ROUGH FRAMING — CHAPTER 6

After the foundation is built and the batter boards are removed, the carpenter builds the framework. The framework consists of beams, trusses, walls and partitions, flooring, ceilings, sheathing and siding, stairways, roof framing and coverings (Chapter 7), and doors and windows (Chapter 8). This chapter familiarizes the carpenter with materials, tools, and techniques used to build the framework.

TYPES OF FRAMING

Framing consists of *light, heavy,* and *expedient* framing.

LIGHT FRAMING

There are three principal types of framing for light structures: western, balloon, and braced. Figure 6-1, page 6-2, illustrates these types of framing and specifies the nomenclature and location of the various members.

Light framing is used in barracks, bathhouses, and administration buildings. Figure 6-2, page 6-3, shows some details of a 20-foot wide building (such as ground level, window openings, braces, and splices) and labels the framing parts.

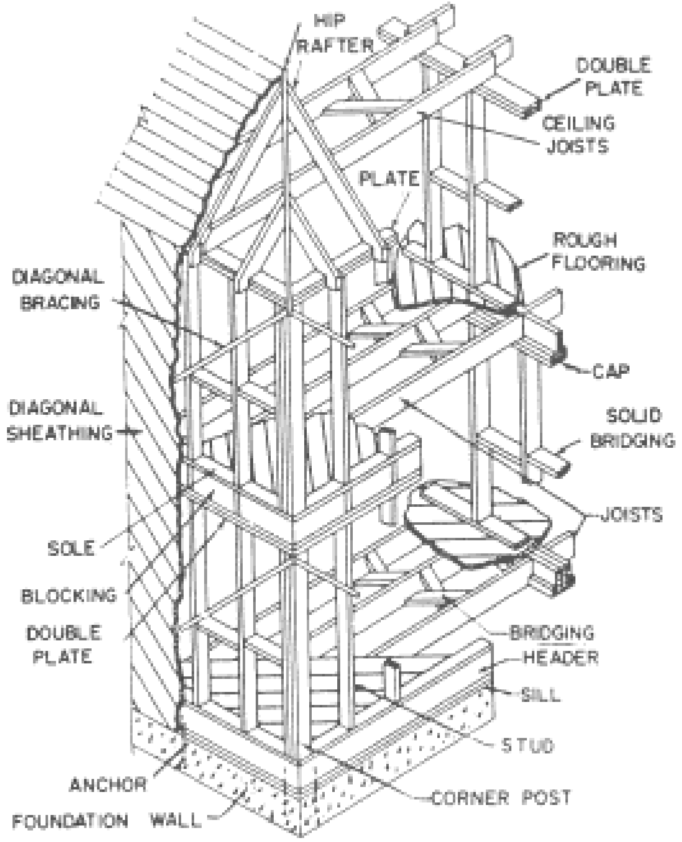
Much of light framing can be done in staging areas while staking out, squaring, and floor framing is being done. Subflooring can begin when a portion of the floor joists has been laid. The better-skilled men should construct the frame, and with good coordination, a large force of men can be kept busy during framing.

Western Frame

The western or platform frame (Figure 6-1, 1) is used extensively in military construction. It is similar to the braced frame, but has boxed-sill construction at each floor line. Also note that cross bridging is used between the joists and bridging is used between the studs. The platform frame is preferred for one-story structures since it permits both the bearing and nonbearing walls (which are supported by the joist) to settle uniformly.

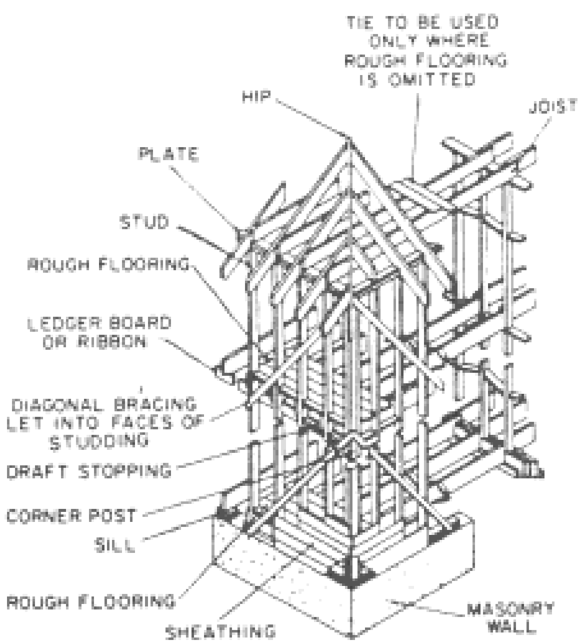
Balloon Frame

The balloon frame (Figure 6-1, 2) is a widely used type of light framing. The major difference between balloon and braced framing in a multistory building is that in balloon framing the studs run the full length, from sill to rafters. It is customary for second-floor joists to rest on a 1- x 4-inch ribbon that has been set into the studs. The balloon frame is less rigid than a braced frame.

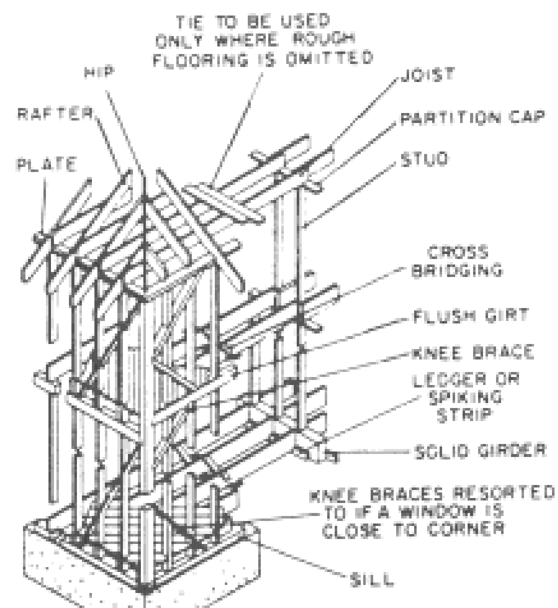


NOTE: STANDARD SPACING FOR STUDS SHOULD BE 16 INCHES CENTER TO CENTER TO RECEIVE STANDARD-SIZE SHEETS OF PLASTERBOARD, SHEETROCK, PLYWOOD, AND SO ON. JOISTS ARE ORDINARILY SPACED SIMILARLY UNLESS STRAPPING OR FURRING STRIPS ARE USED. ROUGH FLOORS, WHERE LAID DIAGONALLY, GIVE ADDITIONAL STRENGTH TO THE STRUCTURE; HOWEVER, WHERE LAID HORIZONTALLY, ECONOMY OF MATERIAL IS OBTAINED. EXTERIOR WALLS SHOULD BE BRACED WITH DIAGONAL BRACES FOR STIFFENING PURPOSES WHEN HORIZONTAL SHEATHING IS USED.

1. WESTERN- (OR PLATFORM-) FRAME CONSTRUCTION



2. BALLOON-FRAME CONSTRUCTION



3. BRACED-FRAME CONSTRUCTION

Figure 6-1. Framing for light structures

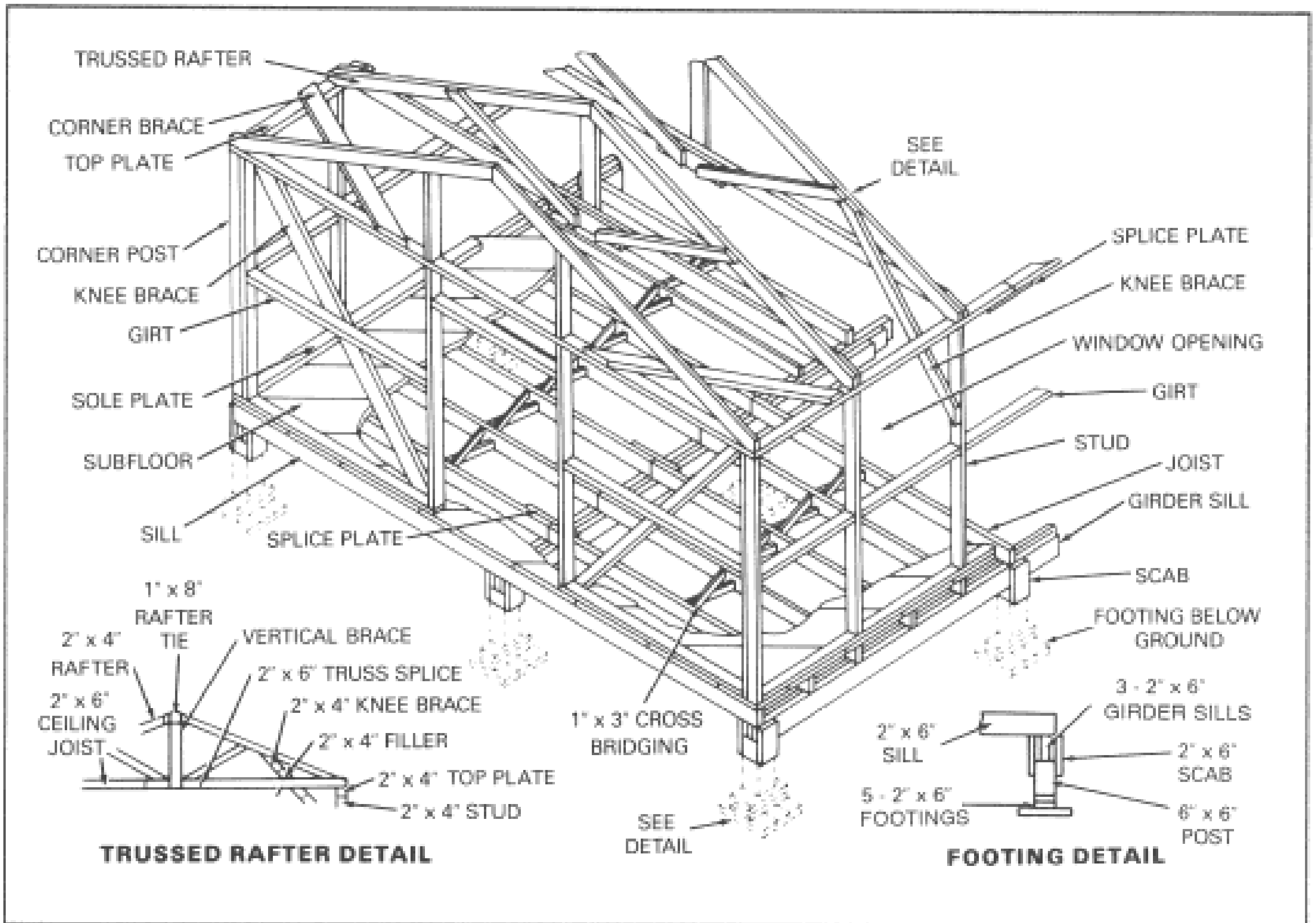


Figure 6-2. Light-framing details

Braced Frame

A braced frame (Figure 6-1, 3) is much more rigid than a balloon frame. Exterior studs extend only between floors and are topped by girts that form a sill for the joists of the succeeding floor. Girts are usually 4 x 6 inches. With the exception of studs, braced frame members are heavier than those in balloon framing. Sills and corner posts are customarily 4 x 6 inches. Unlike the studs, corner posts extend from sill to plate. Knee braces, usually 2 x 4 inches, are placed diagonally against each side of the corner posts. Interior studding for braced frames is the same as for balloon-frame construction.

HEAVY FRAMING

Heavy-frame buildings are more permanent, and are normally used for warehouses and shops. Heavy framing is seldom used in TO construction. Figure 6-3, page 6-4, shows the details of heavy framing. Heavy framing consists of framing members at least 6 inches in dimension (timber construction). Long, unsupported areas between walls are spanned by built-up roof trusses.

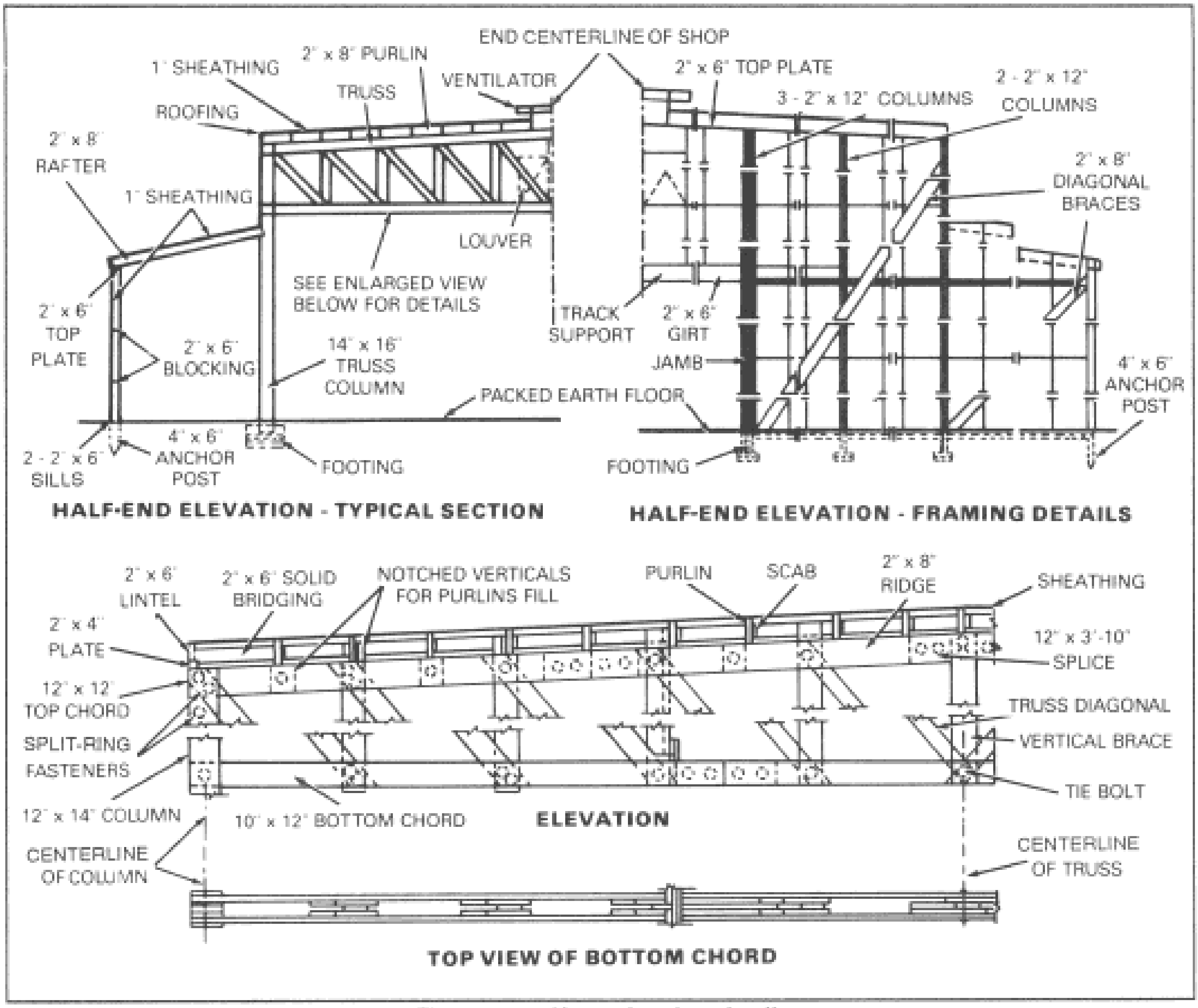


Figure 6-3. Heavy-framing details

EXPEDIENT FRAMING

Some field conditions require expedient framing techniques. For example—

- Light siding. Chicken wire and water-resistant bituminous paper can be sandwiched to provide adequate temporary framing in temperate climates.
- Salvaged framing. Salvaged sheet metal, such as corrugated material or gasoline cans, can be used as siding in the construction of emergency housing.
- Local timber. Poles trimmed from saplings or bamboo can be constructed into reasonably sound framing and may be secured with native vines if necessary.
- Wood-substitute framing. Adobe (soil, straw, and water—mixed until spreadable) can be used to form walls, floors, and foundations. A similar mixture may be used to form sun-dried bricks.
- Excavations. Proper excavation and simple log cribbing may also be covered with sod and carefully drained to give adequate shelter.

CONNECTIONS

Weak points in a structure usually occur at the connections (joints and splices) between pieces of lumber. However, these connections can be structurally sound if done correctly. Such weak points are usually a sign of poor workmanship.

JOINTS

Joints are connections between two pieces of timber that come together at an angle. The types of joints most commonly used in carpentry are butt joints and lap joints.

Butt Joints

A butt joint is formed by placing the end of one board against another board so that the boards are at an angle (usually a right angle), forming a corner. The types of butt joints are shown in Figure 6-4 and are described below.

Straight Butt Joint. This joint is formed by placing the square-cut end of one board against the square face of another. The butt end of one board should be square and the face of the other board smooth so that they fit perpendicular to each other. Select the right type of nails or screws to hold such a joint securely. For framing, butt joints are secured by 8d or 10d nails that are toenailed to strengthen the joint. The end grain is the weakest part of a piece of wood when used in joints. A butt joint is made at either one or two end-grain parts. It will be no stronger than the quality of those parts. A butt joint is, therefore, the weakest type of joint. This is especially true if the joint is made of two pieces of wood only.

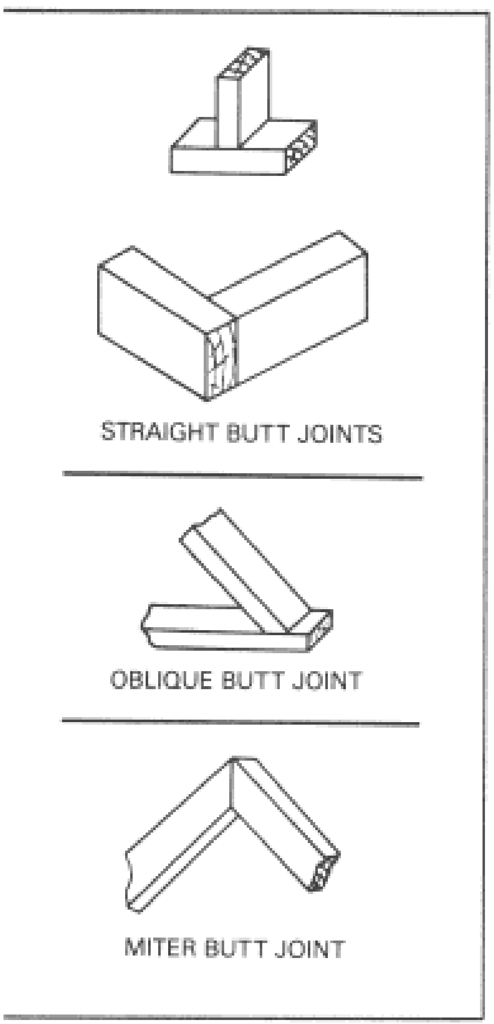


Figure 6-4. Butt joints

Oblique Butt Joint. This joint is formed by butting the mitered end of one board against the face of another board. Bracing is typically made with this joint. It should not be used where great strength is required. The strength of the oblique butt joint depends upon the nailing. The nail size

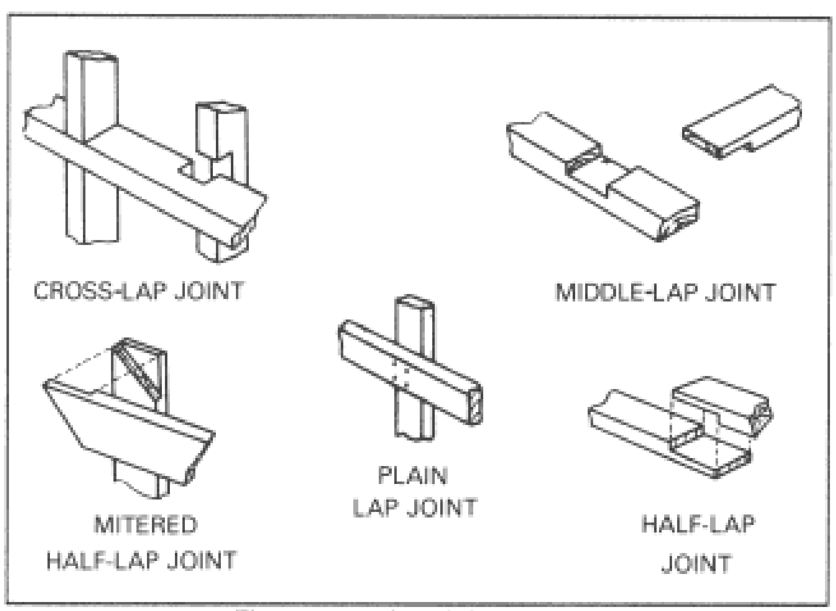


Figure 6-5. Lap joints

depends upon the timber size. Nails should be toenailed to strengthen the joint; not too many nails should be used.

Miter Butt Joint. This joint is formed by bringing the mitered ends of two boards together to form the desired angle. This joint is normally used at corners where a straight butt joint would not be satisfactory. To form a right-angle miter joint (the most commonly used), cut each piece at a 45° angle so that when the pieces are joined they will form a 90° angle. The miter joint is used mostly in framing. *However, it is a very weak joint and should not be used where strength is important.*

Lap Joints

The lap joint is the strongest joint. Lap joints (Figure 6-5) are formed in one of two ways: a plain lap joint or a half-lap splice joint.

Plain Lap Joint. This joint is formed by laying one board over another and fastening the two with screws or nails. This is the simplest and most often used method of joining. This joint is as strong as the fasteners and material used.

Half-Lap Splice Joint. This joint is formed by cutting away equal-length portions (usually half) from the thickness of two boards. The two are then joined so that they overlap and form a corner. Overlapping surfaces must fit snugly and smoothly. Overlaps should be sawed on the waste side of the gauge line, to avoid cutting laps oversize by the thickness of the cut. *This joint is relatively strong and easy to make.*

NOTE: Some useful variations of the half-lap joint are the cross-lap, the middle-lap, and the mitered half-lap joints.

SPLICES

Splices connect two or more pieces of material that extend in the same line. The joint will be as strong as the unjoined portions. The type of splice used depends on the type of stress and strain that the spliced timber must withstand.

- *Vertical supports* (longitudinal stress) require splices that resist compression.
- *Trusses, braces, and joists* (transverse and angular stress) require splices that resist tension.
- *Horizontal supports,* such as girders or beams, require splices that resist bending tension and compression.

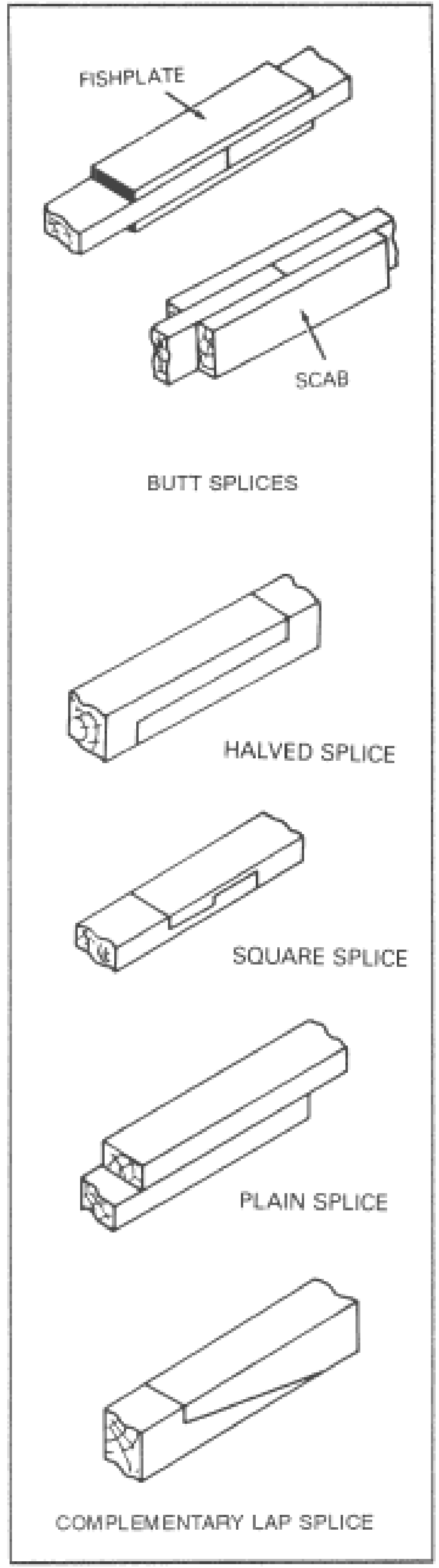


Figure 6-6. Splices

For example, splices for resisting compression are usually worthless for resisting tension or bending. Figure 6-6 shows splice types; Figure 6-7 shows splice stresses.

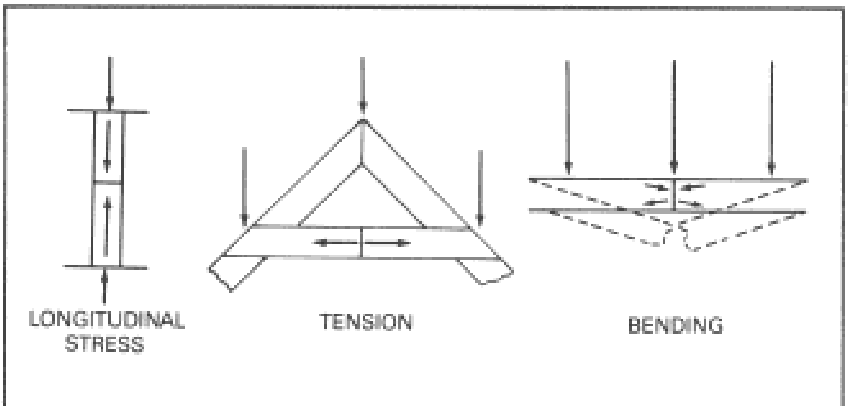


Figure 6-7. Splice stresses

Compression-Resistant Splices. Compression-resistant splices support weight or exert pressure and will resist compression stress only. The most common types of compression-resistant splices are the *butt splice* and the *halved splice.*

Butt Splice. This splice is constructed by butting the squared ends of two pieces of timber together and securing them in this position with two wood or metal pieces fastened on opposite sides of the timber. The two short supporting pieces keep the splice straight and prevent buckling. Metal plates used as supports in a butt splice are called *fishplates.* Wood plates are called *scabs* and are fastened in place with bolts or screws. Bolts, nails, or corrugated fasteners may be used to secure scabs. If nails are used with scabs, they are staggered and driven at an angle away from the splice. Too many nails, or nails that are too large, will weaken a splice.

Halved Splice. This splice is made by cutting away half the thickness of equal lengths from the ends of two pieces of timber, then fitting the tongues (laps) together. The laps should be long enough to provide adequate bearing surfaces. Nails or bolts may be used to fasten the halved splice. **Note: To give the halved splice resistance to tension as well as compression, fishplates or scabs may be used.**

Tension-Resistant Splices

In members such as trusses, braces, and joists, the joint undergoes stress in more than one direction; this creates tension, buckling the member in a predictable direction. Tension-resistant splices provide the greatest practical number of bearing surfaces and shoulders within the splice.

Square Splice. This splice is a modification of the compression halved splice. Notches are cut in the tongues or laps to provide an additional locking shoulder. The square splice may be fastened with nails or bolts. **Note**: **It may be greatly strengthened by using fishplates or scabs.**

Long, Plain Splice. This splice is a hasty substitute for the square splice. A long overlap of two pieces is desirable to provide adequate bearing surface and enough room for fasteners to make up for the lack of shoulder lock.

Bend-Resistant Splices

Horizontal timbers supporting weight undergo stress at a splice that results in compression of the upper part; this has a tendency to crush the fibers. Tension of the lower part also tends to pull the fibers apart. Bend-resistant splices resist both compression and tension. Make a bend-resistant splice as follows:

Step 1. Cut oblique, complementary laps in the end of two pieces of timber.

Step 2. Square the upper lap (bearing surface) to butt it against the square of the other lap. This offers maximum resistance to crushing.

Step 3. Bevel the lower tongue.

Step 4. Fasten a scab or fishplate along the bottom of the splice to prevent separation of the pieces.

NOTE: **When this splice cannot be done, a butt joint, halved splice, or square splice secured by fishplates or scabs may be used.**

SILLS

There are four types of wood sill construction: platform construction, balloon-framed construction, braced-framed construction, and the builtup sill. The sill is the foundation that supports a building and is the first part of a building to be set in place. It rests directly on the foundation posts or on the ground and is joined at the corners and spliced when necessary. Figure 6-8, page 6-8, shows the most common sills. The type of sill used depends on the type of construction used in the frame. To prevent air from entering into the building, spread a thin bed of mortar on top of the foundation wall. This also provides a solid base for the sill. Another technique is to use a sill sealer made of fiberglass. Place insulation material and a termite shield under the sill if desired.

PLATFORM CONSTRUCTION

Box sills are commonly used with platform framing, which is the most common type of framing. These may be used with or without the sill plate.

The sill or sill plate is anchored to the foundation wall for supporting and fastening joists with a header at the end of the joists resting on the foundation wall. In this type of sill, the sill is laid edgewise on the outside edge of the sill plate.

BALLOON-FRAMED CONSTRUCTION

“T” sills are usually used in balloon framing. There are two types of T-sills: one for dry, warm climates and one for colder climates. They are made the same, except that in the latter case the joists are nailed directly to the studs and sills and headers are used between the floor joists.

BRACED-FRAMING SILLS

Braced-framing sills (Figure 6-8) are usually used in braced-framing construction. The floor joists are notched and nailed directly to the sill and studs.

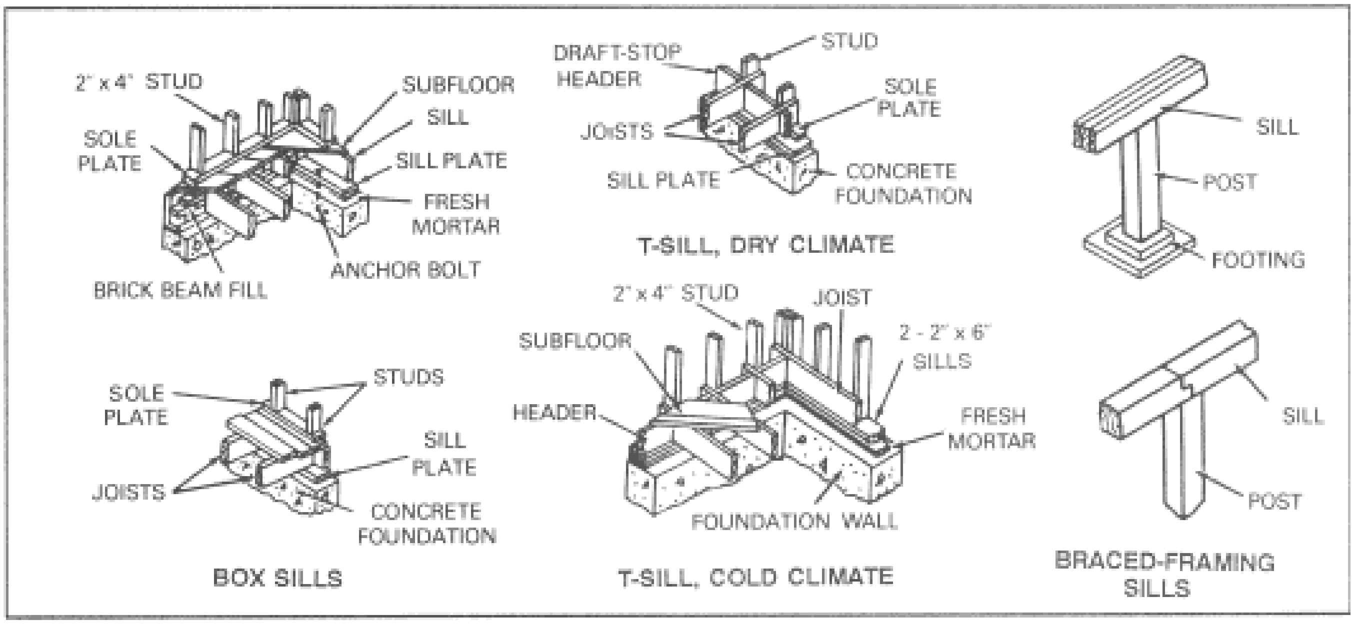


Figure 6-8. Types of sills

BUILT-UP SILLS

If posts are used in the foundation, use either sills made of heavy, single timbers or built-up sills. Built-up sills are made with two or more light timbers, such as 2 x 4s. A built-up sill is used when heavy, single timbers are not available and lighter lumber (such as a 2 x 4) alone would not support the building load. Figure 6-9 shows how to make a corner joint for a builtup sill.

Whether heavy timber or built-up sills are used, the joints should be over posts. The size of the sill depends on the load to be carried and the spacing of the posts. The sill plates are laid directly on the post or, in expedient framing, directly on graded earth. When earth floors are used, nail the studs directly to the sill.

GIRDERS

The distance between two outside walls is usually too great to be spanned by a single joist. A *girder is* used for intermediate support when two or more joists are needed to cover the span. A girder is a large beam that supports other smaller beams or joists. A girder may be made of timber, steel, reinforced concrete, or a combination of these materials.

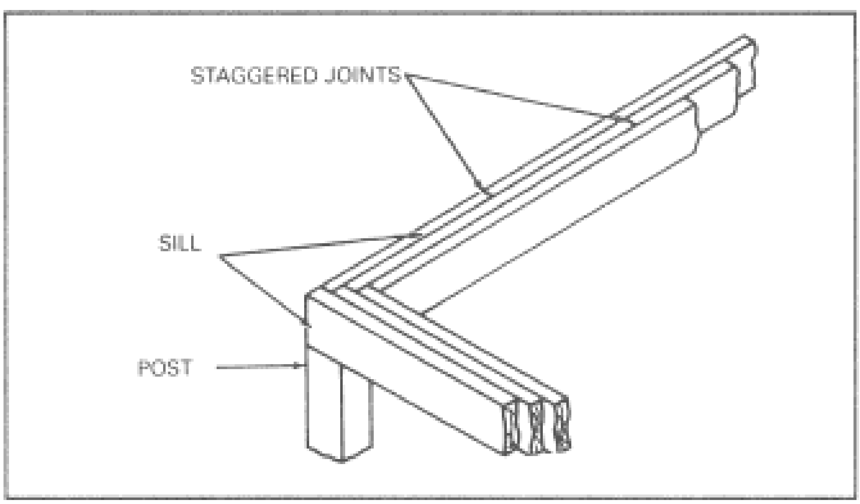


Figure 6-9. Corner joint of a built-up sill

Wooden girders are more common than steel in light-frame buildings. Built-up and solid girders should be of seasoned wood. Common types of wood girders include solid, built-up, hollow, and glue-laminated. Hollow beams resemble a box made of 2 x 4s, with plywood webs. They are often called box beams. Built-up girders are usually made of several pieces of framing lumber (Figure 6-10). Built-up girders warp less easily than solid wooden girders and are less likely to decay in the center.

Girders carry a large part of the building weight. They must be rigid and properly supported at the foundation walls and on the columns. They must be installed properly to support joists. The ends of wood girders should bear at least 4 inches on posts.

CAUTION Precautions must be taken to avoid or counteract any future settling or shrinking, which would cause distortion of the building.

A girder with a ledger board is used where vertical space is limited. This provides more headroom in basements and crawl spaces. A girder with joist hangers is used where there is little headroom or where the joists must carry an extremely heavy load. These girders are shown in Figure 6-11, page 6-10.

SIZE REQUIREMENTS

Carpenters should understand the effect of length, width, and depth on the strength of wood girders before attempting to determine their size.

Principles that govern the size of a girder are the—

- Distance between girder posts.
- Girder load area.
- Total floor load on the girder per square foot.
- Load on the girder per linear foot.
- Total load on the girder.
- Material to be used.
- Wood moisture content and types of wood used, since some woods are stronger than others.

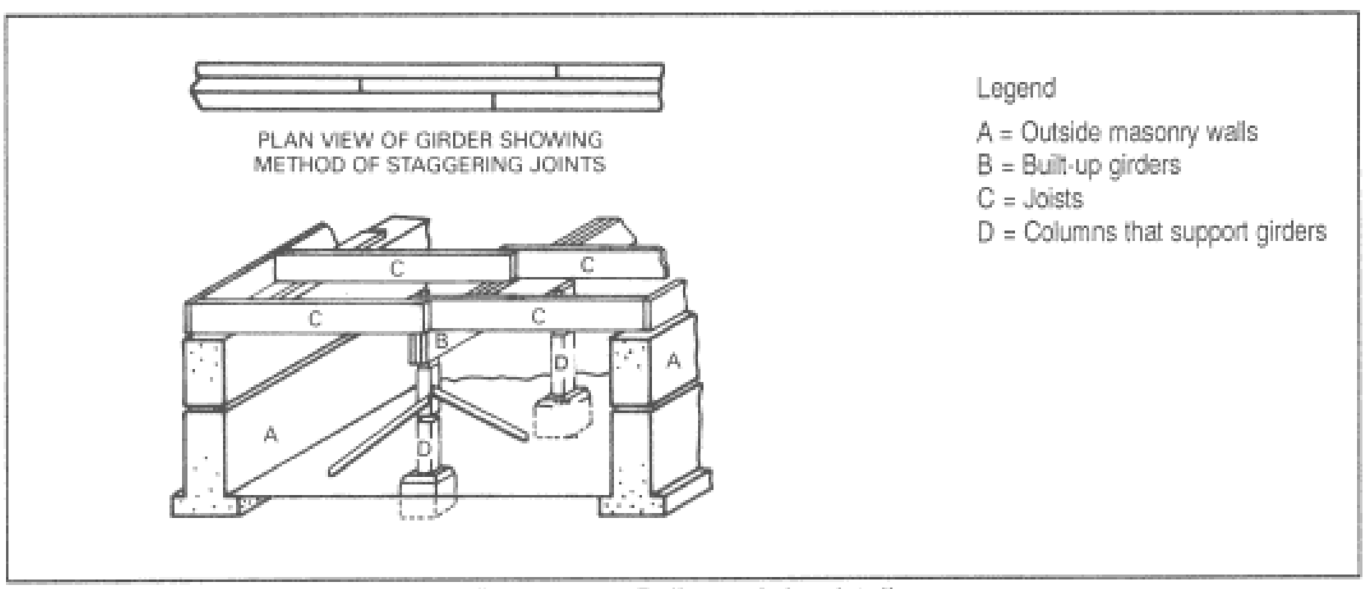


Figure 6-10. Built-up girder details

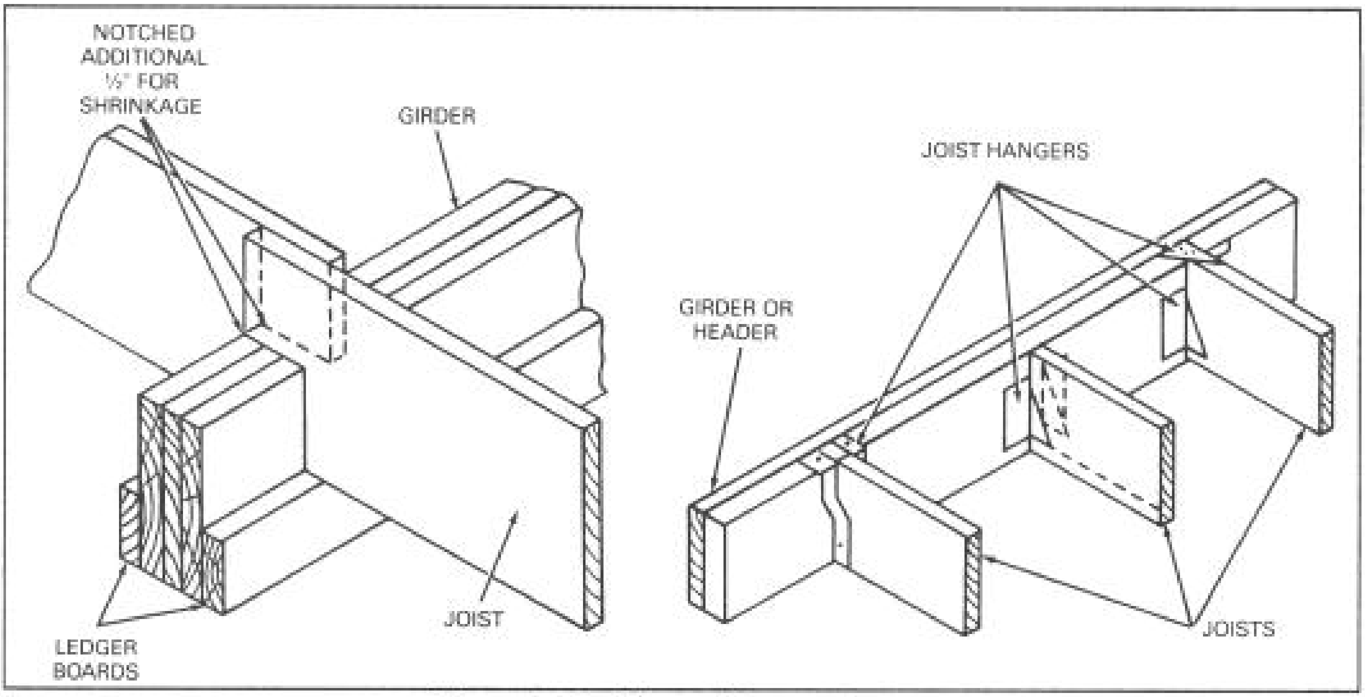


Figure 6-11. Joist-to-girder attachment

A girder should be just large enough to support an ordinary load. Any size larger than that wastes material. For greater carrying capacity, it is better to increase a girder's depth (within limits) than its width. When the depth of a girder is doubled (the width of lumber, such as 2 x 8 or 2 x 6), the safe load increases four times. For example, a girder 3 inches wide and 12 inches deep will carry four times as much weight as a girder 3 inches wide and 6 inches deep. Table 6-1 gives the sizes of built up wood girders for various loads and spans.

LOAD AREA

A building load is carried by foundation walls and the girder. Because the ends of each joist rest on the girder, there is more weight on the girder than on any of the walls. Before considering the load on the girder, it may be well to consider a single joist.

Example 1. Suppose a 10-foot plank weighing 5 pounds per foot is lifted by two men. If the men were at opposite ends of the plank, they would each support 25 pounds.

Now assume that one of these men lifts the end of another 10-foot plank of the same weight as the first one. A third man lifts the opposite end of that plank. The two men on the outside are each now supporting one-half of the weight of one plank (25 pounds apiece), but the man in the center is supporting one-half of each of the two planks (50 pounds).

The two men on the outside represent the foundation walls. The center man represents the girder. The girder carries one-half of the weight, and the other half is equally divided between the outside walls. However, the girder may not always be located halfway between the outer walls.

Example 2. Imagine the same three men lifting two planks that weigh 5 pounds per foot. One of the planks is 8 feet long and the other is 12 feet long. The total length of these two planks is the same as before. The weight per foot is the same, so the total weight in both cases is 100 pounds.

One of the outside men is supporting one-half of the 8-foot plank) or 20 pounds. The man on the opposite outside end is supporting one-half of the 12-foot plank, or 30 pounds. The man in the center is supporting one-half of each plank (50 pounds). This is the same total weight he was lifting before.

NOTE: To determine the girder load area: a girder will carry the weight of the floor on each side to the midpoint of the joists that rest upon it.

FLOOR LOAD

After the girder load area is known, the total floor load per square foot must be determined, for **safety purposes.** Both dead and live loads must be considered.

Dead Load

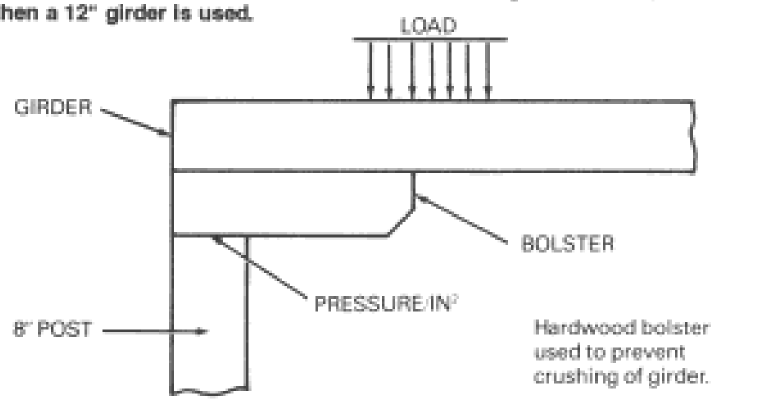
The dead load consists of all building structure weight. The dead load per square foot of floor area is carried directly or indirectly to the girder by bearing partitions. The dead load varies according to the construction method and building height. The structural parts in the dead load are—

Table 6-1. Sizes of built-up wood girders

(Based on Douglas fir 4-square guideline framing; deflection not over 1/360 of span; allowable fiber stress 1,600 lb/in²)

LOAD PER LINEAR FOOT OF GIRDER	LENGTH OF SPAN (FEET)				
	6	7	8	9	10
	NOMINAL SIZE OF GIRDER REQUIRED (INCHES)				
750	6 x 8	6 x 8	6 x 8	6 x 10	6 x 10
900	6 x 8	6 x 8	6 x 10	6 x 10	8 x 10
1050	6 x 8	6 x 10	8 x 10	8 x 10	8 x 12
1200	6 x 10	8 x 10	8 x 10	8 x 10	8 x 12
1350	6 x 10	8 x 10	8 x 10	8 x 12	10 x 12
1500	8 x 10	8 x 10	8 x 12	10 x 12	10 x 12
1650	8 x 10	8 x 12	10 x 12	10 x 12	10 x 14
1800	8 x 10	8 x 12	10 x 12	10 x 12	10 x 14
1950	8 x 12	10 x 12	10 x 12	10 x 14	12 x 14
2100	8 x 12	10 x 12	10 x 14	12 x 14	12 x 14
2250	10 x 12	10 x 12	10 x 14	12 x 14	12 x 14
2400	10 x 12	10 x 14	10 x 14	12 x 14	
2550	10 x 12	10 x 14	12 x 14		
2700	10 x 12	10 x 14	12 x 14		
2850	10 x 14	12 x 14	12 x 14		
3000	10 x 14	12 x 14			
3150	10 x 14	12 x 14			
3300	12 x 14	12 x 14			

NOTES:
1. The 6" girder is figured as being made with three pieces 2" dressed to 1 3/4" thickness.
2. The 8" girder is figured as being made with four pieces 2" dressed to 1 3/4" thickness.
3. The 10" girder is figured as being made with five pieces 2" dressed to 1 3/4" thickness.
4. The 12" girder is figured as being made with six pieces 2" dressed to 1 3/4" thickness.
5. For solid girders, multiply the above loads by 1.130 when a 6" girder is used; 1.150 when an 8" girder is used; 1.170 when a 10" girder is used; and 1.180 when a 12" girder is used.



- Floor joists for all floor levels.
- Flooring materials, including the attic if it is floored.
- Bearing partitions.
- Attic partitions.
- Attic joists for the top floor.
- Ceiling laths and plaster, including the basement ceiling if it is plastered.

The total dead load for a light-frame building similar to an ordinary frame house is the dead-load allowance per square foot of all structural parts added together.

- The allowance for an average subfloor, finish floor, and joists without basement plaster should be 10 pounds per square foot.
- If the basement ceiling is plastered, allow an additional 10 pounds per square foot.
- If the attic is unfloored, make a load allowance of 20 pounds for ceiling plaster and joists when girders or bearing partitions support the first-floor partition.
- If the attic is floored and used for storage, allow an additional 10 pounds per square foot.

Live Load

The live load is the weight of furniture, persons, and other movable loads, not actually a part of the building but still carried by the girder. The live load per square foot will vary according to the building use and local weather conditions. Snow on the roof is also a part of the live load.

- Allowance for the live load on floors used for living purposes is 30 pounds per square foot.
- If the attic is floored and used for light storage, allow an additional 20 pounds per square foot.
- The allowance per square foot for live loads is usually governed by local building specifications and regulations.

The load per linear foot on the girder is easily figured when the total load per square foot of floor area is known.

Example. Assume that the girder load area of the building shown in Figure 6-12 is sliced into 1-foot lengths across the girder. Each slice represents the weight supported by 1 foot of the girder. If the slice is divided into 1-foot units, each unit will represent 1 square foot of the total floor area. To determine the load per linear foot of girder, multiply the number of units by the total load per square foot.

Note in Figure 6-12 that the girder is off-center. Remember that half of the load is supported by the girder and half by the foundation walls. Therefore, the joist length to be supported on one side of the girder is **7 feet** (one half of 14 feet) and the other side is 5 **feet** (one half of 10 feet), for a total distance of **12 feet** across the load area. Since each slice is 1 foot wide, it has a total floor area of 12 square feet.

Assume that the total floor load for each square foot is 70 pounds. Multiply the length times the width to get the total square feet supported by the girder (7 *feet x 12 feet = 84 square feet).*

84 square feet x 70 pounds per square feet (live and dead load) = 5,880 pounds total load on the girder

BUILT-UP GIRDERS

Figure 6-10, page 6-9, shows a *built-up girder.* Notice that the joists rest on top of the girder. This type of girder is commonly used in frame building construction. To make a built-up girder, select lumber that is as free from knots and other defects as possible.

Built-up girders are usually made of three pieces of framing lumber nailed together. (The pieces must be nailed securely to prevent individual buckling.) For proper arrangement of the pieces of lumber, the end grains should match the example in Figure 6-13. The nailing pattern should be square across the ends of the board (1 1/2 inches from each end) and then diagonal every 16 inches as shown in Figure 6-13. This pattern increases the strength of the girder. A typical two- or three-piece girder of 2-inch lumber should be nailed on both sides with 16d common nails.

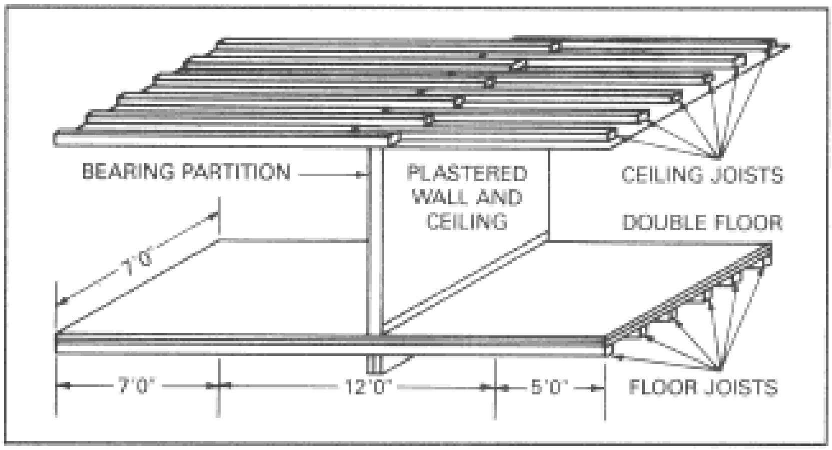


Figure 6-12. Girder load area

SPLICING

Methods for splicing girders differ according to whether the girder is built-up or solid-beam.

Built-Up Girders

The lumber for a built-up girder should be long enough so that no more than one joint will occur over the span between footings. The joints in the beam should be staggered, and the planks must be squared at each joint and butted tightly together.

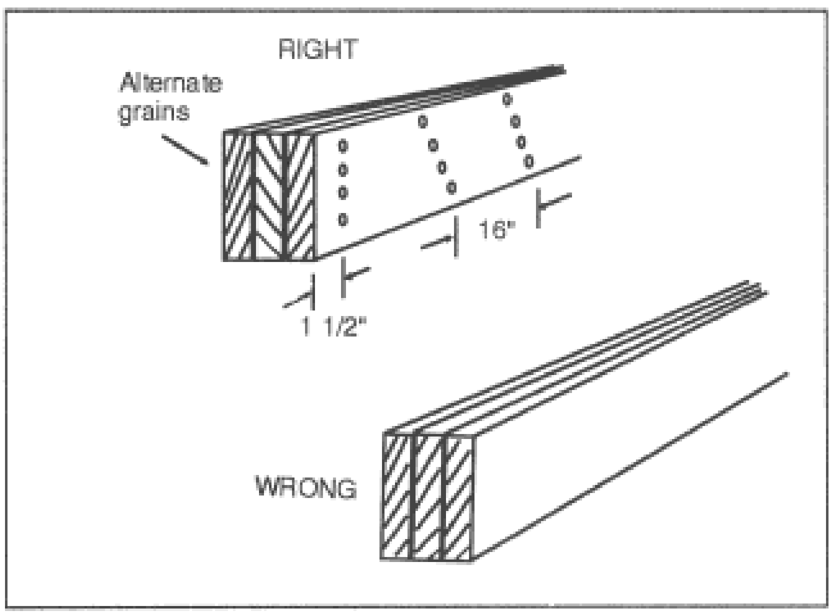


Figure 6-13. Built-up girder lumber arrangement

Solid-Beam Girders

To splice solid beams, use half-lap joints or butt joints (Figure 6-14.) See Splices on page 6-6.

Half-Lap. Sometimes a half-lap joint is used to join solid beams (Figure 6-14). This is done by performing the following steps:

Step 1. Place the beam on one edge so that the annual rings run from top to bottom.

Step 2. Lay out the lines for the half-lap joint as shown in Figure 6-14.

Step 3. Make cuts along these lines, then check with a steel square to ensure a matching joint.

Step 4. Repeat the process on the other beam.

Step 5. Nail a temporary strap across the joint to hold it tightly together.

Step 6. Drill a hole through the joint with a drill bit about 1/16 inch larger than the bolt to be used, and fasten the joint with a bolt, a washer, and a nut.

Butt Joints. When a strapped *butt joint is* used to join solid beams (Figure 6-14, page 6-13), the ends of the beams should be cut square. The straps, which are generally 18 inches long, are bolted to each side of the beams.

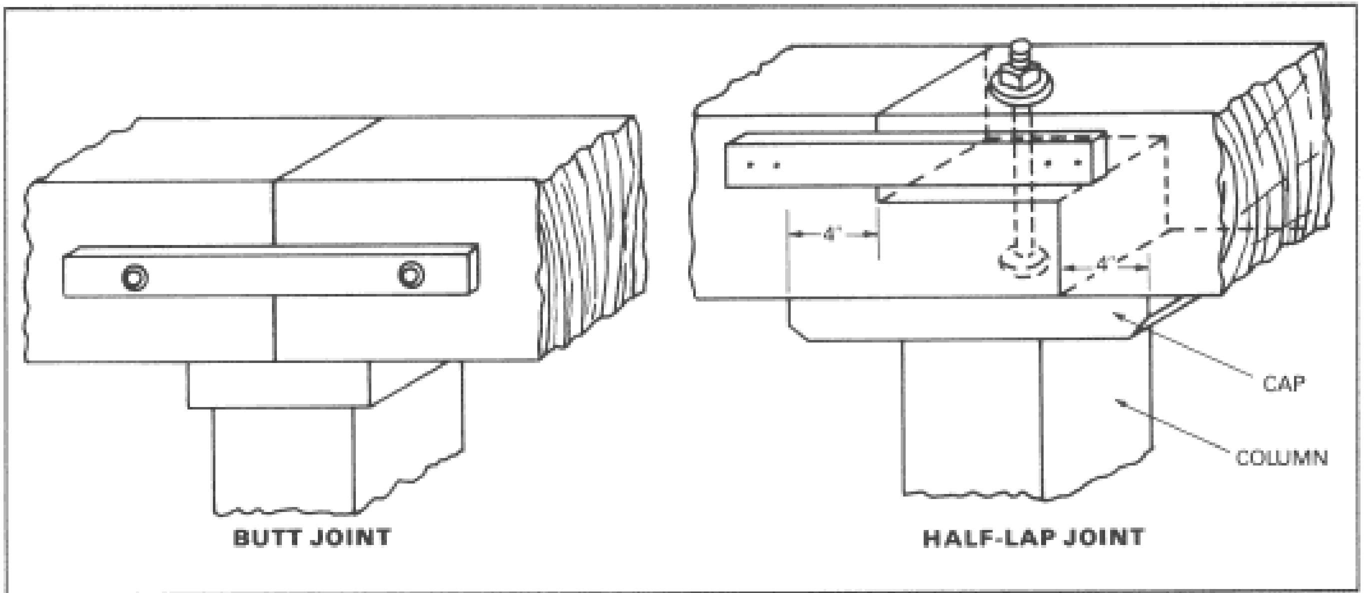


Figure 6-14. Butt and half-lap joints

GIRDER SUPPORTS

When building a small frame building, the carpenter should know how to determine the proper size of girder supports (called *columns* or *posts).*

A *column* or *post is* a vertical member that supports the live and dead loads placed upon it. It may be made of wood, metal, or masonry.

- *Wooden columns* may be solid timbers or several pieces of framing lumber nailed together with 16d or 20d common nails.
- *Metal columns* are made of heavy pipe, large steel angles, or I-beams.

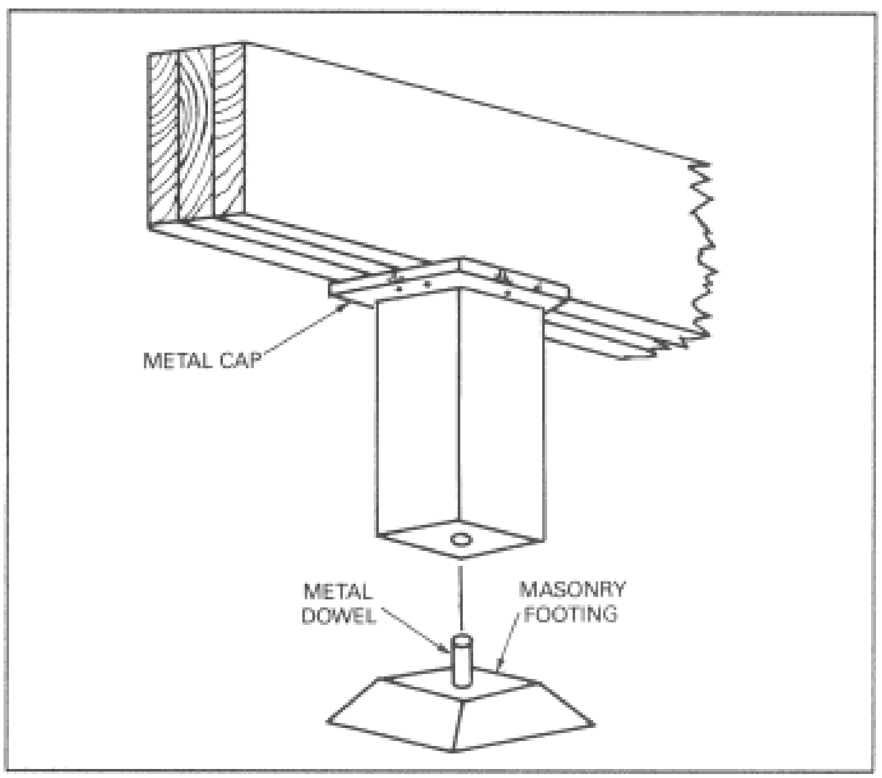


Figure 6-15. Use of metal cap and masonry footing

A column must have a bearing plate at the top and bottom which distributes the load evenly across the column. Basement posts that support girders should be set on masonry footings. Columns should be securely fastened at the top to the load-bearing member and at the bottom to the footing on which they rest.

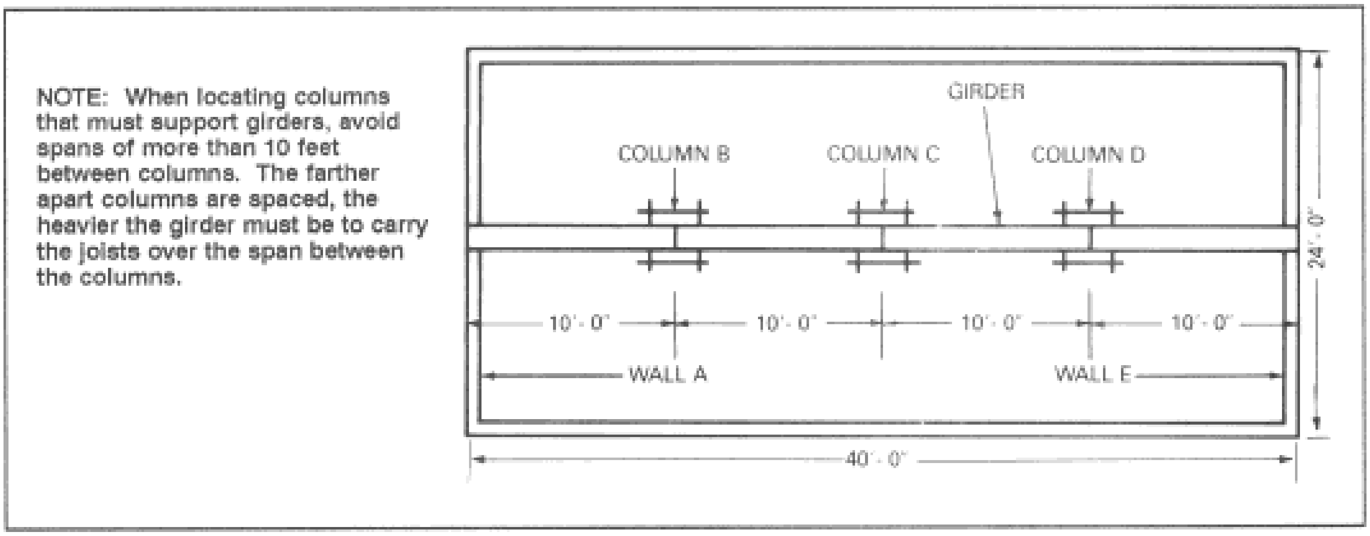


Figure 6-16. Column spacing

Figure 6-15 shows a solid wooden column with a metal bearing cap drilled to permit fastening it to the girder. The bottom of this type of column may be fastened to the masonry footing by a metal dowel. The dowel should be inserted in a hole drilled in the bottom of the column and in the masonry footing. The base is coated with asphalt at the drilling point to prevent rust or rot.

A good arrangement of a girder and supporting columns for a 24- x 40-foot building is shown in Figure 6-16.

- Column B will support one-half of the girder load between wall A and column C.
- Column C will support one-half of the girder load between columns B and D.
- Column D will share equally the girder loads with column C and wall E.

GIRDER FORMS

Forms for making concrete girders and beams are made from 2-inch-thick material dressed on all sides. The bottom piece of material should be constructed in one piece to avoid using cleats. The temporary cleats shown in Figure 6-17 are nailed on to prevent the form from collapsing when handled.

FLOORING

After the foundation and deck framing of a building are completed, the floor is built.

FLOOR JOISTS

Joists are the wooden members, usually 2 or 3 inches thick, that make up the body of the floor frame (Figure 6-18, page 6-16). The flooring or subflooring is nailed to the joists. Joists as small

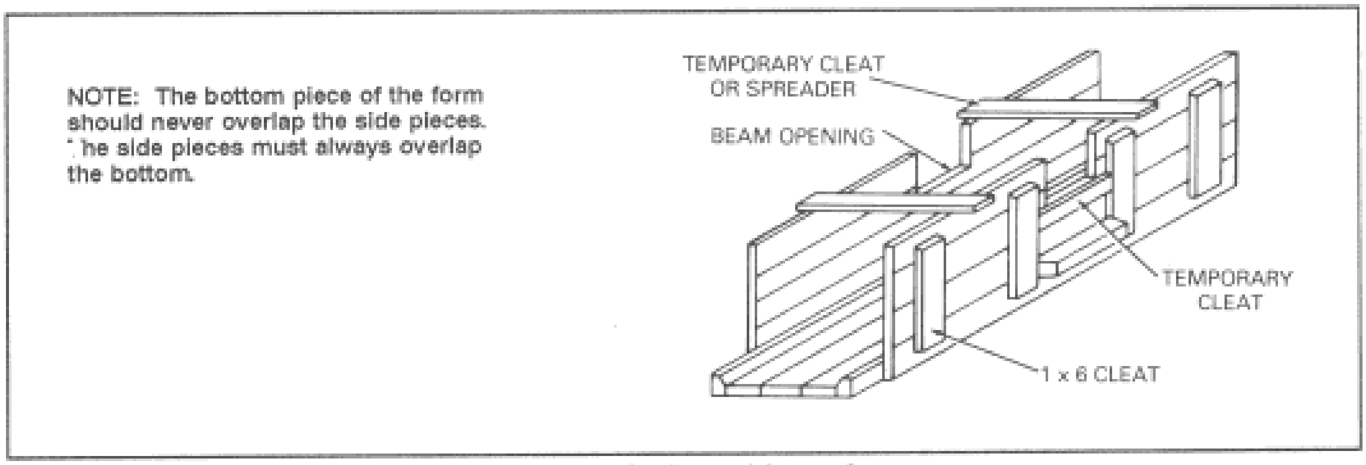


Figure 6-17. Girder and beam form

as 2 x 6 are sometimes used in light frame buildings. These are too small for floors with spans over 10 feet, but are frequently used for ceiling joists.

Joists usually carry a uniform load of materials and personnel; these are live loads. The weight of joists and floors is a dead load. The joists carry the flooring load directly on ends nearest the sills, girders, bearing partitions, or bearing walls. Joists are spaced 16 or 24 inches apart, center to center. Sometimes the spacing is 12 inches, but where such spacing is made necessary by the load, heavier joists should be used.

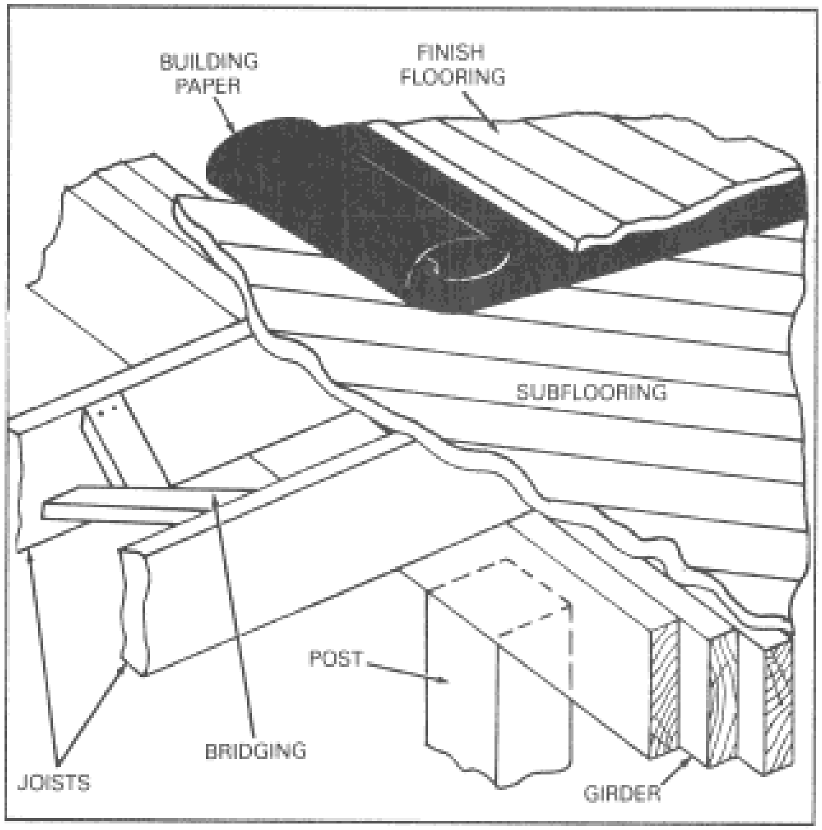


Figure 6-18. Floor joists

To support heavily concentrated loads or a partition wall, you may need to double the joist or place two joists together. Two typical reinforced joists are shown in Figure 6-19.

In joining joists to sills, be sure that the connection can hold the load that the joist will carry. The joist-connecting method in Figure 6-20, A, is used most often because it provides the strongest joint. The methods shown in Figure 6-20, B and C, are used when it is not desirable to use joists on top of the sill. The ledger plate should be securely fastened. If the joist must be notched, it should not be notched to the sill and girder over one-third of its depth to prevent splitting (Figure 6-20, D).

Joists must be level when framed to girders. If the girder is not the same height as the sill, the joist must be notched as shown in Figure 6-20, C. If the girder and sill are the same height, the joists must be framed to keep the joist level. The joist is always placed crown up. This counteracts the weight on the joists. In most cases there will be no sag below a straight line.

The simplest way to carry joists on steel girders is to rest them on top (as shown in Figure 6-20, E), provided headroom is not restricted. If there is a lack of headroom, use straps or hangers (iron stirrups) as shown in Figure 6-20, F. These art among the strongest joist supports.

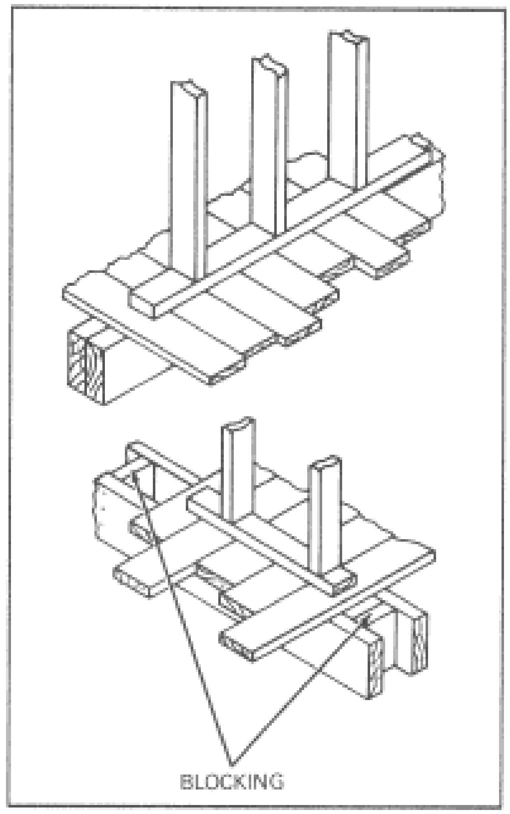


Figure 6-19. Reinforced joists

In connecting joists to girders and sills where posts are used, a 2 x 4 is nailed to the face of the sill or girder, flush with the bottom edge. This is called a *ledger*. These pieces should be nailed securely with 20d nails spaced 12 inches apart. When 2 x 6 or 2 x 8 joists are used, it is better to use 2 x 4 ledgers. This prevents joists from splitting at the notch.

When joists are 10 inches or more deep, 2 x 4s may be used as ledgers without reducing the strength of the joists. If a notch is used, joist ties may be used to overcome this loss of strength. These ties are short 1 x 4 boards nailed across the joists. Board ends are flush with the top and bottom edges of the joists.

Overhead joists are joined to plates as shown in Figure 6-21, A and B. The inner end of the joist rests on the partition wall plates. If a joist is to rest on plates or girders, the joist is cut long enough to extend the full width of the plate or girder. Alternatively, the joists are cut to meet in the center of the plate or girder and connected with

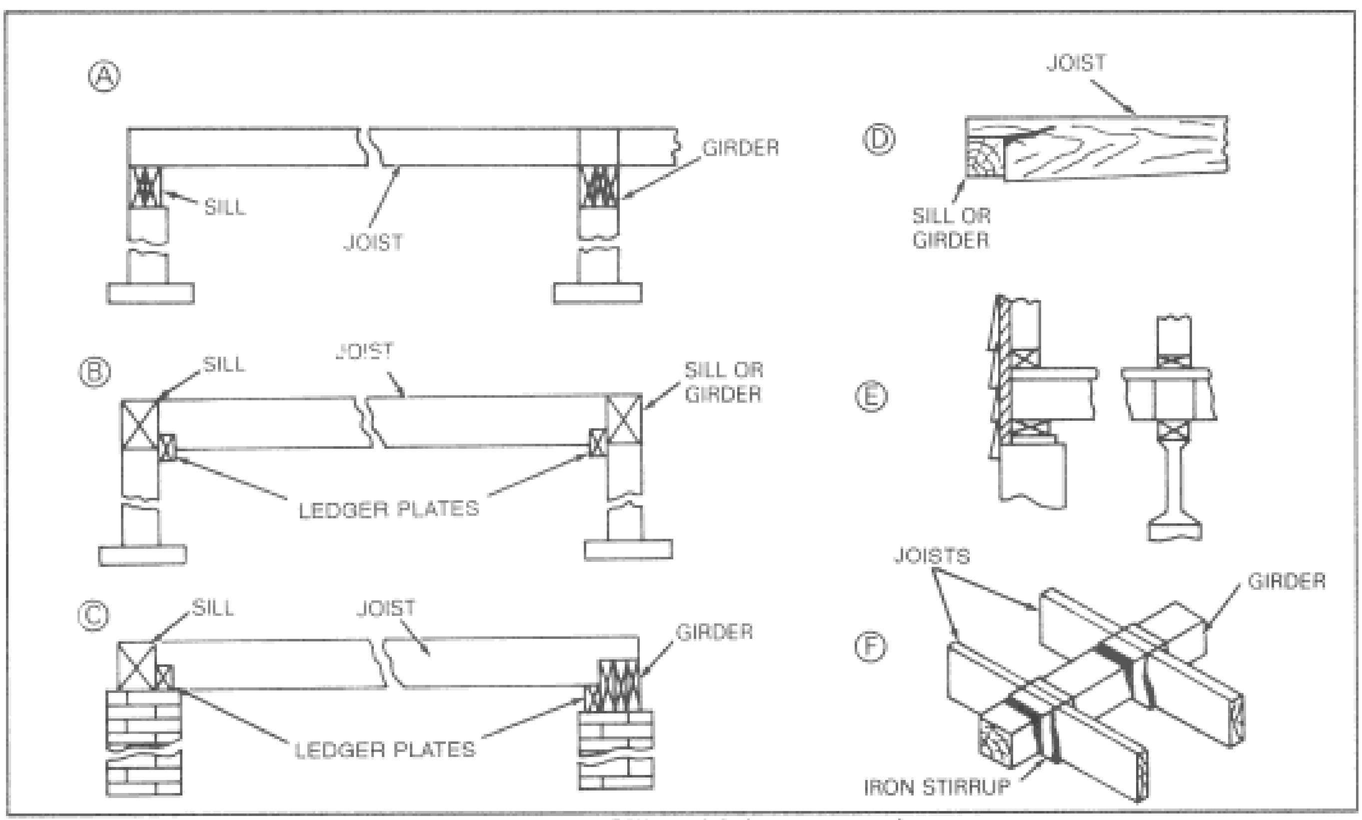


Figure 6-20. Sill and joist connections

a scab. When the ends of two joists lie side by side on the plate, they should be nailed together. Joists may also be joined to girders with ledgers (Figure 6-21, C and D).

FLOOR JOISTS FOR PLATFORM CONSTRUCTION

Check the plans to determine the size and direction of the joists. If the sizes for joists are not specified on the plans, consult Tables 6-2 and 6-3 to determine the appropriate size.

FLOOR BRIDGING

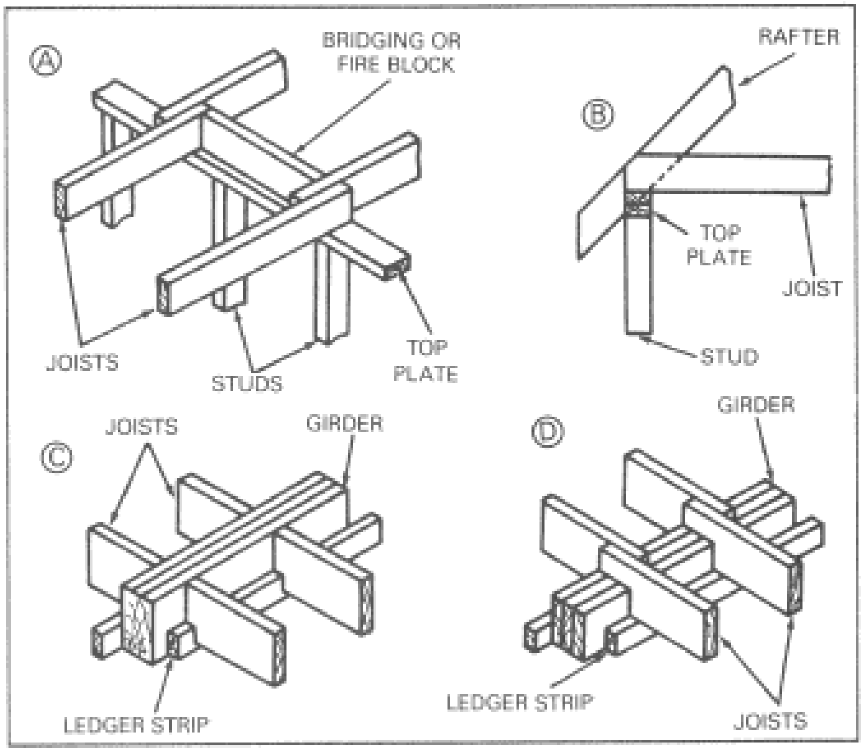


Figure 6-21. Top plates and ledgers

Joists tend to twist from side to side, especially when used over a long span. Floor frames are bridged for stiffening and to prevent unequal deflection of the joists. This stiffening also enables an overloaded joist to receive some help from the joists on either side of it. A pattern for the bridging stock is obtained by placing a piece of material between the joists, then marking and sawing it. When sawed, the cut will form the correct angle.

Table 6-2. Allowable spans for floor joists using nonstress-graded lumber

Size of Floor Joists (Inches)	Spacing of Floor Joists (Inches)	Maximum Allowable Span (Feet and Inches)							
		Group I		Group II		Group III		Group IV	
		Plastered Ceiling Below	Without Plastered Ceiling Below	Plastered Ceiling Below	Without Plastered Ceiling Below	Plastered Ceiling Below	Without Plastered Ceiling Below	Plastered Ceiling Below	Without Plastered Ceiling Below
2 x 6	12	10-6	11-6	9-0	10-0	7-6	8-0	5-6	6-0
	16	9-6	10-0	8-0	8-6	6-6	7-0	5-0	5-0
	24	7-6	8-0	6-6	7-0	5-6	6-0	4-0	4-0
2 x 8	12	14-0	15-0	12-6	13-6	10-6	11-6	8-0	8-6
	16	12-6	13-6	11-0	11-6	9-0	10-0	7-0	7-6
	24	10-0	11-0	9-0	9-6	7-6	8-0	6-0	6-6
2 x 10	12	17-6	19-0	16-6	17-6	13-6	14-6	10-6	11-6
	16	15-6	16-6	14-6	15-6	12-0	13-0	9-6	10-0
	24	13-0	14-0	12-0	13-0	10-0	10-6	7-6	8-6
2 x 12	12	21-0	23-0	21-0	21-6	17-6	19-6	13-0	14-6
	16	18-0	20-0	18-0	19-6	15-6	16-6	12-0	13-0
	24	15-0	16-6	15-0	16-6	12-6	13-6	10-0	10-6

Note: The group classifications in this table refer to the species and minimum grades of nonstress-graded lumber. See Table 6-3.

The three kinds of bridging are: *solid (horizontal) bridging, cross bridging*, and *compression bridging* (Figure 6-22, page 6-20). Cross bridging is used most often. It is very effective and requires less time than horizontal bridging. Cross bridging looks like a cross and is made of pieces of lumber, usually diagonally cut 1 x 3 or 2 x 3 between the floor joists. Each piece is nailed to the top of each joist and forms a cross (x) between the joists. Cross bridging should be made so that the two pieces of the cross are against each other. Compression is metal bridging between joists.

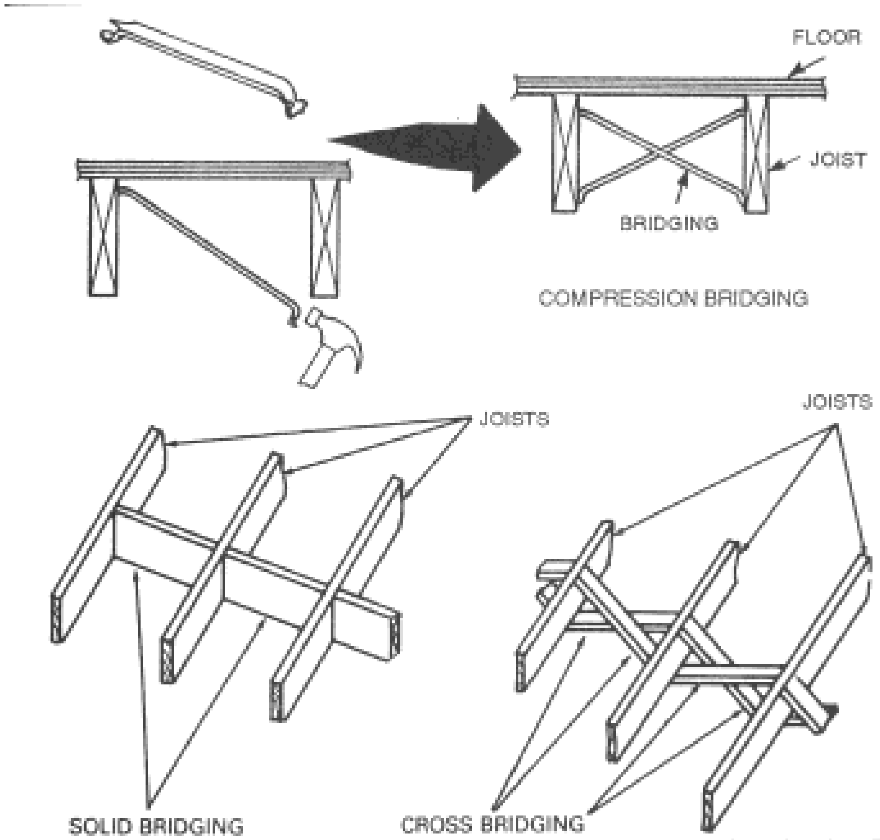


Figure 6-22. Type of bridging

Bridging should be nailed at the tops with 8d or 11 Id nails, and the bottoms should be left free until the subfloor is laid. This allows the joists to adjust to their final position and keeps the bridging from pushing up the joists and causing unevenness in the floor. The bottom ends of the bridging may then be nailed, forming a continuous truss across the floor. This prevents overloaded joists from sagging.

Cutting and fitting the bridging by hand is a slow process. A power saw should be used if it is available. One line of bridging should be placed on joists more than 8 feet long. On joists more than 16 feet long, two lines should be used.

Table 6 3. Group classification—nonstress-graded lumber

Species	Minimum Grade
Group I	
Douglas Fir and Larch	Construction
Group II	
Bald Cypress	No. 2
Douglas Fir (South)	Construction
Fir, White	Construction
Hemlock, Eastern	No. 1
Hemlock, West Coast and Western	Construction
Pine, Red (Norway Pine)	No. 1
Redwood, California	Select Heart
Spruce, Eastern	No. 1
Spruce, Sitka	Construction
Spruce, White and Western White	Construction

Group III	
Cedar, Western	Construction, West Coast Studs
Cedar, Western Red and Incense	Construction
Douglas Fir and Larch	Standard, West Coast Studs
Douglas Fir (South)	Standard
Fir, Balsam	No. 1, Standard
Fir, White	West Coast Studs
Hemlock, Eastern	No. 2, Standard
Hemlock, West Coast and Western	West Coast Studs
Pine, Ponderosa, Lodgepole, Sugar, and Idaho White	Construction
Redwood, California	Construction
Redwood, California (studs only)	Two Star
Spruce, Engelmann	Construction, Standard
Spruce, Sitka	West Coast Studs
Spruce, White and Western White	Standard
Group IV	
Cedar, Western	Utility
Cedar, Western Red and Incense	Utility
Douglas Fir and Larch	Utility
Douglas Fir (South)	Utility
Fir, White	Utility
Hemlock, West Coast and Western	Utility
Pine, Ponderosa, Lodgepole, Sugar, and Idaho White	Utility
Redwood, California	Merchantable
Redwood, California (studs only)	One Star
Spruce, Engelmann	Utility
Spruce, Sitka	Utility
Spruce, White and Western White	Utility

FLOOR OPENINGS

Floor openings for stairwells, ventilators, and chimneys are framed by a combination of *headers* and *trimmers.* Headers run at right angles to the direction of the joists and are doubled. Trimmers run parallel to the joists and are actually doubled joists. The joists are framed at right angles to the headers of the opening frame. These shorter joists, framed to headers, are called *tail beams, tail joists,* or *header joists.* The number of headers and trimmers needed at any opening depends upon—

- The shape of the opening—whether it is a simple rectangle or contains additional angles.
- The direction in which the opening runs, in relation to the joist direction.
- The position of the opening, in relation to partitions or walls.

Figure 6-23, page 6-20, shows examples of openings. One runs parallel to the joist and requires two headers and one trimmer. The other runs at right angles to the joists and requires one header and two trimmers. The openings shown in Figure 6-24, page 6-21, are constructed with corner angles supported in different ways. The cantilever method (shown on the right of Figure 6-24) requires that the angle be fairly close to a supporting partition with joists from an adjacent span that run to the header.

To frame openings of the type shown in Figure 6-25—

Step 1. Headers 1 and 2 are nailed to trimmers A and C with three 20d nails.

Step 2. Headers 1 and 2 are nailed to short joists X and Y with three 20d nails.

Step 3. Headers 3 and 4 are nailed to headers 1 and 2 with 16d nails spaced 6 inches apart.

Step 4. Trimmers A and C are nailed to headers 3 and 4 with three 20d nails.

Step 5. Trimmers B and D are nailed to trimmers A and C with 16d nails spaced 12 inches apart.

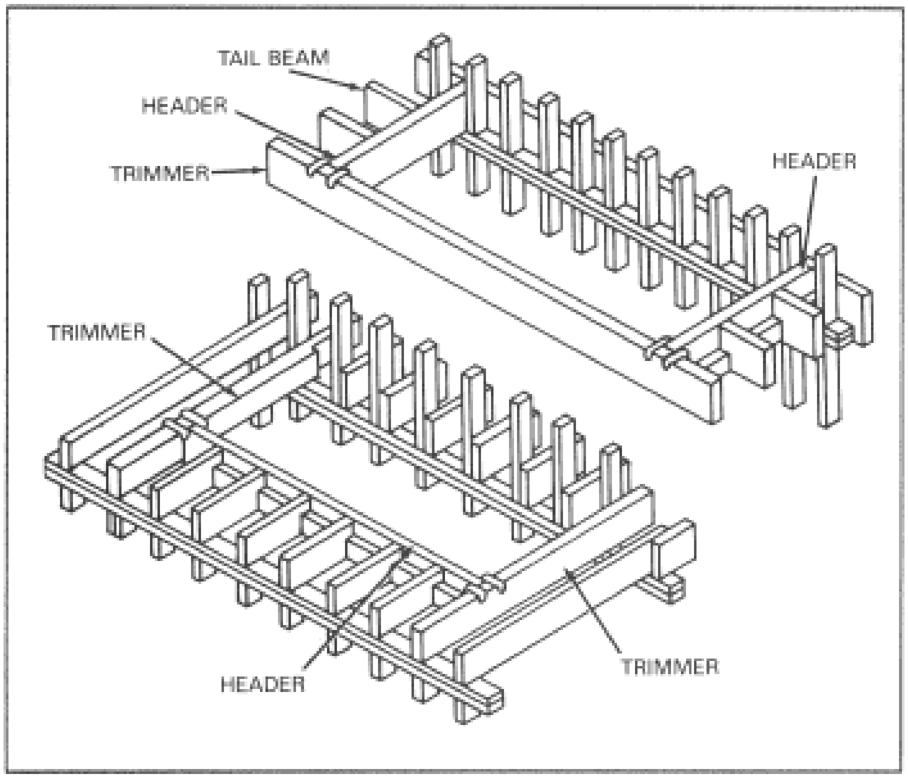


Figure 6-23. Floor openings

SUBFLOORS

The subfloor (Figure 6-26, page 6-22), if included in the plans, is laid diagonally on the joist framework and nailed with 8d to 10d nails. Subflooring boards 8 inches wide or more should have at least three nails per joist. Where the subfloor is more than 1 inch thick, larger nails should be used. The subfloor is normally laid before the walls are framed so that it can be walked on while walls are being framed.

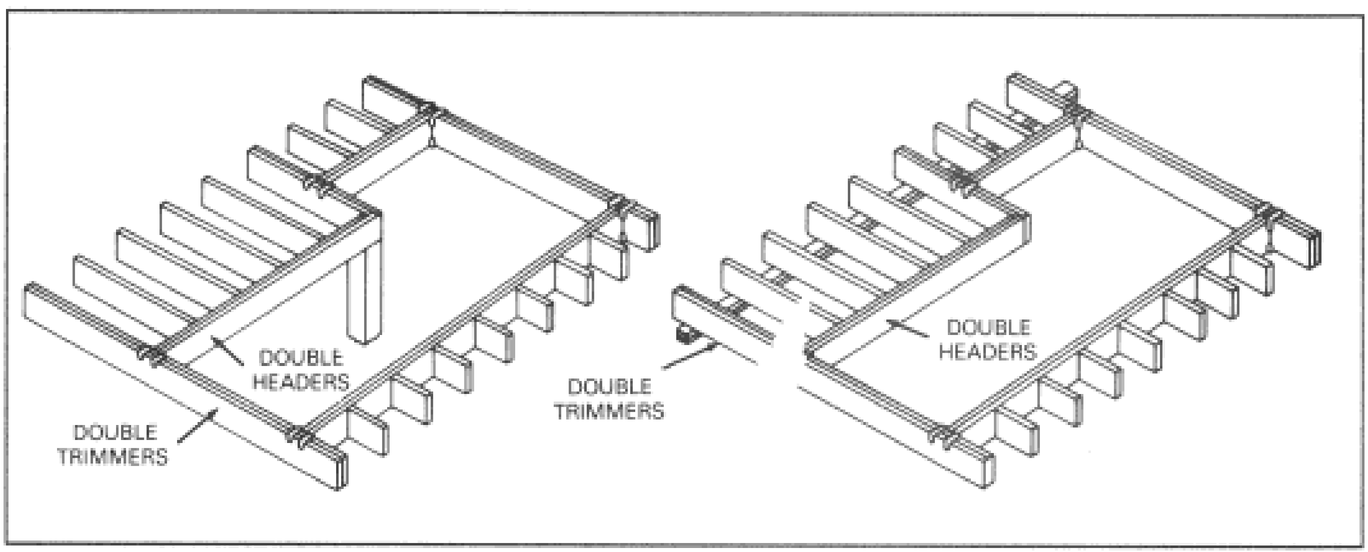


Figure 6-24. Double headers and trimmers

FINISH FLOORS

A finish floor in the TO is normally of 3/4-inch material, square-edged or tongue-and-groove (Figure 6-27, page 6-22). Finish flooring varies from 3 1/2 to 7 1/2 inches wide. It is laid directly on floor joists or on a subfloor and nailed with 8d common nails in every joist. When a subfloor exists, building paper is used between it and the finish floor to keep out dampness and insects.

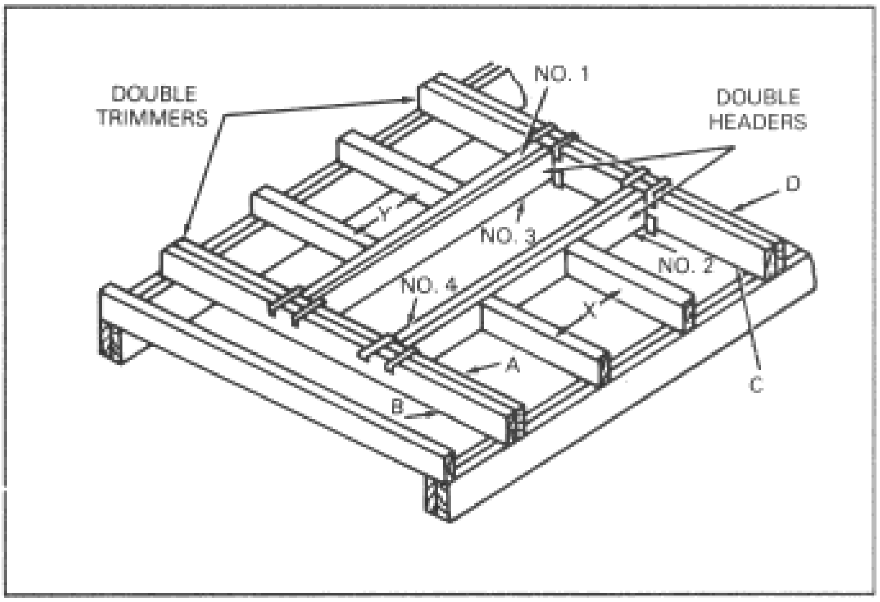


Figure 6-25. Floor-opening construction

In warehouses, where heavy loads are to be carried on the floor, 2-inch material should be used for the finish floor. Such flooring is also face-nailed with 16d or 20d nails. It is not tongue-and-groove, and it ranges in width from 4 to 12 inches. The joints are made on the center of the joist.

Wood Floors

Wood floors must be strong enough to carry the load. The type of building and its intended use determine the arrangement of the floor system, the thickness of the sheathing, and the approximate spacing of the joists.

Concrete Floors

Concrete floors may be constructed for shops where earthen or wood floors are not suitable. These include aircraft repair and assembly shops, shops for heavy equipment, and certain kinds of warehouses.

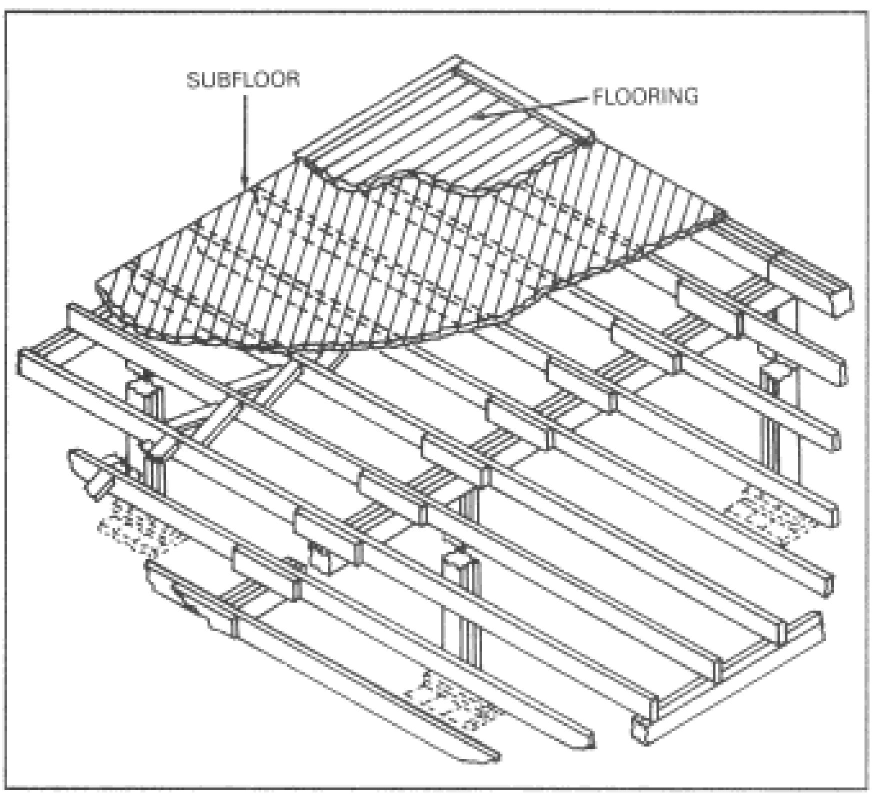


Figure 6-26. Subfloor

After the earth has been graded and compacted, concrete is placed on the ground. The floor should be reinforced with steel or wire mesh. The foundation wall may be placed first and the concrete floor placed after the building is completed. This gives protection to the concrete floor while it sets.

Drainage is provided for the floor area around the footing and the area near the floor, to prevent flooding after heavy rains. A concrete floor is likely to be damp unless it is protected.

Miscellaneous Floors

These types of floors include *earth, adobe brick, duckboard, or rushes.* Miscellaneous flooring is used when conventional materials are unavailable or where there is a need to save time or labor. Such floors may be used if facilities are temporary or if required by the special nature of a structure. Selection of material is usually determined by availability.

Duckboard is widely used for shower flooring. Earthen floors are common; they conserve both materials and labor if the ground site is even without extensive grading. Rush or thatch floors are primarily an insulating measure and must be replaced frequently.

WALLS AND PARTITIONS

Once the floor is in place, it is used to support the wall frame. Wall framing (Figure 6-28) consists of studs, diagonal bracing, cripples, trimmers; headers, and fire blocks. It is supported by the floor sole plate. The vertical members of the wall framing are the studs. They support the top plates and the upper part of the building, or everything above the top plate line. Studs support the lath, plaster, and insulation on the inside and wall sheathing on the outside.

Walls and partitions, which are classed as framed constructions, are composed of studs. Studs are usually closely spaced, slender, 2 x 4 vertical members. They are arranged in a row with their ends bearing on a long horizontal member called a *bottom plate* or *sole plate,* and their tops are capped with another plate, called a *top plate.* Double top plates are used to tie walls and partitions together. The bearing strength of stud walls is determined by the strength of the studs. Figure 6-29, page 6-24, shows a typical wall construction.

Partition walls divide the inside space of a building. In most cases, these walls are framed as part of the building. Where floors are to be installed, the partition walls are left unframed.

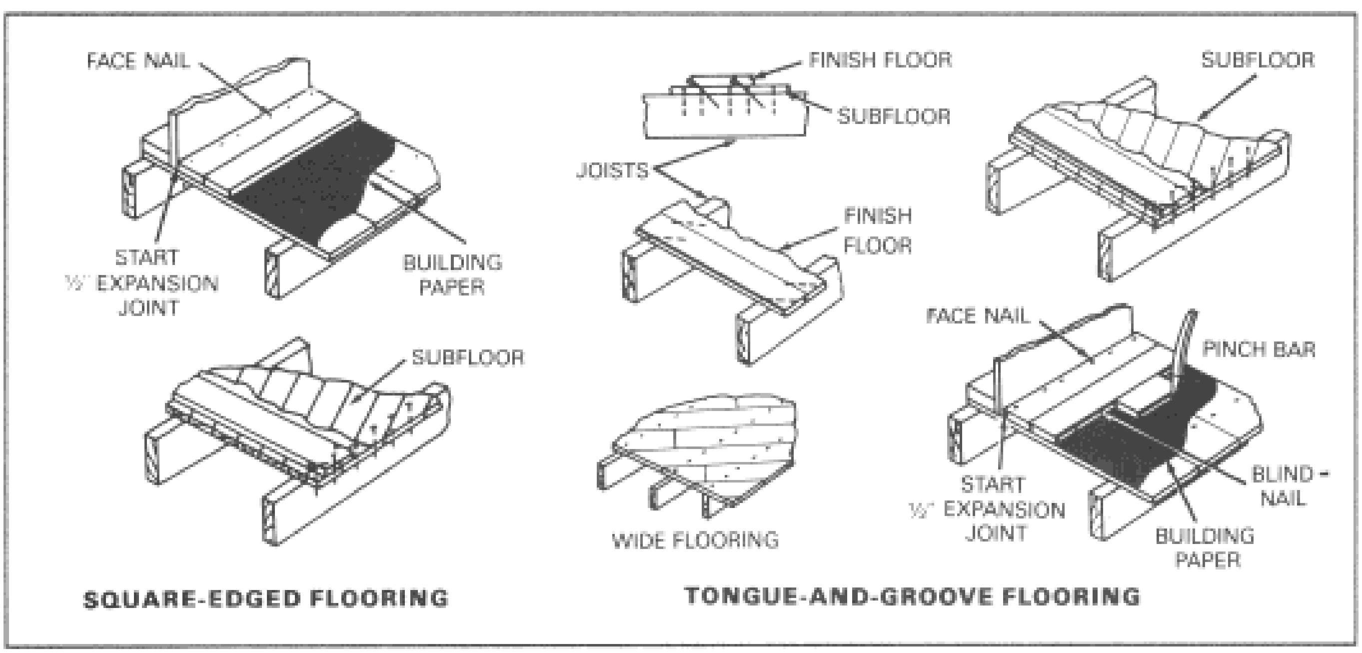


Figure 6-27. Square-edged and tongue-and-groove finish flooring

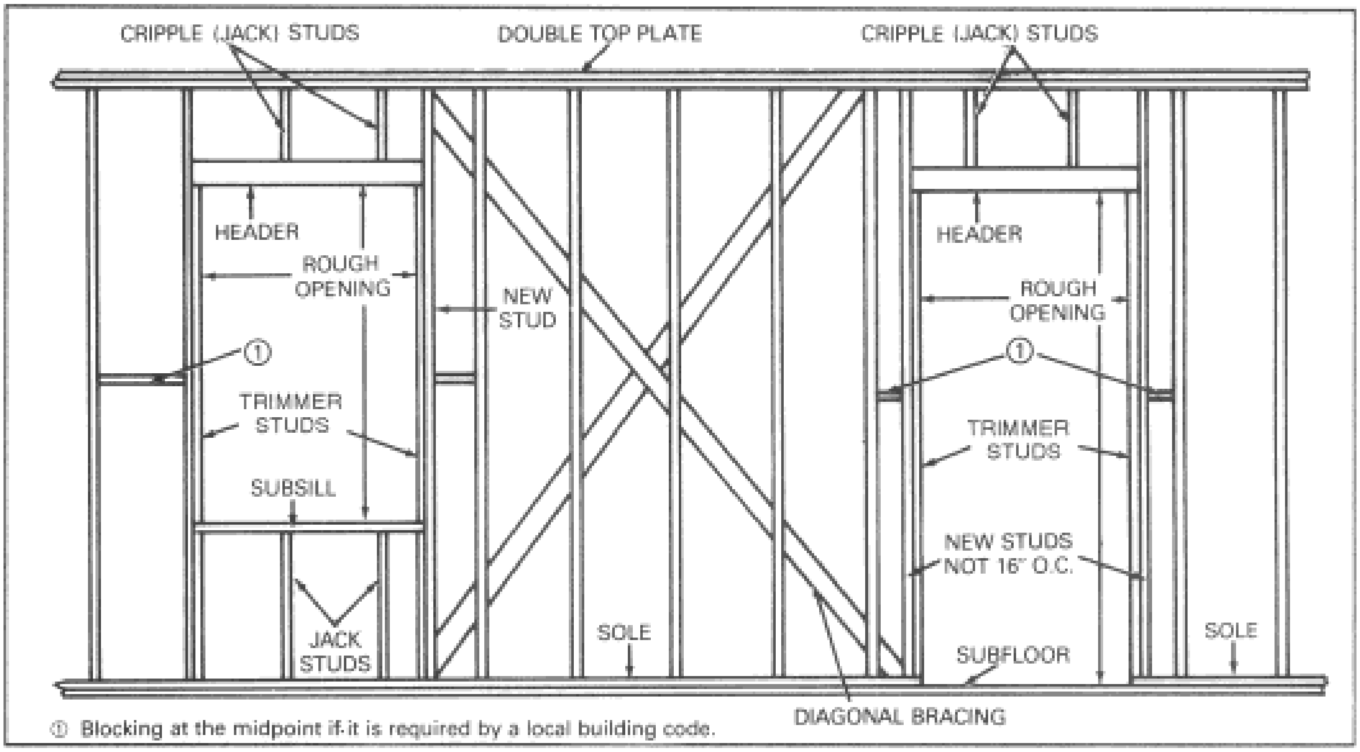


Figure 6-28. Typical wall-frame details

The two types of partition walls are bearing and nonbearing. The bearing type supports ceiling joists; the nonbearing type supports only itself, and may be put in at any time after the other framework is installed. Only one cap or plate is used. A sole plate should be used in every case, as it helps distribute the load over a larger area.

Partition walls are framed the same as outside walls; door openings are framed as outside openings. Where there are corners or where one partition wall joins another, corner posts or T-posts are used as in the outside walls. These posts provide nailing surfaces for the inside wall finish. Partition walls in a TO one-story building may or may not extend to the roof. The top of the studs has a plate when the wall does not extend to the roof. If the wall extends to the roof, the studs are joined to the rafters.

CORNER POSTS

A corner post forms an inside corner and an outside corner which provides a good nailing base for inside wall coverings. Figures 6-30, page 6-24, and 6-31, page 6-25, show two of the most common types of corner posts as they would appear constructed. The studs used at the corners of frame construction are usually built up from three or more ordinary studs to provide greater strength. These built-up assemblies are called *corner posts.* They are set up, plumbed, and temporarily braced. Corner posts may also be made in any of the following ways (Figure 6-32):

- A 4x 6 with a 2 x 4 nailed on the board side, flush with one edge (Figure 6-32, A). This type of corner is for a 4-inch wall. Where walls are thicker, heavier timber is used.
- A 4 x 4 with a 2 x 4 nailed to each of two adjoining sides (Figure 6-32, B).
- Two 2 x 4s nailed together with blocks between them and a 2 x 4 flush with one edge (Figure 6-32, C). This is the most common method.

- A 2 x 4 nailed to the edge of another 2 x 4, the edge of one flush with the side of the other (Figure 6-32, D). This type is used extensively in the TO where no inside finish is needed.

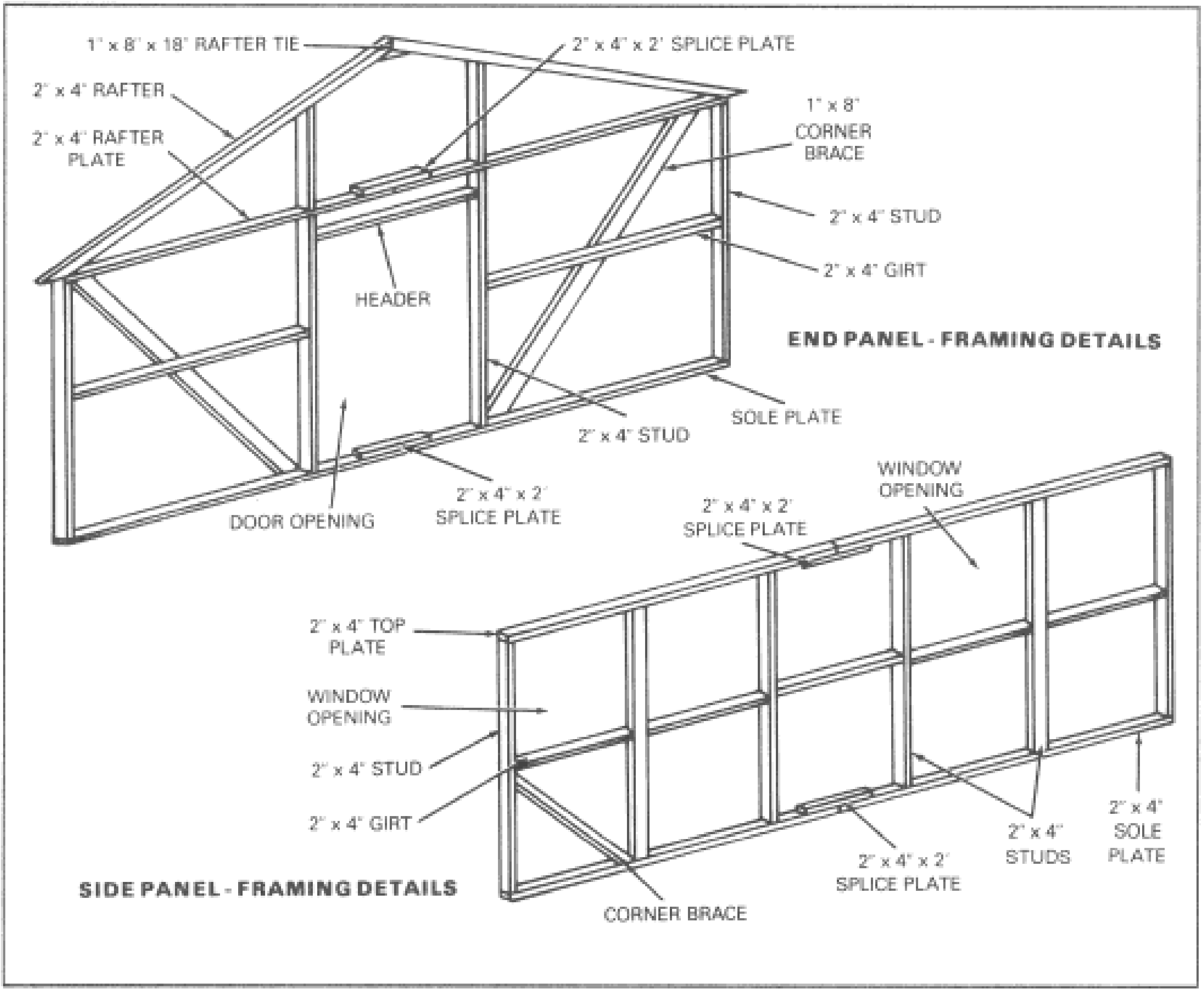


Figure 6-29. Typical wall construction

PARTITION POSTS

There are two types of partition posts—T-posts and double T-posts.

T-Posts

Whenever a partition meets another wall, a stud wide enough to extend beyond the partition on both sides is used. This provides a solid nailing base for the inside wall finish. This type of stud is called a T-

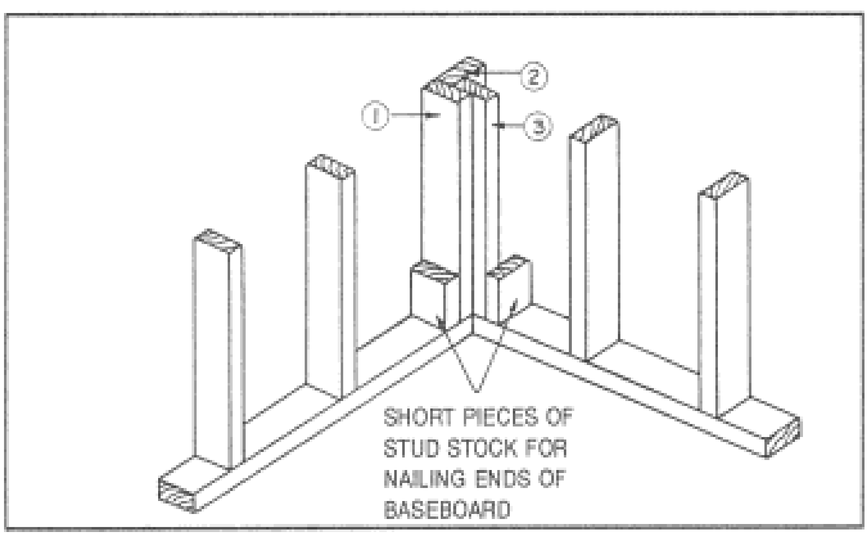


Figure 6-30. Corner-post construction using ordinary 2 x 4 studs

post and is made in any of the following ways (Figure 6-33):

- A 2 x 4 may be nailed and centered on the face side of a 4 x 6 (Figure 6-33, A).
- A 2 x 4 may be nailed and centered on two 4 x 4s nailed together (Figure 6-33, B).
- Two 2 x 4s may be nailed together with a block between them and a 2 x 4 centered on the wide side (Figure 6-33, C).
- A 2 x 4 may be nailed and centered on the face side of a 2 x 6, with a horizontal bridging nailed behind them to give support and stiffness (Figure 6-33, D).

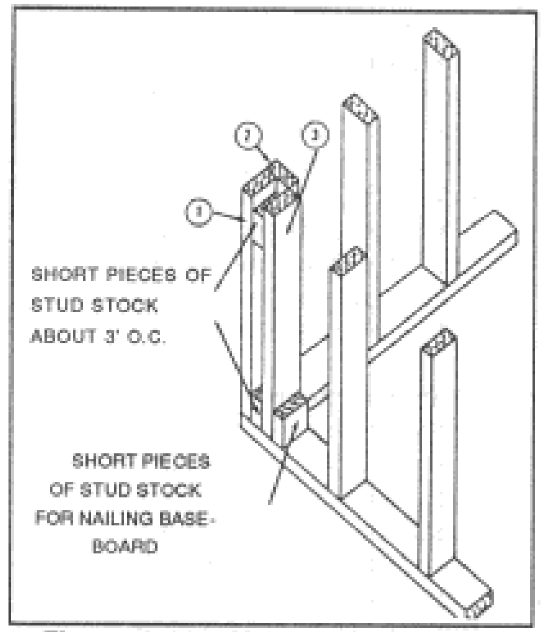


Figure 6-31. Alternate corner-post construction using ordinary 2 x 4 studs

Double T-Posts

When a partition is finished on one side only, the partition post used is a simple stud, set in the outside wall, in line with the side of the partition wall, and finished as shown in Figure 6-34, page 6-26. These posts are nailed in place along with the corner posts. The exact position of the partition walls must be determined before the posts are placed. When walls are more than 4 inches thick, wider timber is used.

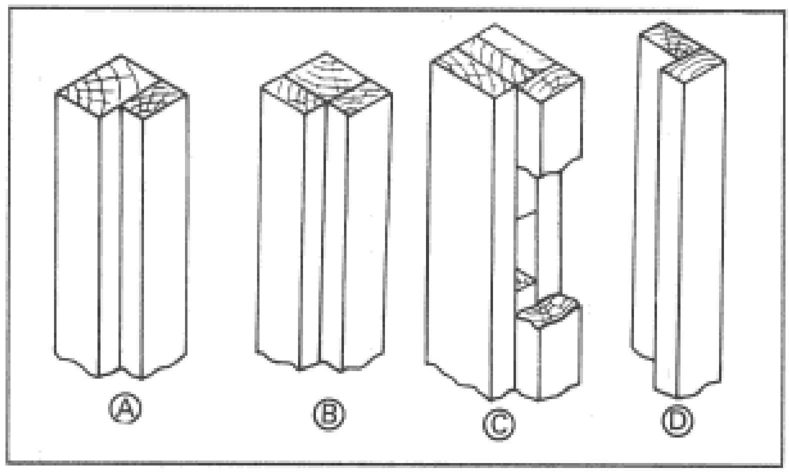


Figure 6-32. Corner-post construction using both 2-inch and 4-inch lumber

In special cases (for example, where partition walls cross), a double T-post is used. It is made as described above, and by nailing another 2 x 4 to the opposite wide side, as shown in Figure 6-34, A, B, and C (C is the most common).

STUDS

After the sills, plates, and braces are in place and the window and door openings are laid out, the studs are placed and nailed with two 16d or 20d nails through the plates. The remaining studs are laid out on the sills or soles by measuring, from one corner, the distances the studs are to be set apart. Studs are normally spaced 12, 16, or 24 inches on center, depending upon the outside and inside finish material. If vertical

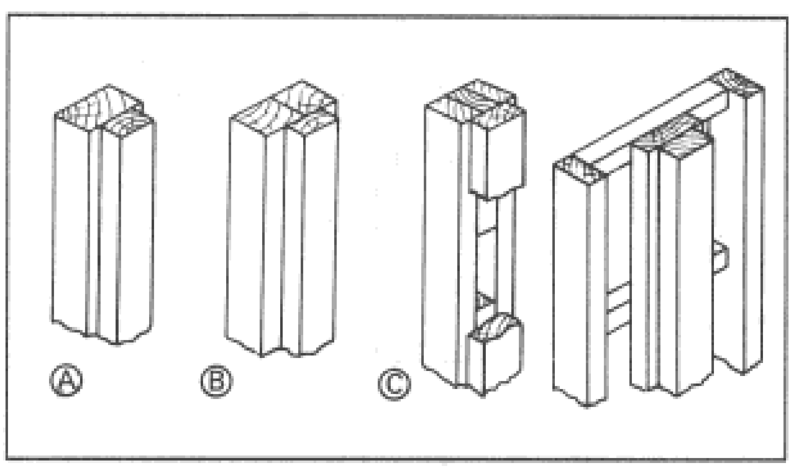


Figure 6-33. T-Post construction

siding is used, studs **are set wider apart since the hori**zontal girts between them provide a nailing surface.

To double the post of the door opening, the outside studs are first placed into position and nailed securely. Then short studs (or *trimmers)* the size of the vertical opening are cut and nailed to the inside face of the outside studs as shown in Figure 6-35 on the sole plate.

The sill of a window opening must be framed. This sill is specified single or double. When it is double, the top header is nailed to the opening studs at the correct height and the trimmer next. The sill headers are toenailed to the trimmer. The door header is framed as shown in Figure 6-35. The jack stud rests on the sole plate.

GIRTS

Girts are always the same width as the studs and are flush with the face of the stud, both outside and inside. They are used in hasty construction when the outside walls are covered with vertical siding. Studs are placed from 2 to 10 feet apart, with girts spaced about 4 feet apart, running horizontally between them. The vertical siding acts in the same way as the studs and helps carry the weight of the roof. This type of construction is used extensively in the TO.

TOP PLATE AND SOLE PLATE

The *top plate* ties the studding together at the top and forms a finish for the walls. It supports the lower ends of the roof rafters. The top plates serve as connecting links between the wall and the roof, just as the sills and girders are connecting links between the floors and the walls. The plate is made up of one or two pieces of framing lumber the same size as the studs.

If the studs at the end of the building extend to the rafters, no plate is used at the end of the building. When used on top of partition walls, the plate is sometimes called the cap. Where the plate is doubled, the first plate or bottom section is nailed with 16d or 20d nails to the top of the corner posts and to the studs. The connection at the corner is made as shown in Figure 6-36. After the single plate is nailed securely and the corner braces are nailed into place, the top part of the plate is nailed to the bottom section with 10d nails. The plate may be nailed over each stud or spaced with two nails every 2 feet. Care must be taken to make sure all joints are staggered. The edges of the top section and the corner joints are lapped.

All partition walls and outside walls are finished either with a 2 x 4 or with a piece of lumber the same thickness as the wall. This lumber is laid horizontally on the floor or joists. It carries the bottom end of the studs, and is called the *sole* or *sole plate.* The sole should be nailed with two 16d or 20d nails at each joist it crosses. If it is laid lengthwise on top of a girder or joist, it should be nailed with two nails every 2 feet.

BRIDGING

Frame walls are bridged, in most cases, to make them more sturdy. There are two methods of bridging—horizontal or diagonal (Figure 6-37).

Horizontal

Horizontal bridging is nailed between the studs horizontally and halfway between the sole and top plates. This bridging is cut to lengths that correspond to the distance between the studs at the bottom. Such bridging not only stiffens the wall but also helps straighten studs.

Diagonal

Diagonal bridging is nailed between the studs at an angle. It is more effective than the horizontal type since it forms a continuous truss and keeps the walls from sagging. Whenever possible, interior partitions and exterior walls should be bridged alike.

PLUMBED POSTS AND STRAIGHTENED WALLS

After the corner post, T-post, and intermediate wall studs have been nailed to the plates or girts, the walls must be plumbed and straightened so that permanent braces and rafters may be installed. This is done by using a level or plumb bob and a chalk line.

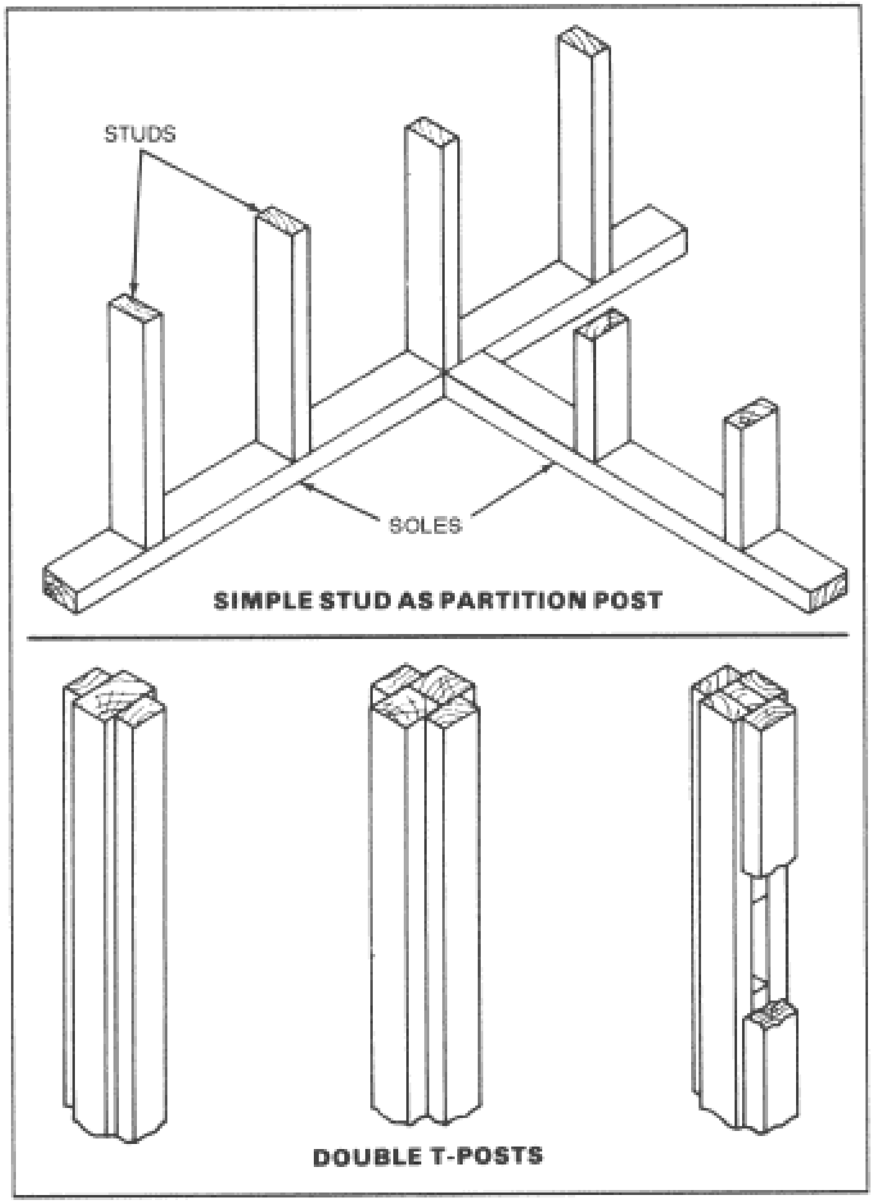


Figure 6-34. Partition posts

Plumbing Posts

There are two methods for plumbing posts.

Method 1. To plumb a corner with a plumb bob—

Step 1. Attach a string to the bob. The string should be long enough to extend to or below the bottom of the post.

Step 2. Lay a rule on top of the post so that 2 inches of the rule extend over the post on the side to be plumbed.

Step 3. Hang the bob line over the rule so that the line is 2 inches from the post and extends to the bottom of it, as shown in Figure 6-38.

Step 4. With another rule, measure the distance from the post to the center of the line at the bottom of the post. If it does not measure 2 inches, the post is not plumb.

Step 5. Move the post inward or outward until the distance from the post to the center of the line is exactly 2 inches, then nail the temporary brace in place.

Step 6. Repeat this procedure from the other outside face of the post. The post is then plumb.

NOTE: This process is carried out for each corner post of the building. If a plumb bob or level is not available, use a rock, half-brick, or small piece of metal.

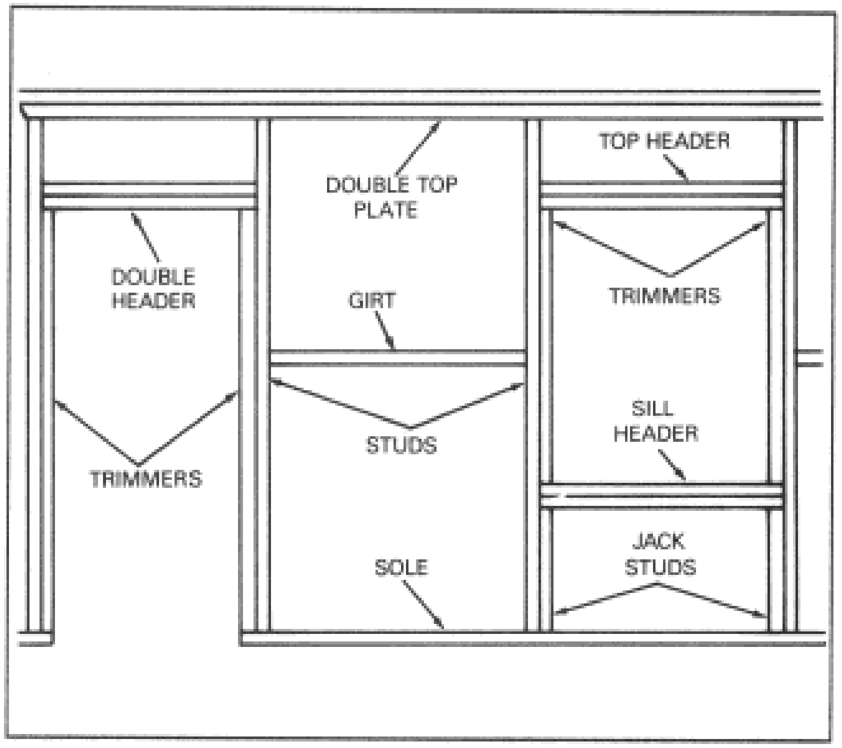


Figure 6-35. Door and window framing

Method 2. An alternative method of plumbing a post is shown in the inset in Figure 6-38. 1b use this method—

Step 1. Attach the plumb-bob string securely to the top of the post to be plumbed. Be sure that the string is long enough to allow the plumb bob to hang near the bottom of the post.

Step 2. Use two blocks of wood, identical in thickness, as gauge blocks.

Step 3. Tack one block near the top of the post between the plumb-bob string and the post

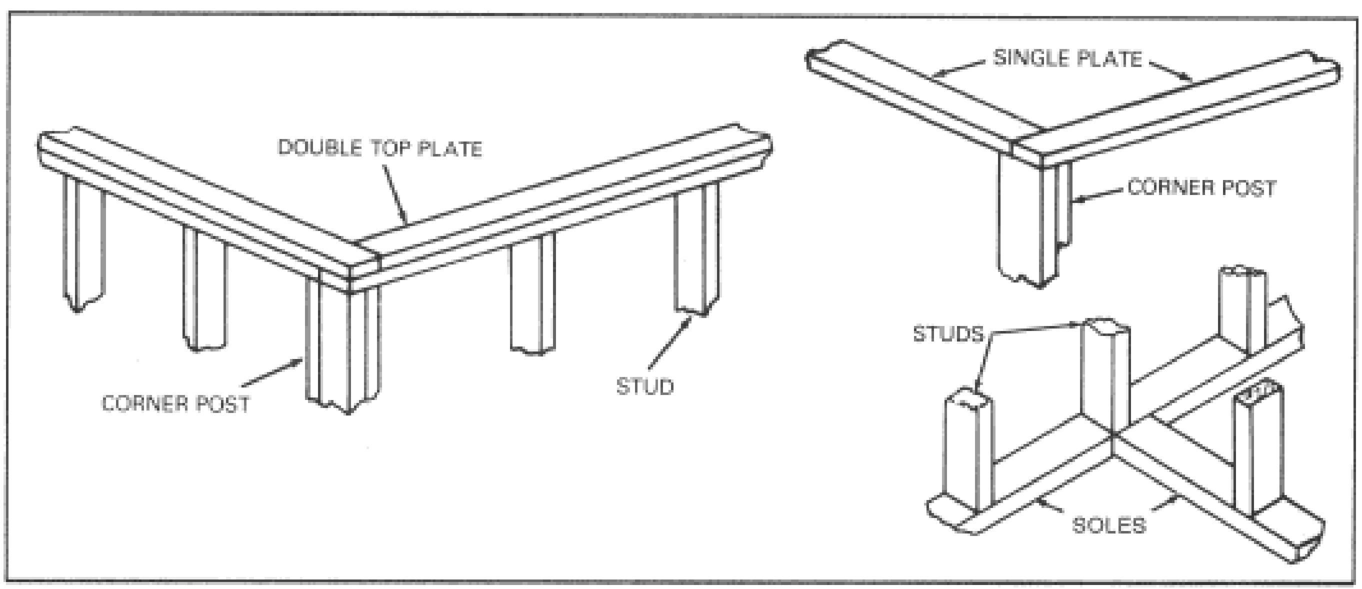


Figure 6-36. Top-plate and sole-plate construction

(gauge block 1).

Step 4. Insert the second block between the plumb-bob string and the bottom of the post (gauge block 2).

Step 5. If the entire face of the second block makes contact with the string, the post is plumb.

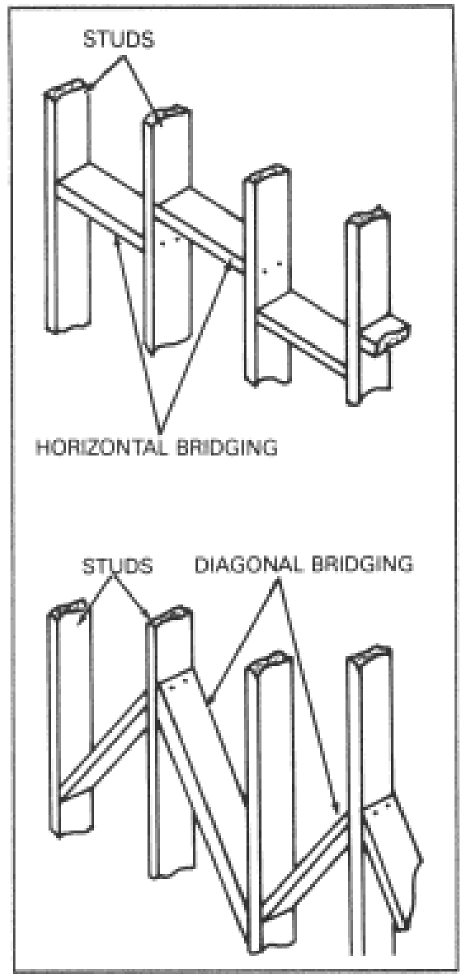


Figure 6-37. Types of wall bridging

Straightening Walls

The following procedure is carried out for the entire perimeter of the building. Inside partition walls should be straightened the same way (Figure 6-39).

Step 1. Plumb one corner post with a level or a plumb bob. Nail temporary braces to hold the post in place. Repeat this procedure for all corner posts.

Step 2. Fasten a chalk line to the outside of one corner post at the top and stretch the line to the corner post at the opposite end of the building. Then fasten the line to this post.

Step 3. Place a 3/4-inch block under each end of the line for clearance.

Step 4. Place temporary braces at intervals small enough to hold the wall straight.

Step 5. Nail the brace when the wall is far enough away from the line to permit a 3/4-inch block to slide between the line and the plate.

BRACING

Bracing is used to stiffen framed construction and make it rigid. Bracing may be used to resist winds, storms, twists, or strains. Good bracing keeps corners square and plumb. Bracing prevents warping, sagging, and shifting that could otherwise distort the frame and cause badly fitting doors and windows and cracked plaster. The three methods commonly used to brace frame structures are let-in, cut-in, and diagonal-

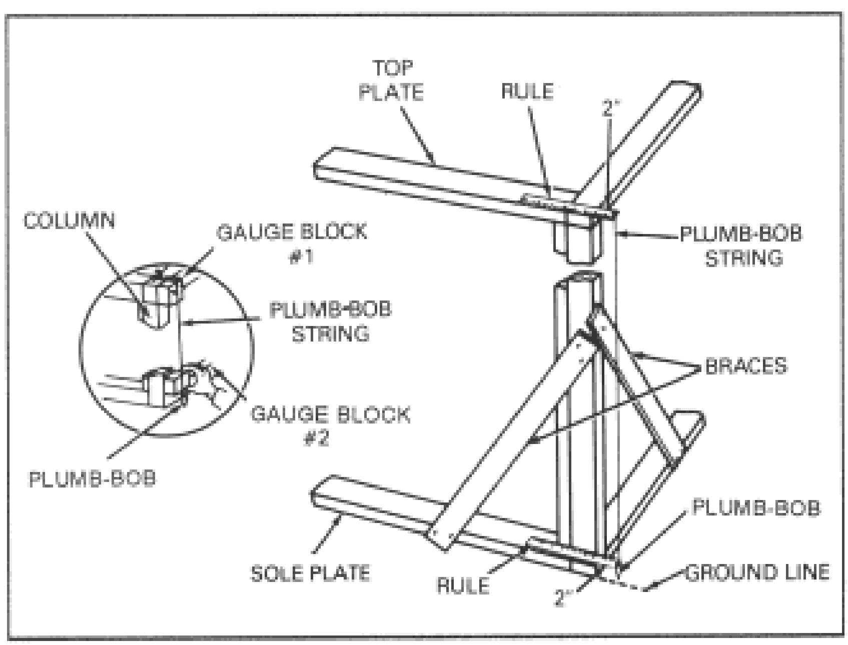


Figure 6-38. Plumbing a post

sheathing bracings (Figure 6-40).

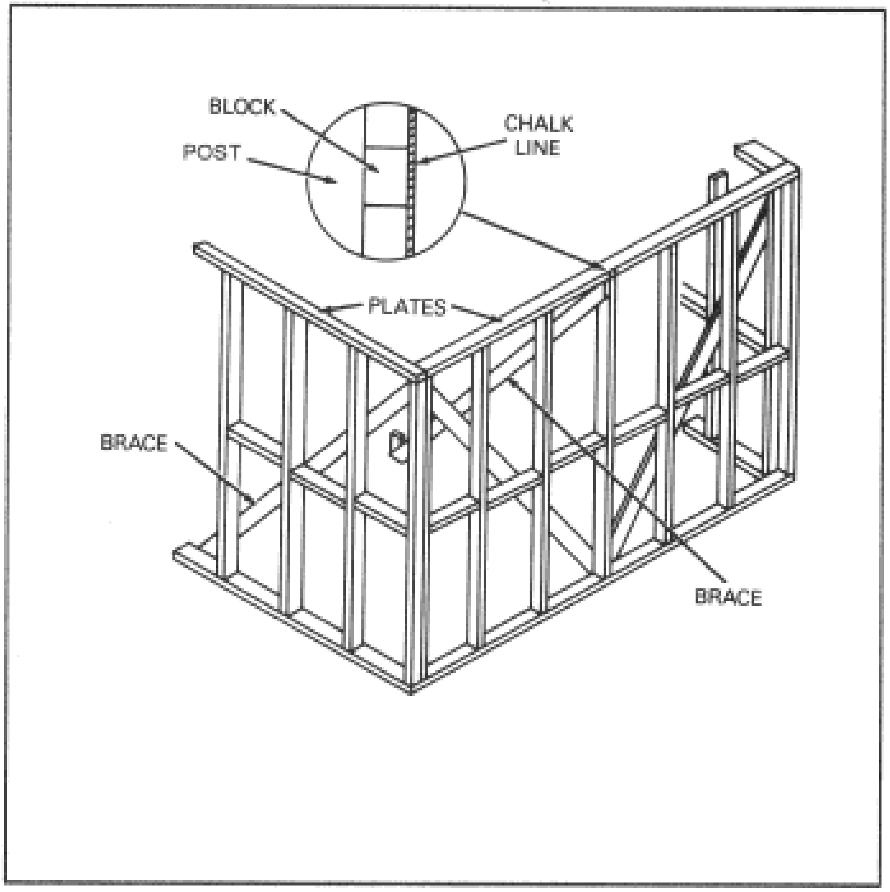


Figure 6-39. Straightening a wall

Let-In Bracing

Let-in bracing is set into the edges of studs, flush with the surface. The studs are always cut to let in the braces; the braces are never cut. Usually 1 x 4s or 1 x 6s are used, set diagonally from top plates to sole plates, or between top or sole plates and framing studs.

Cut-In Bracing

Cut-in bracing is toenailed between studs. It usually consists of 2 x 4s cut at an angle to permit toenailing. They are inserted in diagonal progression between studs running up and down from corner posts to the sill or plates.

Diagonal-Sheathing Bracing

The strongest type of bracing is diagonal sheathing. Each board braces the wall. If plywood sheathing 5/8 inch thick or more is used, other methods of bracing may be omitted.

EXTERIOR WALLS

The exterior surfaces of a building usually consist of vertical, horizontal, or diagonal sheathing and composition, sheet metal, or corrugated roofing. However, in TOs, those materials are not always available and substitutes must be provided. Concrete blocks, brick, stone rubble, metal, or earth may be substituted for wood in treeless regions. In the tropics, improvised siding and roofs can be made from bamboo and grasses. Roofing felt, sandwiched between two layers of light wire mesh, may serve for wall and roof materials where the climate is suitable. Refer to TMs 5-302-1 and 5-302-2 for details on substitute, expedient, and improvised construction.

The following paragraphs cover the types of sheathing, siding, and building paper that may be used.

Sheathing

Sheathing is nailed directly onto the framework of the building. It is used to strengthen the building; provide a base wall onto which the finish siding can be nailed; act as insulation; and, in some cases, be a base for further insulation. Some of the common types of sheathing are—

- Wood, 1 inch thick by 6, 8, 10, or 12 inches wide of No. 1 common square or matched-edge material.
- Gypsum board, 1/2 inch thick by 4 feet wide and 8 feet long.
- Fiberboard, 25/32 inch thick by 2 or 4 feet wide and 8, 9, 10, or 12 feet long.
- Plywood, 1/4, 3/8, 1/2, or 5/8 inches thick by 4 feet wide and 8, 9, 10, or 12 feet long.

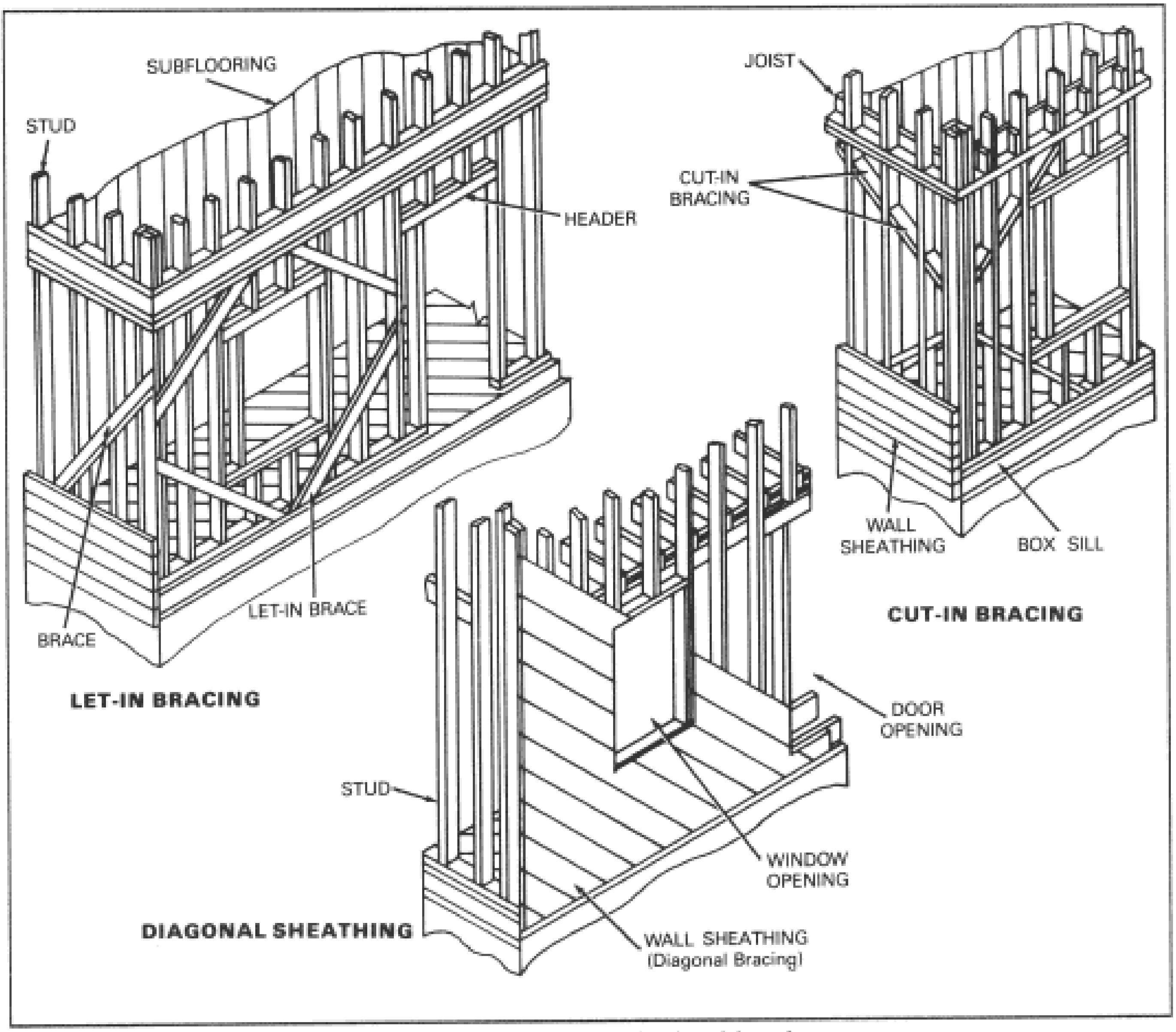


Figure 6-40. Three methods of bracing

Wood. Wood wall sheathing comes in almost all widths, lengths, and grades. However, it is normally 6 to 12 inches wide and 3/4 inch thick. Lengths are selected for economical use and the sheathing is either square- or matched-edge. Sheathing 6 or 8 inches wide should be nailed with two 8d nails at each stud crossing. Wider boards should be nailed with three 8d nails. It is laid on tight, with all joints made over the studs. It may be nailed on horizontally or diagonally (Figure 6-41); however, diagonal application adds much greater strength to the structure. If the sheathing is to be put on horizontally, start at the foundation and work toward the top. If it is to be put on diagonally, start at a bottom corner of the building and work toward the opposite wall.

Gypsum Board. This type of sheathing is made by casting a gypsum core into a heavy, water-resistant, fibrous envelope. The long edges of the 4 x 8 boards are tongue and grooved. Each board is 1/2 inch thick. Gypsum board is generally used with wood siding. Gypsum board should be nailed with 13/4- or 2-inch galvanized roofing nails spaced 7 inches on center. Gypsum board can be nailed (together with the wood siding) directly to the studs (Figure 6-42). Gypsum sheathing is fireproof, water resistant, and windproof. It does not warp or absorb water and does not require the use of building paper.

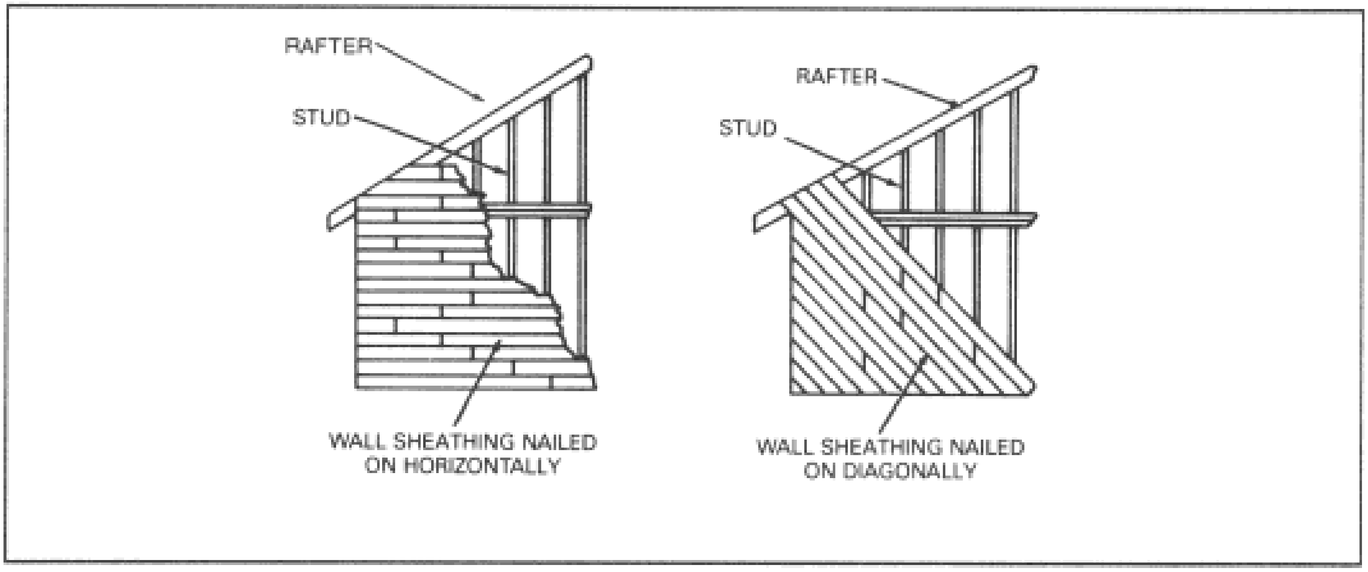


Figure 6-41. Horizontal and diagonal sheathing

Plywood. Plywood is highly recommended for wall sheathing (Figure 6-42). It adds a lot more strength to the frame than using diagonally applied wood boards. When this sheathing is used, corner bracing can be omitted. For this reason and because of their large size, weight, and stability, plywood panels are faster and easier to apply. Plywood provides a tight, draft-free installation of high insulation value.

The minimum thickness of plywood wall sheathing should be 1/4 inch for 16-inch stud spacing, and 3/8 inch for 24-inch stud spacing. The panels should be installed with the face grain **parallel** to the studs. A little more stiffness can be gained by

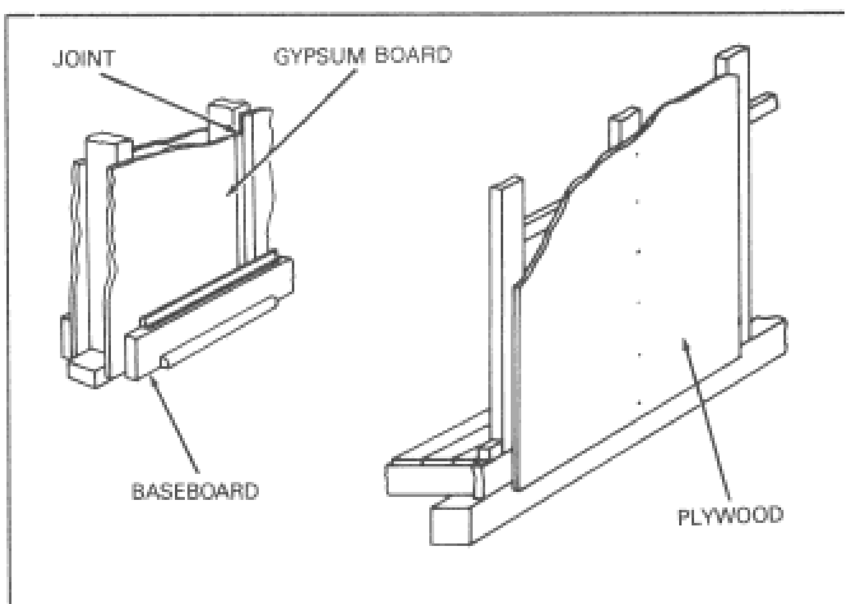


Figure 6-42. Gypsum and plywood sheathing

installing them across the studs, but this requires more cutting and fitting. Use 6d common nails for 1/4-, 3/8-, and 1/2-inch panels. At the edges of the panels, space the nails not more than 6 inches on center; elsewhere, not more than 12 inches on center.

Siding

The siding for exterior walls should be decay-resistant, hold tight at the joints, and take and hold paint well.

Wood Siding. Wood siding should be decay-resistant, well-seasoned lumber. It should hold tight at the joints and take and hold paint well. It ranges from 1/2 to 3/4 inch thick by 12 inches wide.

Vertical Wood Siding. Vertical wood siding (Figure 6-43) is nailed securely to girts with 8d or 10d nails. The cracks are covered with wood strips called battens. To make this type of wall more weatherproof, some type of tar paper or light roll roofing may be applied between the siding and the sheathing.

Horizontal Wood Siding Horizontal wood siding (Figure 6-43) is cut to various patterns and sizes to be used as the finished outside surface of a structure. There are two types bev*eled siding* and *drop siding* (Figure 6-43).

Beveled. Beveled siding is made with beveled boards, thin at the top edge and thick at the butt. It is the most common form of wood siding. It comes in 1 inch for narrow widths, and 2 inches and over for wide types. Beveled siding is usually nailed at the butt edge, through the top edge of the board below. Very narrow siding is quite often nailed near its thin edge, like shingles. It is nailed to solid sheathing over which building paper has been attached. Window and door casings are first framed. The siding butts are put against the edges of these frames. Corners may be mitered, or the corner boards may first be nailed to the sheathing. Siding is then fitted against the edges.

Drop. Drop siding is used as a combination of sheathing and siding or with separate sheathing. It comes in a wide variety of face profiles and is either shiplapped or tongue and grooved. If used as a combined sheathing and siding material, tongue-and-groove lumber is nailed directly to the studs with the tongue up. When sheathing is not used, the door and window casings are set after the siding is up. If sheathing is first used and then building paper is added, drop siding is applied with beveled siding, **after** the window and door casings are in place.

Corrugated-Metal Siding. Corrugated metal is often used as wall cover since it requires little framing, time, and labor. It is applied vertically and nailed to girts. Nails are placed in the ridges. Sheathing can be used behind the iron with or without building paper. Since tar paper used behind metal will cause the metal to rust, a resin-sized paper should be used.

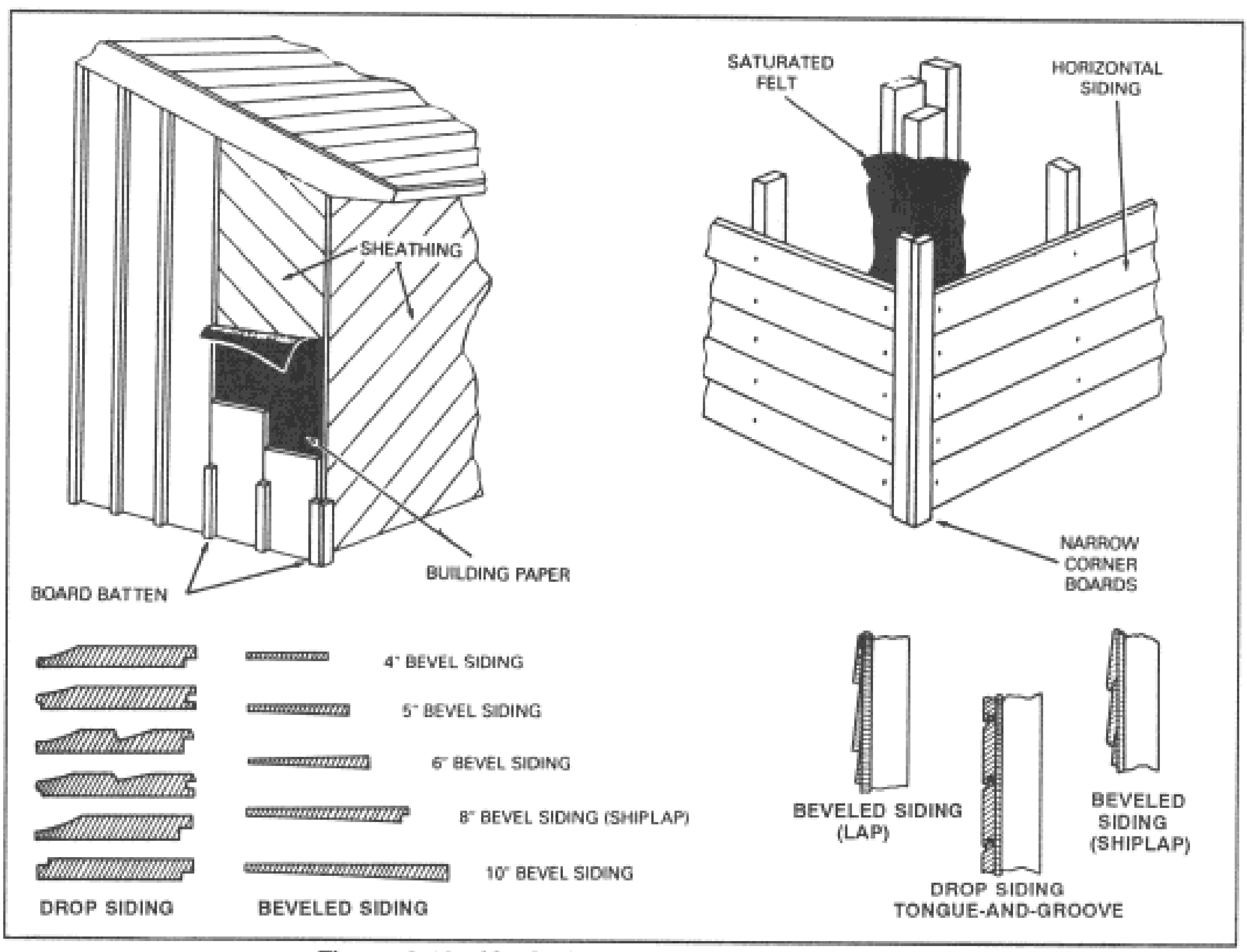


Figure 6-43. Vertical and horizontal wood siding

Vinyl and Aluminum Siding. Vinyl and aluminum sidings are popular, low-maintenance, low-cost wall covering. They can be backed with polystyrene or other board reinforcement, both to give the siding a strong base and an insulating R factor value.

Figure 6-44, page 6-34, shows the most common vinyl and aluminum sidings and installation accessories. Some variations exist between manufacturers, but the basic rules for installation are universal. They are—

- Nail in the center of slots.
- Do not nail tightly, leave loose for contracting and expanding.
- Leave at least 1/4-inch clearance at all stops.
- Do not stretch tight.
- Strap and shim all uneven walls.

Step 1. Place outside and inside corners with the bottom of the trim even with the area to weatherproof. Use a level or transit to maintain a constant horizontal line.

Step 2. Using a level, transit, or chalk line, place the bottom of the starter strip level with the bottom of the corner trim. The starter strip will butt the edge of the trim.

Step 3. Snap the bottom of the siding onto the starter strip and slide it tight into the corner trim, then out 1/4 inch to allow for expansion and contraction of materials in changing temperatures. Nail with roofing nails, 16 inches on center, in the center of the slot, without driving the nails home (leaving approximately 1/16 of an inch between the nailhead and the wall sheathing).

Step 4. Attach additional pieces of siding in a like manner, except the additional pieces will be placed on top of earlier placed pieces (as top end and bottom ends, like male and female ends in tongue-and-groove materials). Lap tight, then pull away 1/4 inch.

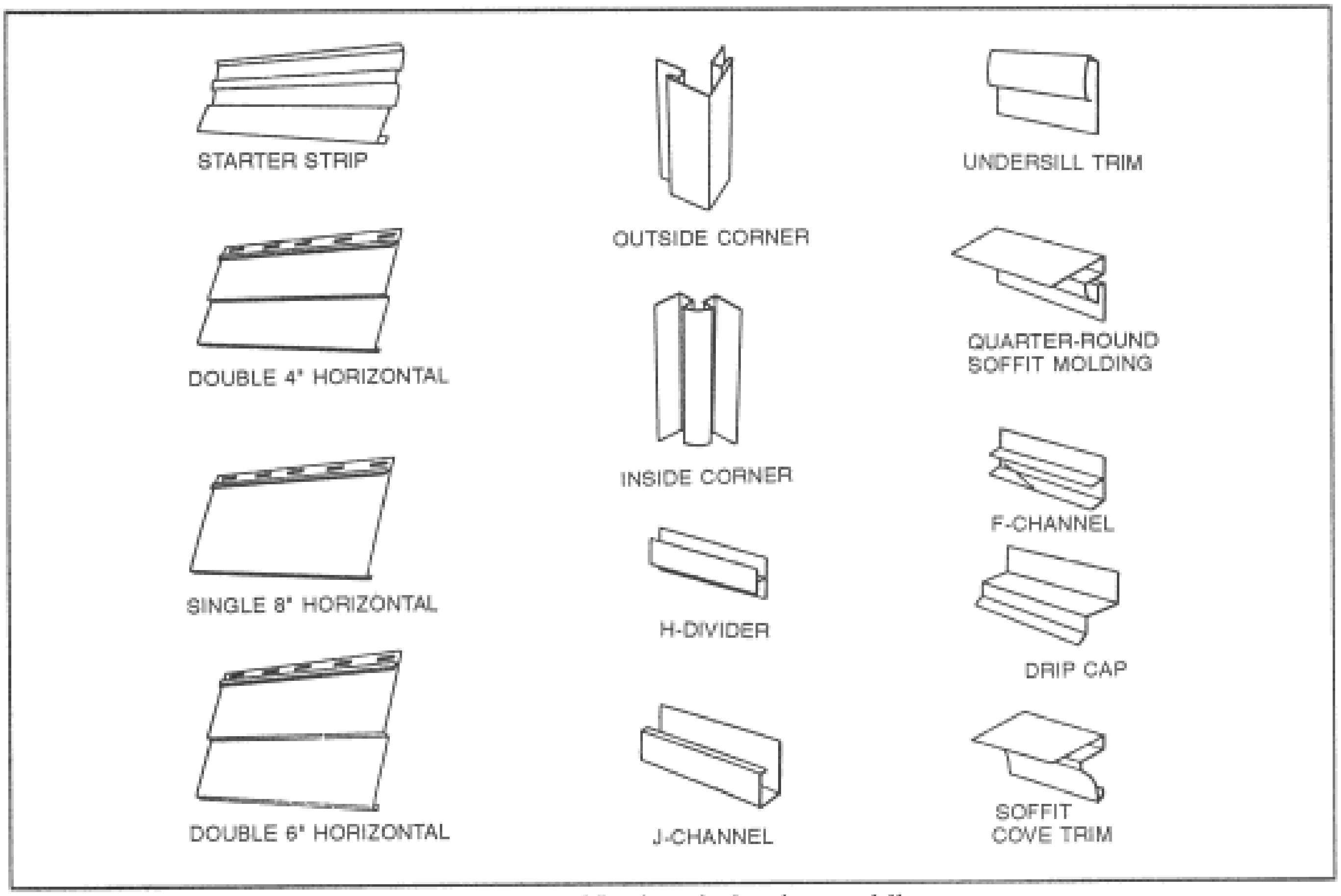


Figure 6-44. Vinyl and aluminum sidings

NOTE: **When ending a "run" into a corner or a J-channel, cut so that installation is 1/4 inch from butt to trim.**

Step 5. Install J-channels on surfaces where the siding run breaks (as in a window or door). The J-channel provides a weatherproof surface.

On vertical breaks, butt the siding as described in the previous paragraph. On horizontal breaks, install the undersill trim inside the J-channel. The undersill trim is a fastening device. On surfaces such as the top of the door or window trim, this channel will hold pieces of siding that were cut (removing the part of siding that "snaps" onto the top of previous pieces) tight, keeping them from flapping in the breeze. On surfaces such as where the siding butts into the soffit or below windows, a slotting tool is used to pierce the part of the siding that slides into the undersill trim. This pierce pushes out part of the siding and forms a catch. This is used when siding is pushed into the undersill trim, providing fastening for the top of a section of siding where nailing is not possible.

Building Paper

Building paper comes in several types. The most common type is resin-sized. It is generally red or buff in color (sometimes black). It comes in rolls, usually 36 inches wide; each roll containing 500 square feet and weighing 18 to 50 pounds. Normally, this building paper is not waterproof.

Another type is heavy paper saturated with a coal-tar product, sometimes called sheathing paper. This type is waterproof and insulates against heat and cold. In wood-frame buildings to be covered with siding, shingles, or iron, building paper is used to protect against heat, cold, or dampness. Building paper is applied horizontally from the bottom of the wall, and nailed with roofing nails at the laps. Overlapping the paper helps water runoff. Care must be taken not to tear the paper. The waterproof paper is also used in the built-up roof when the roof is nearly flat. Several layers are used, with tar between the layers.

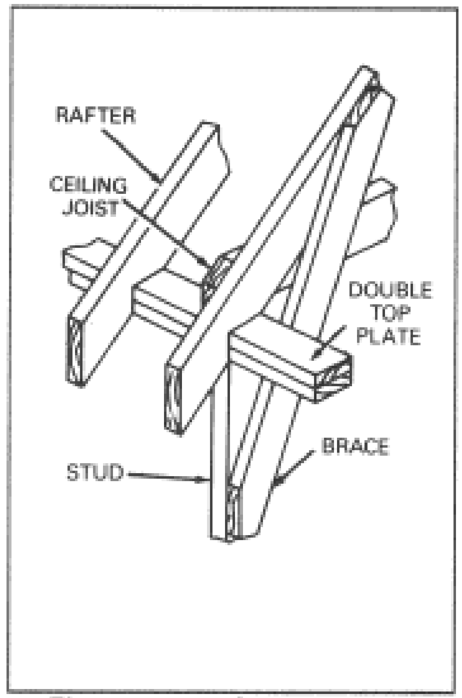


Figure 6-46. One method of bracing attic plate

CEILINGS

Ceiling joists form the framework of the ceiling of the room. They are usually lighter than floor joists but must be large enough and strong enough to resist bending and buckling.

Ceiling joists are usually installed 16 inches or 24 inches on center, starting at one side of the building and continuing across, parallel to the rafters (Figures 6-45 and 6-46). Extra joists, if needed, may be placed without affecting the spacing of the prime joists.

Selecting and installing the ceiling joists are much the same as for floor joists. Ceiling joists are nailed to both the plates and the rafters, if possible, and lapped and nailed over bearing partitions. Joists that lie beside rafters on a plate are cut at the same pitch as the rafter, flush with the top of the rafter. Joists are installed crown or camber up.

WALL OPENINGS

In addition to doors and windows (Chapter 8), other wall openings are needed.

STOVEPIPES

Stovepipes may extend outside a building through a side wall to eliminate the need for flashing and waterproofing around the pipe (Figures 6-47 and 6-48). The opening should be cut in an area selected to avoid cutting studs, braces, plates, or other structural members. Sheathing must be cut back in a radius 6 inches greater than that of the pipe. Safety thimbles or other insulation must be used on the inside and outside of the

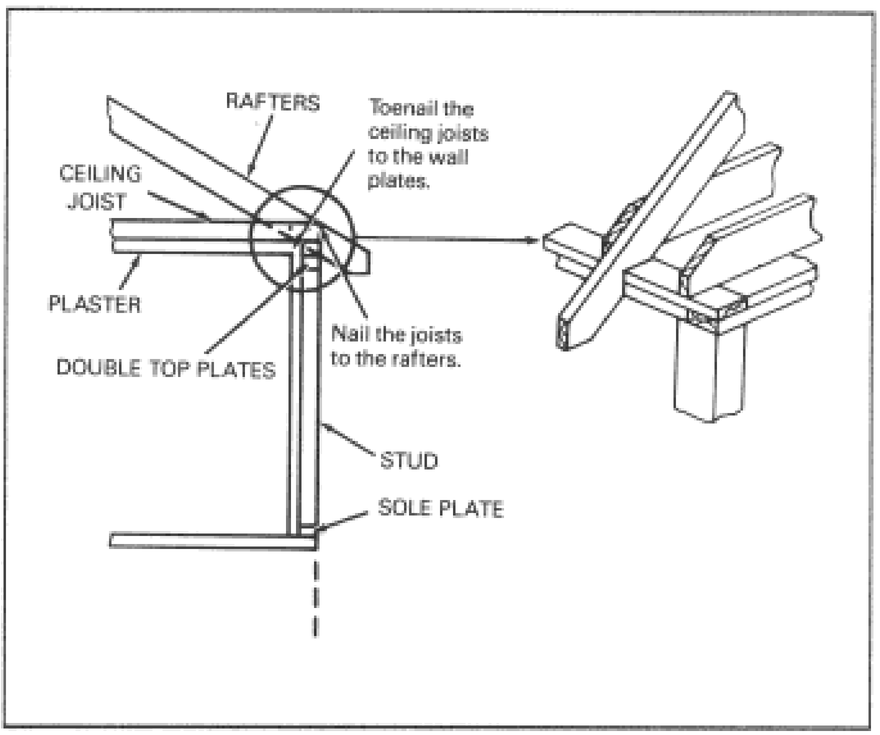


Figure 6-45. Built-up plate supporting joist and roof rafters

sheathing. Sheet metal insulation may be constructed and used as a single insulator on the outside.

Make the opening for the stovepipe as follows:

Step 1. Cut a hole through the sheet metal where the stovepipe will penetrate.

Step 2. Mark a circle on the metal 1/2 inch larger in diameter than the pipe. Then make another circle within this circle, with a diameter 2 inches less than the diameter of the first.

Step 3. With a straightedge, draw lines through the center of the circle from the circumference. These marks should be from 1/2 to 3/4 inch apart along the outer circumference.

Step 4. Cut out the center circle, then cut to the outside of the circle along the lines drawn.

Step 5. After the lines have been cut, bend the metal strips outward at a 45° angle.

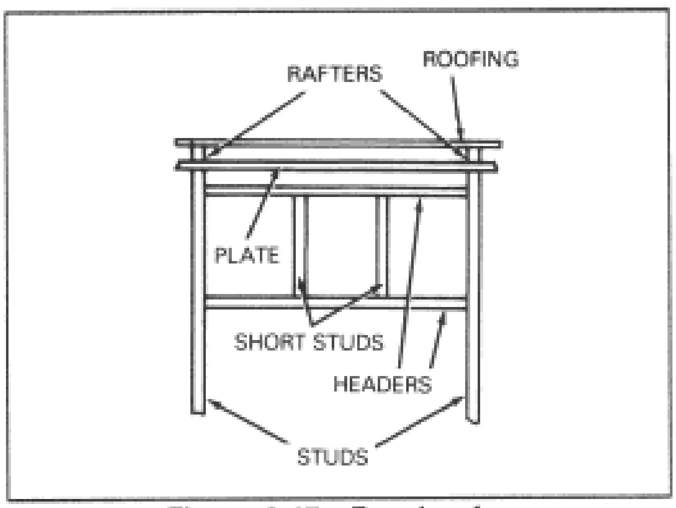


Figure 6-47. Framing for stovepipe

Step 6. Force the pipe through the hole to the desired position.

NOTE: Very little water will leak around this joint.

VENTILATORS

Ventilation is necessary to prevent condensation in buildings. Condensation may occur in the walls, in the crawl space under the structure, in the basement, on windows, and in many other places. Condensation is most likely to occur during the first six to eight months after a building is built and in extreme cold weather when interior humidity

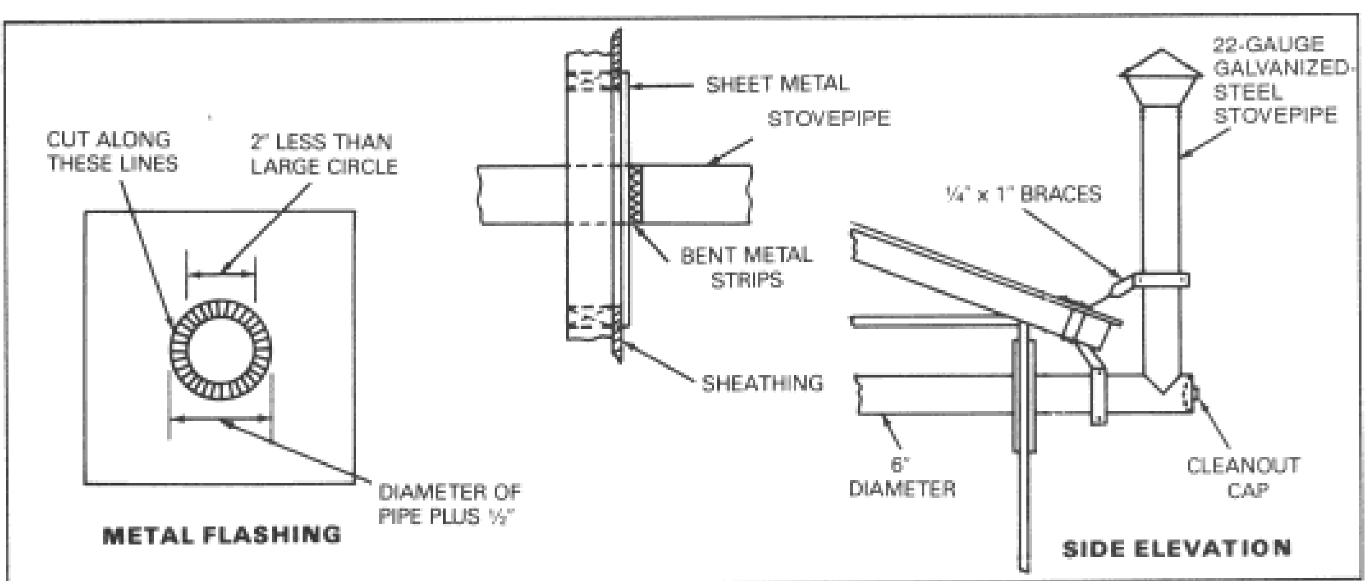


Figure 6-48. Installing stovepipe

is high. Proper ventilation under the roof allows moisture-laden air to escape during the winter heating season and allows the hot, dry air of the summer season to escape. The upper areas of a structure are usually ventilated by louvers or ventilators. (Types of ventilators are shown in Figure 6-49.)

Upper Structure

One of the most common methods of ventilating is to use wood or metal louver frames. There are many types, sizes, and shapes of louvers.

Determine the size and number of ventilators by the size of the area to be ventilated. One square foot of vent should be placed for each 150 square feet of floor space **without** soffit vents and for each 300 square feet of floor space **with** soffit vents. The minimum net open area should be 1/4 square inch per square foot of ceiling area.

Louver frames are usually 5 inches wide. The back edge of the frame should be rabbeted out for a screen, a door, or both. Louvers have ¾-inch slats, which are spaced about 1 3/4 inches apart. The slats should have sufficient slant or slope to prevent rain from driving in. For the best results, upper-structure louvers should be placed as near to the top of the gable as possible.

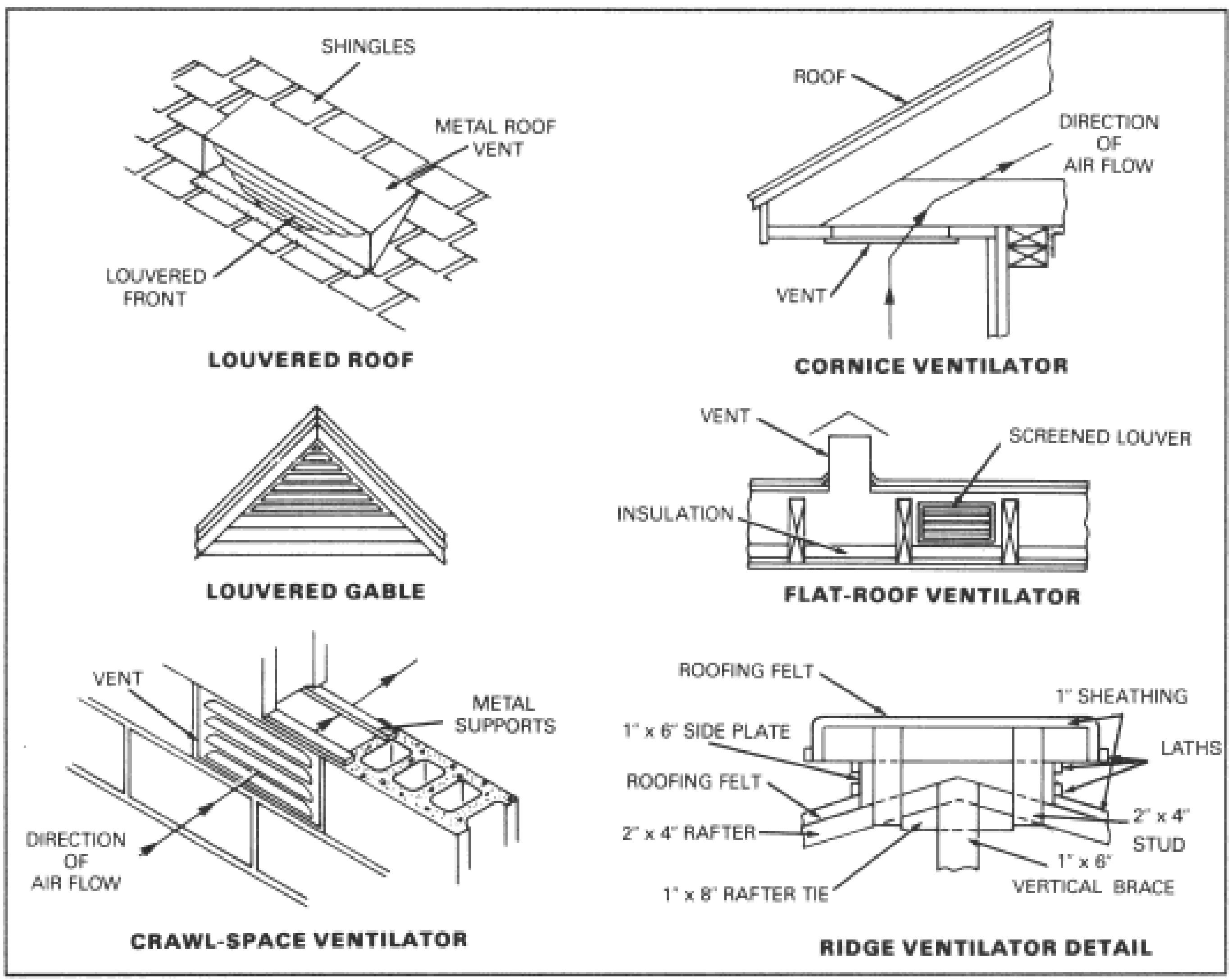


Figure 6-49. Types of ventilators

Crawl Spaces

Crawl spaces under foundations (of structures without basements) should be well ventilated. Air circulation under the flooring prevents excessive condensation which causes warping, swelling, twisting, and rotting of the lumber. The crawl space ventilators are usually called *foundation louvers*. They are set into the foundation as it is built. A good foundation vent should be equipped with a copper or bronze screen and adjustable shutters for opening and closing the louver. Louver sizes should be figured on the same basis as upper-structure louvers 1/4 square inch for each square foot of under-floor space.

STAIRWAYS

Stair work is made up of the framing on the sides, known as stringers (or carriages), and the steps known as treads. Sometimes risers are framed into the stairs at the back of the treads. The stringers (or carriages) are 2 to 3 inches thick and 8 or more inches wide. They are cut to form the step of the stairs.

There are usually three stringers to a stair if stairs are more than 36 inches wide—one at each of the two outer edges and one at the center. Floor joists must be properly framed around the stairwell (or well hole) to have enough space for the stair framing and the finished trim.

Step stringers are fastened at the top and bottom as shown in Figures 6-50 and 6-51. These figures also show the foundation and give the sizes of the step treads, as well as installation methods and post construction. The types of steps shown are the most common in field construction.

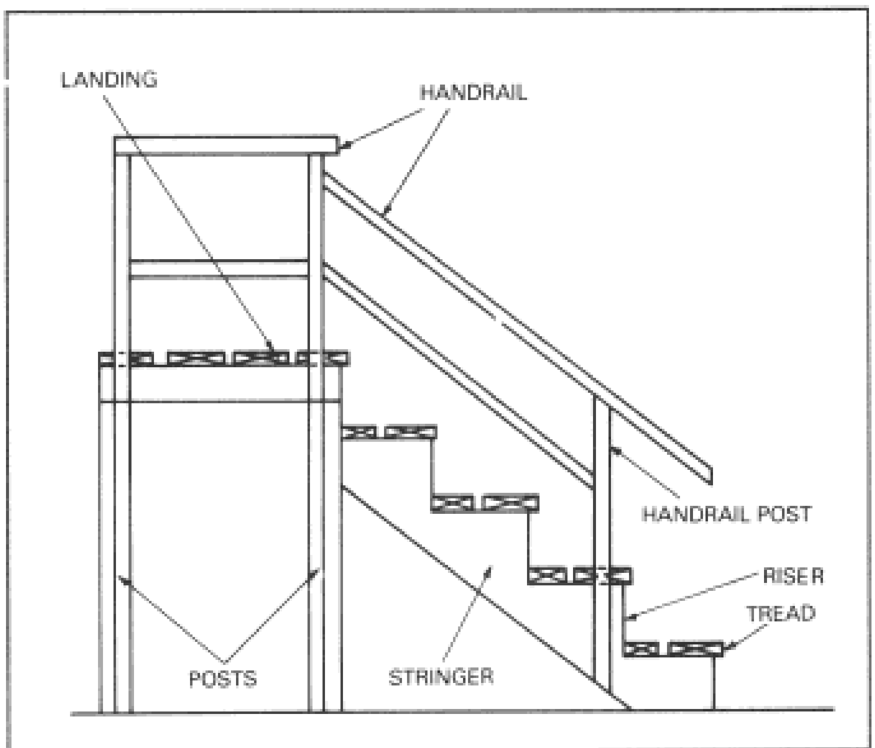


Figure 6-50. Typical stairway

STAIRWAY FRAMING

To frame simple, straight, string stairs (Figure 6-52,)—

Step 1. Take a narrow piece of straight stock, called a story pole, and mark on it the distance from the lower-floor to the upper-floor level. This is the lower-room height, plus the thickness of the floor joists and the rough and finished flooring. It is also the total rise of the stairs. Keep in mind that a flight of stairs forms a right triangle. The rise is the height of the triangle, the run is the base, and the length of the stringers is the hypotenuse.

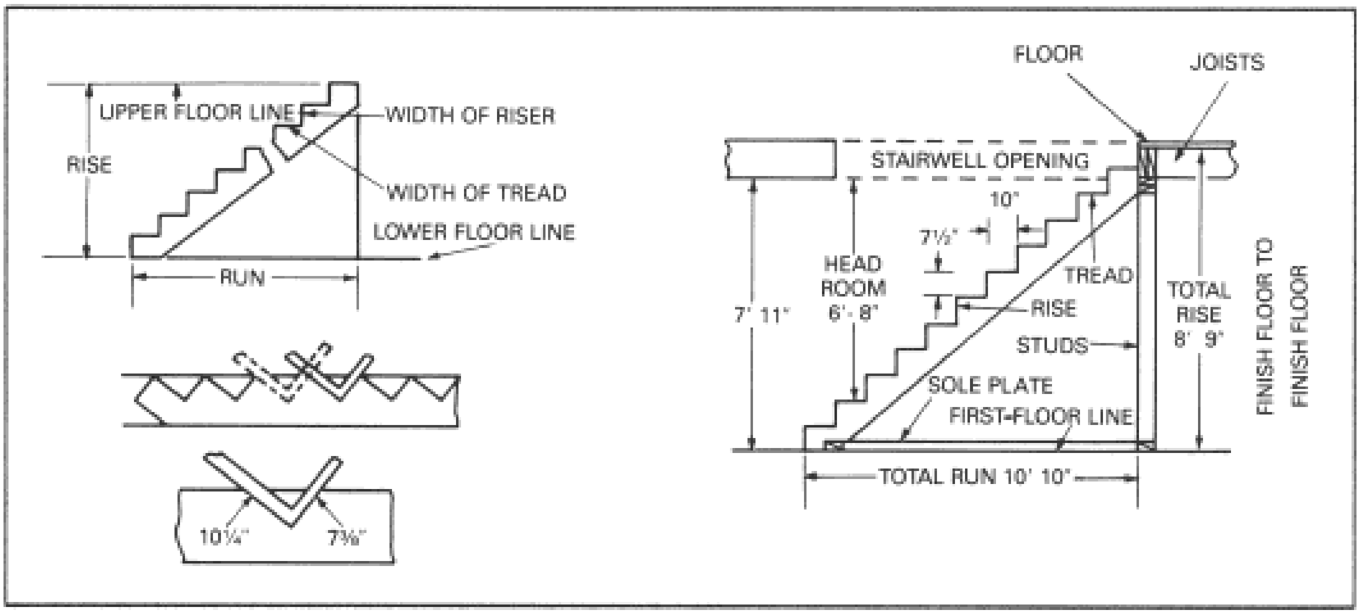


Figure 6-51. Step construction

Step 2. Set dividers at 7 inches, the average distance from one step to another.

Step 3. Step off this distance on the story pole.

Step 4. Adjust the divider span slightly if this distance will not divide evenly into the length of the story pole. Step off this distance again.

Step 5. Continue this adjusting and stepping off until the story pole is marked off evenly. 1he span of the dividers must be near 7 inches. This represents the rise of each step.

Step 6. Count the number of spaces stepped off evenly by the dividers on the story pole. This will be the total number of risers on the stairs.

Step 7. Measure the length of the stairwell opening for the length of the run of the stairs. This length may also be obtained from the plans. The stairwell-opening length forms the base of a right triangle. The height and base of the

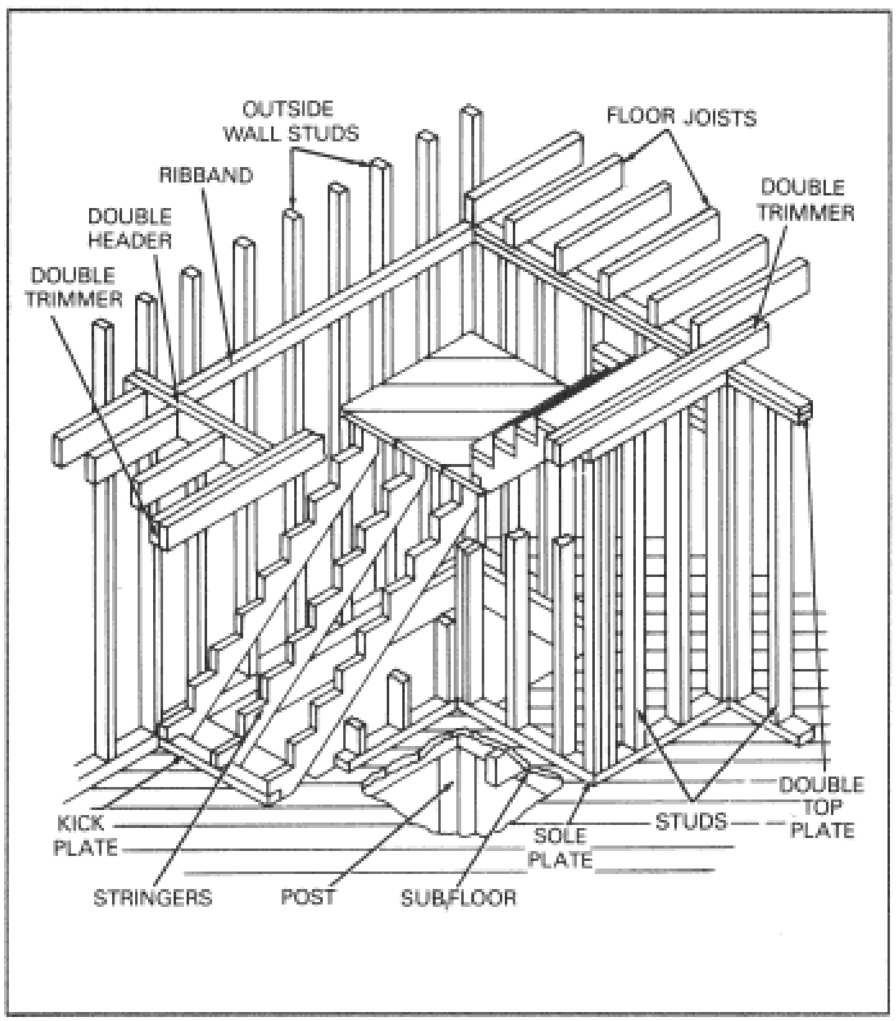


Figure 6-52. Complete stairway detail

triangle have now been obtained.

RISERS AND TREADS

To determine the width of each tread, divide the number of risers less one—since there is always one more riser than tread—into the run of the stairs. This number is used on the steel square in laying off the run and rise of each tread and riser on the stringer stock. These figures will be about 7 and 10 inches, respectively, since the ideal run and rise totals 17 inches. Lay off the run and rise of each step on the stringer stock equal to the number of risers previously determined by dividing the story pole into equal spaces. The height, base, and hypotenuse of the right triangle are now complete.

The following are two rules of thumb that may be used to check the dimensions of risers and treads:

- Riser height + tread width = between 17 and 19 inches.
- Riser height x tread width = between 70 and 75 inches.

If the sum of the height of the riser and the width of the tread falls between 17 and 19 inches and the product of the height of the riser and the width of the tread equals between 70 and 75 inches, the design is satisfactory