Pulling on the wire will remove the spreaders one after another as the concrete level rises in the forms.

Tie Wires

Tie wires hold the forms secure against the lateral pressures of unhardened concrete. Double strands are always used. Ties keep wall forms together as the concrete is positioned; Figure 5-8 shows two ways of doing this. The wire should be No. 8 or 9 gauge, black, annealed iron wire. Barbed wire may be used in an emergency. Tie spacing should be the same as the stud placing, but never more than 3 feet. Each tie is formed by looping the wire around a wale, bringing it through the form, and looping it around the wale on the opposite side. The tie wire is made taut by twisting it with a smooth metal rod or a spike.

NOTE: Wire ties should be used only for low walls or when *tie rods* are not available.

Tie Rods

An alternate to tie wires and spreaders, the tie rod and spreader combination is shown in Figure 5-9, page 5-6. After the form is removed, each rod is broken off at the notch. If appearance is important, the holes should be filled with a mortar mix.

The use of a wood strip as a wedge when curtain walls and columns are placed at the same time is shown in Figure 5-10, page 5-6. In removing the forms, the wedge is removed first.

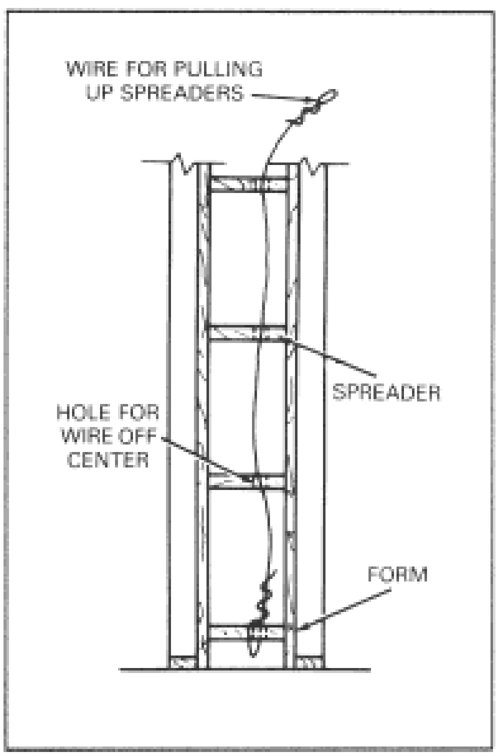


Figure 5-7. Removing wood spreaders

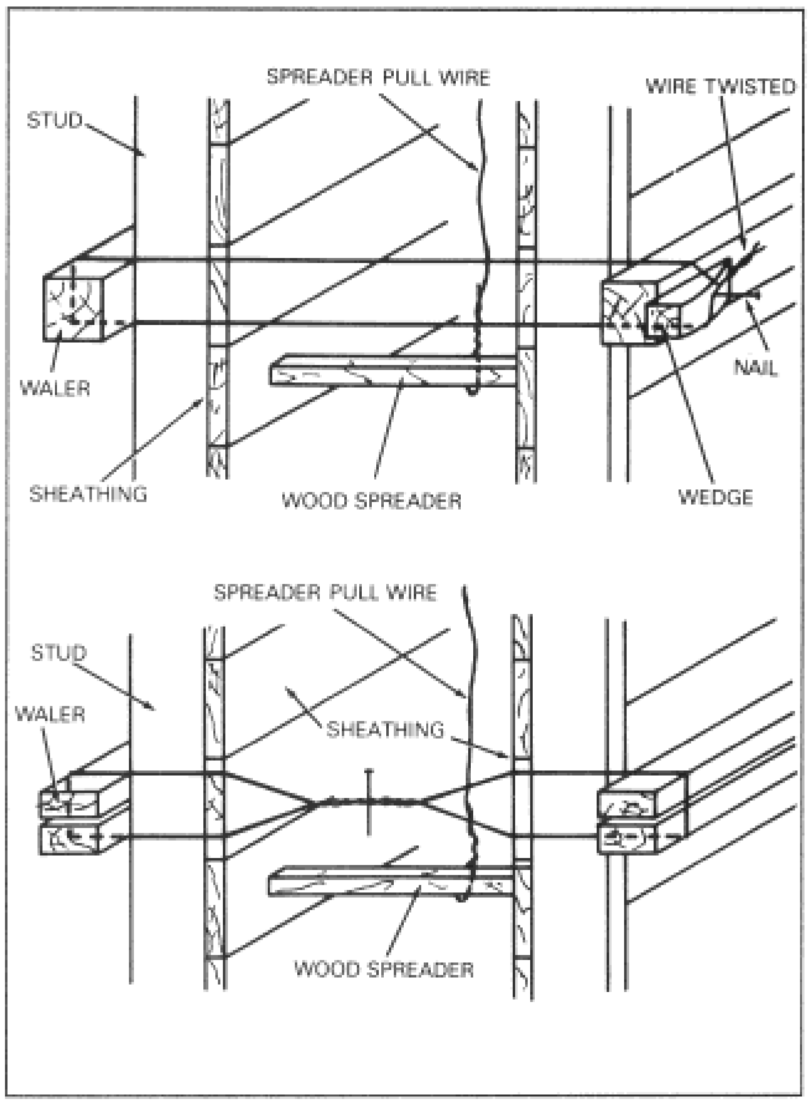
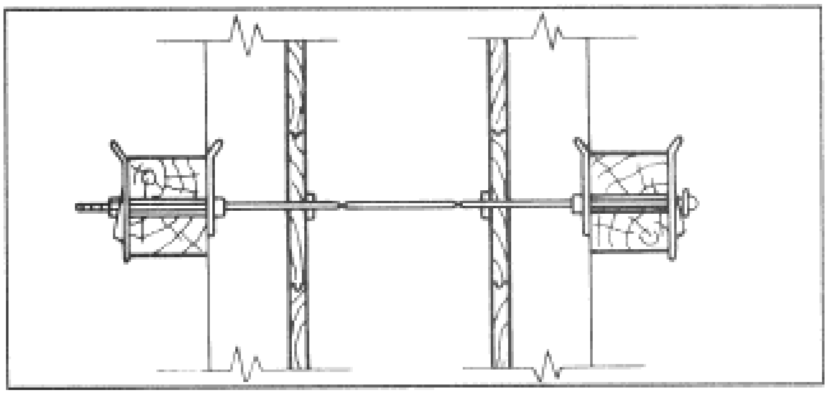


Figure 5-8. Wire ties for form walls



whether the bottom is to be left until the concrete is strong enough for shoring to be removed. Beam forms receive little bursting pressure but must be shored at close intervals to prevent sagging.

The bottom of the form is the same width as the beam; it is in one piece for its full width. Form sides are 1-inch tongue-and-groove material; they lap over the bottom (as shown). The sheath is nailed to 2 x 4 struts placed on 3-foot centers. A 1 x 4 piece is nailed along the struts to support the joists for the floor panel. The sides of the form are not nailed to the bottom but are held in position by continuous strips. Crosspieces nailed on top serve as spreaders. After erection, the slab panel joints hold the beam in place.

A beam and girder assembly is shown in Figure 5-13, page 5-8. The beam bottom butts tightly against the side of the girder and rests on a 2 x 4 nailed to the girder side. Details in Figure 5-13 show the clearances for stripping and the allowances for movement caused by the concrete's weight. The 4 x 4 posts are spaced to support the concrete and are wedged at the bottom or top for easy removal.

COLUMN FORMS

Sheathing runs vertically in column forms to save saw cuts. Corner joints are firmly nailed to ensure watertight construction. Battens or narrow strips of boards (cleats) are placed directly over the joints to fasten the several pieces of vertical sheathing together.

A column and footing form is shown in Figure 5-11. The column form is erected after the steel reinforcement is assembled and is tied to dowels in the footing. The form should have a **cleanout** hole in the bottom to help remove debris. The lumber removed to make the cleanout holes should be nailed to the form so that it can be replaced before the concrete is positioned.

BEAM AND GIRDER FORMS

Figure 5-12 shows both beam and girder forms. The type of construction of these forms depends on whether the form is to be removed in one piece or

FLOOR FORMS

Floor panels are built as shown in Figure 5-14, page 5-9. The 1-inch tongue-and-groove sheathing or 3/4-inch plywood is nailed to 1 x 4 cleats

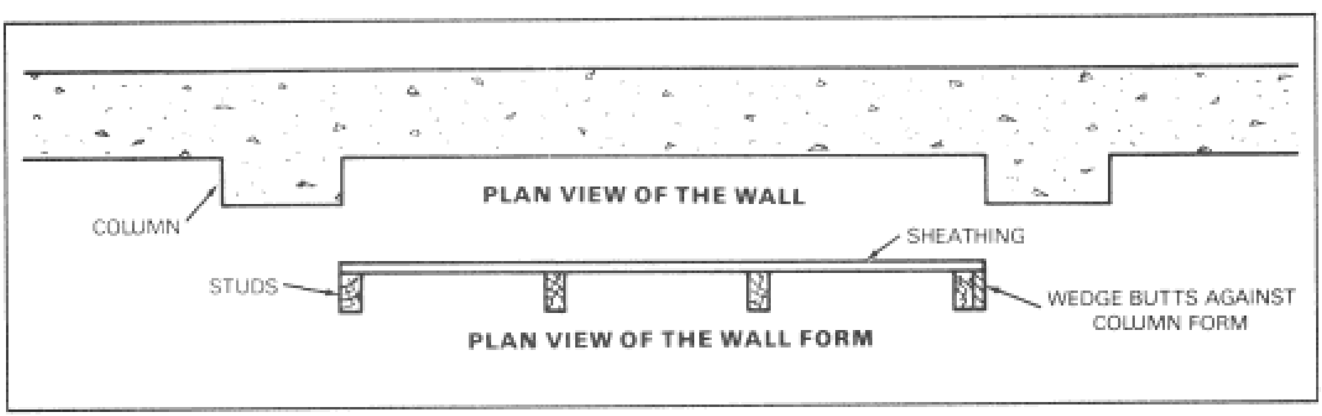
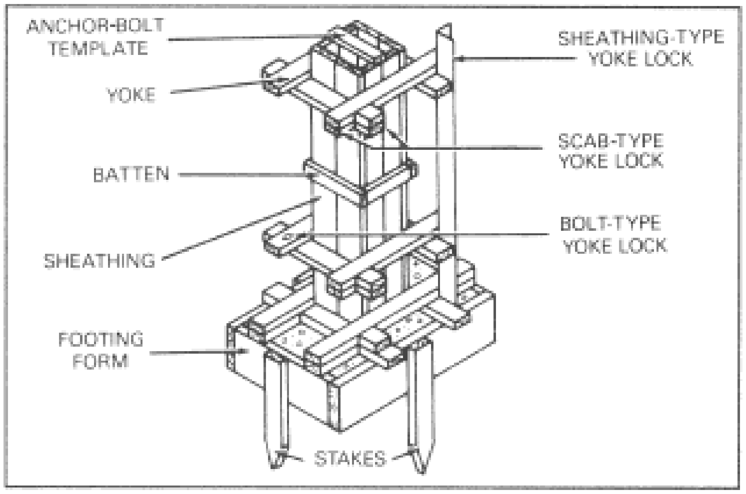


Figure 5-10. Wall form for curtain walls



on 3-foot centers. These panels are supported by 2 x 6 joists. Spacing of joists depends on the thickness of the concrete slab and the span of the beams. If the slab spans the distance between two walls, the panels are used in the same manner as when beams support the floor slab.

STAIR FORMS

A method for building stair forms up to 3 feet in width is shown in Figure 5-15, page 5-9. The underside of the steps should be 1-inch tongue-and-groove sheathing. This platform should extend 12 inches beyond each side of the stairs to support stringer bracing blocks. The back of the panel is shored with 4 x 4 pieces (as shown). The 2 x 6 cleats nailed to the shoring should rest on wedges to make both adjustments and removal of the posts easy. The side stringers are 2 x 12 pieces cut as required for the treads and risers. The face of the riser should be 2-inch material, beveled (as shown).

FORM REMOVAL

Forms should be built to allow easy removal without danger to the concrete. Before concrete is placed, forms are treated with oil or other coating material to prevent the concrete from sticking. The oil should penetrate the wood to prevent water absorption. A light

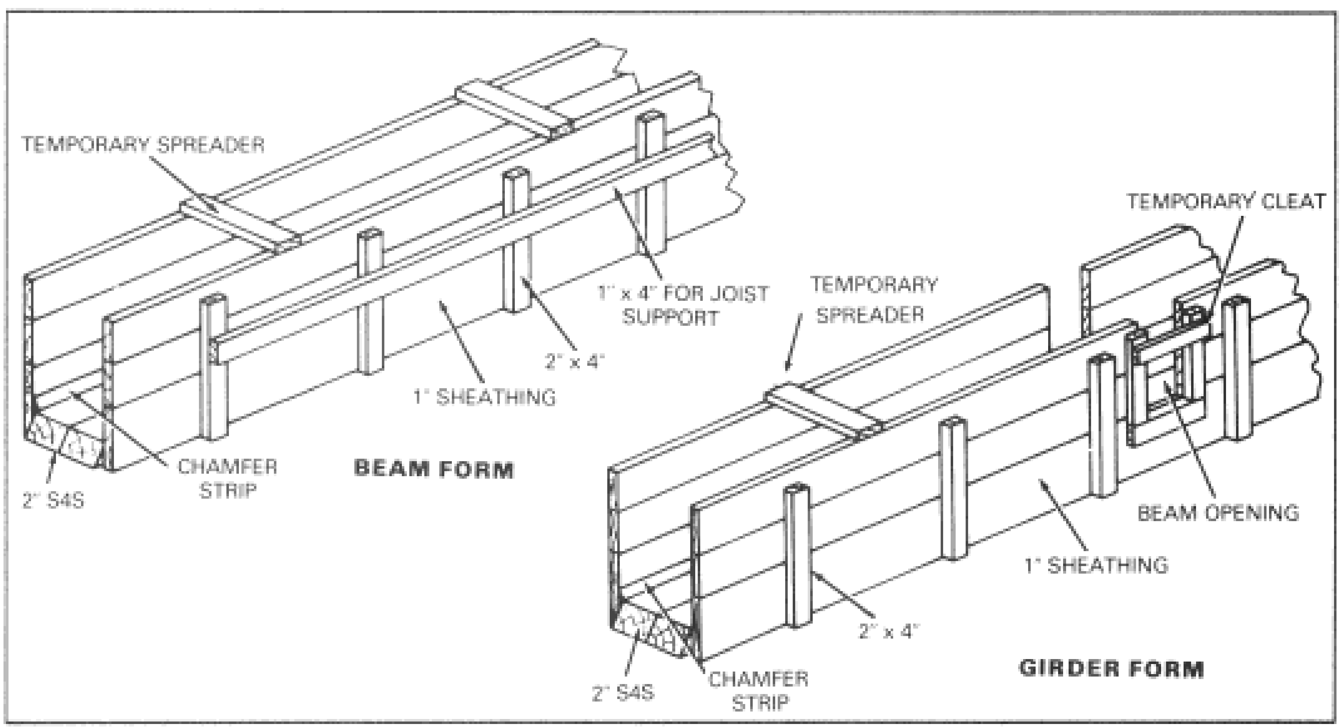


Figure 5-12. Beam and girder forms

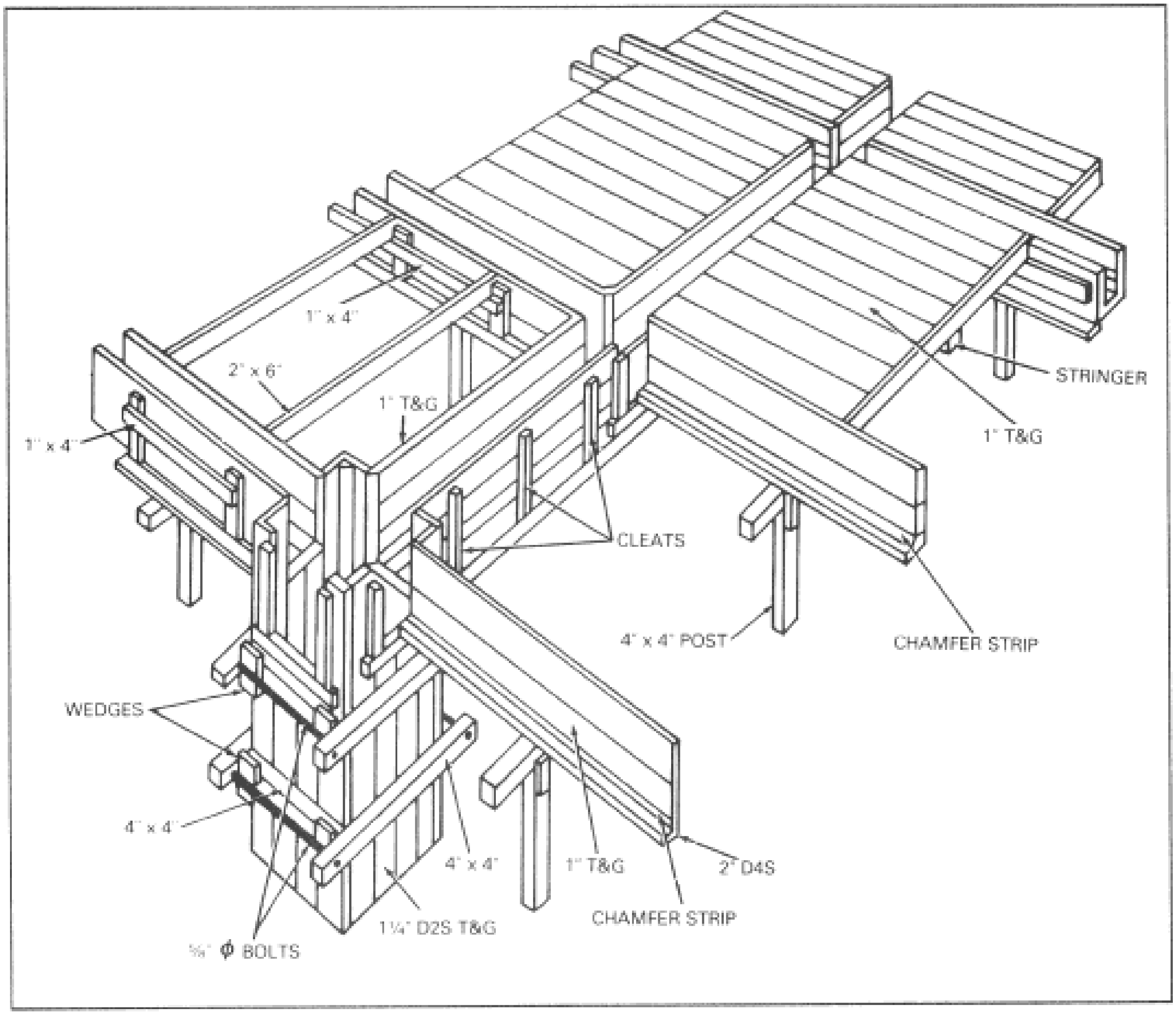


Figure 5-13. Beam, column and floor form

bodied petroleum oil will do. On plywood, shellac is more effective than oil. If forms are to be reused, painting helps preserve the wood.

If form oil is not available, wetting with water may be substituted in an emergency to prevent sticking.

Wood wedges should be used to wedge forms against concrete, rather than a pinchbar or other metal tool. To avoid breaking the edges of concrete, forms should not be jerked off after wedging has been started at one end. Forms to be reused should be cleaned and oiled immediately. Nails should be removed as forms are stripped.

CAUTION

--Permit only workmen doing the stripping in the immediate area.
--Do not remove forms until the concrete has set.
--Pile stripped forms immediately to avoid congestion, exposed nails, and other hazards.

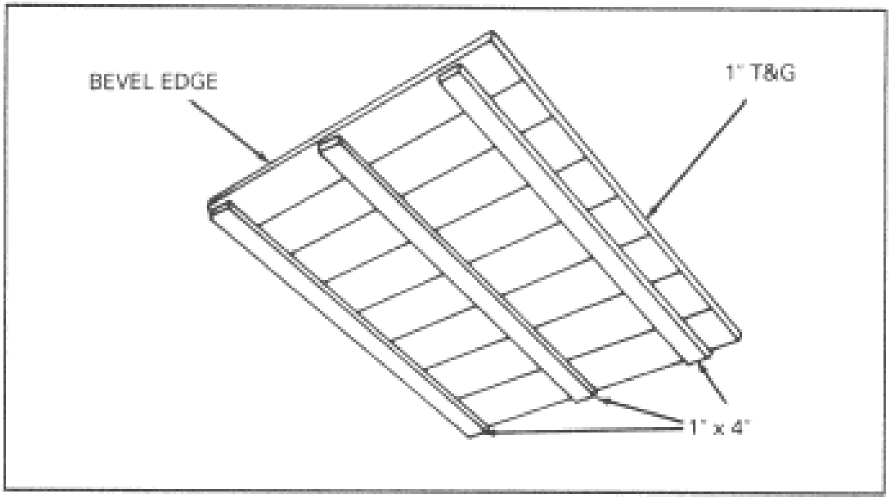


Figure 5-14. Floor slab form

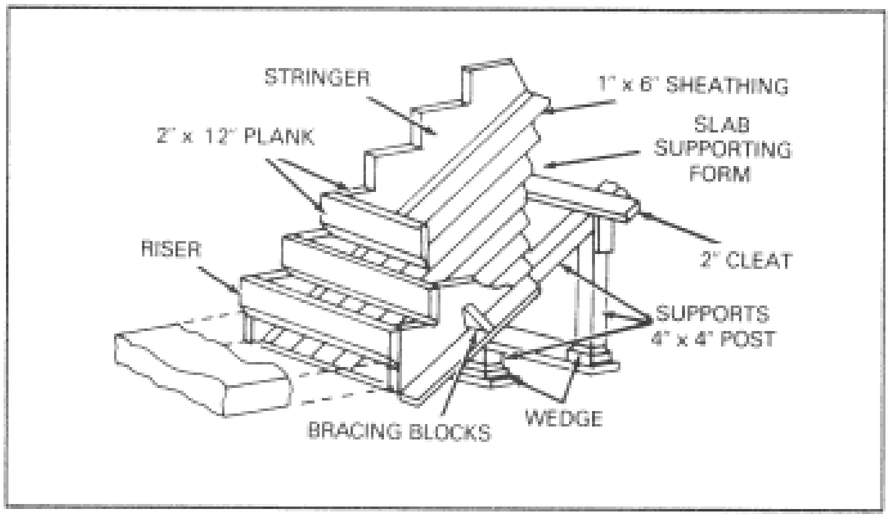


Figure 5-15. Stairway slab form

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.

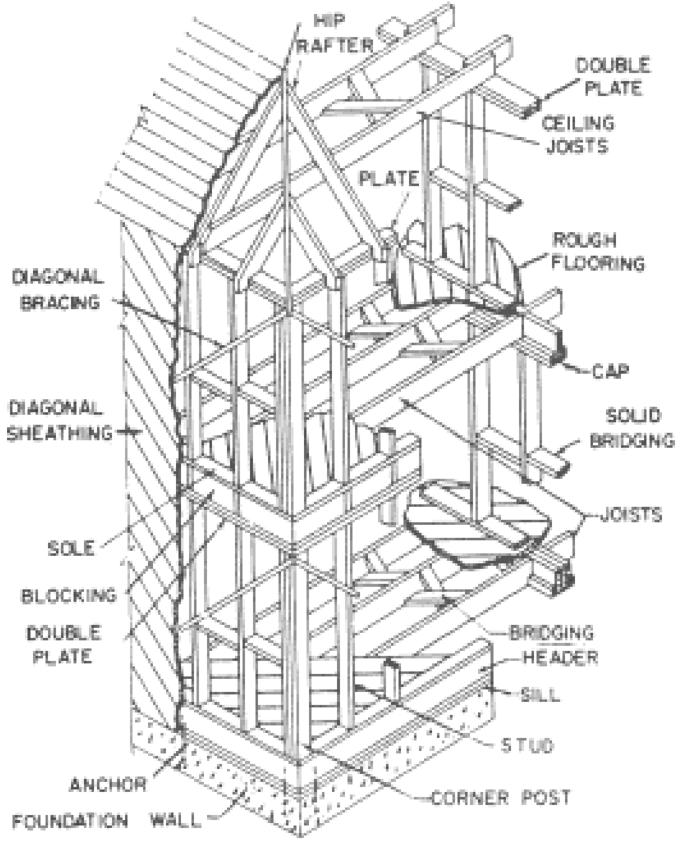
Much of light framing can be done in staging areas while staking out, squaring, and floor framing is being done. Subflooring can begin when a portion of the floor joists has been laid. The better-skilled men should construct the frame, and with good coordination, a large force of men can be kept busy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

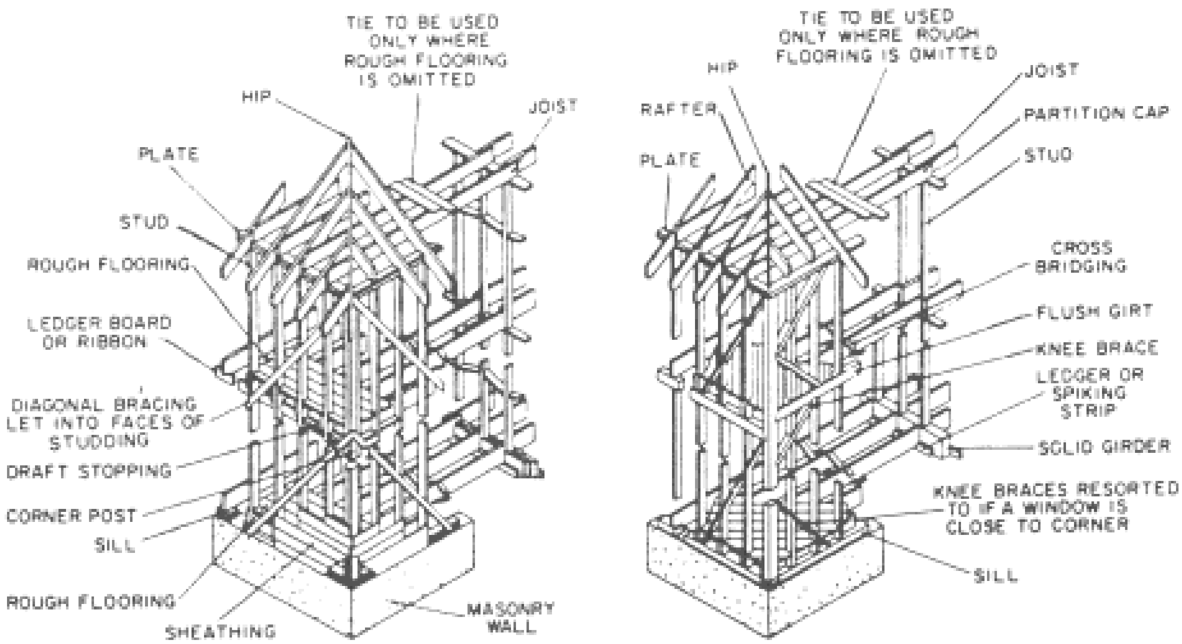
Balloon Frame

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

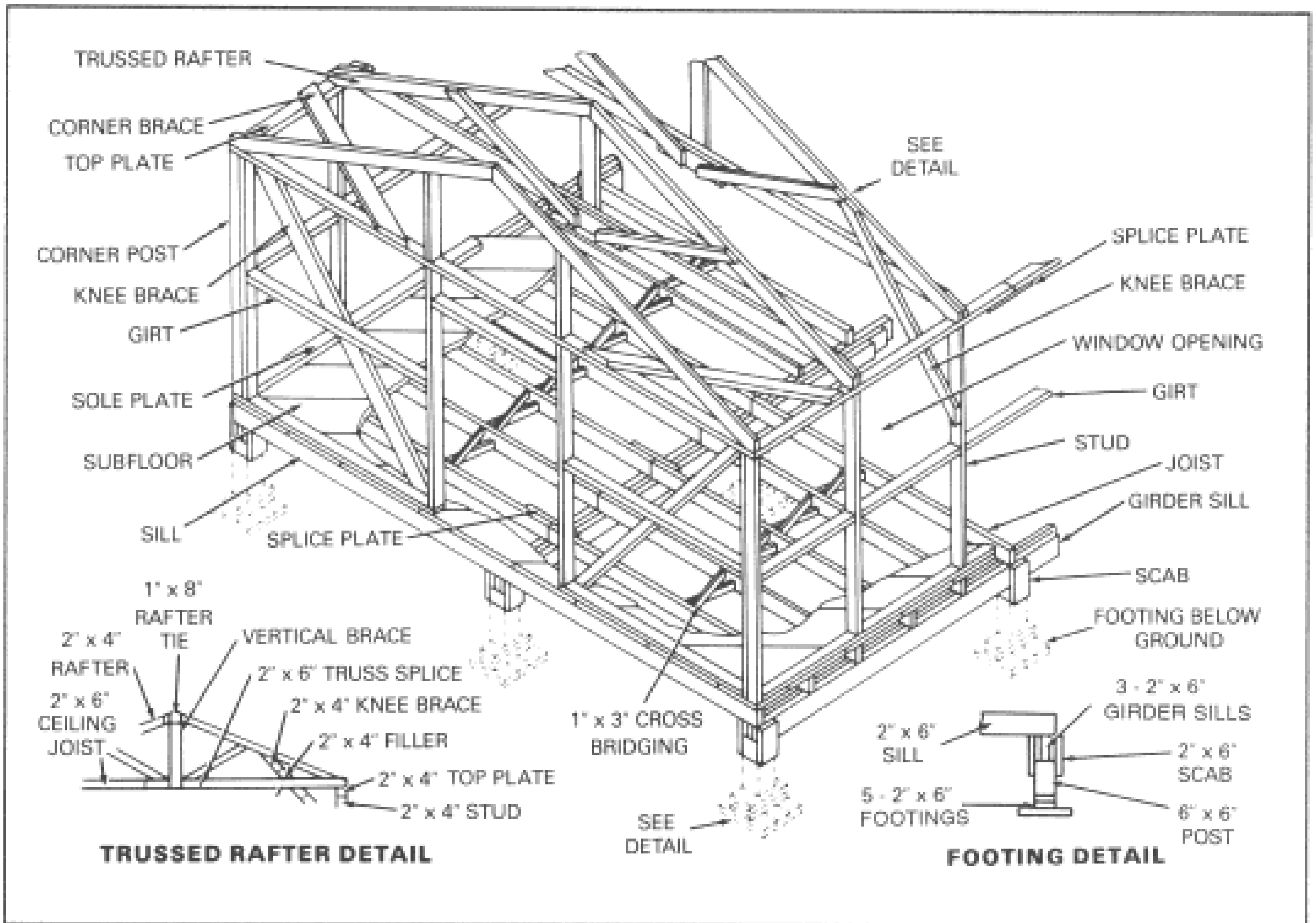


Figure 6-2. Light-framing details

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.

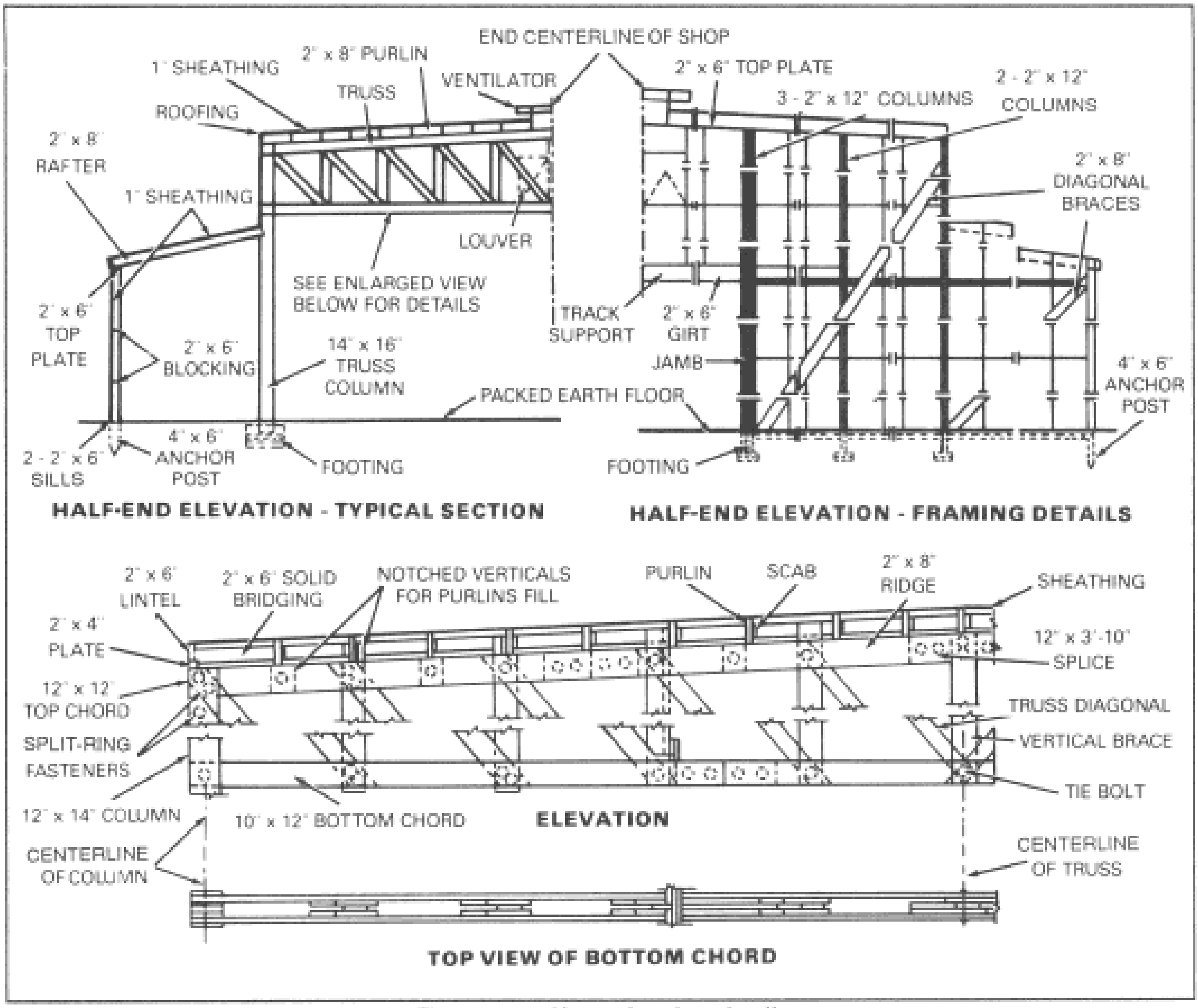


Figure 6-3. Heavy-framing details

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.

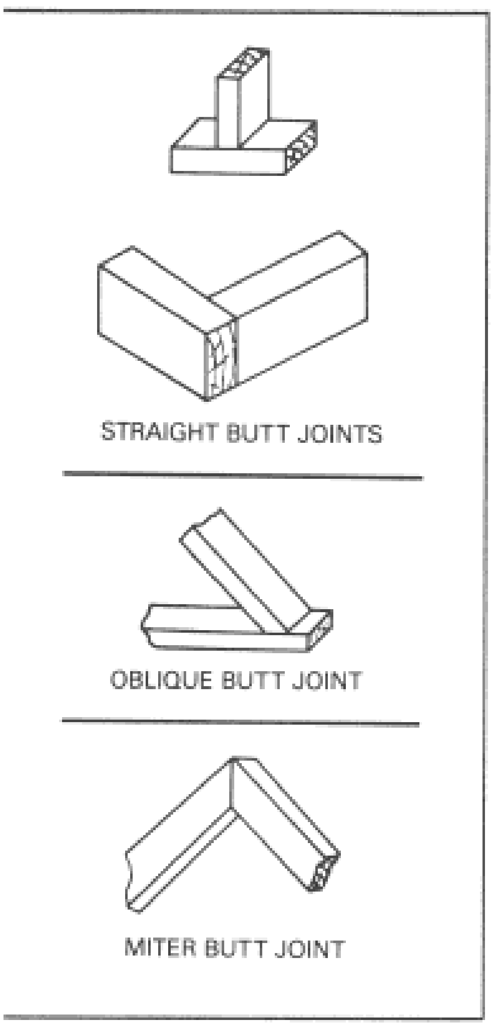


Figure 6-4. Butt joints

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

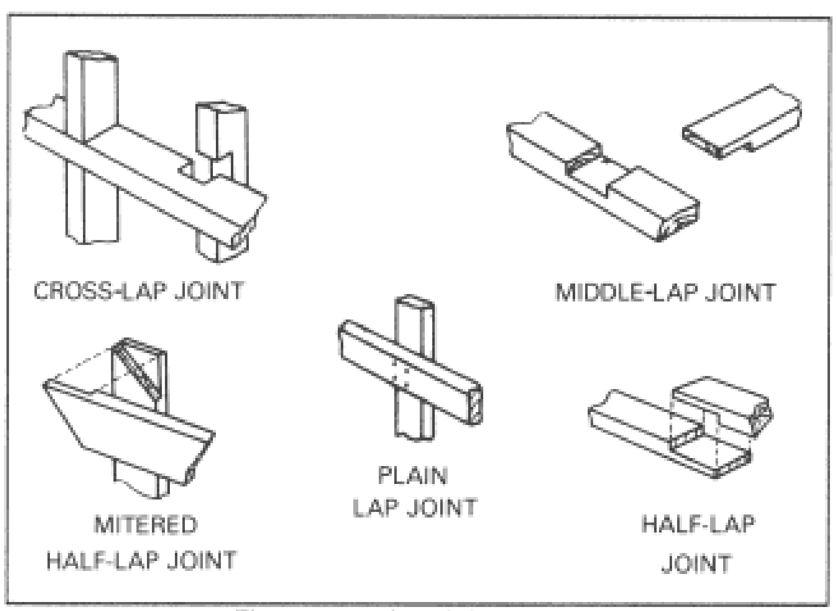


Figure 6-5. Lap joints

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.

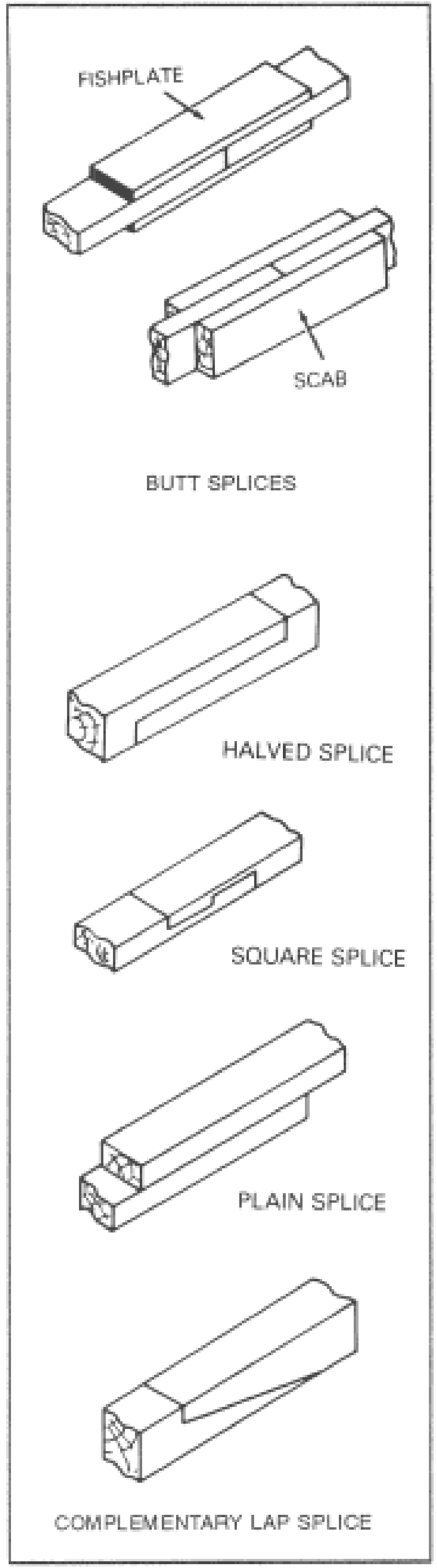


Figure 6-6. Splices

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.

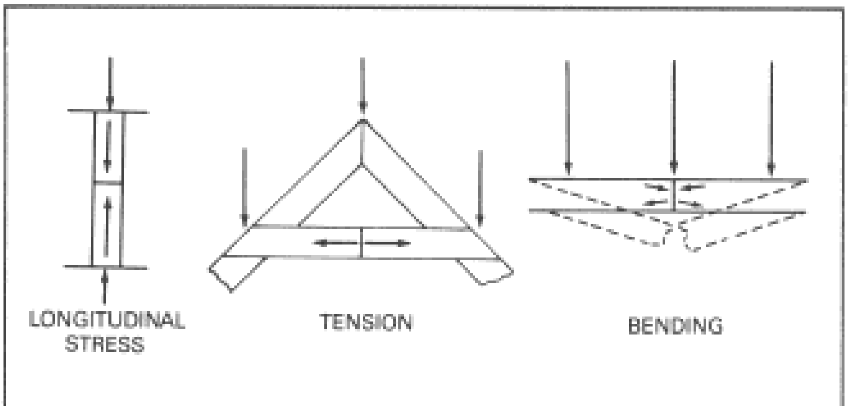


Figure 6-7. Splice stresses

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.

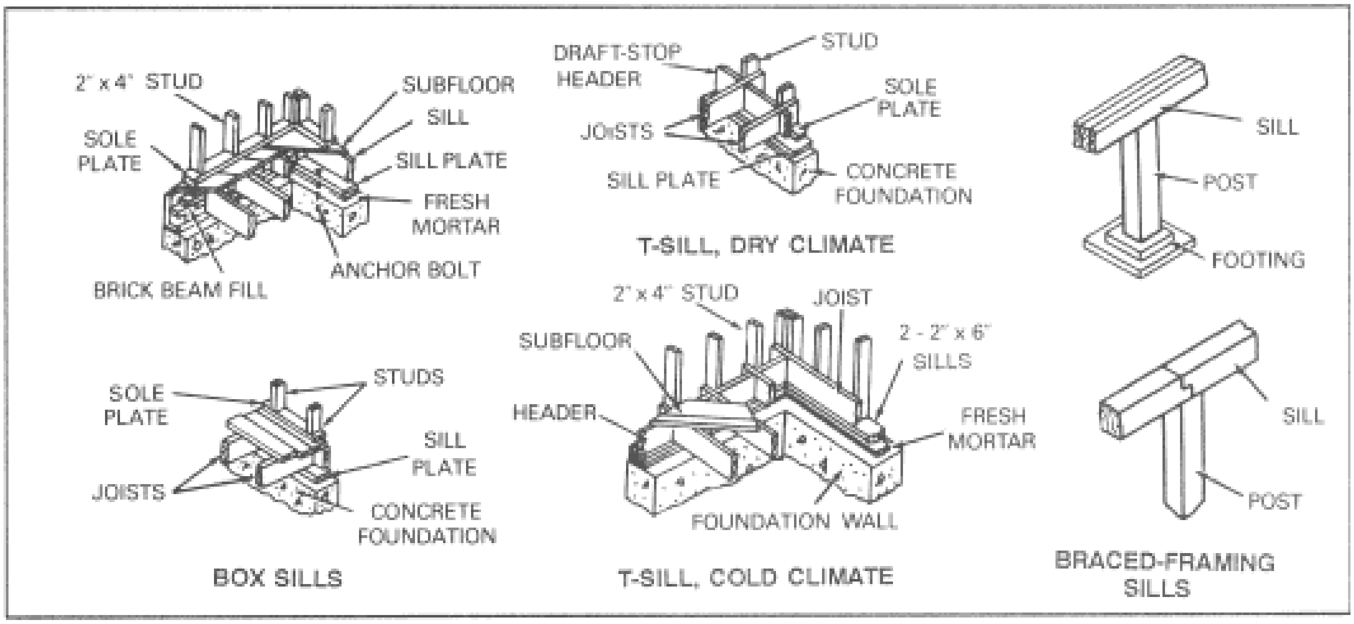


Figure 6-8. Types of sills

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.

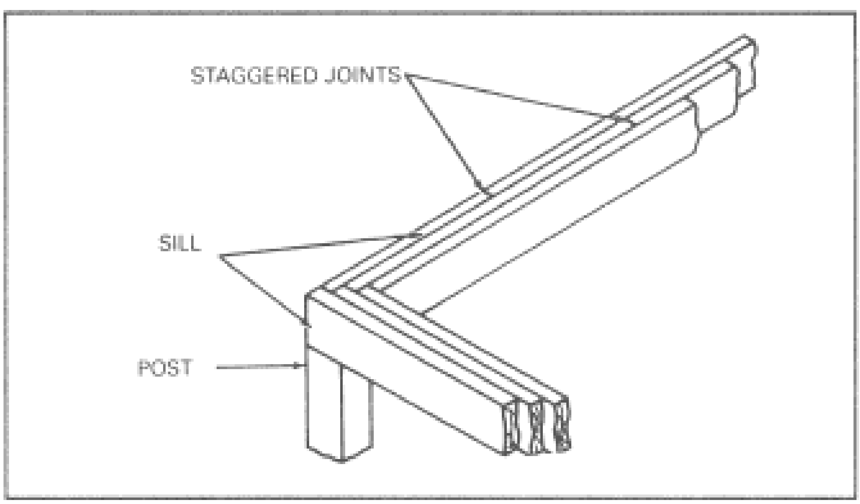


Figure 6-9. Corner joint of a built-up sill

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.

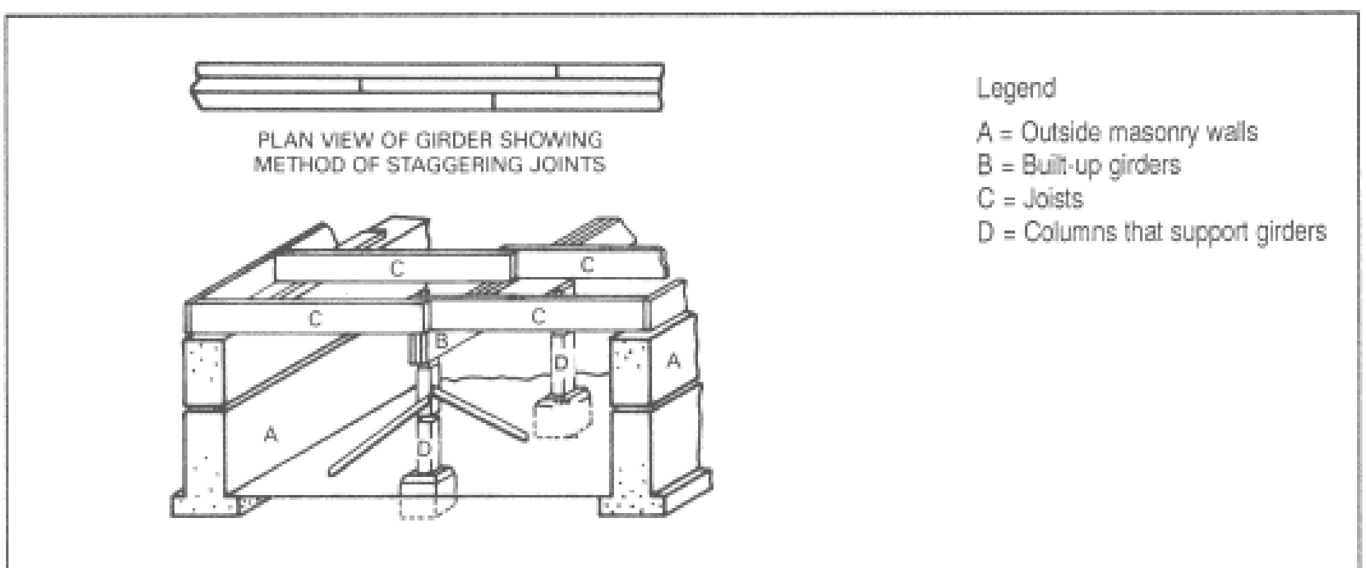


Figure 6-10. Built-up girder details

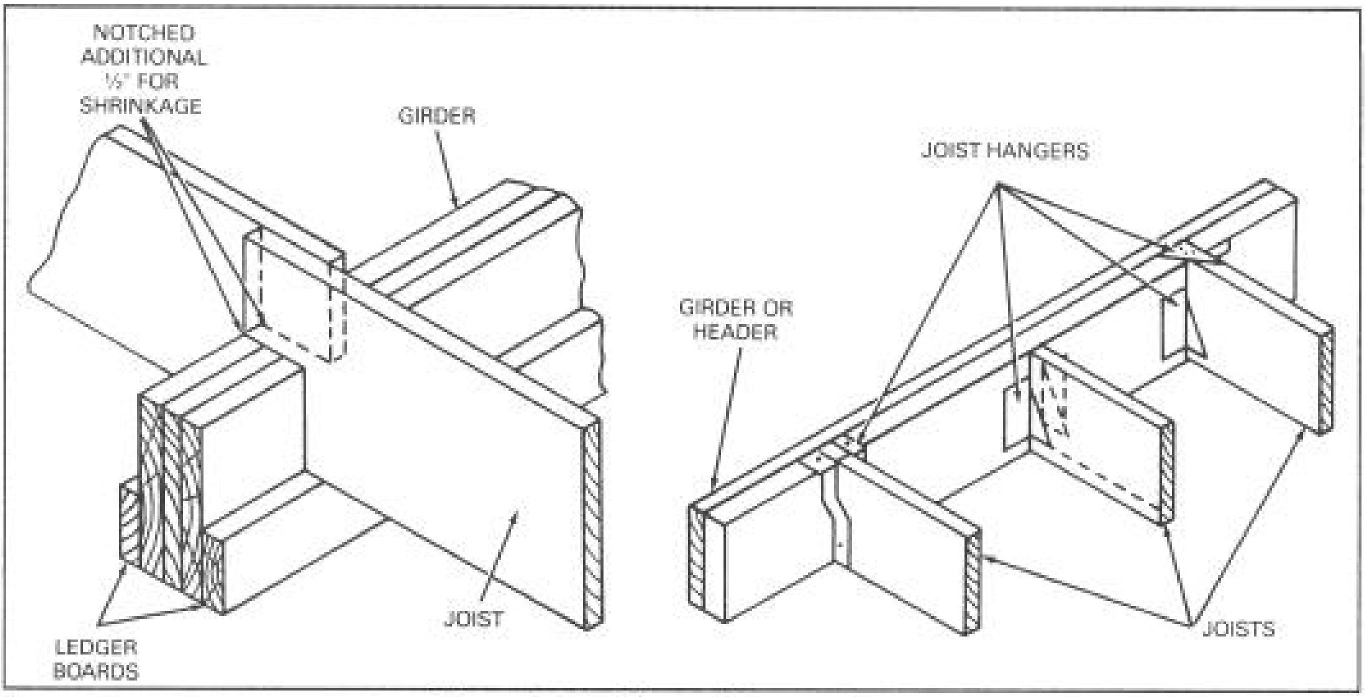


Figure 6-11. Joist-to-girder attachment

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—

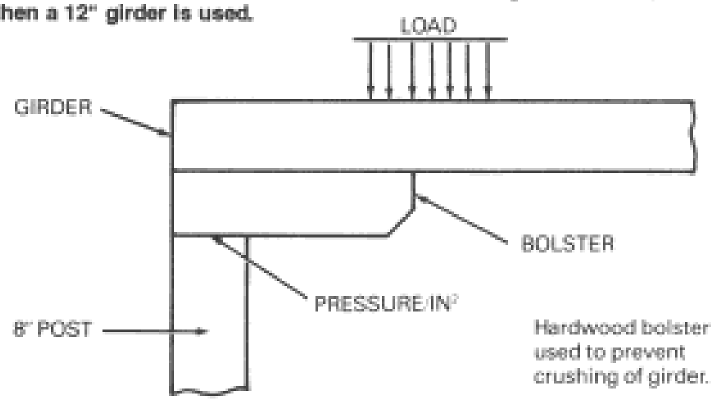
Table 6-1. Sizes of built-up wood girders

(Based on Douglas fir 4-square guideline framing; deflection not over 1/360 of span; allowable fiber stress 1,600 lb/in^2)

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.

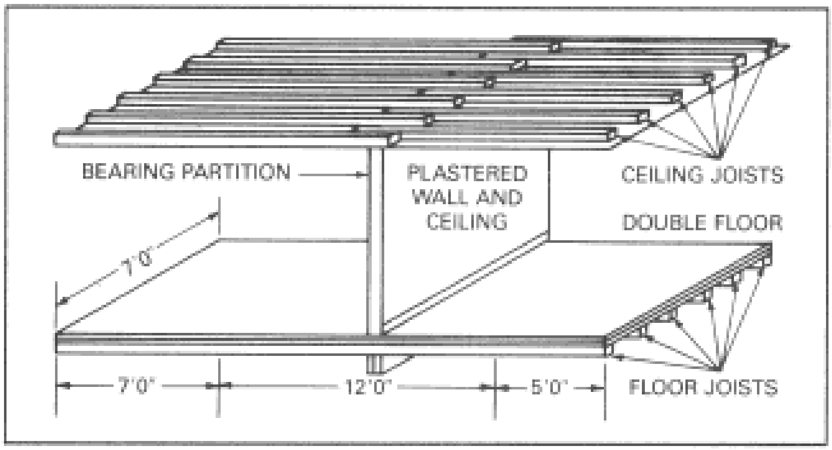


Figure 6-12. Girder load area

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.

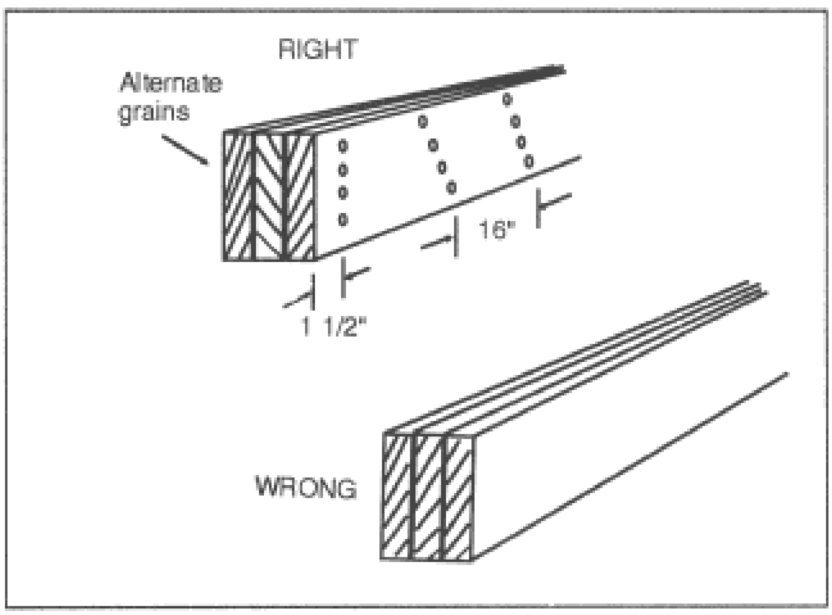


Figure 6-13. Built-up girder lumber arrangement

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.

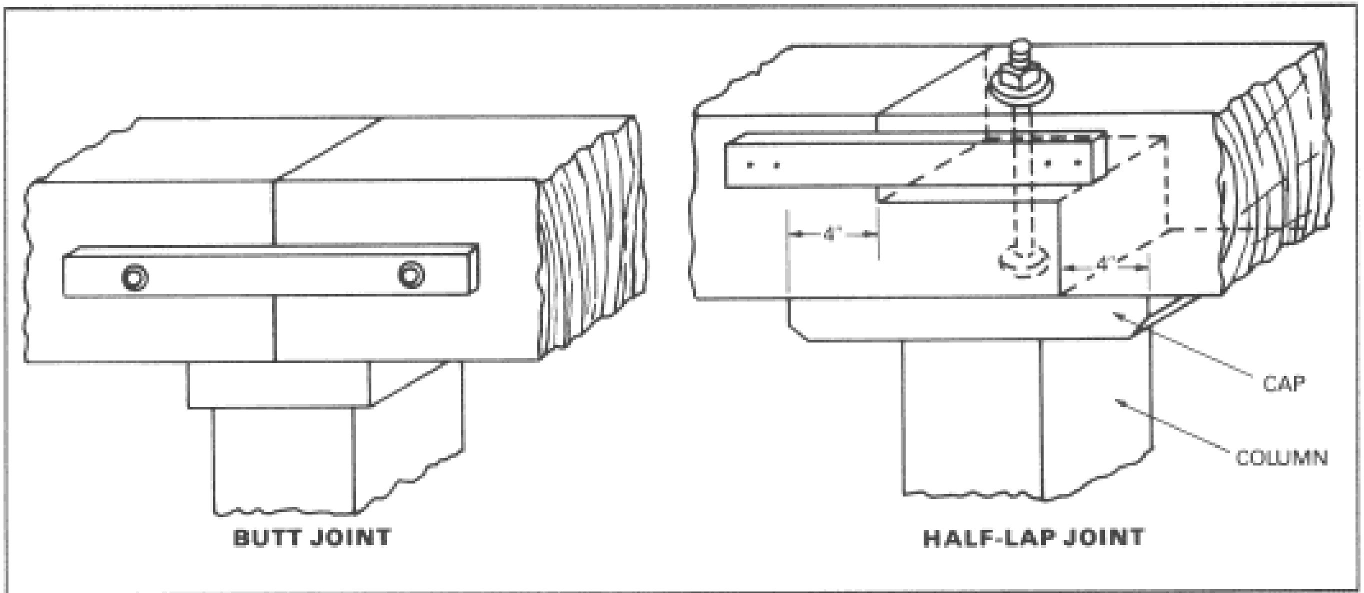


Figure 6-14. Butt and half-lap joints

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.

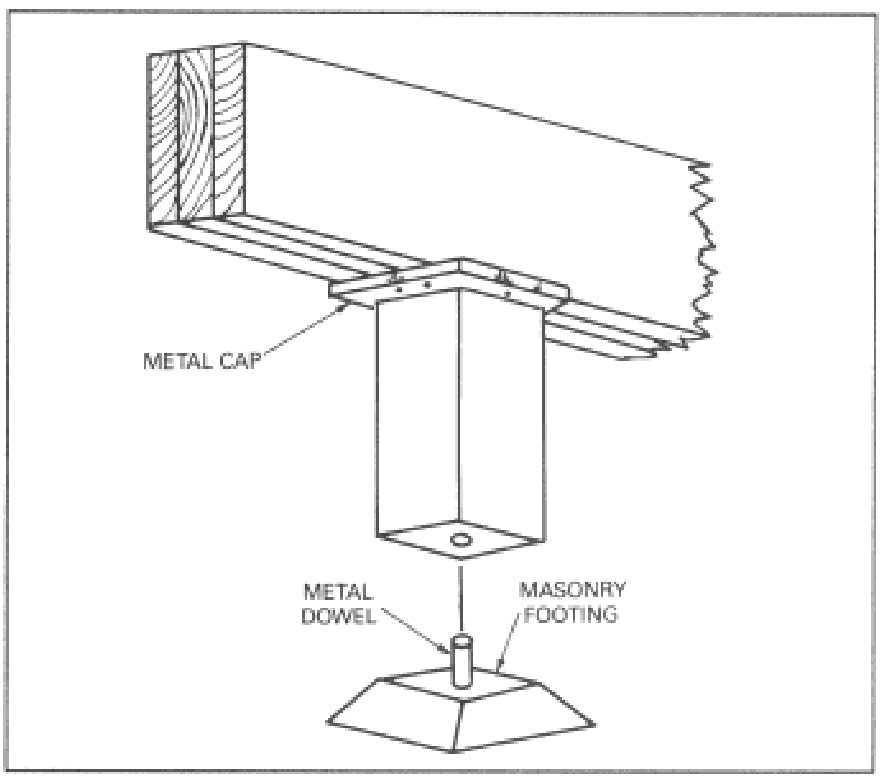


Figure 6-15. Use of metal cap and masonry footing

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.

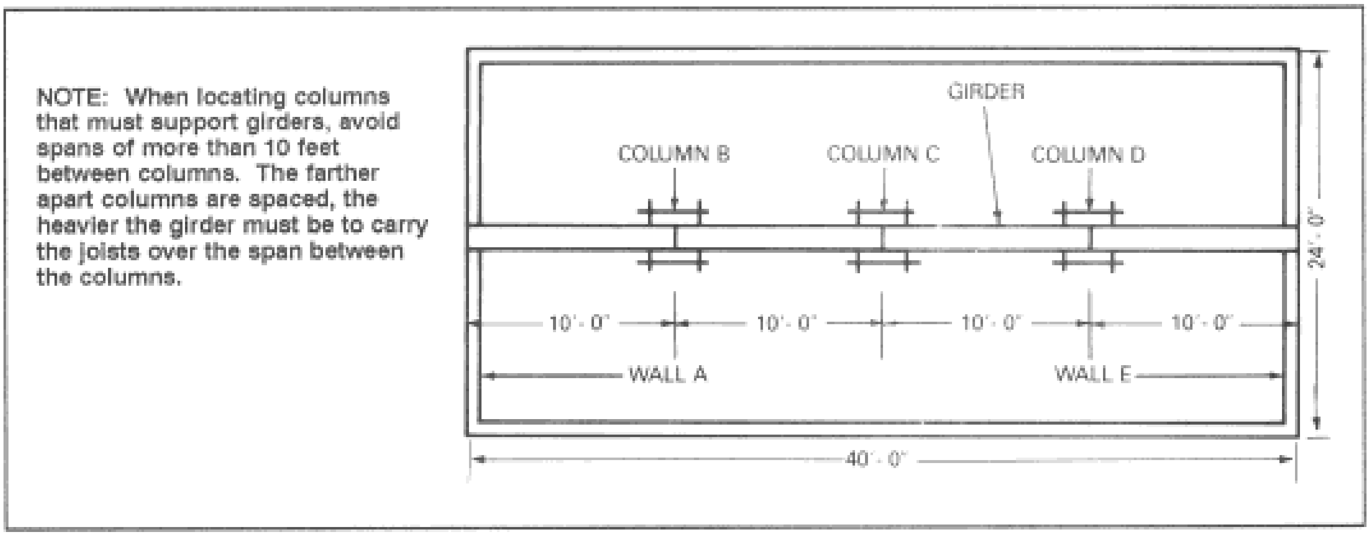


Figure 6-16. Column spacing

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