. Since the run of the rafter is 10 feet, multiply 10 by the line length for 1 foot. The answer is  $144 \frac{2}{12}$  inches, or 12 feet and  $\frac{1}{6}$  inch. The amount of overhang (normally 1 foot) must be added if an overhang is to be used. This makes a total of 13 feet, which is an odd length for timber. Use a 14-foot timber.

Rafter length = total run x line length + overhang  
 $10 \times 14 \frac{5}{12}$  inches =  $144 \frac{2}{12}$  inches = 12 feet +  $\frac{1}{6}$  inch = 13 feet

**Step-Off Method.** The rafter length of any building may be determined by "stepping it off by successive steps with the square, as follows:

*Step 1.* Step off the same number of steps as there are feet in the run. For example, if a building is 20 feet 8 inches wide, the run of the rafter would be 4 inches over 10 feet.

*Step 2.* This 4 inches is taken care of in the same manner as the full-foot run; that is, with the square at the last step position, make a mark on the rafters at the 4-inch mark (Figure 7-9, step 1).

*Step 3.* With the square held for the same cut as before, make a mark along the tongue. This is the line length of the rafter. The seat cut and hangover are made as described above and shown in Figure 7-9, steps 2, 3, and 4.

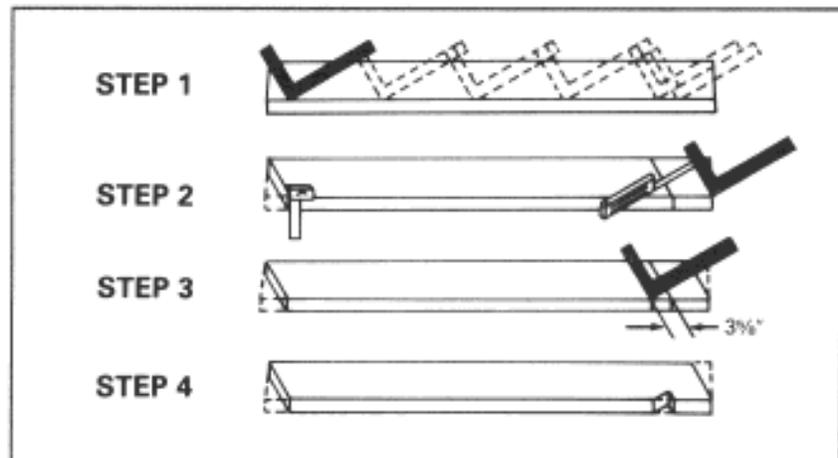


Figure 7-9. Step-off method

**NOTE: When laying off rafters by any method, be sure to recheck the work carefully. When two rafters have been cut, it is best to put them in place to see if they fit. Minor adjustments may be made at this time without serious damage or waste of material.**

**Table Method.** The framing square may have one or two types of rafter tables on the blade. One type gives both the line length of any pitch of rafter per foot of run and the line length of any hip or valley rafter per foot of run. The difference in length of the jack rafter, spaced 16 or 24 inches (on center), is also shown in the table. Where the jack, hip, or valley rafter needs side cuts, the cut is given in the table. The other type of table gives the actual length of a rafter for a given pitch and span.

*Rafter Table, Type 1.* Type 1 (Figure 7-10) appears on the face of the blade. This type is used to determine the length of the common, valley, hip, and jack rafters and the angles at which they

must be cut to fit at the ridge and plate.

To use the table, the carpenter must first know what each figure represents.

- The row of figures in the first line represents the length of common rafters per foot of run, as the title at the left-hand end of the blade indicates.
- Each set of figures under each inch division mark represents the length of rafter per foot of run, with a rise corresponding to the number of inches over the number. (For example, under the 16-inch mark appears the number 20.00 inches. This number equals the length of a rafter with a run of 12 inches and a rise of 16 inches. Under the 13-inch mark appears the number 17.69 inches, which is the rafter length for a 12-inch run and a 13-inch rise.) See the Type 1 layout example below.

**NOTE: The other five lines of figures in the table will not be discussed, as they are seldom used in the TO.**

The remaining procedure for laying out the rafters after the length has been determined is as described previously.

**EXAMPLE - Rafter layout, table method, Type 1**

**NOTE:** To use the table for laying out rafters, the width of the building must first be known.

Suppose the building is 20 feet 8 inches wide and the rise of the rafters is to be 13 inches per foot of run. The total run of the rafter will be 10 feet 4 inches (or 10 1/3 feet). Look at the first line of Figure 7-10. Under the 13-inch mark appears the number 17.69, which is the length (in inches) of a rafter with a run of 1 foot and a rise of 13 inches. To find the length of this rafter, use the following formula:

Rafter length = total run x length of common rafter per ft of run + 12

10 1/3 x 17.69 inches = 182.79 inches  
 182.79 inches + 12 = 15 3/12 feet

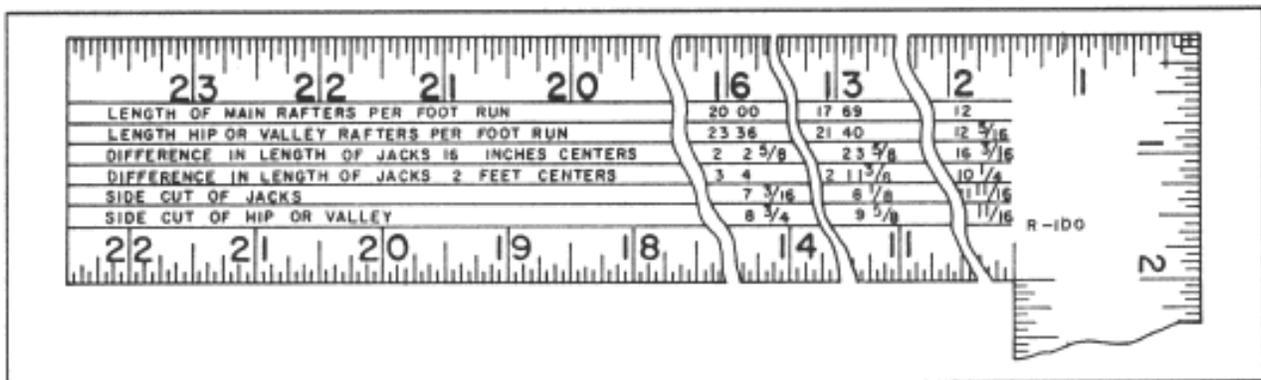


Figure 7-10. Rafter table, Type 1

**Rafter Table, Type 2.** Type 2 (Figure 7-11, page 7-8) appears on the back of the blade of some squares. This shows the run, rise, and pitch of rafters of the seven most common pitches of roof.

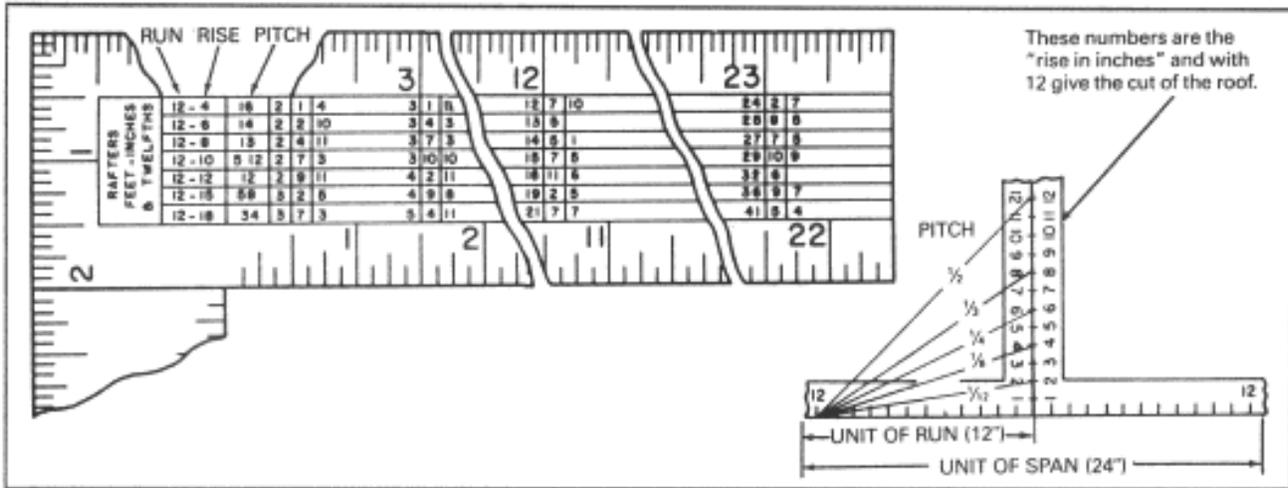


Figure 7-11. Rafter table, Type 2

The figures are based on the horizontal measurement of the building from the center to the outside.

The rafter table and the outside edge of the back of the square, both the body and tongue, are in twelfths. (The inch marks may represent twelfths of an inch or twelfths of a foot.) This table is used in connection with the marks and figures on the **outside** edge of the square. At the left end of the table are figures representing the run, the rise, and the pitch:

- In the first column, the figures are all 12 (12 inches or 12 feet). They represent the run of 12.
- The second column of figures represents various rises.
- The third column of figures (in fractions) represents the various pitches.

These three columns of figures show that a rafter with a run of 12 and a rise of 4 has a  $\frac{1}{6}$  pitch, 12 and 6 has a  $\frac{1}{4}$  pitch, and 12 and 12 has a  $\frac{1}{2}$  pitch. For example, use this scale for—

- A roof with a  $\frac{1}{6}$  pitch (or the rise of  $\frac{1}{6}$  the width of the building) and a run of 12 feet. Find  $\frac{1}{6}$  in the table, then follow the same line of figures to the right until directly beneath the figure 12. Here appear the numbers 12, 7, 10, which is the rafter length required and which represents 12 feet 7  $\frac{10}{12}$  inches.
- A roof with a  $\frac{1}{2}$  pitch (or a rise of  $\frac{1}{2}$  the width of the building) and a run of 12 feet. The rafter length is 16, 11, 6, or 16 feet 11  $\frac{6}{12}$  inches.
- A roof with a run of more than 23 feet. For example, if the run is 27 feet, find the length for 23 feet, then find the length for 4 feet and add the two. The run for 23 feet with a pitch of  $\frac{1}{4}$  is 25 feet 8  $\frac{5}{12}$  inches. For 4 feet, the run is 4 feet 5  $\frac{8}{12}$  inches. The total run for 27 feet is 30 feet 2  $\frac{1}{12}$  inches.

**NOTE: When the run is in inches, the rafter table reads inches and twelfths instead of feet and inches.**

See the Type 2 rafter table layout example at the top of the next page.

After the length of the rafter has been found, the rafter is laid out as explained previously.

### EXAMPLE - Rafter layout, table method, Type 2

*If the pitch is 1/2 and the run is 12 feet 4 inches, add the rafter length of a 12-foot run to that of a rafter length of a 4-inch run, as follows:*

- *For a run of 12 feet and 1/2 pitch, the length is 16 feet 11 6/12 inches.*
- *For a run of 4 inches and 1/2 pitch, the length is 5, 7, 11. In this case, the 5 is inches, the 7 is twelfths, and the 11 is 11/12 of 1/12, which is nearly 1/12.*
- *Add it to the 7 to make it 8, making a total of 5 8/12 inches, then add the two lengths together.*
- *This sum is 17 feet 5 2/12 inches.*

*Rafter lengths are given in the table. The overhang must be added. NOTE: When the roof has an overhang, the rafter is usually cut square to save time. When the roof has no overhang, the rafter cut is plumb, but no notch is cut in the rafter for a seat. The level cut is made long enough to extend across the plate and the wall sheathing. This type of rafter saves material, although little protection is given to the side wall.*

## TRUSSES

A truss is a framed or jointed structure composed of straight members connected only at their intersections in such a way that if loads are applied at these intersections, the stress in each member is in the direction of its length. Straight, sound timber should be used in trusses. The types of trusses used in building construction are shown in Figure 7-12. (The Howe and Fink trusses are most commonly used.) Truss terms are listed in Figure 7-13, page 7-10.

Trusses are used for large spans to give wide, unobstructed floor space for such large buildings as shops and hangars. Sometimes small buildings are trussed to save material. These small trusses act as rafters and give the roof rigidity.

The web members of a truss divide it into triangles. The members indicated by heavy lines normally carry tensile stresses for vertical loads. Sometimes the top chords of these trusses slope slightly in one or two directions for roof drainage, but this does not change the type of truss. The necessary number of subdivisions, or panels, depends upon the length of the span and the type of construction.

### Truss Supports

Trusses are supported by bearing walls, posts, or other trusses. To brace a truss to a wall or post, knee braces are used as shown in Figure 7-14. These braces tend to make a truss of the entire building by tying the wall to the roof.

### Purlins

Purlins are used in roof construction to support corrugated sheet metal if it is used, or to support the sheathing of roofs framed with trusses.

- In small roofs, purlins are inserted between the rafters and nailed through the rafters.
- In large buildings where heavy trusses are used, the purlins are continuous members that rest

on the trusses and support the sheathing.

- In small buildings, such as barracks, mess halls, and small warehouses, 2 x 4s are used for

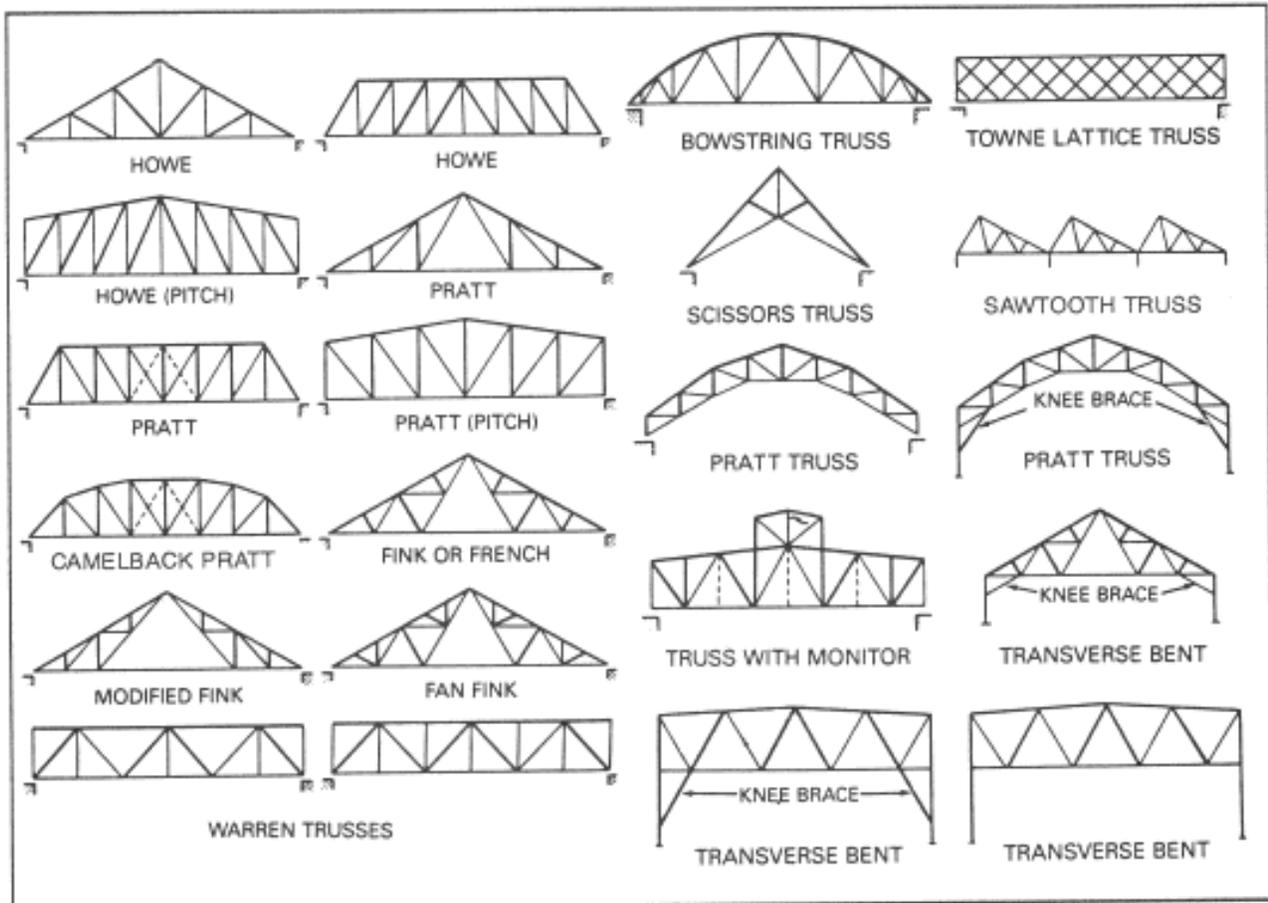


Figure 7-12. Types of trusses

purling, with the narrow side up.

### Truss Layout

To lay out a truss, use Figure 7-15 and the following steps:

*Step 1.* Get the material to a level spot of ground where work benches will be almost level.

*Step 2.* Obtain from the blueprints the measurement of all pieces to be used in the truss.

*Step 3.* Lay out the length on the different sizes of timber and cut them accurately.

*Step 4.* After all lengths are cut, lay them in their correct position to form a truss.

*Step 5.* Nail them together temporarily.

*Step 6.* Lay out the location of all holes to be bored. Recheck the measurements for accuracy.

*Step 7.* Bore holes to the size called for on the print. Use a brace and bit or the woodborer that accompanies the air compressor. Bore holes perpendicular to the face of the timber.

*Bottom Chord.* A member that forms the lower boundary of the truss.

*Top Chord.* A member that forms the upper boundary of the truss.

*Chord Member.* A member that forms part of either the top or bottom chord.

*Member.* The component that lies between any adjacent joints of a truss; it can be of one or more pieces of structural material.

*Web Member.* A member that lies between the top and bottom chords.

*Joint.* Any point in a truss where two or more members meet; sometimes called a *panel point*.

*Panel Length.* The distance between any two consecutive joint centers in either the top or bottom chords.

*Pitch.* The ratio of the height of truss to the span length.

*Height of Truss.* The vertical distance at midspan from the joint center at the ridge of a pitched truss, or from the centerline of the top chord of a flat truss, to the centerline of the bottom chord.

*Span Length.* The horizontal distance between the centers of the two joints located at the extreme ends of the truss.

Figure 7-13. Truss terms

Step 8. After the holes have been bored, dismantle the truss and withdraw the nails.

### Truss Assembly

Assembling a truss after it has been cut and bored is simple (Figure 7-16). In most cases, timber connectors are used where different members of the truss join. Straight, sound timber should be used in trusses.

- Assemble the truss with the timber connectors in place.
- Place the bolts in the holes and tighten them.
- Place washers at the head and nut ends of each bolt.

Rafters are usually made into trusses, as shown in Figure 7-17. Two rafters are connected at the top, using a collar tie well nailed into both rafters. Before any ties or chords are nailed, the rafters should be spread at the lower end to equal the width of the

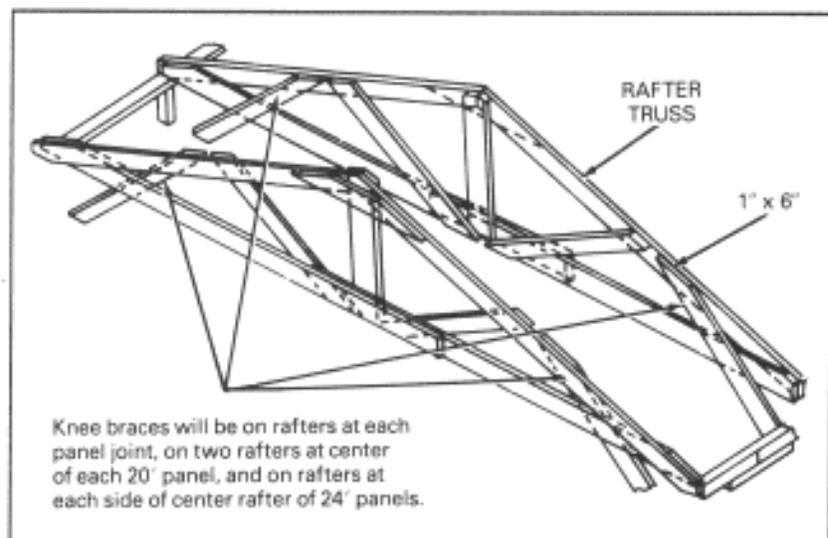


Figure 7-14. Knee braces

building. This is done by using a template or by measuring the distance between the seat cuts with a tape.

A 1 x 6 or 2 x 4 chord is nailed across the rafters at the seat cut to tie them together. This chord forms a truss with the two rafters. A hanger or vertical member of 1 x 6 is nailed to the rafter joint and extends to the chord at midpoint, tying the rafter to the chord.

In wide buildings where the joists or chords must be spliced and there is no support underneath, the rafter and joists support one another as shown in Figure 7-18.

If no additional bracing is needed, the truss is set in place on the plates. If additional bracing is needed, a knee brace is nailed to the chord. The knee brace forms a 45° angle with the wall stud. For easier erection, the knee brace may be omitted until the rafter truss is set in place.

Rafter framing without the use of ridgeboards may be done rapidly by using a truss assembly jig or template. The template is laid out to form a pattern conforming to the exact **exterior** dimensions of the truss.

**Layout.** Lay out a template as shown in Figure 7-19 and as follows:

*Step 1.* Measure and mark a straight line on any selected surface. Mark the exact length of the joists that will form the truss chord. This is baseline A.

*Step 2.* From the center of the baseline and at right angles to it, lay out a centerline (C) to form the leg of a right triangle, the base of which is half the length of the baseline (A), and the hypotenuse

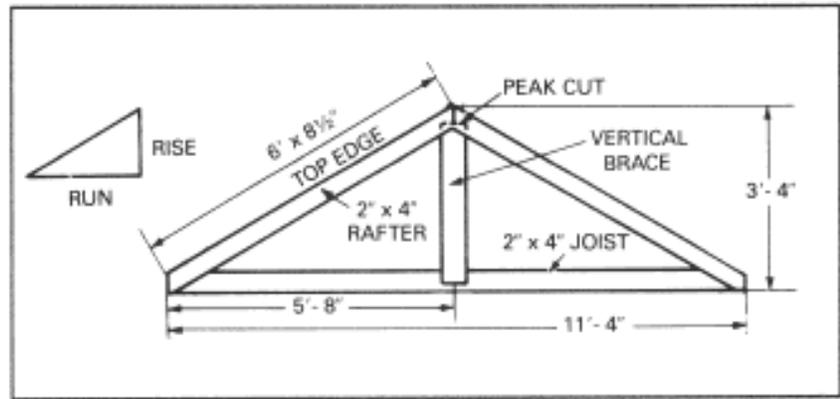


Figure 7-15. Truss layout

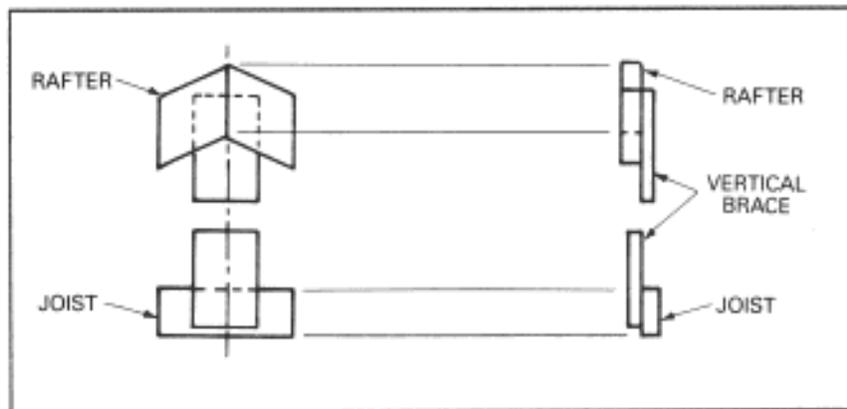


Figure 7-16. Truss assembly

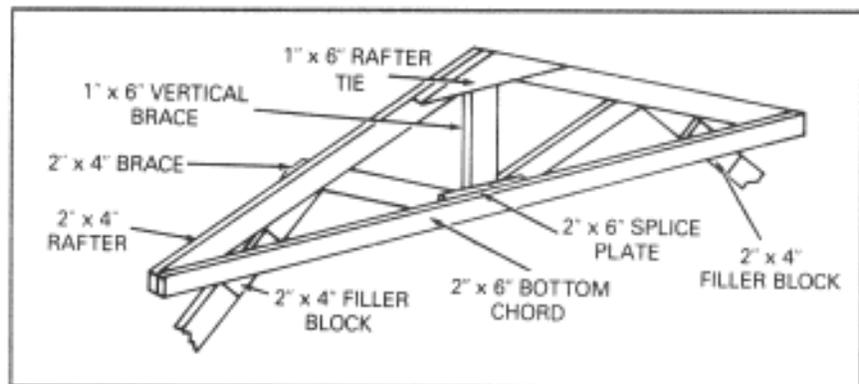


Figure 7-17. Assembling a typical truss

of which (B) is the length of the rafter measured as indicated.

*Step 3.* Nail 2 x 4 x 8 blocks flush with the ends of baseline A and centerline C as shown in Figure 7-19. Mark the centerline on the center jig blocks.

**Assembly.** Assemble with a template as shown in Figure 7-19 and as follows:

*Step 1.* Start the assembly by setting a rafter in the jig with the plate cut fitted over the jig block at one end of the baseline. The peak is flush with the centerline on the peak jig block. Nail a holding block outside the rafter at point D.

*Step 2.* Lay one 2 x 4 joist or chord in place across the base blocks.

*Step 3.* Lay two 2 x 4 rafters in place over the joist.

*Step 4.* Center one end of a 1 x 6 hanger under the rafter peak. Center the rafters against the peak block.

*Step 5.* Nail through the rafters into the hanger using six 8d nails.

*Step 6.* Line up one end of the chord.

*Step 7.* Nail through the rafter with 16d nails.

*Step 8.* Line up the other end of the chord.

*Step 9.* Nail as above.

*Step 10.* Center the bottom of the hangers on top of the chord and nail with 8d nails.

### Installation of Trusses

After the rafters are assembled into trusses, they must be placed on the building (Figure 7-20, page 7-14). Assemble the first set of rafters either in the end section of the building or at the center. Raise rafter trusses into position (by hand) and nail them into place with 16d nails. (Temporary workbenches may be built for the workers to stand on while erecting trusses.) These trusses must be temporarily braced at the end section of the building until the sheathing is applied. Knee braces are not used on every rafter truss unless

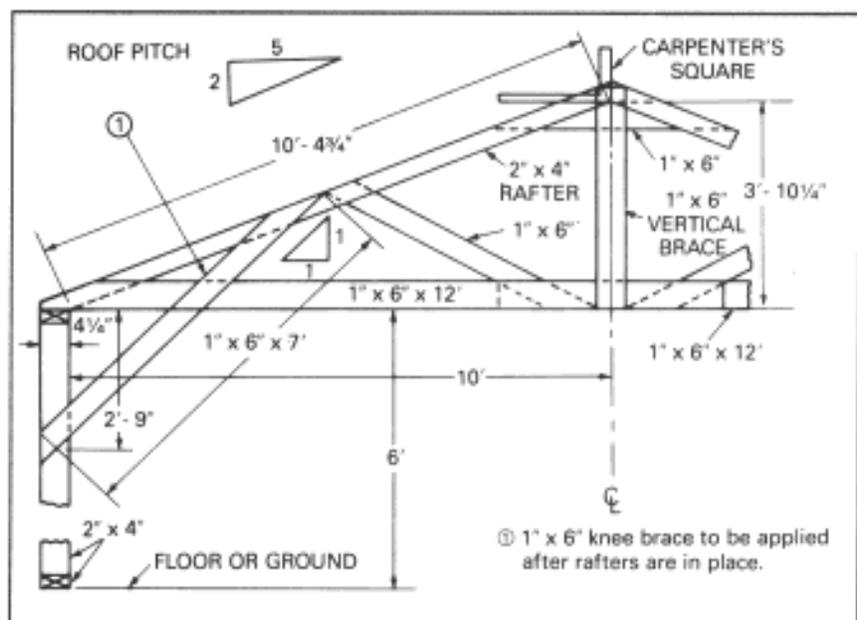


Figure 7-18. Truss- or rafter-support detail

needed. Install trusses as follows:

*Step 1.* Mark the proper positions of all truss assemblies on the top plate. The marks must show the exact position on the face of all rafters (such as south or north).

*Step 2.* Rest one end of a truss assembly, peak down, on an appropriate mark on the top plate on one side of the structure.

*Step 3.* Rest the other end of the truss on the corresponding mark of the top plate on the other side of the structure.

*Step 4.* Rotate the assembly into position using a pole or rope.

*Step 5.* Line up and secure the rafter faces flush against the marks.

*Step 6.* Raise, align, and nail the three assemblies into position. Nail temporary 1 x 6 braces across these three assemblies. Repeat with the other assemblies as they are brought into position. Check the rafter spacing at the peaks as the braces are nailed on.

*Step 7.* Braces may be used as a platform when raising those trusses for which there is not enough room for rotation (Figure 7-21).

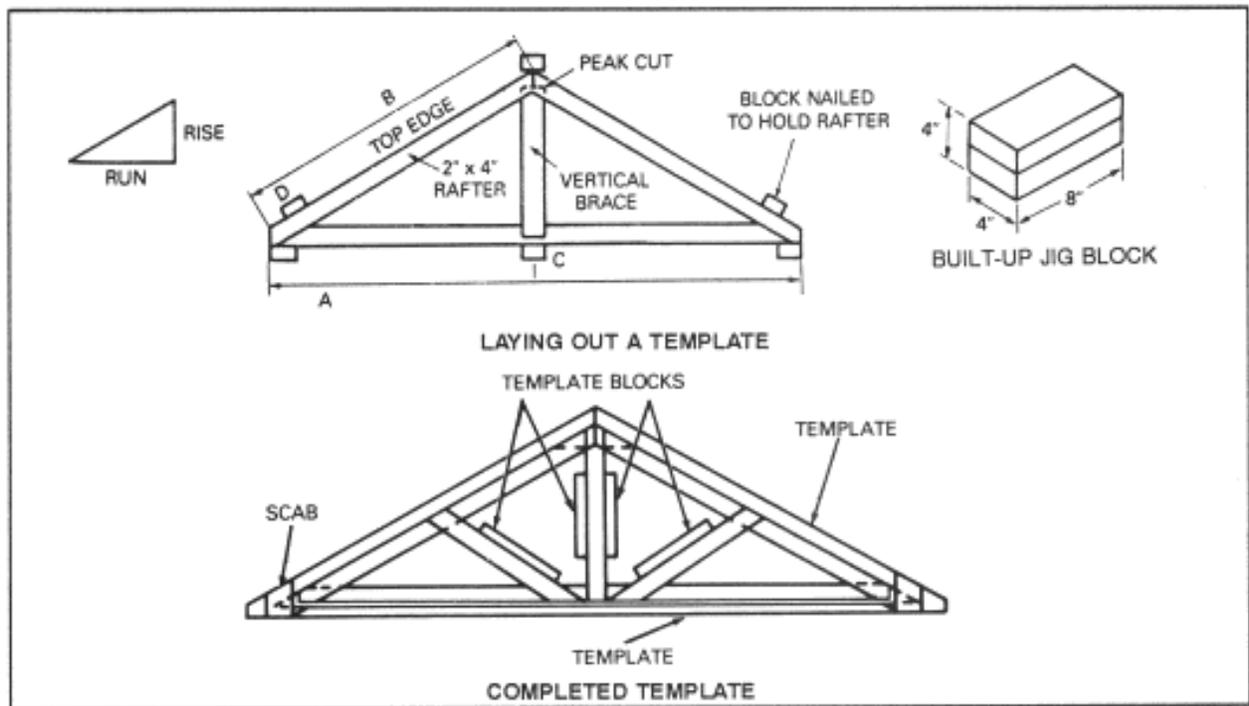


Figure 7-19. Laying out and assembling with a template

## ROOF OPENINGS

Major roof openings are those that interrupt the normal run of rafters or other roof framing. Such openings may be for ventilators, chimneys, trap-door passages, or skylight or dormer windows. Figure 7-22 shows roof-opening construction.

Roof openings are framed by headers and trimmers. Double headers are used at right angles to the rafters, which are set into the headers in the same way as joists in floor-opening construction. Trimmers are actually double rafter construction in roof openings. Nailing strips may be added if needed.

### ROOF DECKING

Procedures for installing plywood sheathing is similar to installing wall sheathing except it is laid perpendicular to the rafters and trusses.

### ROOF COVERINGS

Asphalt and asbestos-cement roof coverings are most frequently used on pitched-roof structures. Built-up roofing is used mainly on flat or nearly flat roofs.

### ASPHALT AND ASBESTOS-CEMENT ROOFING

Asphalt roofing comes in rolls (usually 3 feet wide) called *rolled roofing*, in rolled strips (usually 15 inches wide and 3 feet long), and as individual shingles. The type most commonly used is the flat strip, often called a strip shingle.

A 1 x 3 square-butt shingle is shown in Figure 7-23. This shingle should be laid 5 inches to *the weather*, meaning that 7 inches of each course should be overlapped by the next higher course. The lower, exposed end of a shingle is called the *butt*. The shingle shown in Figure 7-23 has a square butt divided into three tabs. Various other butt shapes are manufactured. Asbestos-cement roofing usually consists of individual shingles.

### Laying Asphalt Roofing

The first step in covering a roof is to erect a scaffold to a height which will bring the eaves about waist-high to a man standing on the scaffold.

Before any roof covering is applied, the roof sheathing must be swept clean and carefully inspected for irregularities, cracks, holes, or other defects. No roofing should be applied unless the sheathing boards are

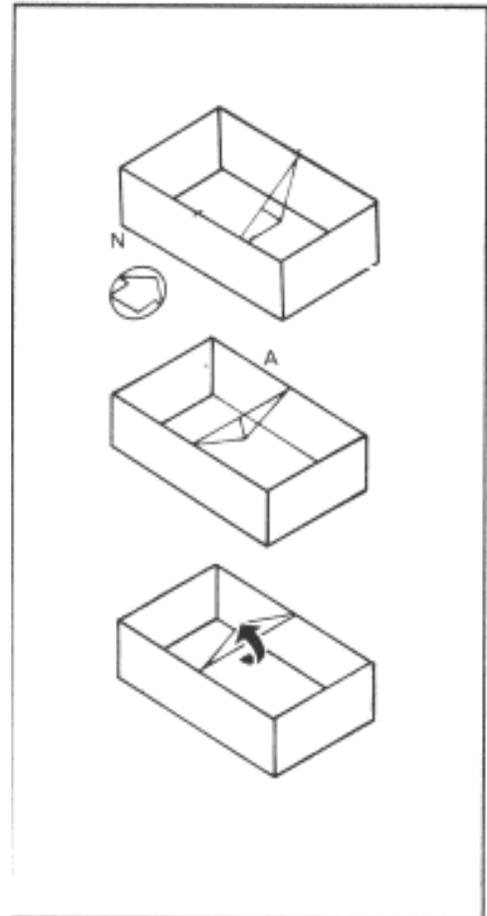


Figure 7-20. Erecting rafter trusses

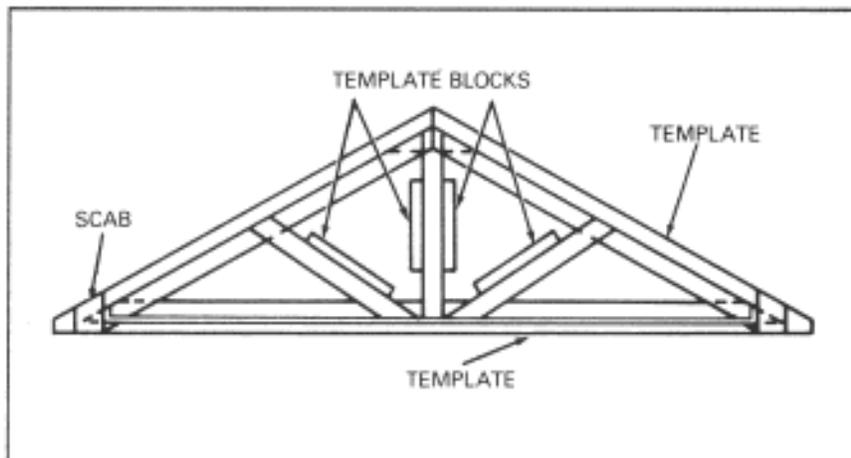


Figure 7-21. Temporary bracing

absolutely dry.

An underlay of roofing felt is first applied to the sheathing. Roofing felt usually comes in 3-foot-wide rolls and should be laid with a 2-inch top lap and a 4-inch side lap.

Bundles of shingles should be distributed along the scaffold before work begins. There are 27 strips in a bundle of 1 x 3 asphalt strip shingles. Three bundles will cover 100 square feet.

After the first course at the eaves (the *starter course*) is laid by inverting the first course of shingles or the starter strip of mineral-surfaced roll roofing, each course that follows is begun by stretching a guideline or by snapping a chalk line from edge to edge. This positions the course.

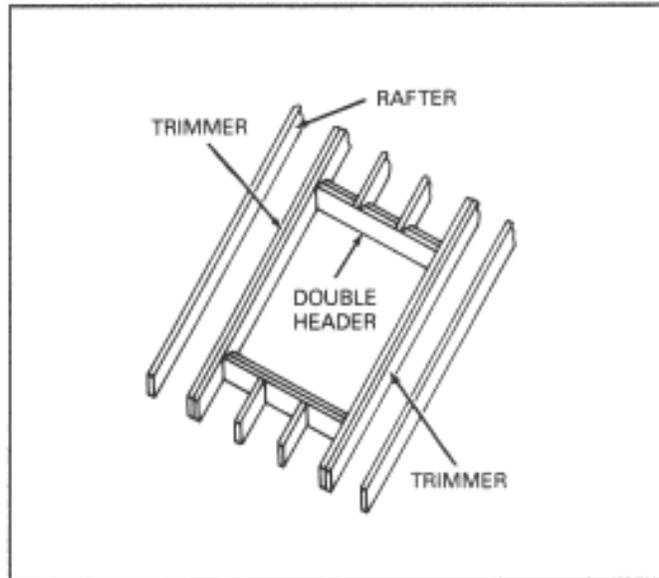


Figure 7-22. Roof-opening construction

Figure 7-24 shows the method of laying a 1 x 3 asphalt strip-shingle roof. Strip shingles should be nailed with 1-inch copper or hot-dipped, galvanized roofing nails, two to each tab; this means six nails to each full strip. Nails should be placed about 6 1/2 inches from the butt edges to ensure that each nail will be covered by the next course (*blind-nailing*) and driven through two courses.

An asbestos-cement roof is laid in about the same way as the asphalt strip shingles.

### Applying Shingles at Hips and Valleys

One side of a hip or valley shingle must be cut at an angle to obtain an edge line that will match the line of the hip or valley rafter. One way to cut these shingles is to use a pattern made as follows:

Select a piece of 1 x 6 material about 3 feet long. Determine the unit length of a common rafter in the roof. Set the framing square back up on the piece to the unit run of a common rafter on the tongue and the unit length of a common rafter on the blade, as shown in Figure 7-25, A. Draw a line along the tongue. Saw the piece along this line and use it as a pattern to cut the shingles as

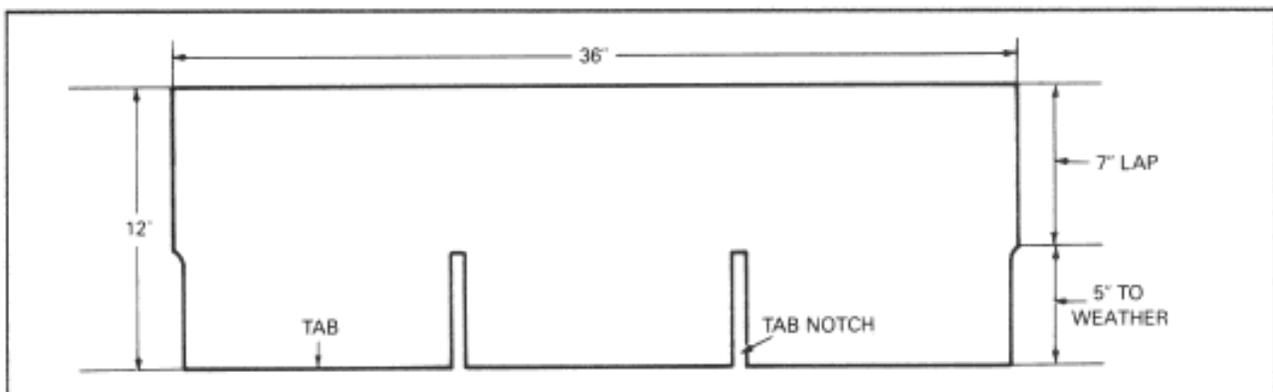


Figure 7-23. Square-butt asphalt strip shingle

shown in Figure 7-25, B.

### Installing Flashing

Places especially susceptible to leakage in roofs and outside walls are made watertight by the installation of *flashing*. Flashing is sheets or strips of a watertight, rustproof material (such as galvanized sheet or sheet copper alloy for valleys and felt for hips). Flashing deflects water from places that are susceptible to leakage. The places in a roof most subject to leakage are the lines along which adjoining roof surfaces intersect (such as the lines followed by ridges, hips, and valleys) and the lines of intersection between roof surfaces and the walls of dormers, chimneys, skylights, and the like.

Ridge lines and hip lines naturally tend to shed water; therefore, they are only moderately subject to leakage. A strip of felt paper usually makes a satisfactory ridge or hip flashing. The ridge or hip is then finished as shown in Figure 7-26. Squares are made by cutting shingles into thirds. The squares are then blind-nailed to the ridge or hip as shown in

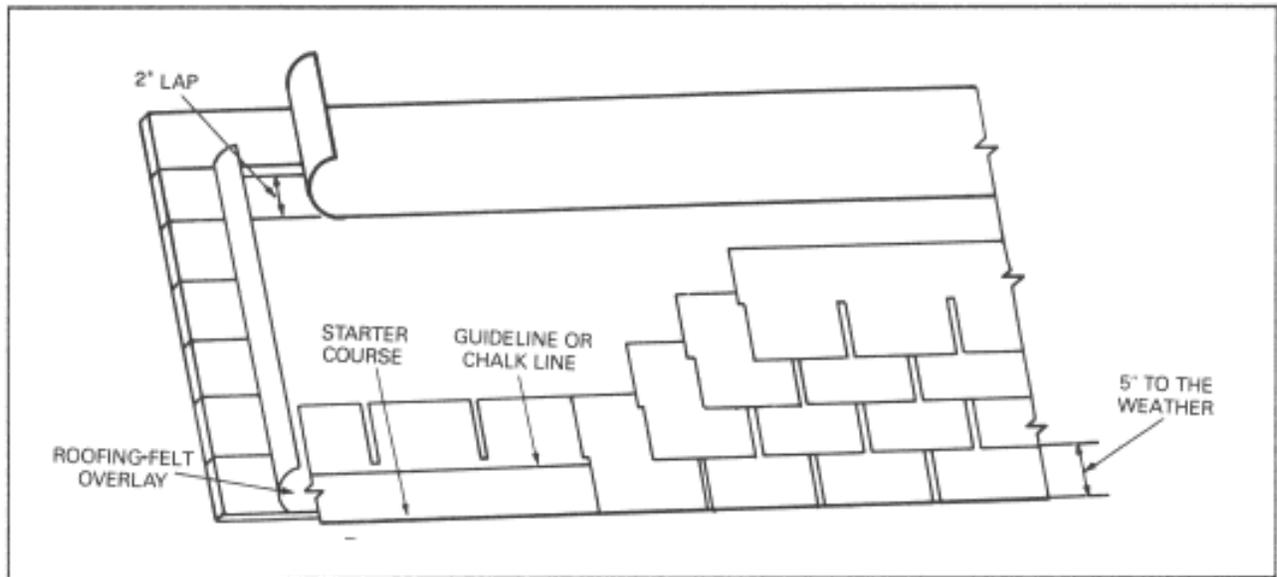


Figure 7-24. Laying an asphalt-shingle roof

Figure 7-26.

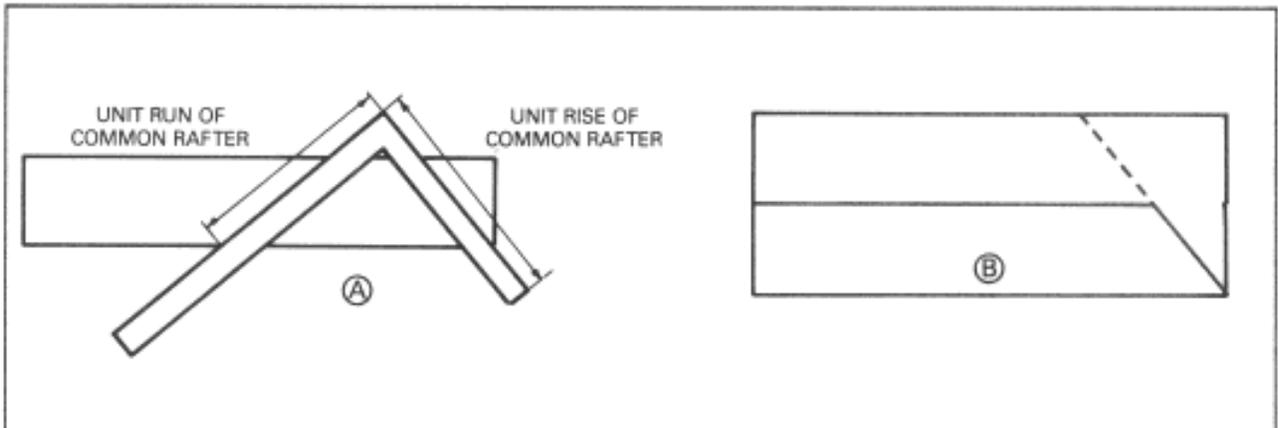


Figure 7-25. Laying out a pattern

Since water gathers in the roof valleys, they are more subject to leakage. Valley flashing varies with the manner in which the valley is to be finished. There are two common types of valley finish: the *open valley* and the *closed valley*.

Figure 7-27 shows part of an open valley. The roof covering does not extend across the valley. The flashing consists of a prefabricated piece of galvanized iron, copper, zinc, or similar metal, with a splash rib or ridge down the center and a small crimp at the edges. The flashing is nailed down to the valley, with nails driven in the edges (outside the crimps), as shown in Figure 7-27. Care must be taken not to drive nails through the flashing inside the crimps, to avoid leakage. Figure 7-28, page 7-18, shows an open valley using rolled roofing.

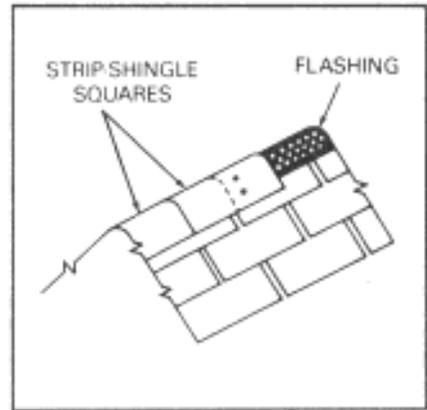


Figure 7-26. Hip or ridge flashing

In the closed valley, the roof covering extends across the valley. Sheet metal flashing is cut into small **sheets measuring**

**about 18 x 10 inches,** called *shingle tins*. This flashing is laid under each course of shingles, along the valley, as the course is laid. After the first course of the double course at the eaves is laid, the first sheet of flashing is placed on top of it. The second course is laid over this one so that the metal is partly covered by the next course. This procedure is continued all the way up the valley.

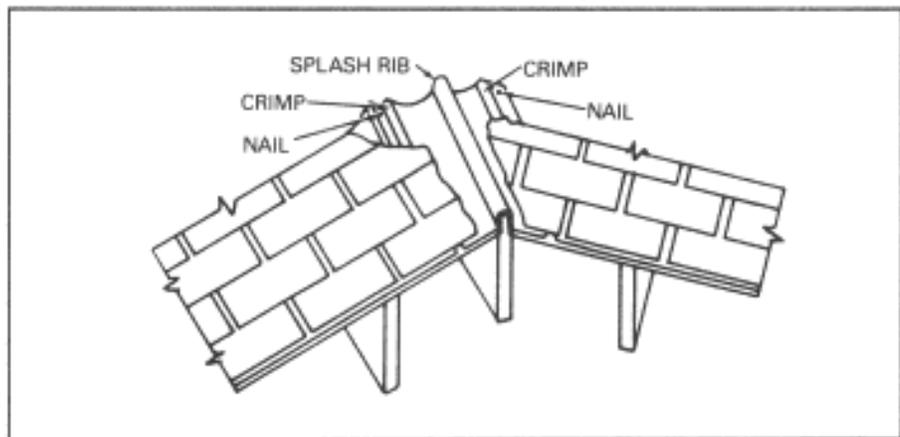


Figure 7-27. Open-valley flashing

Shingle tins measuring about 5 x 7 inches may also be used to lay flashing up the side walls of dormers, chimneys, skylights, and similar openings. Each tin is bent at a right angle so that part of the tin extends up the side wall and the rest lies flat on the roof covering. This is called *side flashing*. In addition to the side flashing, a dormer, chimney, or skylight has a strip of flashing called an *apron* along the bottom of the outer wall or face. A chimney or skylight has a similar strip, called the *saddle flashing*, along the bottom of the inner wall or face. Figure 7-29 shows vertical wall flashing.

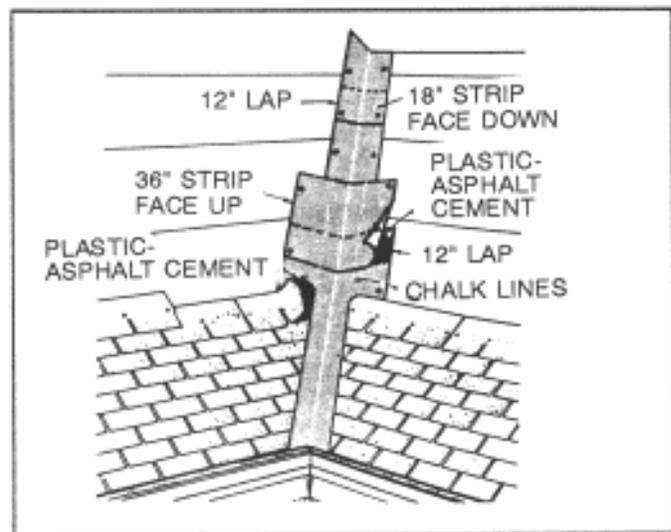


Figure 7-28. Open-valley flashing details using roll roofing

## BUILT-UP ROOFING MATERIAL

The following building papers are used on a built-up roof. Their purpose is to prevent the seepage of bitumen through roof sheathing on which a built-up roof has been applied.

- *Rosin paper* is a felt paper, usually pale red, filled with rosin compound.
- *Kraft paper* is a light brown paper that is usually glazed.
- *Sisal kraft* consists of two layers of glazed kraft paper with a center section of sisal embedded in a black bituminous compound and laminated by heat and pressure.
- *Roofing felt* is a felt paper that has been saturated with a bituminous compound (heavy pitch or asphalt oils). The basic ingredients are usually either asbestos or rag felts. The roll may vary from 32 to 36 inches wide. Weights for built-up roofing vary from 15 to 65 pounds per square. The 15-pound felt is most commonly used because of its light weight.

A binder is used to bond the roofing felt together and form a watertight seal. Asphalt and coal tar are the two main types of bituminous binders used.

Drying out of the binder causes deterioration of built-up roofs.

If this did not happen, a built-up roof would last indefinitely. Asphalt is the preferred binder. It is used on roofs sloping up to 6 inches per foot (1/4 pitch). Asphalt has a melting point of 350° to 410°F. A roof covered with asphalt should be protected with a covering of slag, gravel, or other protective material. Tar has a lower melting point (300° to 350°F) than asphalt, so it will move more easily; therefore, it is not recommended for roofs having a slope of more than 3 inches per foot (1/8 pitch).

Aggregate, crushed stone, or gravel from 1/4 to 5/8 inch in diameter is embedded in a coat of asphalt or tar to hold the roof covering down. It also prevents the binding from disintegrating because of the weather.

Gravel stops on slag or gravel-surfaced roofs, and metal-edge strips on smooth-surfaced built-up roofs are used to finish all exposed edges and eaves to prevent wind from getting under the edges and causing blowoffs. The gravel stop also prevents the loss of gravel or slag off the edge of the roof. The *flashing flange* of the gravel stop or edge strip is placed over the last ply of felt. It should be nailed securely to the roof deck and double felt stripped. Then the finished coat of bitumen and surfacing or cap sheet should be applied. The lip of the gravel stop should extend a minimum of 3/4 inch above the roof deck. The lip of the edge strip should be a maximum of 1/2 inch above the deck. Both should be securely fastened to the fascia board.

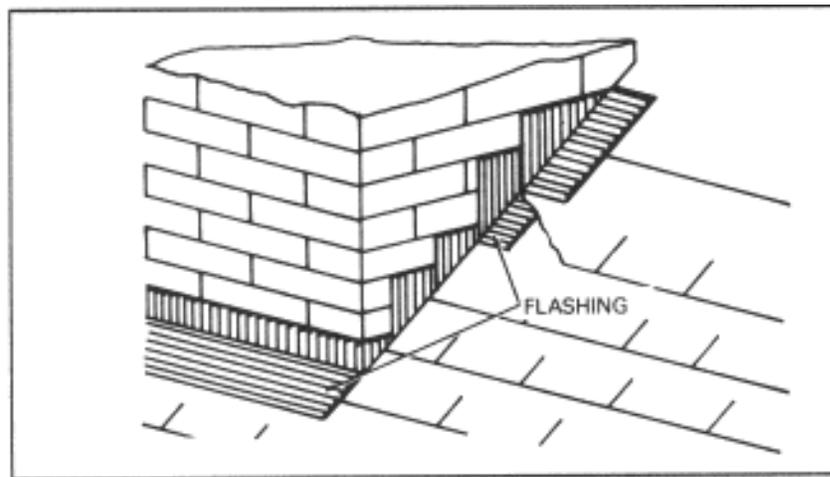


Figure 7-29. Vertical wall flashing

## RE ROOFING

This section provides information on reroofing for the following types of roofs: asphalt-shingle roofs, asphalt-prepared roll roofings, built-up roofs, slate roofs, tile roofs, asbestos-cement roofs, metal roofs, and wood-shingle roofs.

### ASPHALT-SHINGLE ROOFS

The following types of asphalt strip shingles are used for reroofing hospitals and mobilization-type buildings with pitched roofs. These shingles are applied directly over the existing roll roofings.

*Standard-weight shingles* should be four-tab, 10 x 36 inches, and intended for a 4-inch maximum exposure. Weight per square (100 square feet) applied should be approximately 210 pounds. Shingles are fastened with 1 1/4- or 1 1/2-inch nails with heads having a minimum diameter of 3/8 inch. Zinc-coated nails are best.

*Thick-butt shingles* should be three-tab, 1 x 3 feet, and intended for a 5-inch maximum exposure. The entire surface of the shingles should be covered with mineral granules. The bottom part of each shingle, including the part intended to be exposed and a section at least 1 inch above the cutout sections, should be thicker than the remainder of the shingle. Weight per square applied should be approximately 210 pounds. Shingles are fastened with 1 1/2- or 1 3/4-inch nails with heads having a minimum diameter of 3/8 inch. Zinc-coated nails are best.

### Preparation of Roof Decks

The following steps assume that the roof decks are covered with smooth or mineral-surfaced, asphalt-prepared roofing and that the shingles will be applied directly over the existing roofing.

*Step 1.* Drive in all loose and protruding nails flush with the existing roll roofing.

*Step 2.* Cut out all vertical and horizontal buckles and wrinkles in the existing roofing. Nail down the edges of the cuts with 3/4-inch or 1-inch roofing nails so that the entire roof deck is smooth.

*Step 3.* If shingles are applied over smooth-surfaced roofing or over mineral-surfaced roofing which does not match the shingles, apply an 18-inch starting strip of mineral-surfaced roll roofing at the eaves. Use roofing surfaced with granules of the same type and color as the shingles.

*Step 4.* Before the strips are applied, unroll them carefully and lay them on a smooth, flat surface until they lie perfectly flat.

*Step 5.* Nail starter strips at the top at about 18-inch intervals. The lower edge, bent down and nailed to the edge of the sheathing board, should extend about 3/4 inch beyond the edge of the board to form a drip edge. Space the nails in the edge of the sheathing board 6 inches apart.

A starter strip need not be used if the shingles are the same color as the existing roofing and the existing roofing is not buckled. Figure 7-30, page 7-20, shows an example of roof replacement.

### Application of Shingles

Shingles are attached in different ways, depending on the type.

**Standard-Weight, Four-Tab, 10- x 36-Inch Shingles.** Start the first course with a full shingle placed so that one edge, cut off flush with the tab, is also flush with the side of the roof. The bottoms of the tabs are placed flush with the eaves. Place nails about 3/4 inch above each cutout

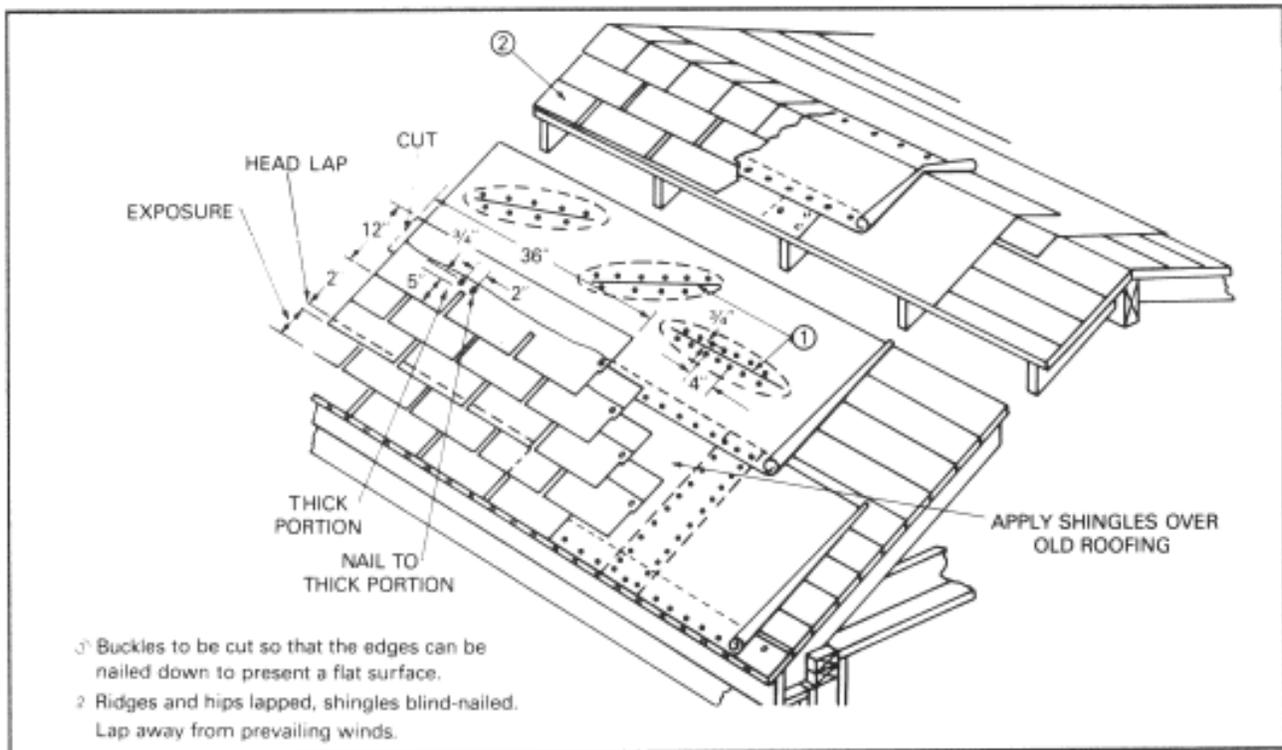


Figure 7-30. Roof replacement

section and in the same relative position at each end of the shingle. Use two nails at every cutout. Nail at the center first, then above the cutout sections nearest the center, and finally at the ends. Nailing may start at one end and proceed regularly to the other. Complete the first course with full-width shingles applied so that the ends barely touch each other.

Start the second course with a shingle from which half a tab has been cut. Place it so that the bottoms of the tabs are flush with the tops of the cutout sections of the shingle in the first course. Complete this course with full-width shingles.

Start the third course with a shingle from which one tab has been cut; the fourth with one from which one and one-half tabs have been cut; and so on, until eventually a full shingle is used again.

**Thick-Butt, Three-Tab Shingles.** Follow the same method described for standard shingles. Always nail these shingles through the thick part, about 3/4 inch above the cutout sections. The importance of nailing through the thick part of asphalt shingles cannot be emphasized too strongly. Practically all difficulties experienced with asphalt shingles on Army buildings have resulted from nailing the shingles too high.

**Hips and Ridges.** Finish hips and ridges with individual shingles furnished especially by the manufacturer or with shingles cut from strip shingles. Hips and ridges may also be finished with a strip of mineral-surfaced roofing 9 inches wide, bent equally on each side and nailed on 2-inch centers 3/4 inch from the edges.

**Open Valleys.** Open valleys may be flashed with 90-pound, 18-inch-wide mineral-surfaced asphalt roll roofing (Figure 7-31) placed over the valley underlayment. It is centered in the valley with the surfaced side down and the lower edge cut flush with the eaves flashing. When it is necessary to splice the material, the ends of the upper segments are laid to overlap the lower segments 12 inches and are secured with asphalt plastic cement. A 36-inch-wide strip is placed over the first strip, centered in the valley with the surfaced side up and secured with nails.

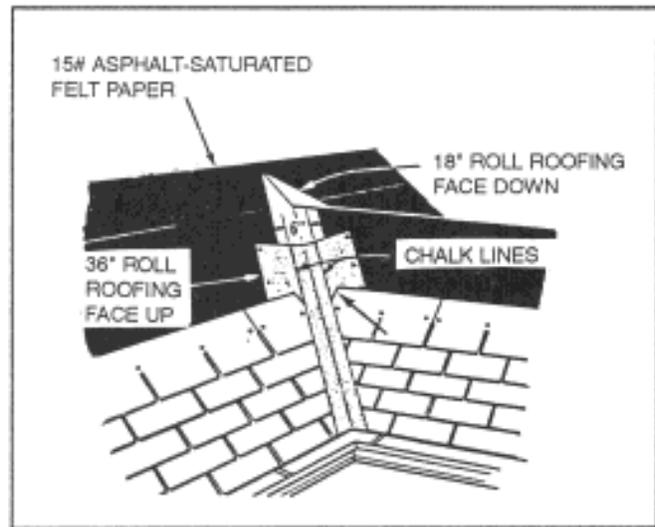


Figure 7-31. Open-valley flashing

Before shingles are applied, a chalk line is snapped on each side of the valley for its full length. The lines should start 3 inches from the valley on both sides. The chalk lines serve as a guide in trimming the shingle units to fit the valley. The upper corner of each end shingle is clipped to direct water into the valley (Figure 7-31). Each shingle is cemented to the valley lining with asphalt cement to ensure a tight seal. No exposed nails should appear along the valley flashing.

**Closed Valleys.** Closed valleys can be used only with strip shingles (Figure 7-32). This method has the advantage of doubling the coverage of the shingles throughout the length of the valley. A valley lining made from a 36-inch-wide strip of 55-pound (or heavier) roll roofing is placed over the valley underlayment and centered in the valley (Figure 7-32).

Valley shingles are laid over the lining by either of two methods:

- Applying both roof surfaces at the same time, with each course in turn woven over the valley.
- Covering each surface to the point approximately 36 inches from the center of the valley and the valley shingles woven in place later.

Either way, the first course at the valley is laid along the eaves of one surface over the valley lining and extended along the adjoining roof surface for at least 12 inches. The first course of the adjoining roof surface is then carried over the valley on top of the previously applied shingle. Each course thereafter is laid alternately, weaving the valley shingles over each other.

The shingles are pressed tightly into the valley and nailed in the usual manner except that no nail should be located closer than 6 inches to the valley centerline and two nails are used at the end of each terminal strip (Figure 7-32).

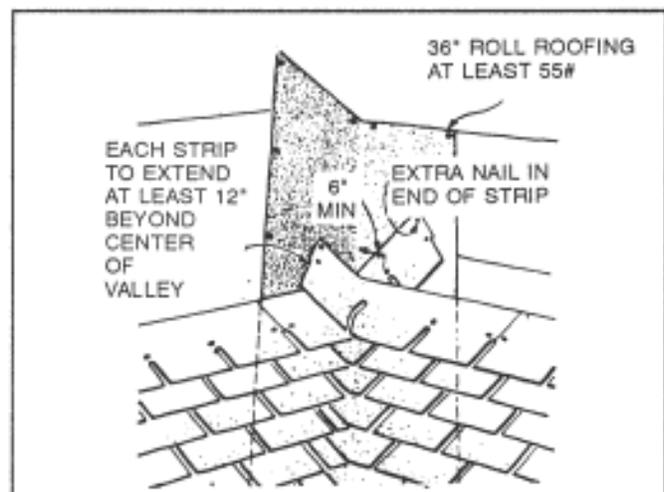


Figure 7-32. Closed-valley flashing using woven strip shingles

## **ASPHALT-PREPARED ROLL ROOFINGS**

There are two types of asphalt-prepared roll roofing: mineral-surfaced and smooth-surfaced.

### **Mineral-Surfaced Roll Roofing**

Mineral-surfaced, asphalt-prepared, two-ply roofing should consist of a layer of 15-pound asphalt-saturated felt and two plies of roll roofing, cemented together with hot asphalt. Cut roll-roofing material into lengths of 18 or 20 feet, stacked free from wrinkles and buckles in protected piles. Maintain the roofing material at a temperature of at least 50°F for 24 hours before laying.

First, cover the roof areas with a layer of 15-pound asphalt-saturated felt, with all joints lapped 2 inches. Nail as required to prevent blowing off during the application of roofing. Next, lay either plain, dry unsurfaced roofing or dry mineral-surfaced roofing as a starter sheet. Lay this upside down parallel to and flush with the eaves. Nail through tin or fiber disks on 12-inch staggered centers; that is, with one row of nails on 12-inch centers placed not more than 2 inches from the lower edge, and with a second row on 12-inch centers staggered with respect to the first and about 8 inches above the first.

Over the lower half of this sheet, apply a uniform coating of hot asphalt at the rate of 30 pounds per 100 square feet. Place the first sheet of roll roofing in the asphalt. Cover the entire roof area, lapping each successive sheet, to obtain a two-ply roofing with a 2-inch head lap. Cement the lower or mineral-surfaced portion of each sheet with hot asphalt to the preceding sheet. Nail the edge through tin or fiber disks on 12-inch staggered centers. Use two rows of nails. Place the first row on 12-inch centers not more than 2 inches above the mineral surfacing and the second row on 12-inch centers staggered with respect to the first and about 8 inches above the first.

Perform the work in such a way that no fastenings or asphalt will show on the finished surface. Apply the asphalt immediately before unrolling the sheet of roofing. Do not apply the asphalt more than 3 feet ahead of the roll. Step the edge of each sheet into the asphalt so that all laps are securely sealed. Place the end laps 6 inches in width with the underlying edges nailed on 6-inch centers, asphalt-cement the overlying edges, and step down firmly. Place one ply of roofing at eaves and edges, turn down neatly, and secure it with a wood member nailed on 8-inch centers.

### **Smooth-Surfaced Roll Roofing**

Before laying the roll-roofing material, cut it into 18-or 20-foot lengths. Stack them free of wrinkles and buckles in protected piles, and maintain them at a temperature of at least 50°F for 24 hours.

For TO construction, apply single-ply roll roofing horizontally with at least 4-inch side laps and 6-inch end laps. Nail the underlying edges of laps through tin or fiber disks on 6-inch centers. Cement overlying laps with hot asphalt or an approved cold-applied sealing compound. Step down firmly on the edges to provide proper adhesion. Double the roofing over the ridge with at least 4-inch laps. Turn roofing down neatly at eaves and edges. Nail the roofing in place on 6-inch centers. Figure 7-33 shows an example.

## **BUILT-UP ROOFS**

Buildings with roofs of relatively low pitch (less than 2 inches per foot), originally roofed with asphalt-prepared roll roofings, should be reroofed with smooth-surfaced asphalt built-up roofing or

with coal-tar-pitch built-up roofing.

Use smooth-surfaced asphalt built-up roofing on buildings with original smooth-surfaced roll roofing.

Use asphalt built-up roofing or coal-tar-pitch built-up roofing on mobilization-type buildings with roofs of relatively low pitch (usually 1/2 inch per foot), originally roofed with wide-selvage, mineral-surfaced roll roofing. If the roof is nearly flat so water collects and stands, the latter type of roofing is best. Asphalt roofs may be smooth- or mineral-surfaced. Coal-tar-pitch roofs must be mineral-surfaced.

## Asphalt Built-Up Roofs

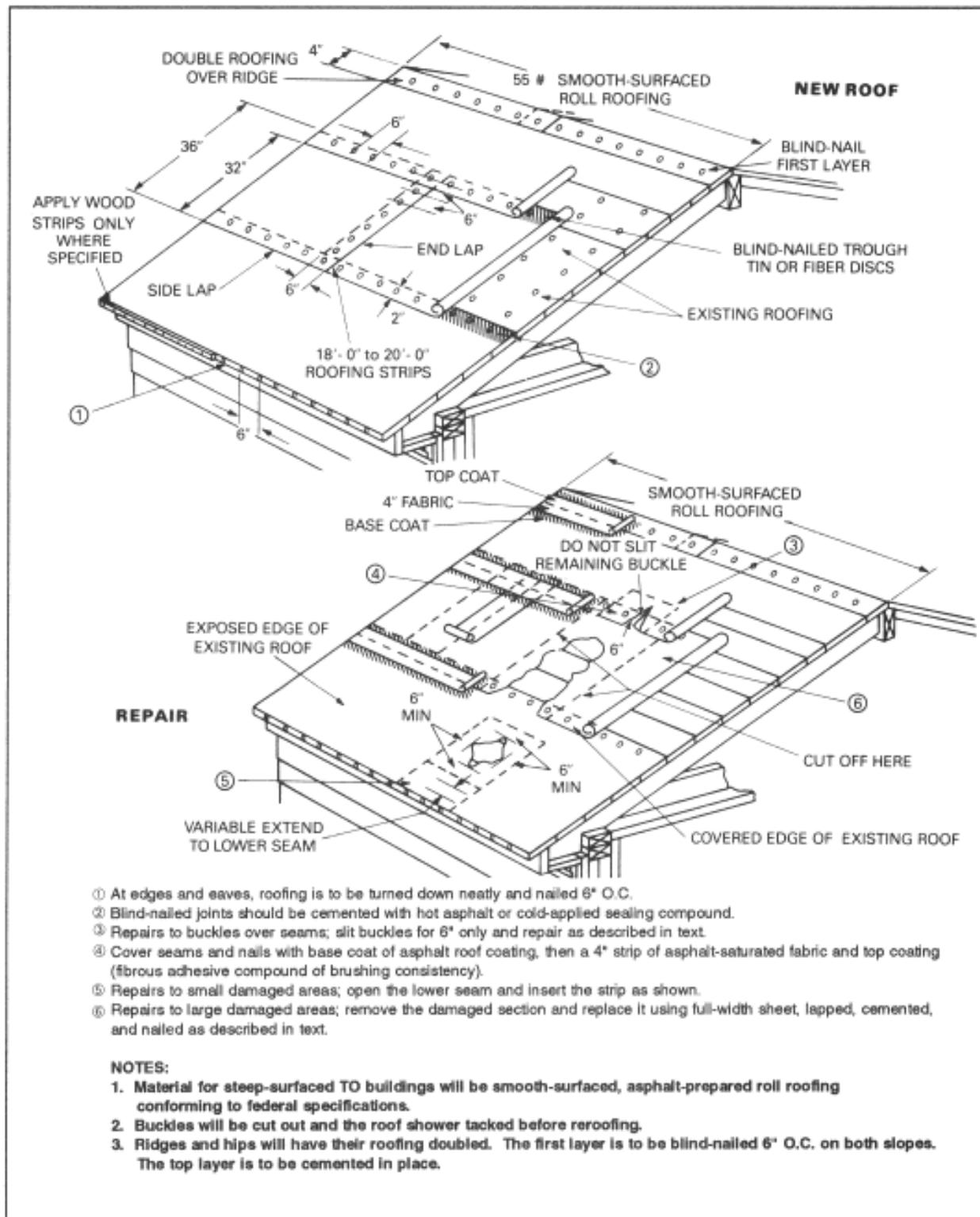


Figure 7-33. Smooth-surfaced roll roofing

Prepare the roof deck by driving in all loose and protruding nails and cutting out all

buckles and wrinkles. Then apply a three-ply, smooth-surfaced asphalt built-up roof as follows:

*Step 1.* Lay one layer of 15-pound asphalt-saturated felt over the entire surface. Lap each sheet 3 inches horizontally and vertically and nail the laps on 12-inch centers. Also nail through the center of each sheet on 12-inch centers staggered with respect to the nails at the horizontal laps. Use nails long enough to penetrate into the sheathing at least 3/4 inch. They should be driven through tin or hard fiber disks.

*Step 2.* Mop the entire surface with a uniform coating of hot asphalt, using 25 pounds per 100 square feet.

*Step 3.* Over this coating of asphalt, lay two additional layers of 15-pound, 36-inch, asphalt-saturated felt. Lap each sheet 19 inches, and lap the sheet ends not less than 6 inches. Nail these felts through tin or hard fiber disks 1 inch from the back edge on 12-inch centers. Use nails long enough to penetrate into the wood sheathing at least 3/4 inch.

*Step 4.* Mop each of these sheets the full width of the lap with hot asphalt, using 25 pounds per 100 square feet.

*Step 5.* Apply a uniform mopping of hot asphalt over the entire surface, using 30 pounds per 100 square feet of roof surface.

**NOTE: Do not heat asphalt above 400°F. Lay the felt while the asphalt is hot, taking care to keep the surface free from wrinkles or buckles.**

The materials needed per 100 square feet of roof surface for the three-ply, smooth-surfaced asphalt built-up roof are—

- Asphalt: 80 pounds.
- Asphalt-saturated felt: 45 pounds.

If the existing roofing is so rough that it is impossible to obtain a smooth surface by the method described above, remove the original roofing and apply a three-ply, smooth-surfaced, asphalt built-up roof. Substitute 30-pound asphalt-saturated felt for the 15-pound felt originally specified.

If a slag or gravel-surfaced roof is desired for mobilization-type buildings, at step 5 above, apply 45 pounds of hot asphalt instead of 30 pounds per 100 square feet. Into this hot coating, place 300 pounds of roofing slag or 400 pounds of roofing gravel per 100 square feet of roof surface.

### **Coal-Tar-Pitch Built-Up Roofs**

Prepare the roof surface as previously described, then apply a three-ply, coal-tar-pitch built-up roof as follows:

*Step 1.* Apply one layer of 15-pound coal-tar-saturated felt over the entire roof surface. Prepare it as described in step 1 of "Asphalt Built-Up Roofs."

*Step 2.* Mop the entire surface with a uniform coating of hot coal-tar pitch, using 30 pounds per 100 square feet.

*Step 3.* Over this coating of coal-tar pitch, lay two additional layers of 15-pound coal-tar-saturated felt 36 inches wide. Lap each sheet 19 inches over the preceding sheet. If 32-inch felt is used, lap each sheet 17 inches. Nail the felt 1 inch from the back edge on 12-inch centers through tin or hard fiber disks. Use nails long enough to penetrate into the wood sheathing at least 3/4 inch. Lap the ends of the sheets at least 6 inches.

*Step 4.* Mop each sheet the full width of the lap with hot coal-tar pitch, using 25 pounds per 100 square feet.

*Step 5.* Apply a uniform pouring of hot coal-tar pitch over the entire surface. Use 55 pounds per 100 square feet. While the pitch is hot, place over it 300 pounds of roofing slag or 400 pounds of roofing gravel per 100 square feet.

The materials required per 100 square feet of roof surface are—

- Coal-tar pitch: 110 pounds.
- Coal-tar-saturated felt: 45 pounds.
- Roofing slag: 300 pounds.

or

- Roofing gravel: 400 pounds.

**NOTE: Do not heat the coal-tar pitch above 375°F. Lay the felt while the coal-tar pitch is still hot, taking care to keep the surface free from wrinkles or buckles.**

## SLATE ROOFS

Very old slate roofs sometimes suffer failure because of the nails used to fasten the slates. In such cases, remove and replace the entire roof, including the felt underlay materials. Remove or drive in any protruding nails. Make every effort to obtain a smooth, even deck similar to the original one. Apply 30-pound asphalt-saturated felt horizontally over the entire roof deck. Lap the sheets not less than 3 inches. Turn them up 6 inches or more on vertical surfaces and **over** 12 inches or more on ridges and hips. Secure the sheets along laps and exposed edges with large-head roofing nails spaced about 6 inches apart.

Re-lay all original slates that are in good condition. Replace defective slates with new slates of the same size, matching the original color and texture as nearly as possible.

Recommended slate sizes for large new buildings are 20 or 22 inches long; for small new buildings, 16 or 18 inches long. Use slates of uniform length, in random widths, and punched for a head lap of not less than 3 inches.

Lay roof slates with a 3-inch head lap. Fasten each slate with two large-head slating nails and drive them so that their heads just touch the slate. Do not drive the nails "home." The opposite is true of wood shingles; therefore, workmen accustomed to laying wood shingles must nail slate carefully.

Bed all slates in an approved elastic cement on each side of hips and ridges within 1 foot of the top and along gable rakes within 1 foot of the edge. Match slate courses on dormer roofs with those on the main roof. Lay slate with open valleys.

## TILE ROOFS

Before reroofing with tiles, restore the roof deck as nearly as possible to its original condition. Replace defective boards and apply asphalt-saturated felt (30-pound type) or prepared roofing. Lap the sheets not less than 3 inches. Turn them up on vertical surfaces for at least 6 inches and **over** ridges and hips for at least 12 inches. Secure the sheets along laps and exposed edges with large-head roofing nails spaced about 6 inches apart.

Tiles must be free from fire cracks or other defects that will impair the durability, appearance, or weather tightness of the finished roof. Special shapes are provided for eaves starters, hips, ridges, top fixtures, gable rakes, and finials. Special shapes for field tile at hips and valleys may be factory-molded or may be job cut from whole tile and rubbed down to clean, sharp lines. Roof tiles for use on Army buildings are generally furnished in one or more of the following types:

- *Mission tiles* are straight-barrel-type, molded to a true arc and machine-punched for one nail and a 3-inch head lap. Use regular cover tile for ridges and hips. Finish with plain mission finials. Eaves closures and hip starters are available. Approved sizes are generally 8 inches wide by 14 to 18 inches long.
- *Spanish tiles* are S-shaped and machine-punched for two nails and a 3-inch head lap. Eaves closures and hip starters are available. Use mission-type cover tiles for hips and ridges. Approved sizes are generally 9 1/2 to 12 inches wide by 12 to 18 inches long.
- *Slab-shingle tiles* are the flat, noninterlocking type, punched for two nails and a 2-inch head lap. Approved sizes are 6 to 10 inches wide, 15 inches long, and 1/2 inch thick.

### Mission and Spanish Tiles

Before starting to lay tiles, mop the wood nailing strips with hot asphalt. Fill the spaces in back of the cant strips with asphalt cement. Lay tiles with open valleys. Set eaves closures back 3 inches from the lower edge of eaves tiles. Lay pan tiles with uniform exposure to the weather. Lay cover tiles in a uniform pattern, except where otherwise necessary to match existing roofs. Give all tiles a minimum lap of 3 inches and extend pan tiles 1 inch over the rear edge of the gutter.

Cut the tiles so that they meet projections with finished joints and point them up with roofer's cement. Waterproof the spaces between field tiles and wood nailing strips at ridges and hips with a fill of roofer's cement. Fit all tiles properly and then secure them with nails long enough to penetrate at least 1 inch into the wood base.

Fill spaces between pan and cover tiles in the first row at the eaves with solid cement mortar made of one part Portland cement, three parts fine sand, and enough clean water to form a plastic mix. Wet all tiles before applying mortar, then press them firmly into the mortar bed. Match the tile courses on dormer roofs with those on the main roof. Cut surplus mortar off neatly. Point up all open joints. Remove loose mortar from exposed surfaces.

Where hurricane winds can be expected, consider reinforcing tile roofs by laying all field tiles in Portland cement mortar. To do this, fill the ends of tiles at eaves, hips, ridges, rakes, and spaces beneath ridges solid with cement mortar. Fill the full width of laps between the tiles, both parallel and perpendicular to the eaves, with cement mortar.

### Slab-Shingle Tiles

Lay slab-shingle tiles with a 2-inch head lap. Secure each tile with two large-head roofing nails. Double the tiles at eaves and project them 1 inch over the rear edge of gutters. Lay all tiles within 1 foot of hips, ridges, and abutting vertical surfaces in roofer's cement. Lay 10- or 12-inch tiles with 1-inch head lap on the sides of dormers. Match the tile courses on dormer roofs with those on the main roof. Lay tile roofs with open valleys.

### **ASBESTOS-CEMENT ROOFS**

Before reroofing with asbestos-cement shingles, restore the roof deck as nearly as possible to its original condition. Replace defective boards, and apply new 30-pound asphalt-saturated felt or prepared roofing in horizontal courses. Lap the sheets not less than 3 inches. Turn them up at least 6 inches on vertical surfaces and **over** at least 12 inches on ridges and hips. Secure the sheets along laps and exposed edges with large-head roofing nails spaced about 6 inches apart.

Re lay all asbestos-cement shingles that are in good condition. Replace defective shingles with new shingles of the same size, matching the originals as nearly as possible in color and texture.

Lay each shingle with a 2-inch head lap and secure it with two large-head slating nails. Drive the nails so that their heads just touch the shingles. Do not drive the nails "home" as in laying wood shingles. Bed all shingles on each side of hips and ridges within 1 foot of the edge in an approved elastic slater's cement. Project the shingles 1 inch over the rear edges of gutters. Lay shingles with a 1-inch head lap on sides of dormers. Match the shingle courses on dormer roofs with those on the main roof. Lay shingles with open valleys.

### **METAL ROOFS**

To conserve critical materials, replace metal roofs with nonmetallic roofing materials.

### **WOOD-SHINGLE ROOFS**

When old roofing is removed—

- Restore the roof deck as nearly as possible to its original condition. Replace rotted boards and pull out or drive down all protruding nails.
- Install flashings and apply new shingles.

If the existing shingle roofs can be made smooth and can be nailed properly, apply new wood shingles directly over weathered wood-shingle roofs. Reroof over existing wood shingles as follows:

*Step 1.* Nail down or cut off curled and warped shingles. Nail loose shingles securely, and remove or drive down protruding nails.

*Step 2.* Cut off the old first-course shingles at the eaves just below the butts of the second course. Replace them with a 1 x 3 or 1 x 4 strip nailed flush with the eaves line.

*Step 3.* Cut back the shingles at the gable ends about 3 inches. Replace them with a 1 x 2, 1 x 3, or 1 x 4 strip nailed flush with the gable end.

*Step 4.* Remove weathered shingles at the ridge. Replace them with a strip of beveled siding, thin edge down, to provide a solid base for nailing the ridge shingles. Treat the hip the same as the ridges.

*Step 5.* Fill open valleys with wooden strips level with the old shingle surface or with a narrow strip placed across the 'V' of the valley to act as a support for new flashings.

*Step 6.* Inspect flashings carefully. Replace terne and galvanized flashings. Reuse old flashings if they are in good condition.

*Step 7.* Use the following nails in applying shingles over an existing roof:

- 5d box or special overroofing nails, 14-gauge, and 1 3/4 inches long for 16- and 18-inch shingles.
- 6d nails, 13-gauge, and 2 inches long for 24-inch shingles.

One square of roofing will need about 3 1/2 pounds of nails.

*Step 8.* Apply new shingles as recommended by their manufacturer.