



**NONRESIDENT
TRAINING
COURSE**



March 1994

Builder 3 & 2, Volume 2

NAVEDTRA 14044

Although the words “he,” “him,” and “his” are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

COMMANDING OFFICER
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ERRATA #1

16 Aug 1999

Specific Instructions and Errata for
Nonresident Training Course

BUILDER 3 & 2, VOLUME 2

1. This errata supersedes all previous erratas. No attempt has been made to issue corrections for errors in typing, punctuation, etc., that do not affect your ability to answer the question or questions.
2. To receive credit for deleted questions, show this errata to your local course administrator (ESO/scorer). The local course administrator is directed to correct the course and the answer key by indicating the questions deleted.
3. Assignment Booklet

Delete the following questions, and leave the corresponding spaces blank on the answer sheets:

Questions

2-43
2-74
3-70
4-40
4-44
4-65
4-66
5-15
5-25

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

*1994 Edition Prepared by
BUCS(SCW) John Buza*

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AND TECHNOLOGY CENTER

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Sailor's Creed

“I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country's Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all.”

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SUMMARY OF THE BUILDER 3&2 RATE TRAINING MANUALS

VOLUME 1

Builder 3&2, Volume 1, NAVEDTRA 14043, is a basic book that should be mastered by those seeking advancement to Builder Third Class and Builder Second Class. The major topics addressed in this book include construction administration and safety; drawings and specifications; woodworking tools, materials and methods of woodworking; fiber line, wire rope, and scaffolding; leveling and grading; concrete; placing concrete; masonry; and planning, estimating, and scheduling.

VOLUME 2

Builder 3&2, Volume 2, NAVEDTRA 14044, continues where Volume 1 ends. The topics covered in this volume include floor and wall construction; roof framing; exterior and interior finishing; plastering, stuccoing, and ceramic tile; paints and preservatives; advanced base field structures; and heavy construction.

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the

assignments. To submit your assignment answers via the Internet, go to:

<http://courses.cnet.navy.mil>

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one “scannable” answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

<http://www.advancement.cnet.navy.mil>

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC (CODE N314)
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
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NETPDTC (CODE N331)
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NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you will receive retirement points if you are authorized to receive them under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 9 points. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty*, BUPERSINST 1001.39, for more information about retirement points.)

COURSE OBJECTIVES

In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following: floor and wall construction; roof framing; exterior and interior finishing; plastering, stuccoing, and ceramic tile; paints and preservatives; advanced base field structures; and heavy construction.

Student Comments

Course Title: Builder 3 & 2, Volume 2

NAVEDTRA: 14044 **Date:** _____

We need some information about you:

Rate/Rank and Name: _____ SSN: _____ Command/Unit _____

Street Address: _____ City: _____ State/FPO: _____ Zip _____

Your comments, suggestions, etc.:

<p>Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.</p>
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NETPDTC 1550/41 (Rev 4-00)

CHAPTER 1

LIGHT FLOOR AND WALL FRAMING

In the normal sequence of construction events, the floor and wall activities follow the completed foundation work. In this chapter, we'll examine established methods of frame construction and discuss in general how floor and wall framing members are assembled. An explanation of subflooring installation, exterior sheathing, interior partitions, and rough openings for doors and windows is also given.

WOOD SILL FRAMING

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe sill layout and installation.

Framing of the structure begins after completion of the foundation. The lowest member of the frame structure resting on the foundation is the sill plate, often called the mud sill. This sill provides a roiling base for joists or studs resting directly over the foundation. Work

in this area is critical as it is the real point of departure for actual building activities.

LAYOUT

The box sill is usually used in platform construction. It consists of a sill plate and header joist anchored to the foundation wall. Floor joists are supported and held in position by the box sill (fig. 1-1). Insulation material and metal termite shields are placed under the sill if desired or when specified. Sills are usually single, but double sills are sometimes used.

Following construction of the foundation wall, the sill is normally the first member laid out. The edge of the sill is setback from the outside face of the foundation a distance equal to the thickness of the exterior sheathing. When laying out sills, remember the comers should be halved together, but are often butted or mitered. If splicing is necessary to obtain required

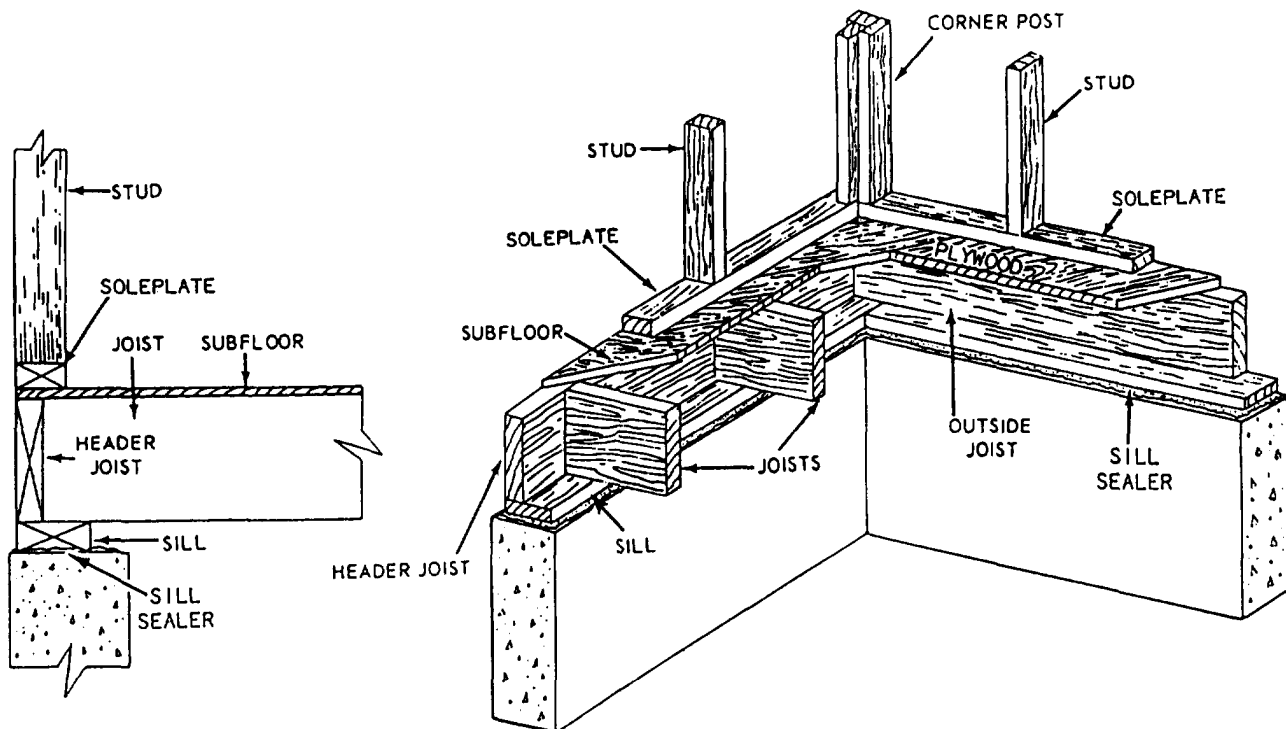


Figure 1-1.—Box-sill assembly.

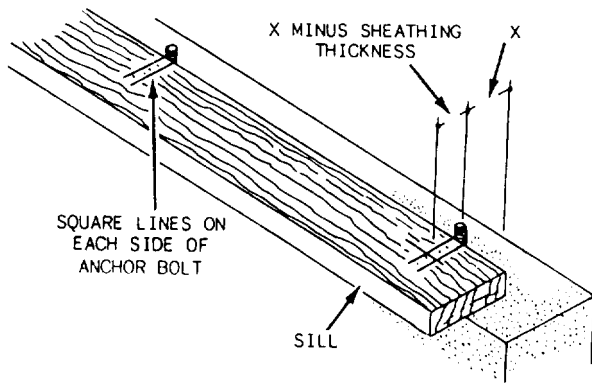


Figure 1-2.—Anchor bolt layout.

length, you should halve the splice joint at least 2 feet and bolt together.

Once the required length has been determined, the next step is to lay out the locations of the anchor bolt holes. Use the following steps:

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

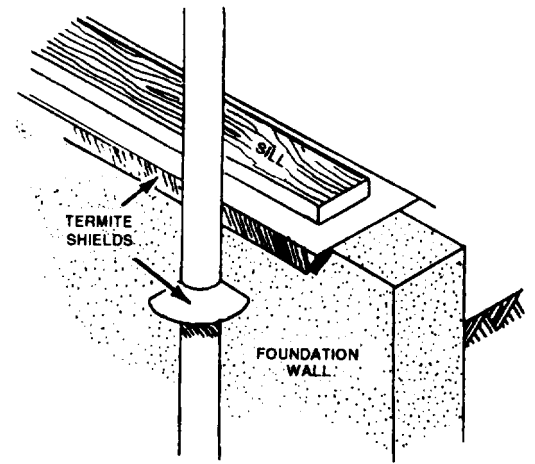


Figure 1-4.—Installing termite shields.

the holes; that is, **X** equals the thickness of the exterior sheathing.

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

When all sill sections are fitted, remove them from the anchor bolts. Install sill sealer (insulation) as shown in figure 1-3. The insulation compresses, filling the irregularities in the foundation. It also stops drafts and reduces heat loss. Also install a termite shield (fig. 1-4) if specified. A termite shield should be at least 26-gauge aluminum, copper, or galvanized sheet metal. The outer edges should be slightly bent down. Replace the sills and

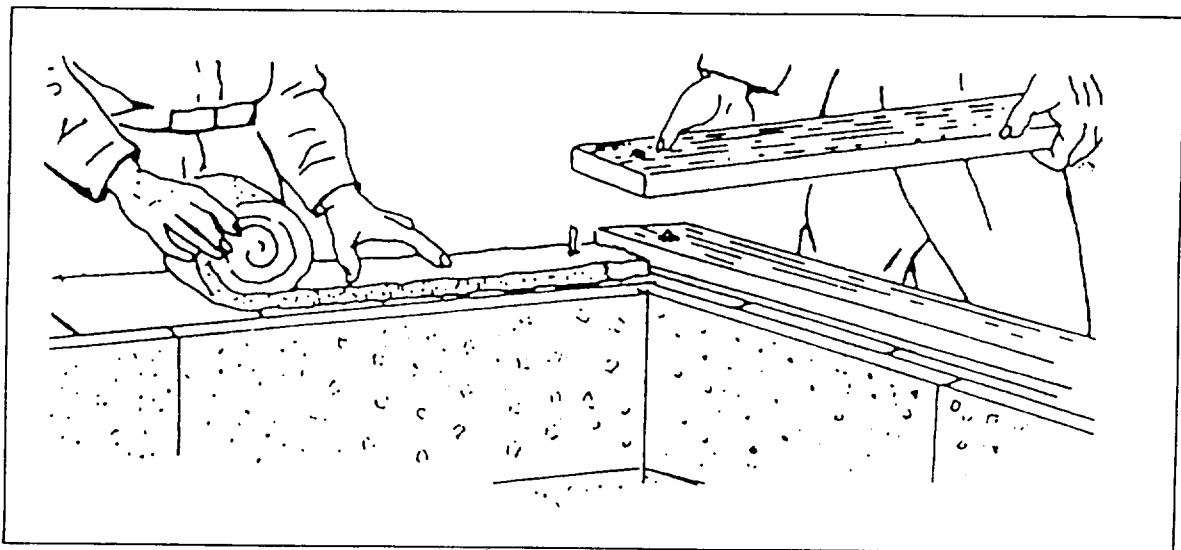


Figure 1-3.—Installing sill sealer.

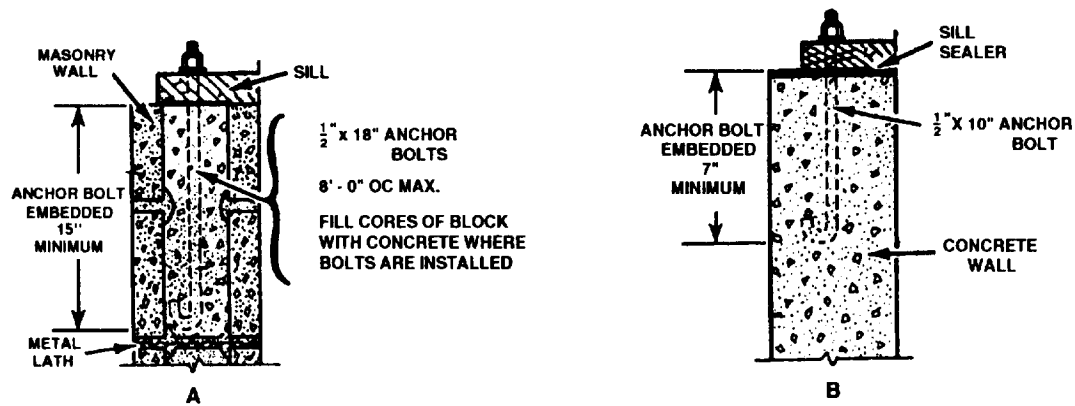


Figure 1-5.—Methods of sill fastening to foundations.

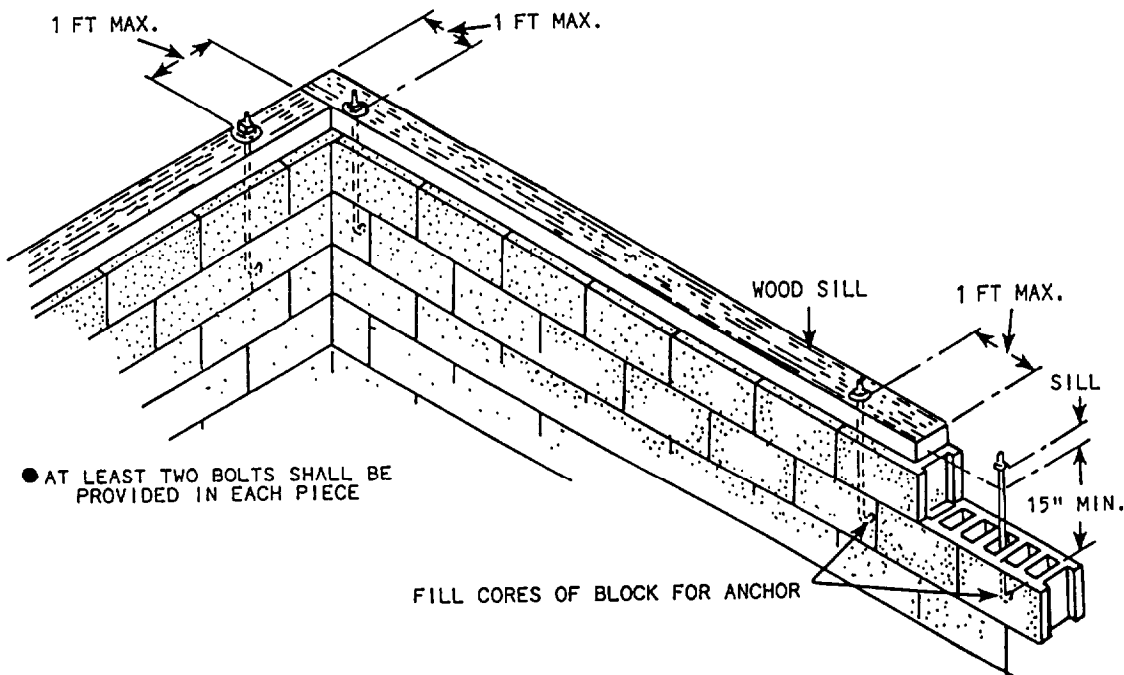


Figure 1-6.—Spacing of anchor bolts.

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

FASTENING TO FOUNDATION WALLS

Wood sills are fastened to masonry walls by 1/2-inch anchor bolts. These bolts, also known as j-bolts because of their shape, should be embedded 15 inches or more into the wall in unreinforced concrete (fig. 1-5,

view A) and a minimum of 7 inches into reinforced concrete (view B). The length of the anchor bolt is found in the specifications; the spacing and location of the bolts are shown on the drawings. If this information is not available, anchor bolt spacing should not exceed 6 feet on center (OC). Also, a bolt must be placed within 1 foot of the ends of each piece (as shown in fig. 1-6).

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

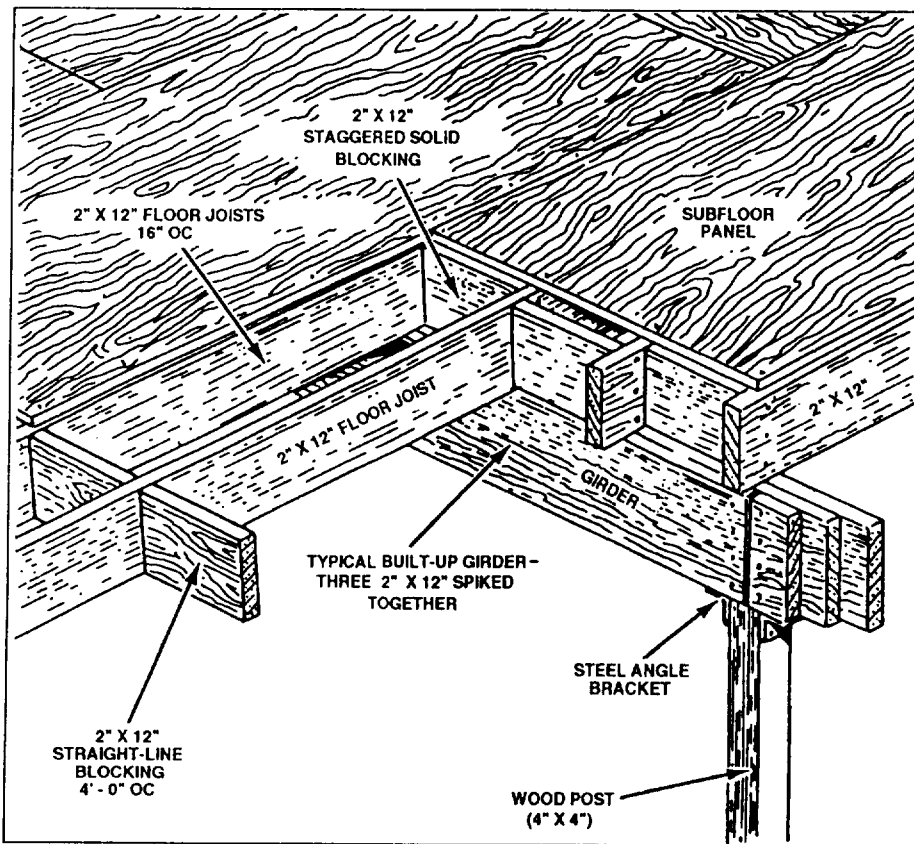


Figure 1-7.—Basic components of floor framing.

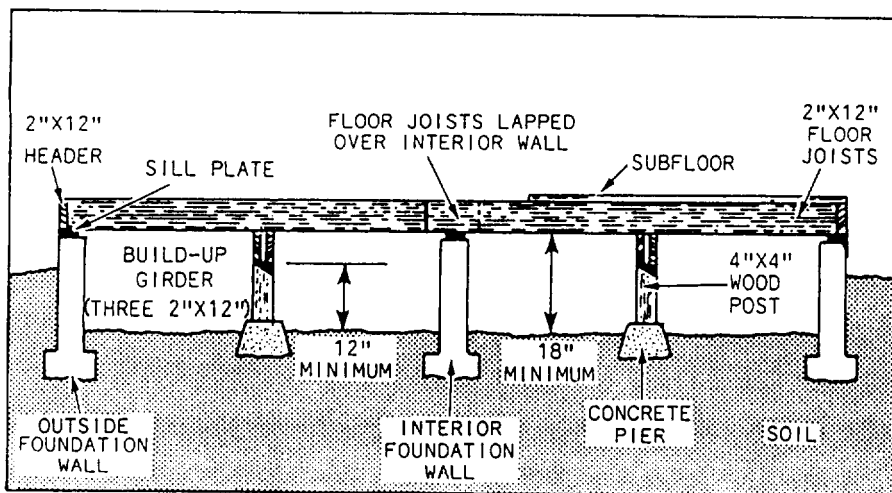


Figure 1-8.—Floor framing on sill plates with intermediate posts and built-up girders.

FLOOR FRAMING

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify members used in floor construction, and the construction methods used with subfloor and bridging.

Floor framing consists specifically of the posts, girders, joists, and subfloor. When these are assembled, as in figure 1-7, they form a level anchored platform for the rest of the construction.

POSTS

Wood or steel posts and girders support floor joists and the subfloor. Sizes depend on the loads carried. The

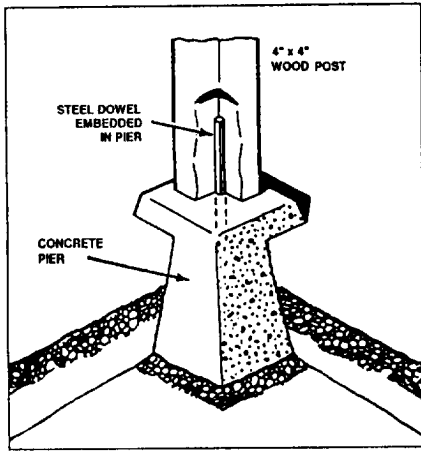


Figure 1-9.—Post fastened using dowel method.

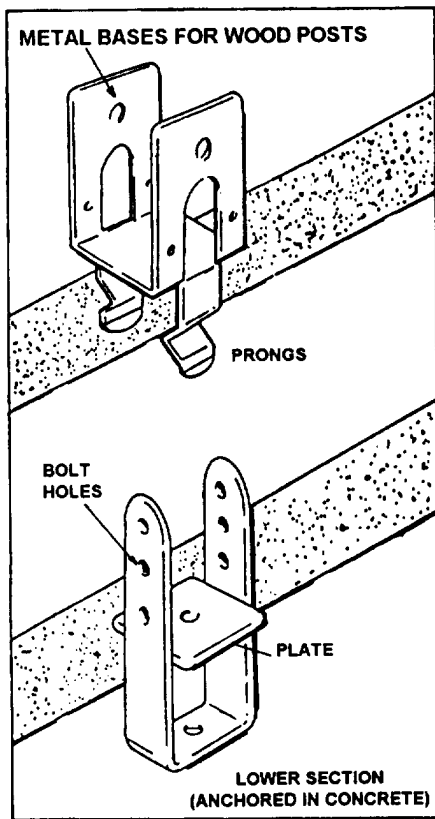


Figure 1-10.—Metal base plates for wood posts.

dimensions and locations are shown on the foundation plan. When required, posts give central support to the long span of girders. Also, girders can be used to support other girders. There should be at least 18 inches clearance between the bottoms of the floor joists and the ground and at least 12 inches between the bottom of the girder and the ground (fig. 1-8).

Wood

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

A wood post can be secured to a concrete pillar in several ways. The post can be nailed to a pier block secured to the top of a concrete pier; it can be placed over a previously inserted 1/2-inch steel dowel in the concrete; or, it can be placed into a metal base set into the concrete pier at the time of the pour. When using the dowel method, make sure the dowel extends at least 3 inches into the concrete and the post, as shown in figure 1-9. A metal base embedded in the concrete (fig. 1-10) is the preferred method since nothing else is needed to secure the base.

As with the bottom of the post, the top must also be secured to the girder. This can be done using angle iron brackets or metal plates. Figure 1-11 shows two metal post caps used with posts and girders, either nailed or bolted to the girders.

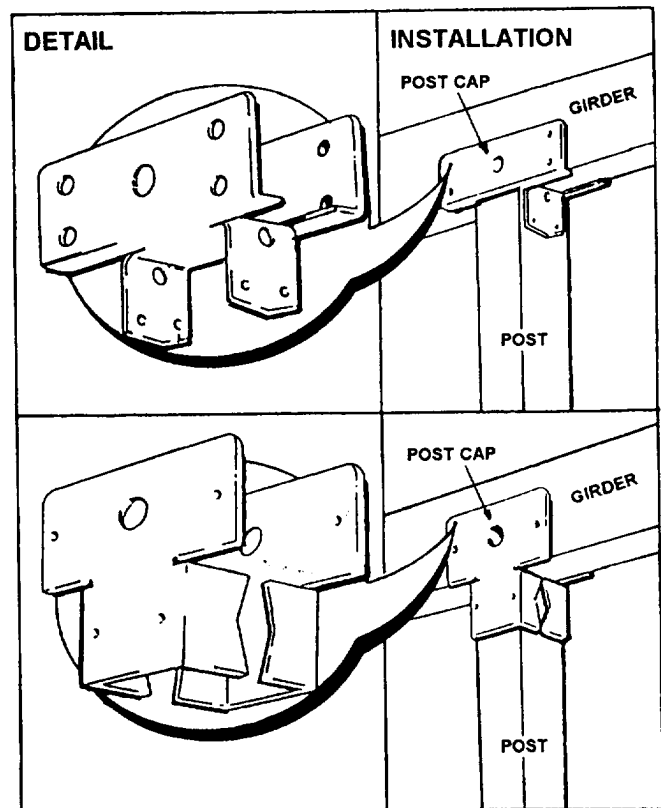


Figure 1-11.—Metal post caps.

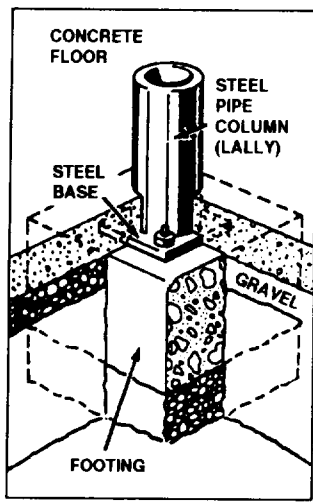


Figure 1-12.—Bolting of steel column.

The base of the steel post is bolted to the top of the pier, as shown in figure 1-12. The post can also be bolted to anchor bolts inserted in the slab prior to pouring.

GIRDERS

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

Steel

Steel pipe columns are often used in wood-frame construction, with both wood and steel girders. When using wood girders, secure the post to the girder with lag bolts. For steel girders, machine bolts are required.

Wood

Wood girders may be a single piece of timber, or they may be laminated (that is, built up) of more than one plank. The built-up girder in figure 1-13, for example, consists of three 2- by 12-inch planks. The

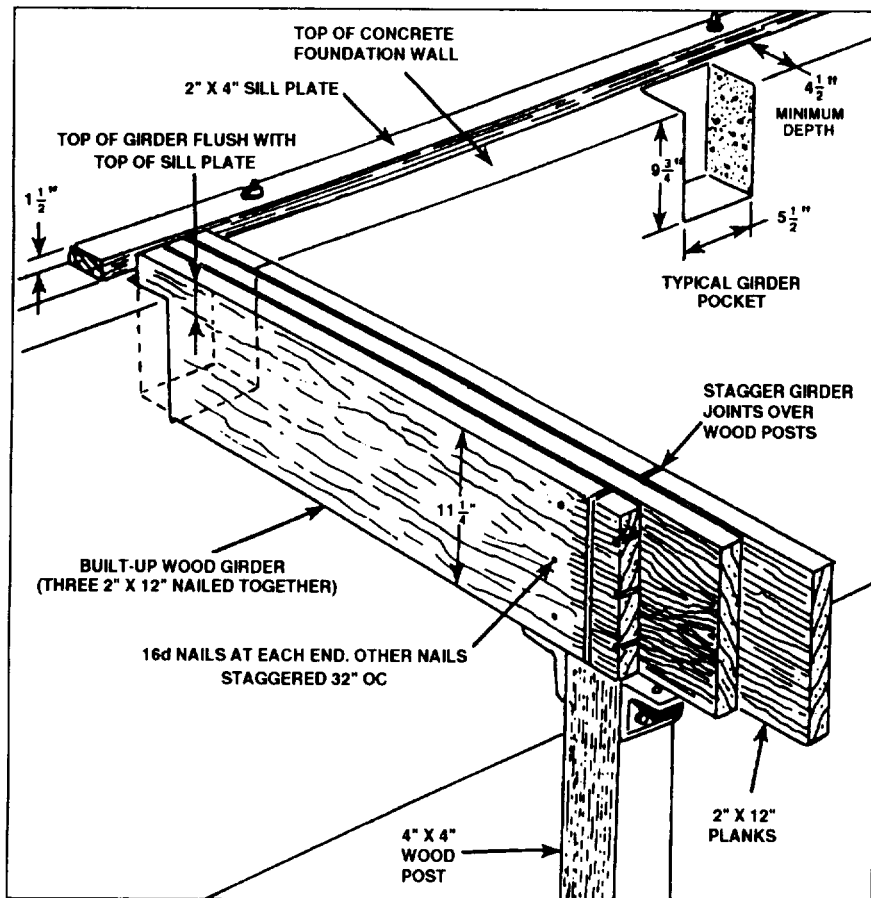


Figure 1-13.—Built-up girder.

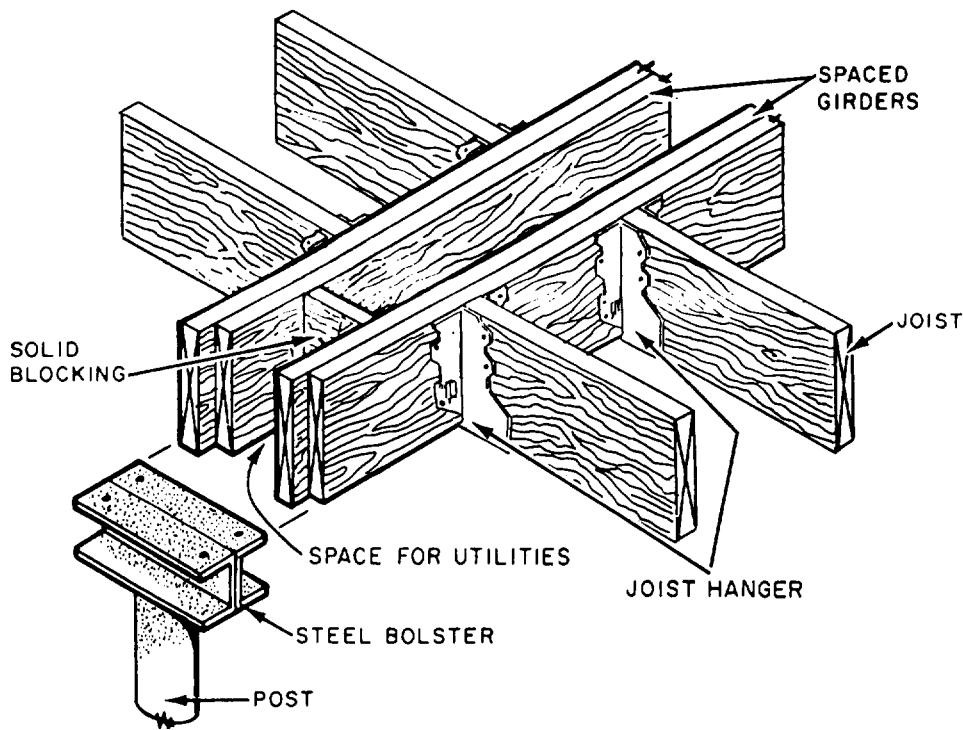


Figure 1-14.—Spaced wood girders.

joints between the planks are staggered. In framing, a built-up girder is placed so that the joints on the outside of the girder fall directly over a post. Three 16-penny (16d) nails are driven at the ends of the planks, and other nails are staggered 32 inches OC. As shown in figure 1-13, the top of the girder is flush with the top sill plate.

When space is required for heat ducts in a partition supported on a girder, a spaced wood girder, such as that shown in figure 1-14, is sometimes necessary. Solid blocking is used at intervals between the two members. A single-post support for a spaced girder usually requires a bolster, preferably metal, with a sufficient span to support the two members.

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

Steel

S-beams (standard) or W-beams (wide flange), both shown in figure 1-15, are most often used as girders in wood-framed construction. Whether the beam is wood

or steel, make sure it aligns from end to end and side to side. Also make sure the length of the bearing post under the girder is correct to ensure the girder is properly supported.

PLACING POSTS AND GIRDERS

Posts must be cut to length and set up before the girders can be installed. The upper surface of the girder may be in line with the foundation plate sill, or the girder ends may rest on top of the walls. Long girders must be

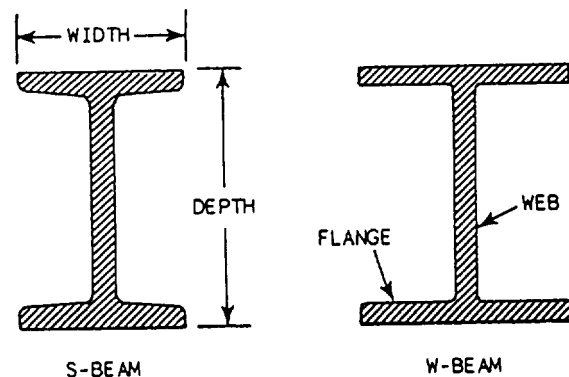


Figure 1-15—Types of steel beams.

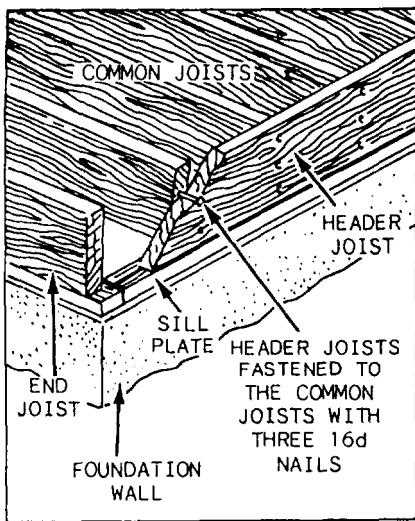


Figure 1-16.—Header joist.

placed in sections. Solid girders must be measured and cut so that the ends fall over the center of a post. Built-up girders should be placed so their outside joints fall over the posts (fig. 1-13).

FLOOR JOISTS

In platform framing, one end of the floor joist rests directly on the sill plate of the exterior foundation wall or on the top plate of a framed outside wall. The bearing should be at least 1 1/2 inches. The opposite end of the joist laps over or butts into an interior girder or wall. The size of joist material (2 by 6, 2 by 10, 2 by 12, and so forth) must be chosen with consideration for the span and the amount of load to be carried. The foundation plan usually specifies the joist size, the spacing between joists, and what direction the joists should travel.

The usual spacing of floor joists is 16 inches OC. Floor joists are supported and held in position over exterior walls by header joists or by solid blocking between the joists. The header-joist system is used most often.

Header

Header joists run along the outside walls. Three 16d nails are driven through the header joists into the ends of the common joists, as shown in figure 1-16. The header and joists are toenailed to the sill with 16d nails. The header joists prevent the common joists from

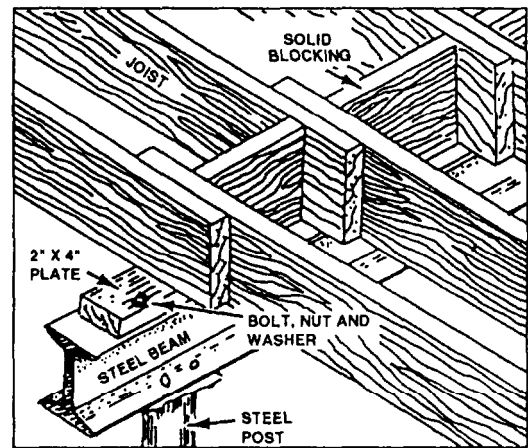


Figure 1-17.—Lapped joists.

rolling or tipping. They also help support the wall above and fill in the spaces between the common joists.

Lapped

Joists are often lapped over a girder running down the center of a building. The lapped ends of the joists may also be supported by an interior foundation or framed wall. It is standard procedure to lap joists the full width of the girder or wall. The minimum lap should be 4 inches. Figure 1-17 shows lapped joists resting on a steel girder. A 2- by 4-inch plate has been bolted to the top of a steel beam. The joists are toenailed into the plate. Solid blocking may be installed between the lapped ends after all the joists have been nailed down. Another system is to put in the blocks at the time the joists are placed.

Double

Joists should be doubled under partitions running in the same direction as the joists. Some walls have water pipes, vent stacks, or heating ducts coming up from the basement or the floor below. Place bridging between double joists to allow space for these purposes (fig. 1-18).

Cantilevered

Cantilevered joists are used when a floor or balcony of a building projects past the wall below, as shown in figure 1-19. A header piece is nailed to the ends of the

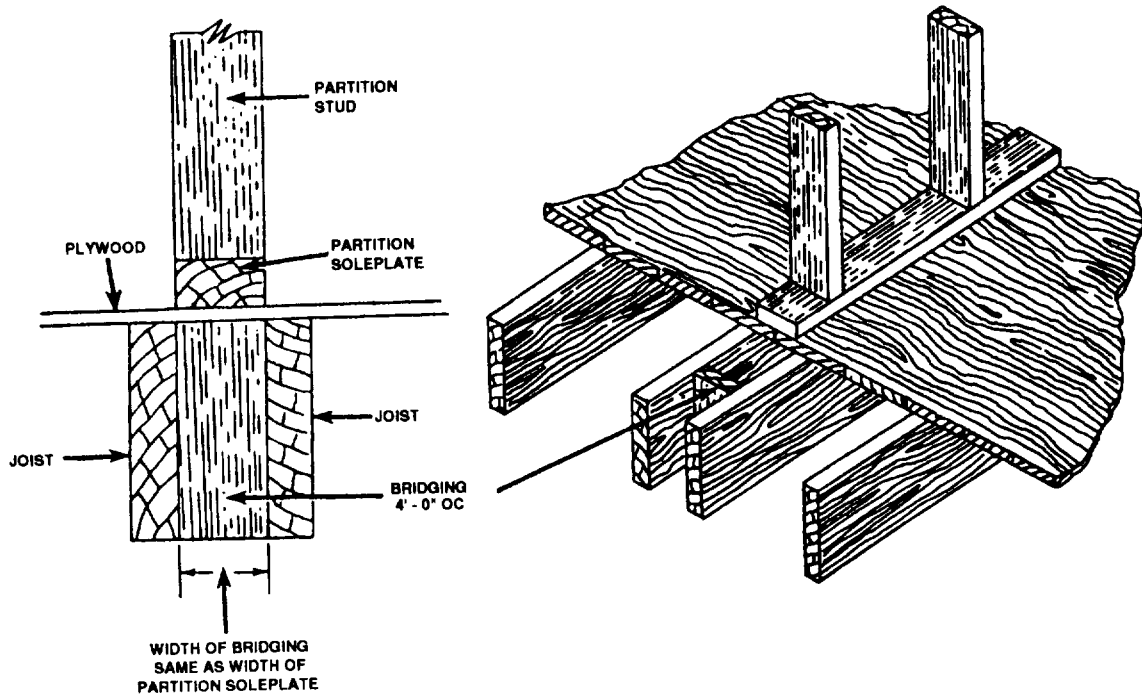


Figure 1-18.—Double joists.

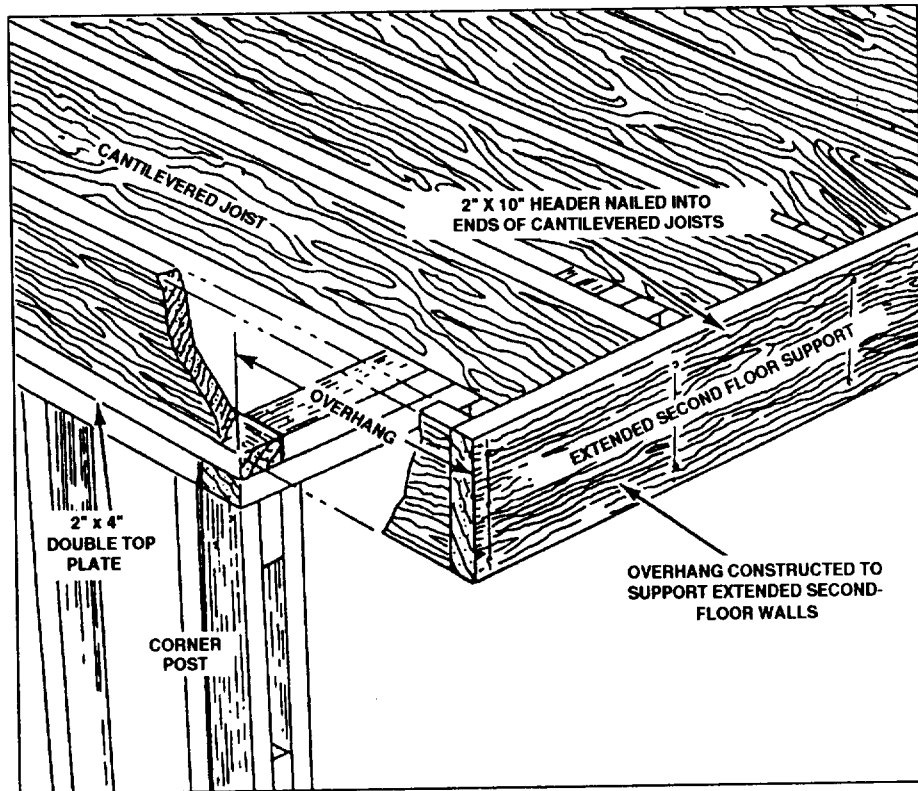


Figure 1-19.—Cantilevered joists.

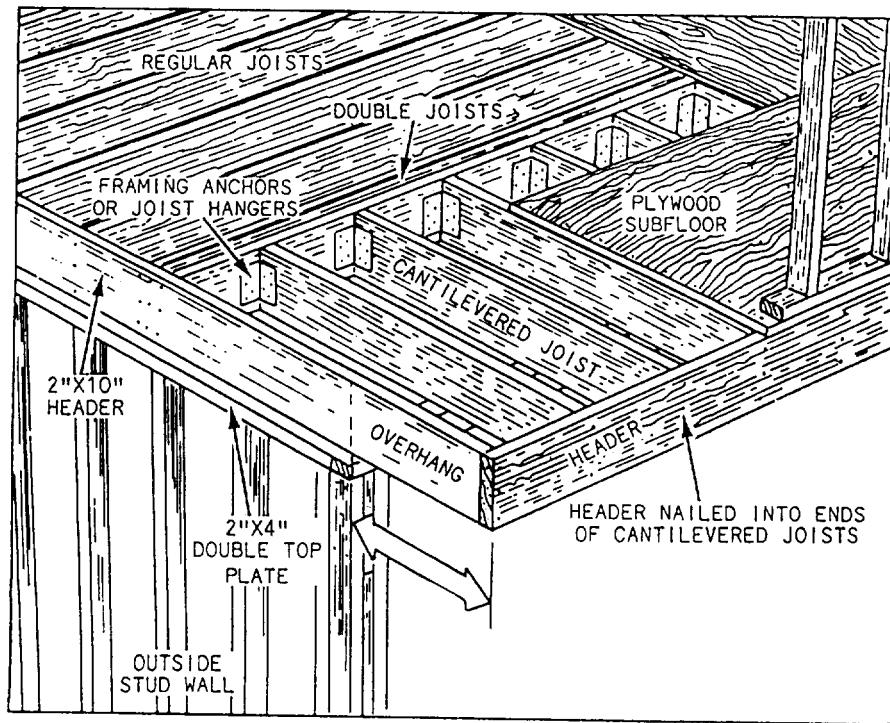


Figure 1-20.—Framing for cantilevered joists.

joists. When regular floor joists run parallel to the intended overhang, the inside ends of the cantilevered joists are fastened to a pair of double joists (fig. 1-20). Nailing should be through the first regular joist into the ends of the cantilevered joists. Framing anchors are strongly recommended and often required by the specifications. A header piece is also nailed to the outside ends of the cantilevered joists.

Butted over a Girder

Joist ends can also be butted (rather than lapped) over a girder. The joists should then be cleated together with a metal plate or wooden cleat, as shown in

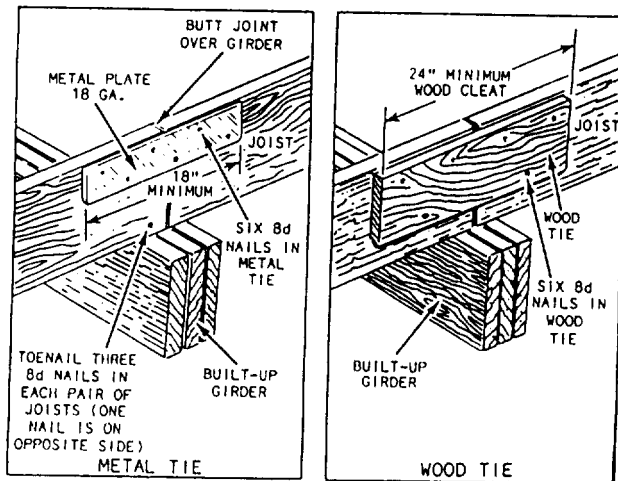


Figure 1-21.—Butting joists over a girder.

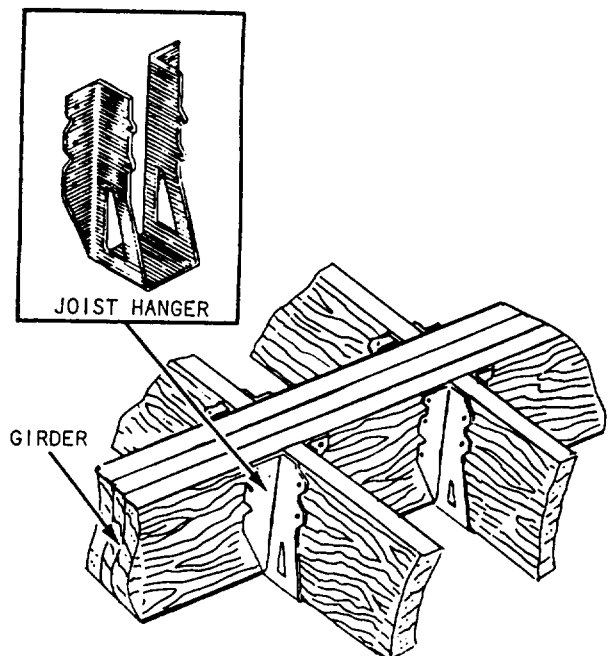


Figure 1-22.—Butting Joists against a girder.

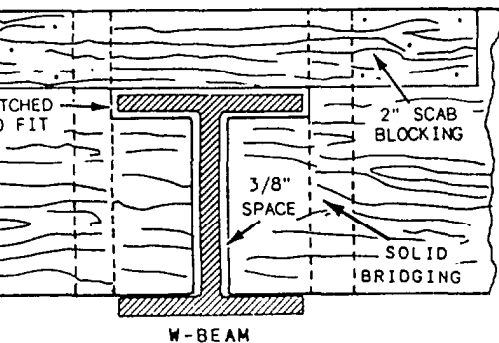
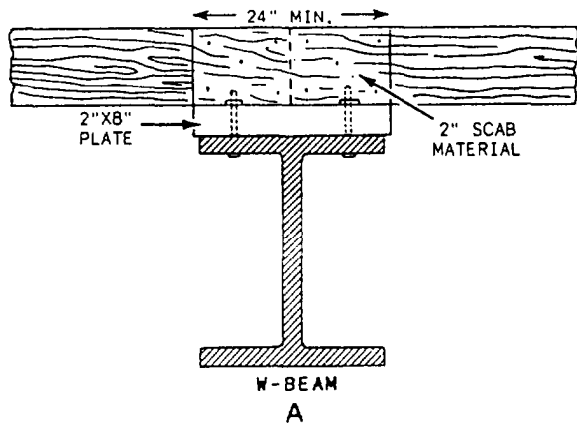


Figure 1-23.—Joists supported by steel beams.

figure 1-21. These can be left out if the line of panels from the plywood subfloor straddles the butt joints.

Butted against a Girder

Butting joists against (rather than over) a girder allows more headroom below the girder. When it is necessary for the underside of the girder to be flush with the joists to provide an unbroken ceiling surface, the joists should be supported with joist hangers (fig. 1-22).

Blocking between Joists

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

Interior Support

Floor joists usually run across the full width of the building. However, extremely long joists are expensive

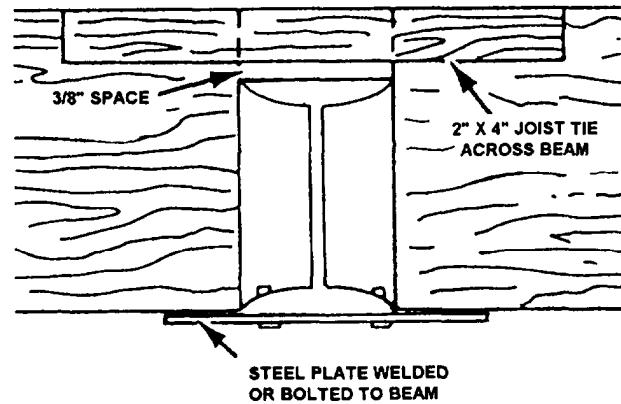


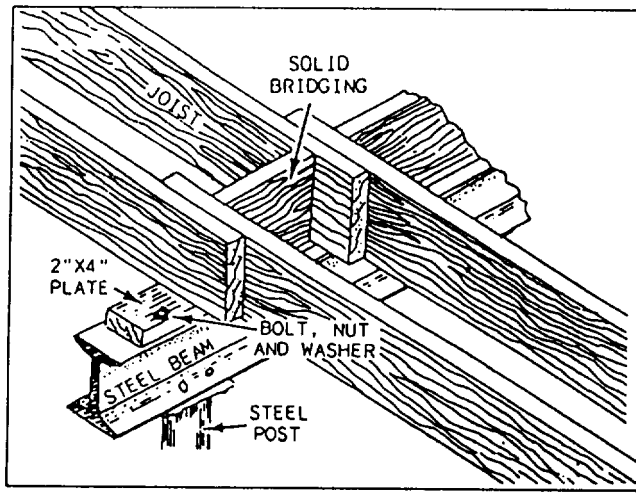
Figure 1-24.—Joists supported on steel plates.

and difficult to handle. Therefore, two or more shorter joists are usually used. The ends of these joists are supported by lapping or butting them over a girder, butting them against a girder, or lapping them over a wall.

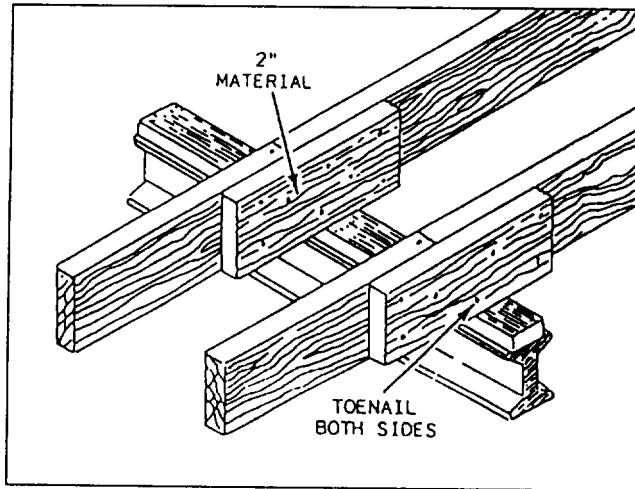
Supported by a Steel Beam

Wood joists are often supported by a steel beam rather than a wood girder. The joists may rest on top of the steel beam (fig. 1-23, view A), or they may be butted (and notched to fit) against the sides of the beam (view B). If the joists rest on top of a steel beam, a plate is fastened to the beam and the joists are toenailed into the plate. When joists are notched to fit against the sides of the beam, allowance must be made for joist shrinkage while the steel beams remain the same size. For average work with a 2- by 10-inch joist, an allowance of 3/8 inch above the top flange of the steel girder or beam is usually sufficient.

Another method of attaching butted joists to a steel girder is shown in figure 1-24. A 3/8-inch space is shown above the beam to allow for shrinkage. Notching the joists so they rest on the lower flange of an S-beam is not recommended; the flange surface does not provide sufficient bearing surface. A wide plate may be bolted or welded to the bottom of the S-beams to provide better support. Wooden blocks may be placed at the bottoms of the joists to help keep them in position. Wide-flanged beams, however, do provide sufficient support surface for this method of



A



B

Figure 1-25.—Joists supported by S-beam using wooden blocks.

construction. Figure 1-25 shows the lapped (view A) and butt (view B) methods of framing over girders.

Bridging between Joists

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

CROSS BRIDGING.— Also known as herringbone bridging, cross bridging usually consists of 1- by 3-inch or 2- by 3-inch wood. It is installed as shown in figure 1-26. Cross bridging is toenailed at each

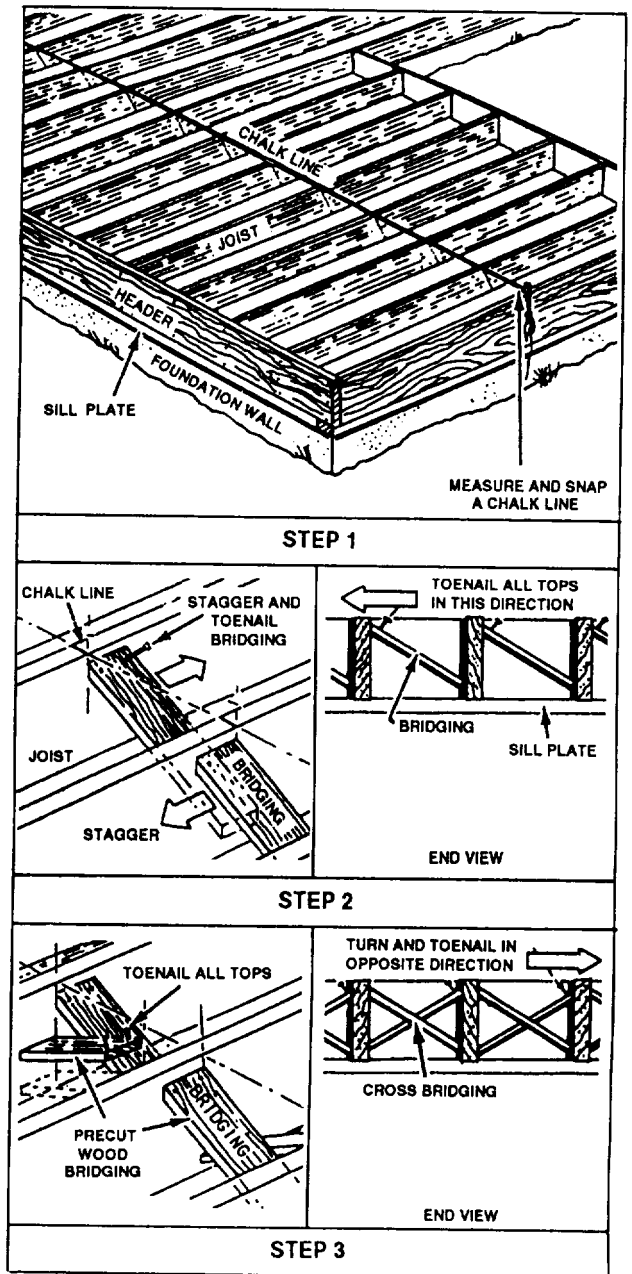


Figure 1-26.—Wood cross bridging.

end with 6d or 8d nails. Pieces are usually precut on a radial-arm saw. Nails are started at each end before the cross bridging is placed between the joists. The usual procedure is to fasten only the top end of the cross bridging. The nails at the bottom end are not driven in until the subfloor has been placed. Otherwise the joist could be pushed out of line when the bridging is nailed in.

An efficient method for initial placement of cross bridging is shown in figure 1-26. In step 1, snap a chalk line where the bridging is to be nailed between the joists. In step 2, moving in one direction, stagger and nail the

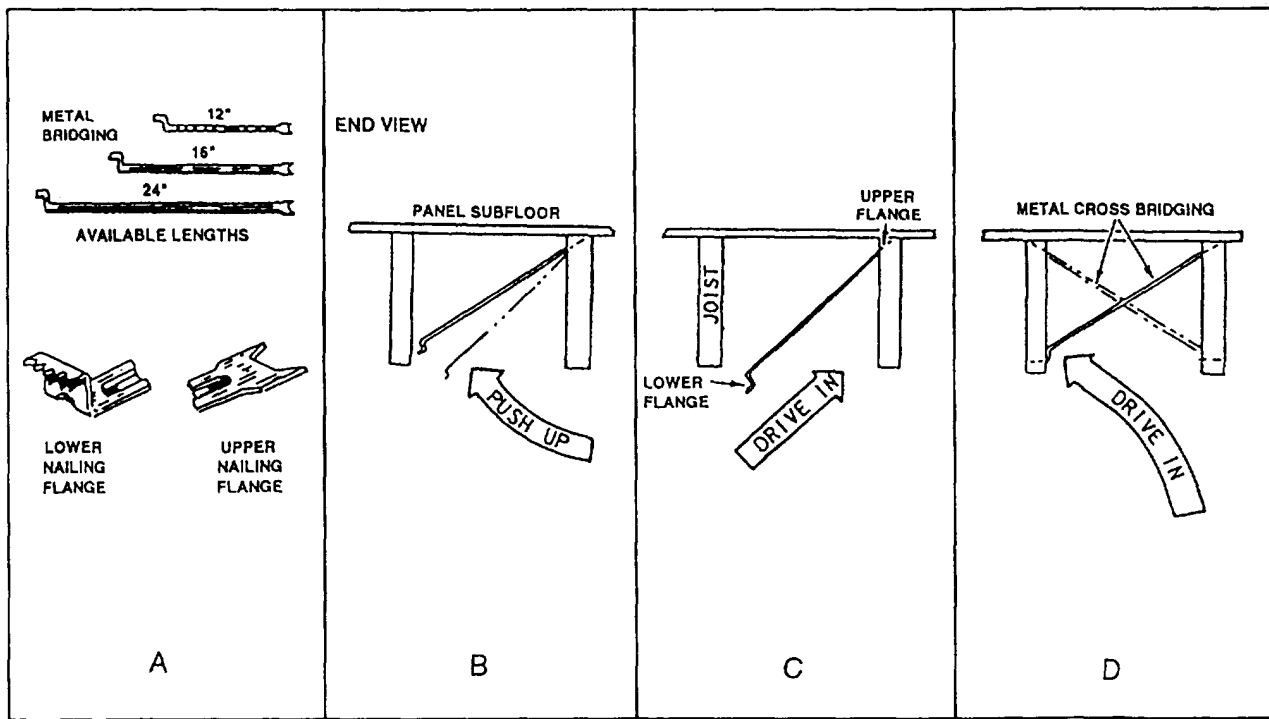


Figure 1-27.—Metal cross bridging.

tops of the bridging. In step 3, reverse direction and nail tops of the opposite pieces into place.

Another approved system of cross bridging uses metal pieces instead of wood and requires no nails. The pieces are available for 12-, 16-, and 24-inch joist spacing (fig. 1-27, view A). You can see how to install this type of cross bridging in views B, C, and D. In view B, strike the flat end of the lower flange, driving the flange close to the top of the joist. In view C, push the lower end of the bridging against the opposite joist. In view D, drive the lower flange into the joist.

SOLID BRIDGING.— Also known as solid blocking, solid bridging (fig. 1-28) serves the same purpose as cross bridging. This method is preferred by many Builders to cross bridging. The pieces are cut from lumber the same width as the joist material. They can be installed in a straight line by toenailing or staggering. If staggered the blocks can be nailed from both ends, resulting in a faster nailing operation. Straight lines of blocking may be required every 4 feet OC to provide a nailing base for a plywood subfloor.

Placing Floor Joists

Before floor joists are placed, the sill plates and girders must be marked to show where the joists are to

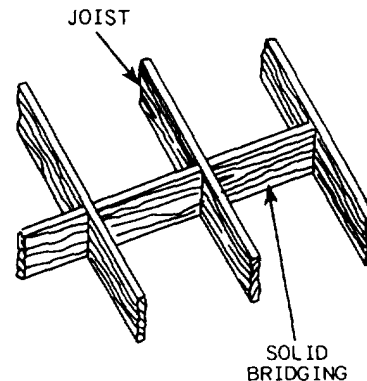


Figure 1-28.—Solid bridging.

be nailed. As we mentioned earlier, floor joists are usually placed 16 inches OC.

For joists resting directly on foundation walls, layout marks may be placed on the sill plates or the header joists. Lines must also be marked on top of the girders or walls over which the joists lap. If framed walls are below the floor unit, the joists are laid out on top of the double plate. The floor layout should also show where any joists are to be doubled. Double joists are required where partitions resting on the floor run in the same direction as the floor joists. Floor openings for stairwells must also be marked.

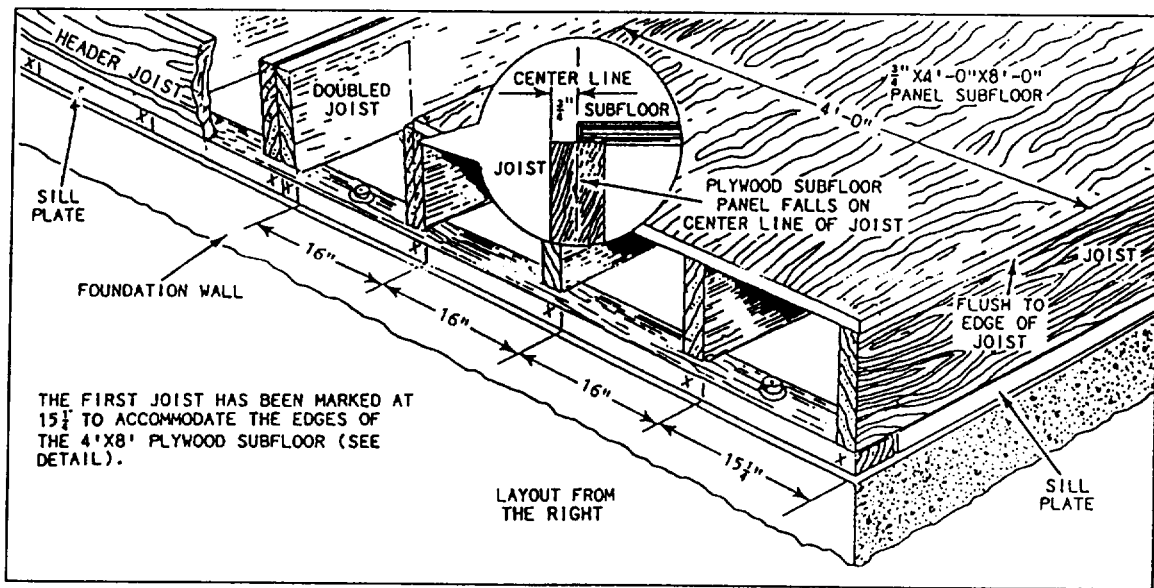


Figure 1-29.—Floor joists layout.

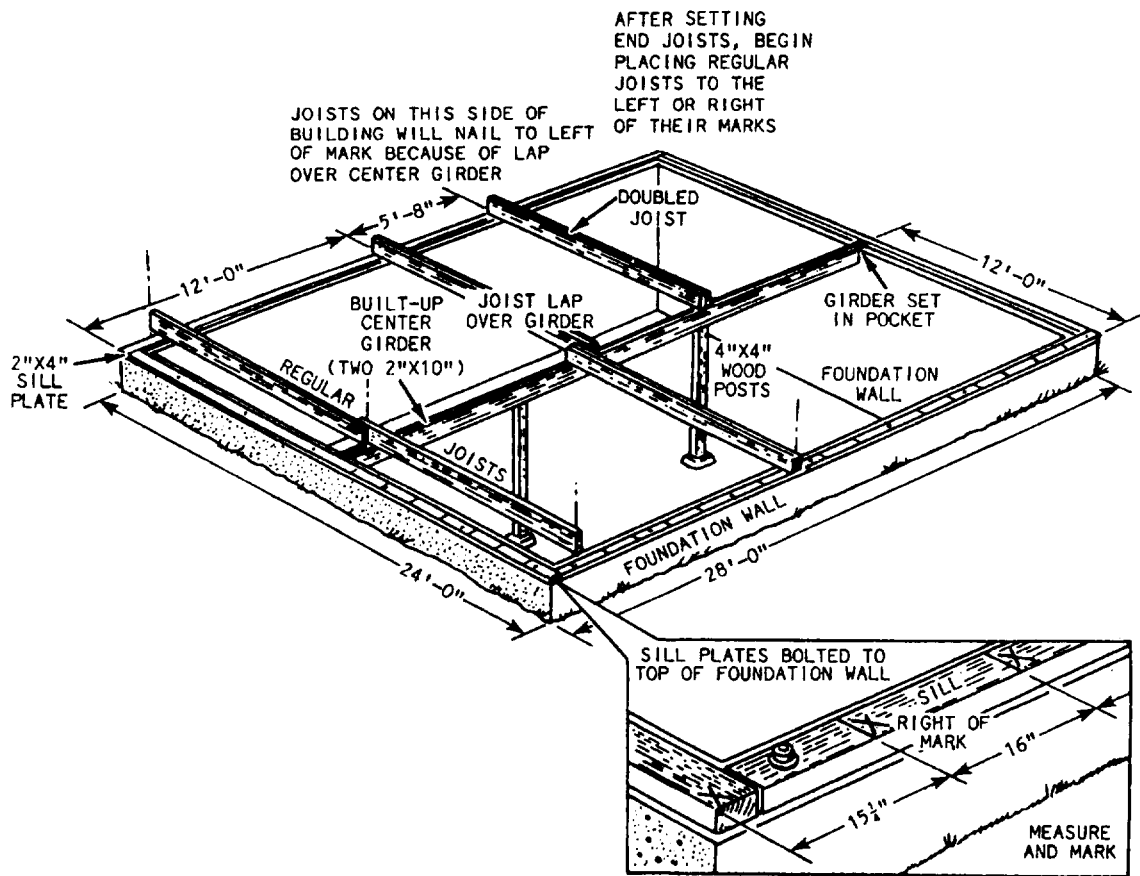


Figure 1-30.—Complete layout for floor joists.

Joists should be laid out so that the edges of standard-size subfloor panels break over the centers of the joists (see insert, fig. 1-29). This layout eliminates additional cutting of panels when they are being fitted and nailed into place. One method of laying out joists this way is to mark the first joists 15 1/4 inches from the

edge of the building. From then on, the layout is 16 inches OC. A layout for the entire floor is shown in figure 1-30.

Most of the framing members should be precut before construction begins. The joists should all be trimmed to their proper lengths. Cross bridging and

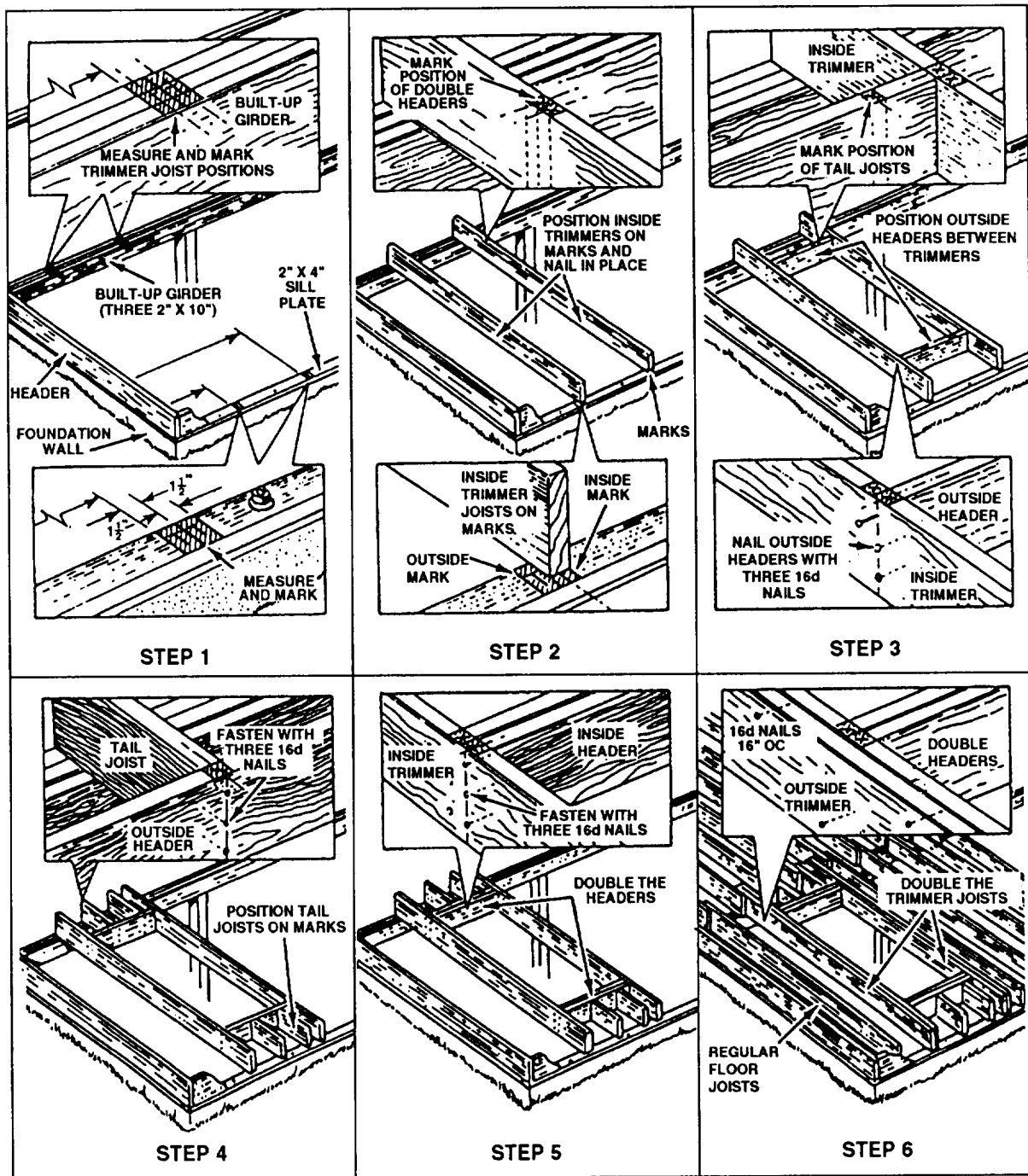


Figure 1-31.—Steps in framing a floor opening.

solid blocks should be cut to fit between the joists having a common spacing. The distance between joists is usually 14 1/2 inches for joists spaced 16 inches OC. Blocking for the odd spaces is cut afterwards.

Framing Floor Openings

Floor openings, where stairs rise to the floor or large duct work passes through, require special framing. When the joists are cut for such openings, there is a loss

of strength in the area of the opening. You need to frame the opening in a way that restores this strength. The procedure is shown in figure 1-31. Refer to the figure as you study the following steps:

1. Measure and mark the positions of the trimmers on the outside wall and interior wall or girder.
2. Position and fasten the inside trimmers and mark the position of the double headers.

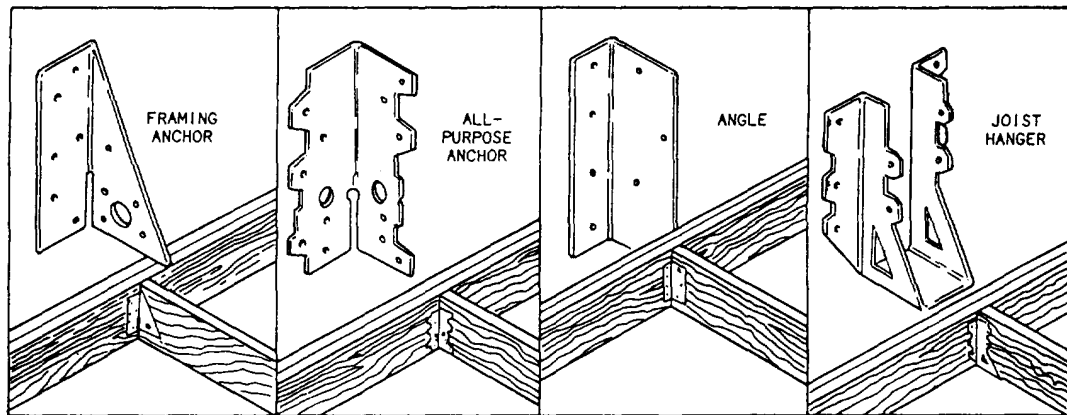


Figure 1-32.—Types of framing anchors.

3. Place the outside pieces between the inside trimmers. Drive three 16d nails through the trimmers into the headers. Mark the position of the tail joists on the headers (the tail joists should follow the regular joist layout).
4. Fasten the tail joists to the outside headers with three 16d nails driven through the headers into the ends of the tail joists.
5. Double the header. Drive three 16d nails through the trimmer joists into the ends of the doubled header pieces. Nail the doubled header pieces to each other with 16d nails staggered 16 inches OC.
6. Double the trimmer joists and fasten them together with 16d nails staggered 16 inches OC.

A pair of joists, called trimmers, is placed at each side of the opening. These trimmers support the headers. The headers should be doubled if the span is more than 4 feet. Nails supporting the ends of the headers are driven through the trimmer joists into the ends of the header pieces. Tail joists (cripple joists) run from the header to a supporting wall or girder. Nails are driven through the header into the ends of the tail joist. Various metal anchors, such as those shown in figure 1-32, are also used to strengthen framed floor openings.

Crowns

Most joists have a crown (a bow shape) on one side. Each joist should be sighted before being nailed in place to make certain the crown is turned up. The joist will later settle from the weight of the floor and straighten out. Caution should be exercised when sighting the

board for the crown. Some crowns are too large and cannot be turned up for use as a joist.

SUBFLOOR

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

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

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

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

Plywood suitable for the subfloor, such as standard sheathing, structural I and II, and C-C exterior grades, has a panel identification index marking on each sheet.

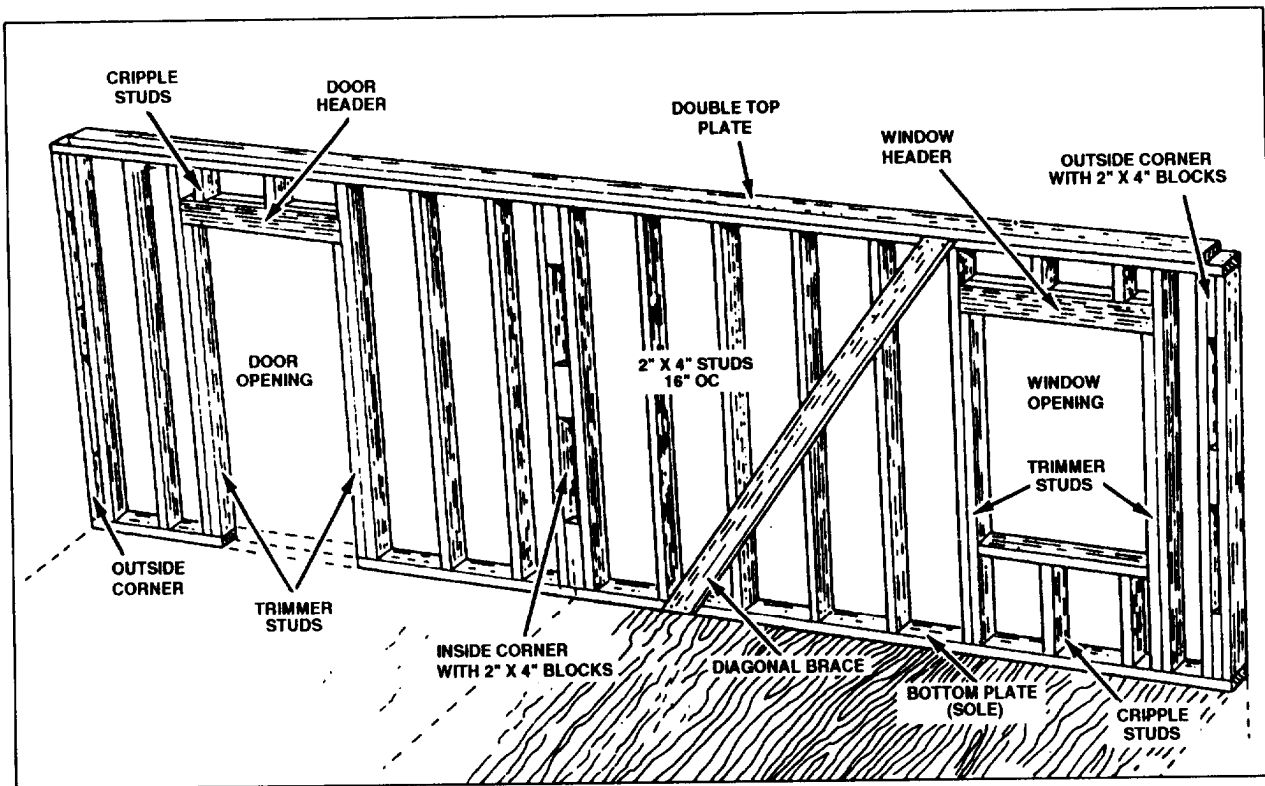


Figure 1-33.—Typical exterior wall.

These markings indicate the allowance spacing of rafters and floor joists for the various thicknesses when the plywood is used as roof sheathing or subfloor. For example, an index mark of 32/16 indicates the plywood panel is suitable for a maximum spacing of 32 inches for rafters and 16 inches for floor joists. Thus, no problem of strength differences between species is involved, as the correct identification is shown for each panel.

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

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

WALL FRAMING

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify wall framing members and explain layout and installation procedures for these members in building construction.

Wall construction begins after the subfloor has been nailed in place. The wall system of a wood-framed building consists of exterior (outside) and interior (inside) walls. The typical exterior wall has door and window openings, as shown in figure 1-33. Interior walls, usually referred to as “partitions,” divide the inside area into separate rooms. Some interior walls have door openings or archways.

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

Traditionally, 2-by 4-inch structural lumber is used for the framed walls of one-story buildings, although the use of heavier structural lumber is specified at certain locations for particular projects. Multistory buildings,

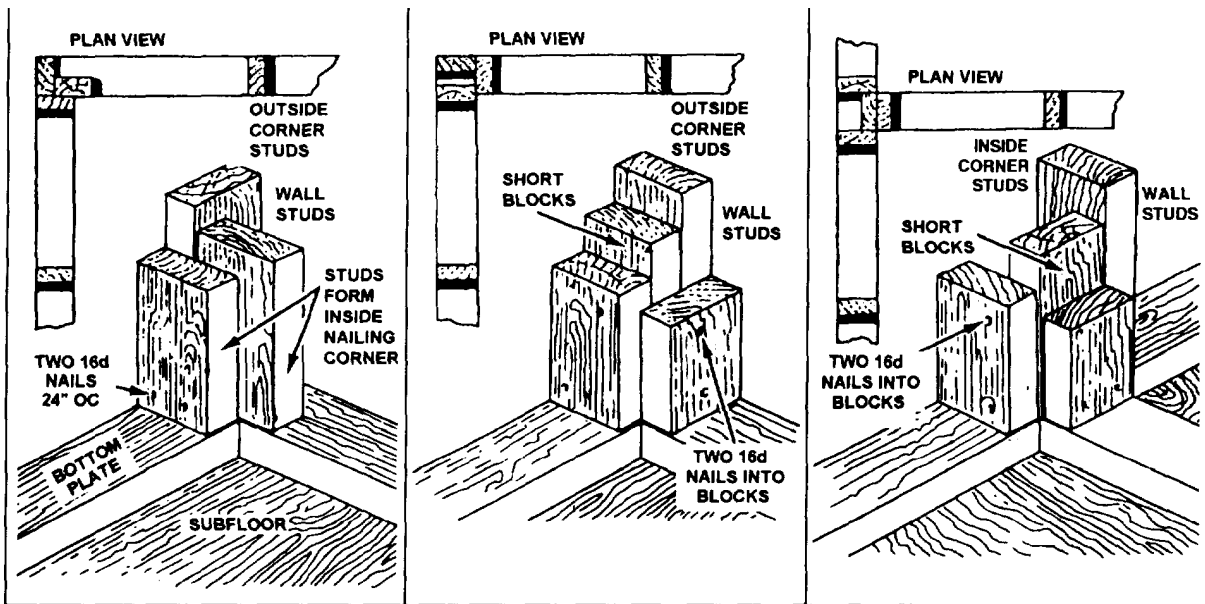


Figure 1-34.—Corner posts.

for example, require heavier structural lumber. This requirement is specific to the lower levels in order to support the weight of the floors above.

STRUCTURAL PARTS

A wood-framed wall consists of structural parts referred to as “wall components” or “framing members.” The components (shown in fig. 1-33) typically include studs, plates, headers, trimmers, cripples, sills, corner posts, and diagonal braces. Each component is essential to the integrity of the total wall structure.

Studs

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

Plates

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

Corner Posts

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

Three typical designs for corner assemblies are shown in figure 1-34. View A shows outside corner construction using only three studs. View B shows outside corner construction using two studs with short blocks between them at the center and ends. A third full-length stud can be used instead of blocks. View C shows inside corner construction using a block laid flat. A full-length stud can be used instead of a block. Note that all corner assemblies should be constructed from straight stud material and should be well nailed. When framing corners, you can use full-length studs or short blocks.

Rough Door and Window Openings

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

Figure 1-35 shows details of rough openings for doors and windows in wood-frame construction. The rough opening for atypical door is framed with a header,

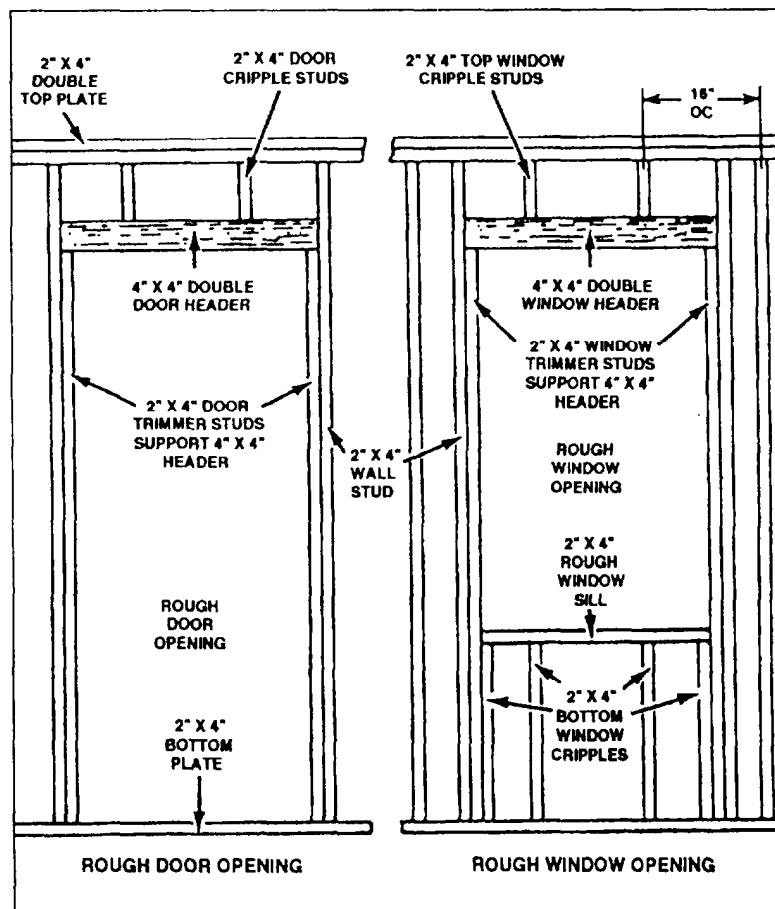


Figure 1-35.—Rough frame openings for doors and windows.

trimmer studs, and, in some cases, top cripple studs. The rough opening for a typical window includes the same members as for a door, plus a rough window sill and bottom cripples.

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

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

The type and size of header is shown in the blueprints. Header size is determined by the width of the

opening and by how much weight is bearing down from the floor above.

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

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

A rough window sill is added to the bottom of a rough window opening. The sill provides support for the finished window and frame to be placed in the wall. The distance between the sill and the header is determined by the dimensions of the window, the window frame, and the necessary clearances at the top and bottom of the frame. Cripple studs, spaced 16 inches OC, are

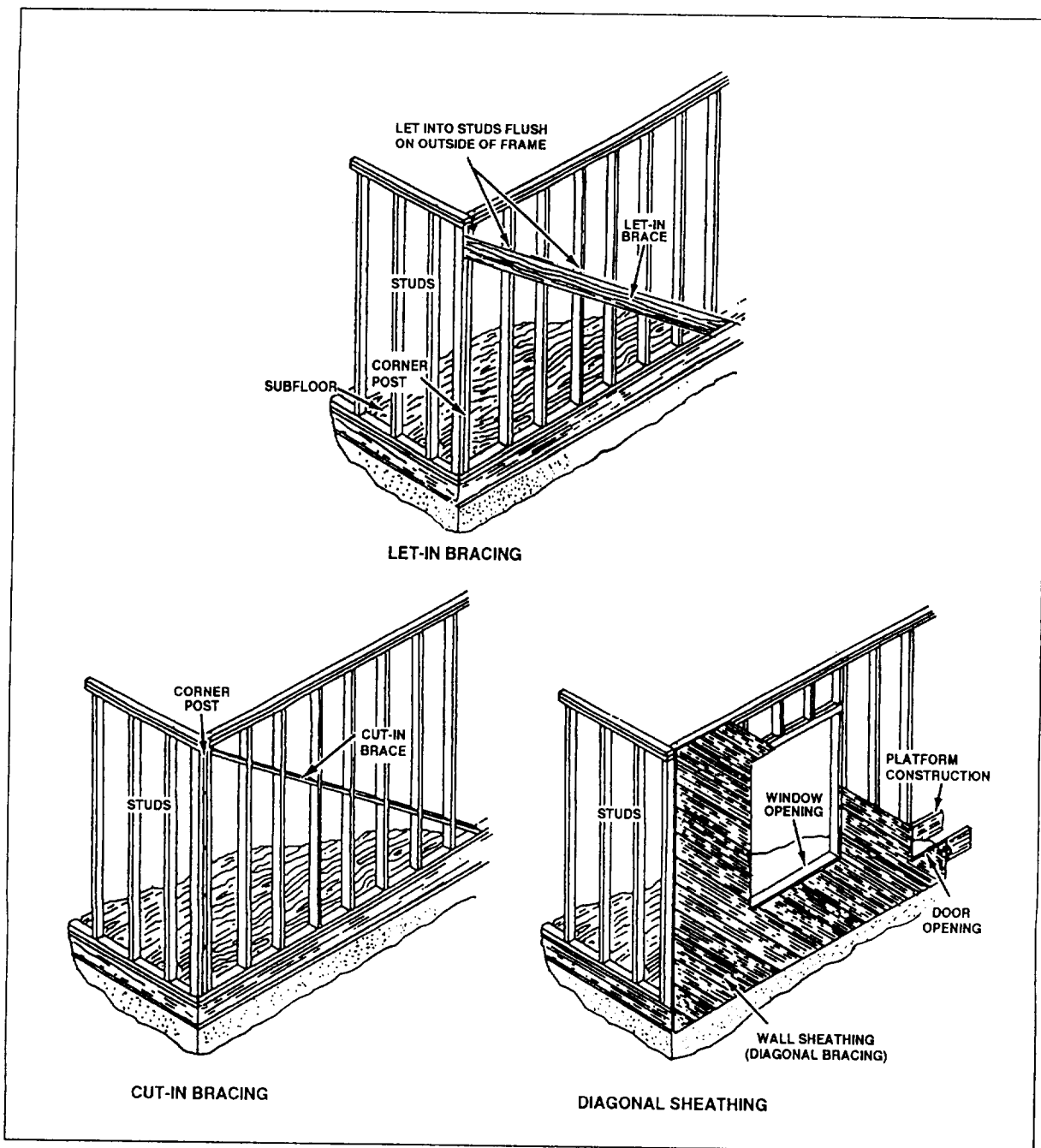


Figure 1-36.—Types of bracing.

nailed between the sill and soleplate. Additional cripple studs may be placed under each end of the sill.

Bracing

Diagonal bracing is necessary for the lateral strength of a wall. In all exterior walls and main interior partitions, bracing should be placed at both ends (where possible) and at 25-foot intervals. An exception to this

requirement is an outside wall covered with structural sheathing nailed according to building specifications. This type of wall does not require bracing.

Diagonal bracing is most effective when installed at a 45° to 60° angle. You can do this after the wall has been squared and still lying on the subfloor. The most widely used bracing system is the 1 by 4 let-in type, as shown in figure 1-36. The studs are notched so that the 1 by 4 piece is flush with the surface of the studs.

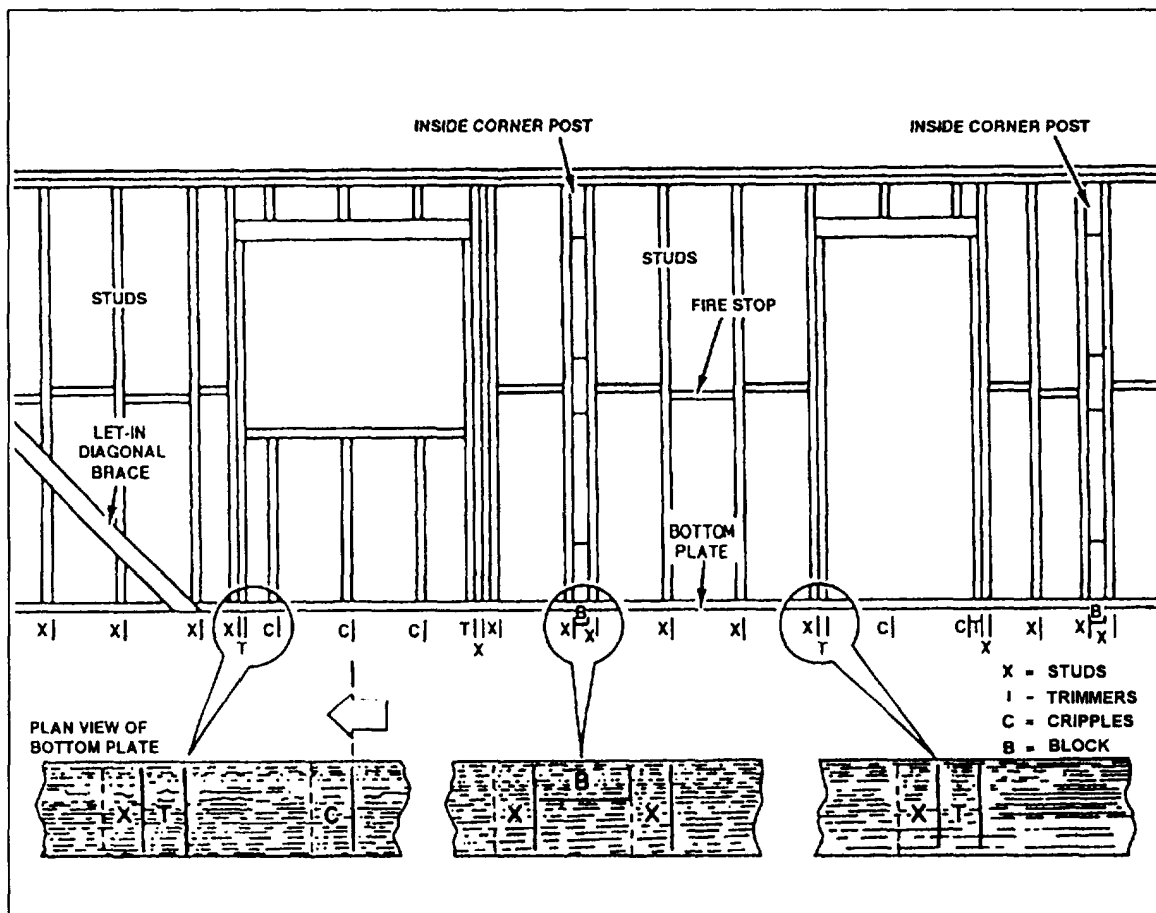


Figure 1-37.—Fire blocking.

Cut-in bracing (fig. 1-36) is another type of diagonal bracing. It usually consists of 2 by 4s cut at an angle and toenailed between studs at a diagonal from the top of a corner post down to the soleplate.

Diagonal sheathing (fig. 1-36) is the strongest type of diagonal bracing. Each board acts as a brace for the wall. When plywood or other panel sheathing is used, other methods of bracing maybe omitted.

Fire stops

Most local building codes require fire stops (also known as fire blocks) in walls over 8 foot 1 inch high. Fire stops slow down fire travel inside walls. They can be nailed between the studs before or after the wall is raised. Fire stops can be nailed in a straight line or staggered for easier nailing. Figure 1-37 shows a section of a framed wall with fire stops.

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

CONSTRUCTION

All major components of a wall should be cut before assembly. By reading the blueprints, you can determine the number of pieces and lengths of all components. The different parts of the wall are then assembled. Any hard, level surface can be used for assembly. After completing nailing, raise the walls in place for securing.

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

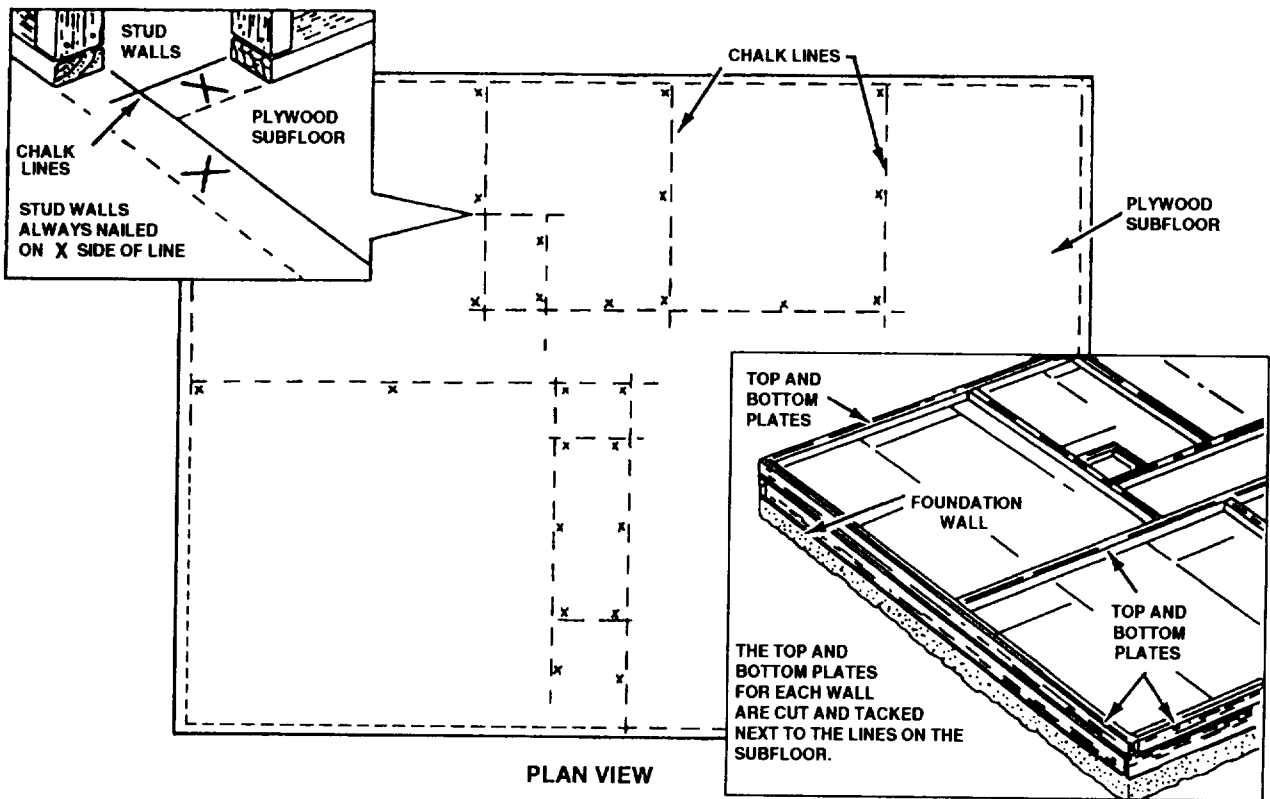


Figure 1-38.—Layout and cutting of plates.

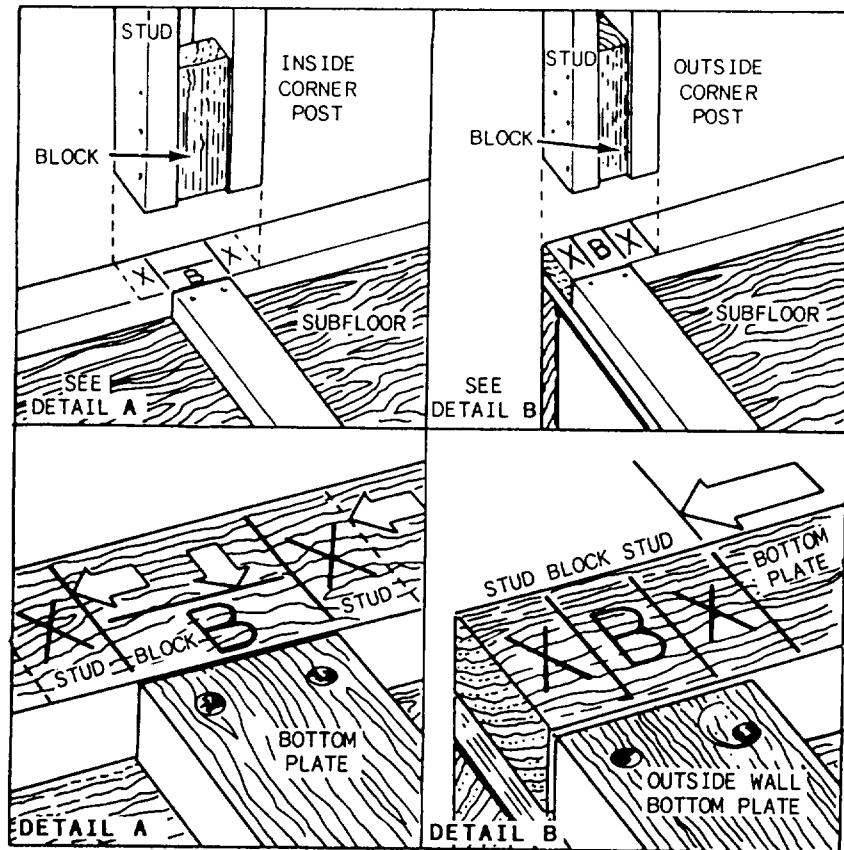


Figure 1-39.—Marking inside and outside corners.

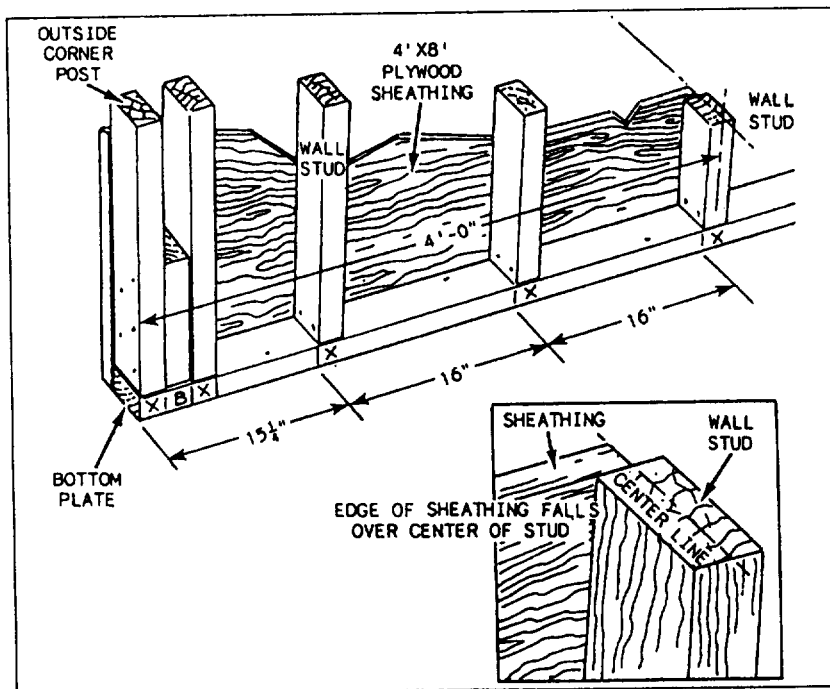


Figure 1-40.—First exterior wall stud layout.

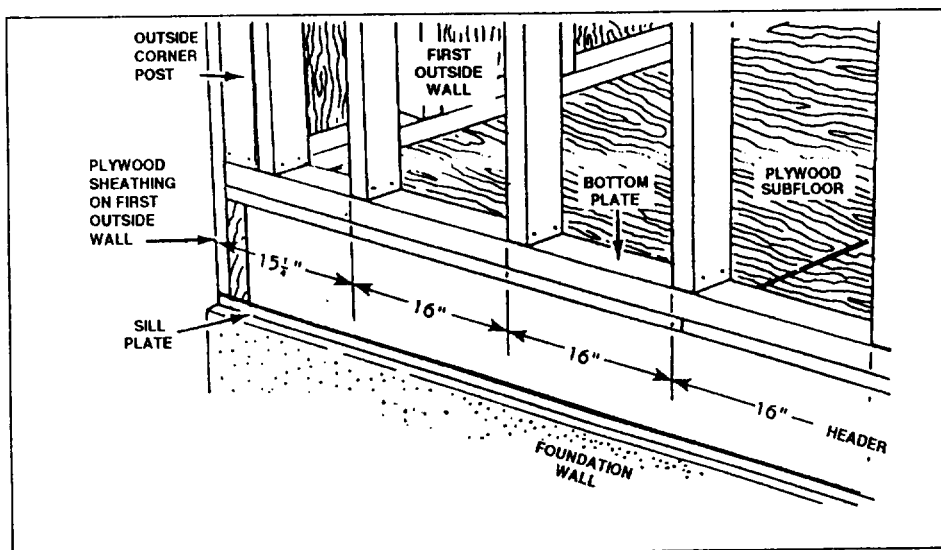


Figure 1-41.—Second exterior wall stud layout.

Horizontal Plate Layout

After all the lines are snapped, the wall plates are cut and tacked next to the lines (fig. 1-38). The plates are then marked off for corner posts and regular studs, as well as for the studs, trimmers, and cripples for the rough openings. All framing members must be clearly marked on the plates. This allows for efficient and error-free framing. Figure 1-37 shows a wall with framing members nailed in place according to layout markings.

A procedure for marking outside and inside corners for stud-and-block corner post construction is shown in figure 1-39. For laying out studs for the first exterior wall, see figure 1-40. In figure 1-40, the plates are marked for the first stud from a corner to be placed 15 1/4 inches from the end of the runner. Studs after the first stud follow 16 inches OC layout. This ensures the edges of standard-size panels used for sheathing or wallboard fall on the centers of the studs. Cripples are laid out to follow the layout of the studs.

A procedure for laying out studs for the second exterior wall is shown in figure 1-41. The plates are

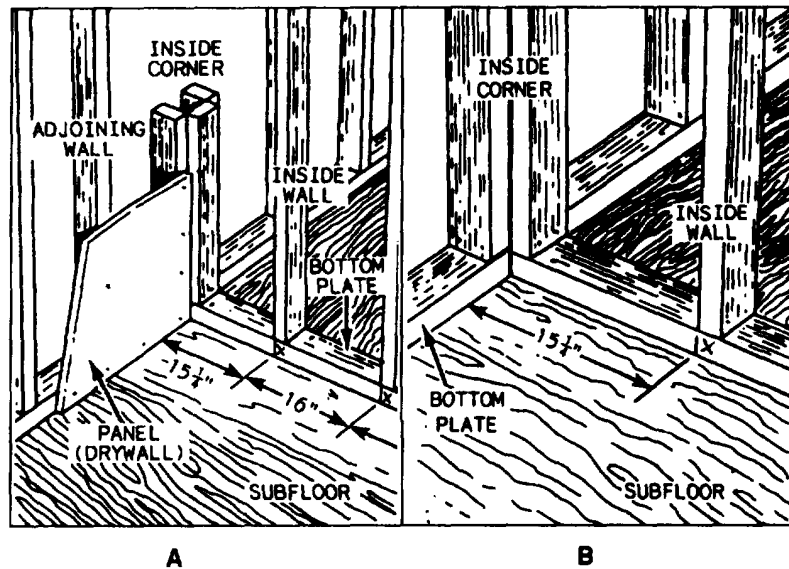


Figure 1-42.—Starting measurement for interior wall.

marked for the first stud to be placed 15 1/4 inches from the outside edge of the panel thickness on the first wall. This layout allows the corner of the first panel on the second wall to lineup with the edge of the first panel on the second wall. Also, the opposite edge of the panel on the second wall will break on the center of a stud.

A procedure for laying out studs for interior walls (partitions) is shown in figure 1-42. If panels are placed on the exterior wall first, the wall plates for the interior wall are marked for the first stud to be placed 15 1/4 inches from the edge of the panel thickness on the exterior wall. If panels are to be placed on the interior wall, the wall plates of the interior wall are marked for the first stud to be placed 15 1/4 inches from the unpaneled exterior wall.

If drywall or other interior finish panels are to be nailed to an adjoining wall (fig. 1-42, view A), you must measure 15 1/4 inches plus the thickness of the material. When panels are to be nailed on a wall first (view B), measure and mark the 15 1/4 inches from the front surface of the bottom plate. These procedures ensure stud alignment remains accurate throughout the nailing process.

Rough openings for doors and windows must also be marked on the wall plates. The rough opening dimensions for a window (fig. 1-43, view A) or wood door (view B) are calculated based on the window or door width, the thickness of the finish frame, and 1/2-inch clearance for shim materials at the sides of the

frame. Some blueprint door and window schedules give the rough opening dimensions, simplifying the layout.

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

A completely laid out bottom plate includes markings for corner posts, rough openings, studs, and cripples. The corner posts are laid out first. Next, the 16-inch marks for the studs and cripples are marked, and then the marks for the rough openings are made.

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

Vertical Layout

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

Some blueprints contain section views giving the exact rough heights of walls. The rough height is the distance from the subfloor to the bottom of the ceiling

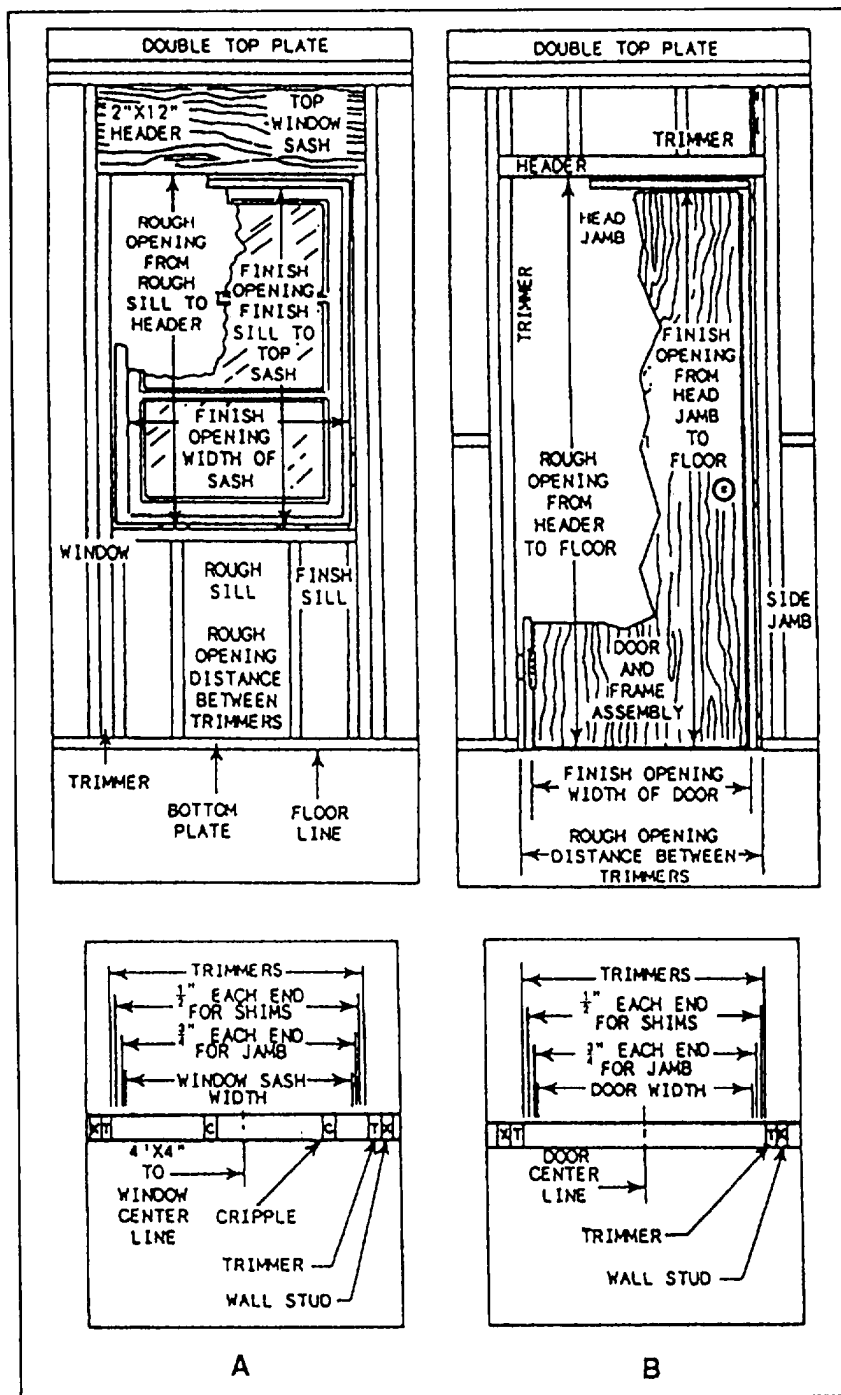


Figure 1-43.—Measurements for windows and doors.

joists. The rough height to the top of the door (the distance from the subfloor to the bottom of the door header) may also be noted on the section drawing. In addition, it may be given in the column for rough opening measurements on the door schedule. The rough height to the top of the door establishes the measurement for the rough height to the top of the window, as window headers are usually in line with door headers.

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

Many Builders prefer to frame the door and window openings before assembling the wall. View A of

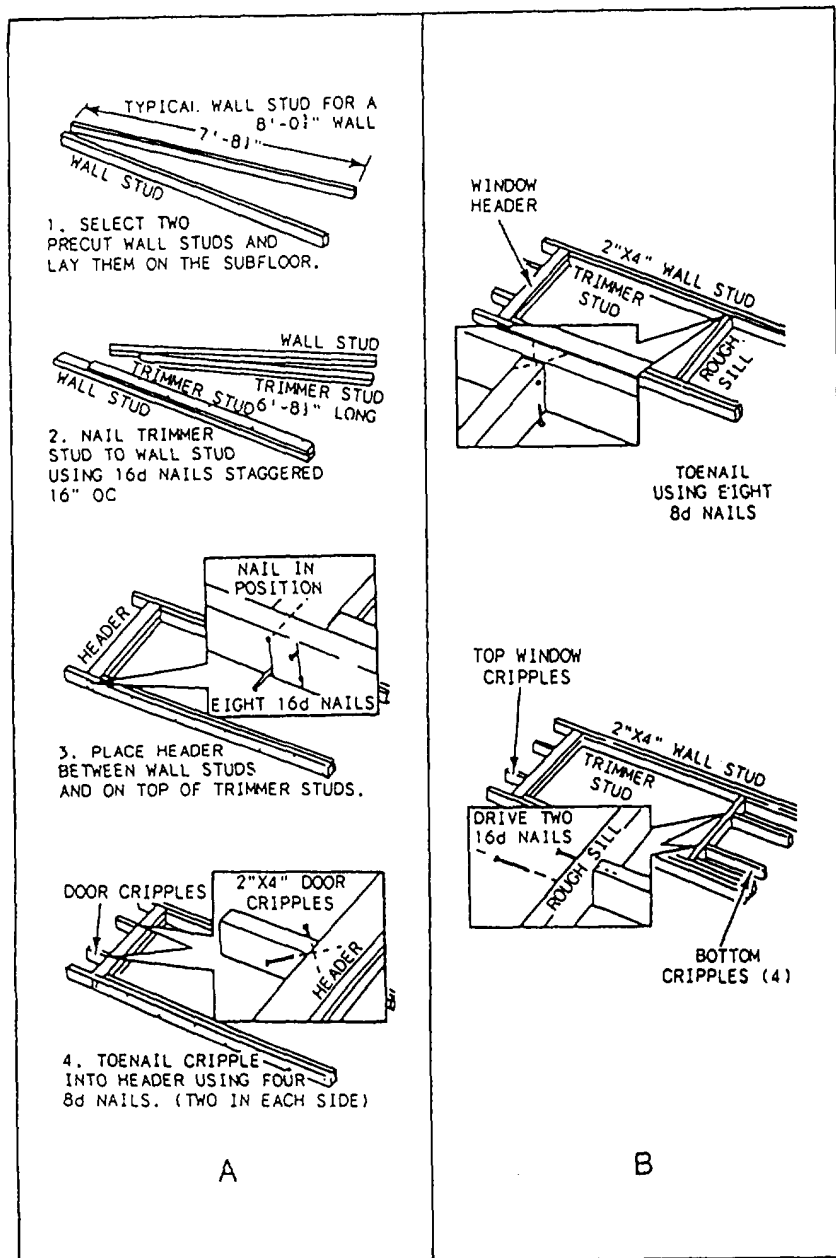


Figure 1-44.—Framing typical door and window openings.

figure 1-44 shows typical door framing; view B shows typical window framing. After stud layout, cripple studs are laid out (usually 16 inches OC) and nailed between the header and top plate and rough window sill and soleplate. It is a good practice to place a cripple stud under each end of a sill.

ASSEMBLY

After the corners and openings for doors and windows have been made up, the entire wall can be nailed together on the subfloor (fig. 1-45). Place top

and bottom plates at a distance slightly greater than the length of the studs. Position the corners and openings between the plates according to the plate layout. Place studs in position with the crown side up. Nail the plates into the studs, cripples, and trimmers. On long walls, the breaks in the plates should occur over a stud or cripple.

Placing the Double Top Plate

The double top plate (fig. 1-46) can be placed while the wall is still on the subfloor or after all the walls have

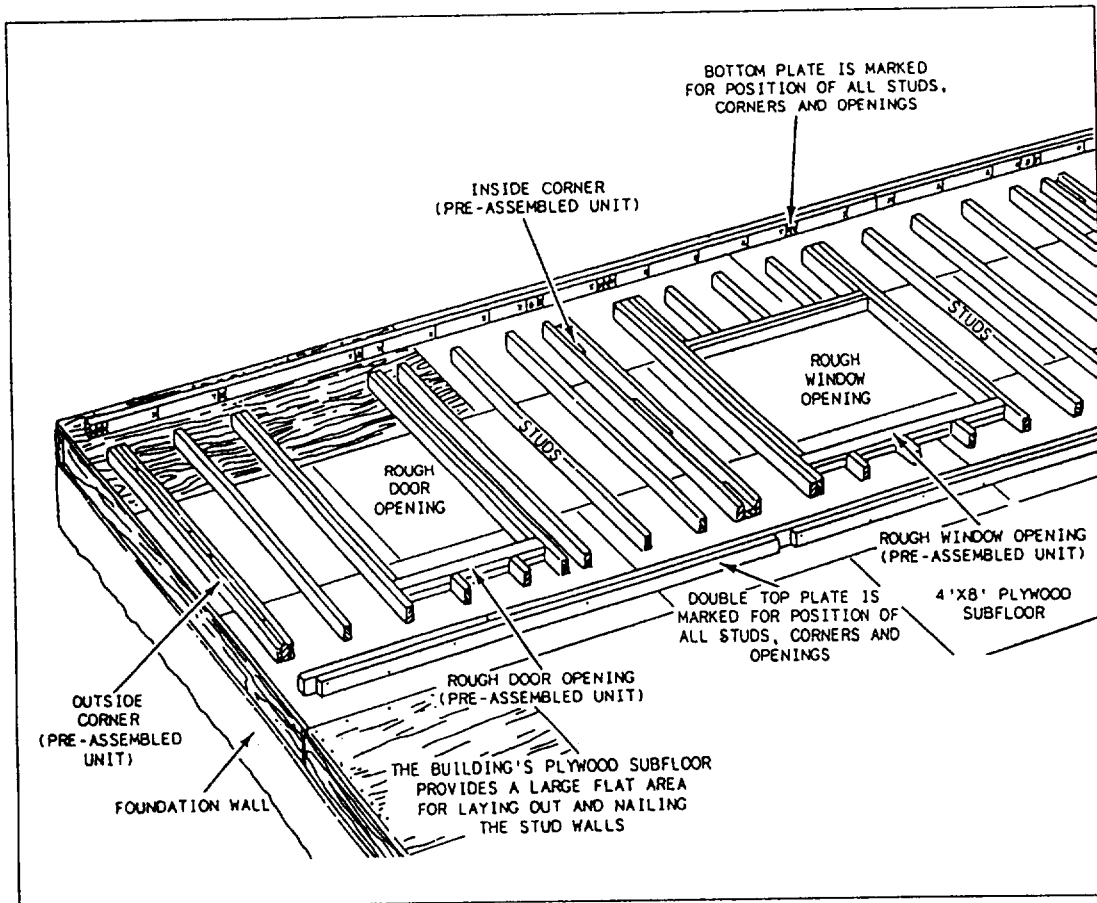


Figure 1-45.—Assembly of wall components.

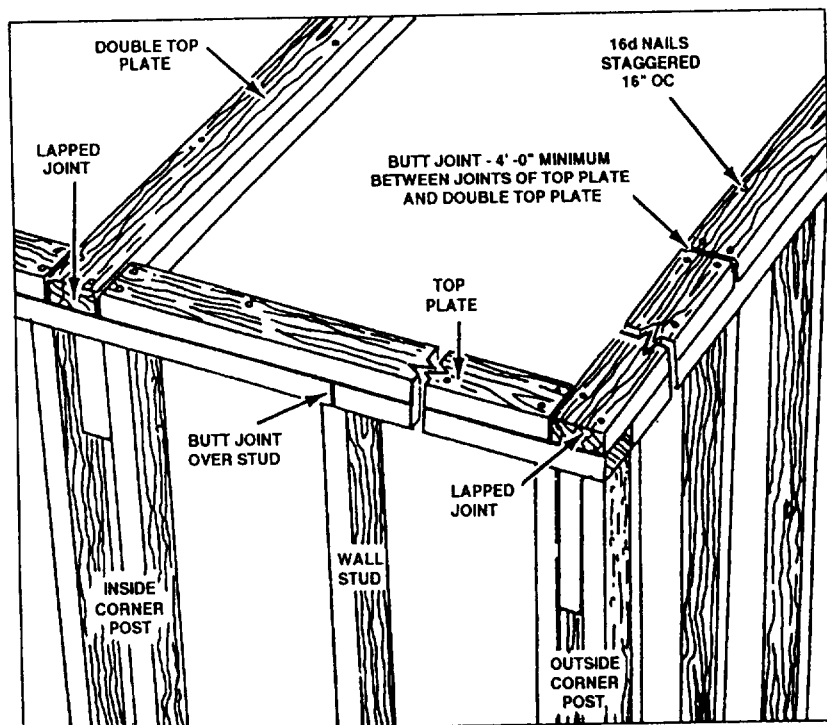


Figure 1-46.—Double top plate.

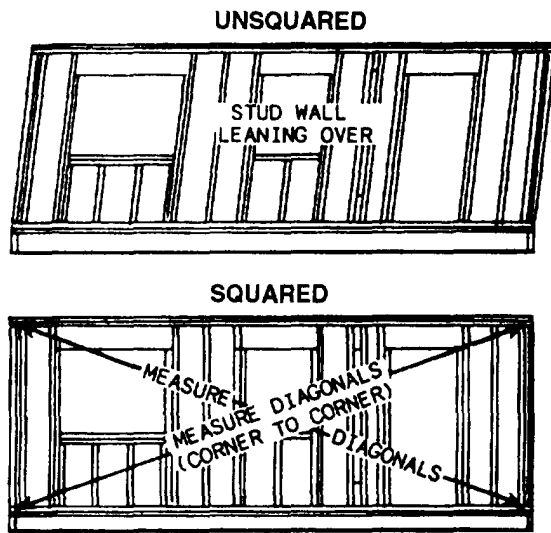


Figure 1-47.—Squaring a wall.

been raised. The topmost plates are nailed so that they overlap the plates below at all corners. This helps to tie the walls together. All ends are fastened with two 16d nails. Between the ends, 16d nails are staggered 16 inches OC. The butt joints between the topmost plates should be at least 4 feet from any butt joint between the plates below them.

Squaring Walls and Placing Braces

A completely framed wall is often squared while it is still lying on the subfloor. In this way, bracing, plywood, or other exterior wall covering can be nailed before the wall is raised. When diagonal measurements are equal, the wall is square. Figure 1-47 shows examples of unsquared and squared walls.

A let-in diagonal brace maybe placed while the wall is still on the subfloor. Lay out and snap a line on the studs to show the location of the brace (fig. 1-48). The studs are then notched for the brace. Tack the brace to the studs while the wall is still lying on the subfloor. Tacking instead of nailing allows for some adjustment after the wall is raised. After any necessary adjustment is made, the nails can be securely driven in.

Raising

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

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

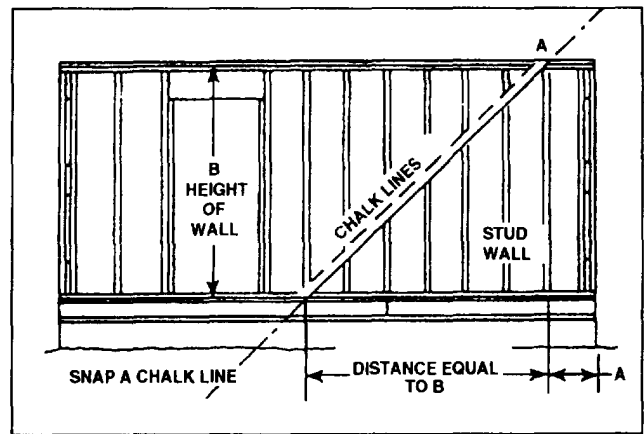


Figure 1-48.—Let-in diagonal brace.

After a wall has been raised, its bottom plates must be nailed securely to the floor. Where the wall rests on a wood subfloor and joists, 16d nails should be driven through the bottom plate and into the floor joists below the wall.

Plumbing and Aligning

Accurate plumbing of the comers is possible only after all the walls are up. Most framing materials are not perfectly straight; walls should never be plumbed by applying a hand level directly to an end stud. Always use a straightedge along with the level, as shown in figure 1-49, view A. The straightedge can be a piece ripped out of plywood or a straight piece of 2 by 4 lumber. Blocks 3/4 inch thick are nailed to each end. The blocks make it possible to accurately plumb the wall from the bottom plate to the top plate.

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

The tops of the walls (fig. 1-49, view B) are straightened (aligned or lined up) after all the corners have been plumbed. Prior to nailing the floor or ceiling joists to the tops of the walls, make sure the walls are aligned. Here's how: Fasten a string from the top plate at one corner of the wall to the top plate at another corner of the wall. You then cut three small blocks from 1 by 2 lumber. Place one block under each end of the string so that the line is clear of the wall.

The third block is used as a gauge to check the wall at 6- or 8-foot intervals. At each checkpoint, a temporary brace is fastened to a wall stud.

When fastening the temporary brace to the wall stud, adjust the wall so that the string is barely touching the gauge block. Nail the other end of the brace to a short 2 by 4 block fastened to the subfloor. These temporary

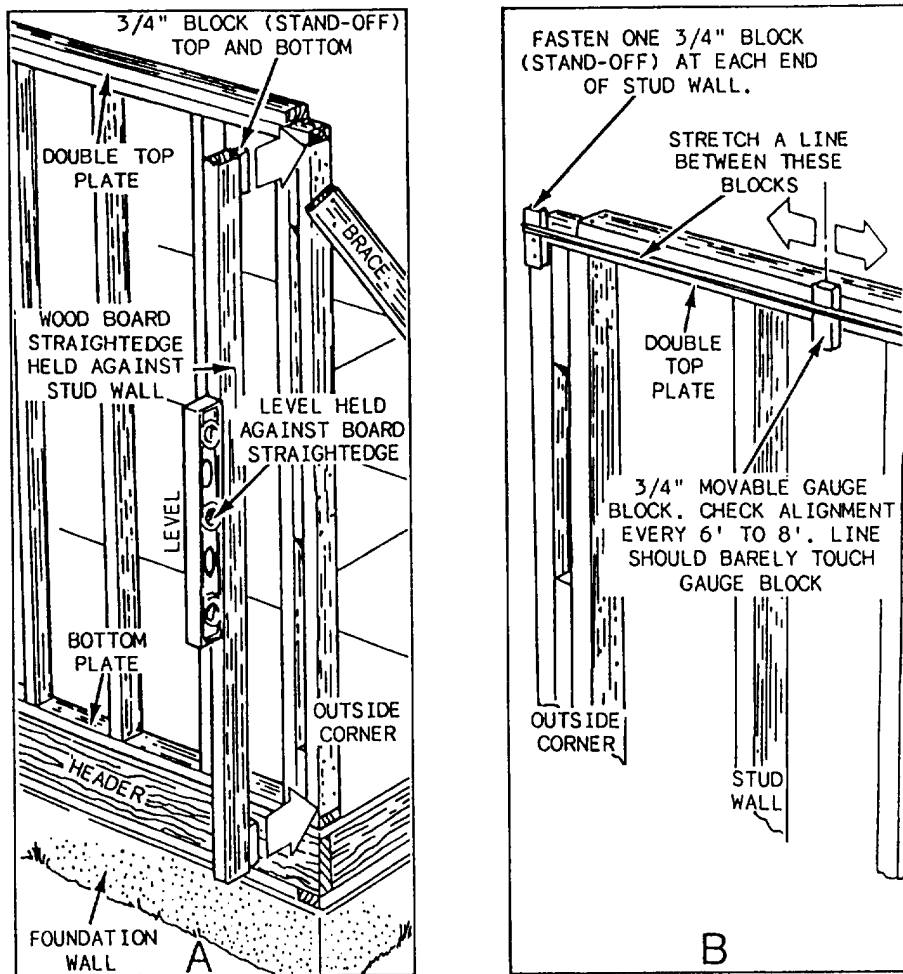


Figure 1-49.—Plumbing and aligning corners and walls.

braces are not removed until the framing and sheathing for the entire building have been completed.

Framing over Concrete Slabs

Often, the ground floor of a wood-framed building is a concrete slab. In this case, the bottom plates of the walls must be either bolted to the slab or nailed to the slab with a powder-actuated driver. If bolts are used, they must be accurately set into the slab at the time of the concrete pour. Holes for the bolts are laid out and drilled in the bottom plate when the wall is framed. When the wall is raised, it is slipped over the bolts and secured with washers and nuts.

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

SHEATHING THE WALLS

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

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

Plywood

Plywood is the most widely used sheathing material. Plywood panels usually applied to exterior

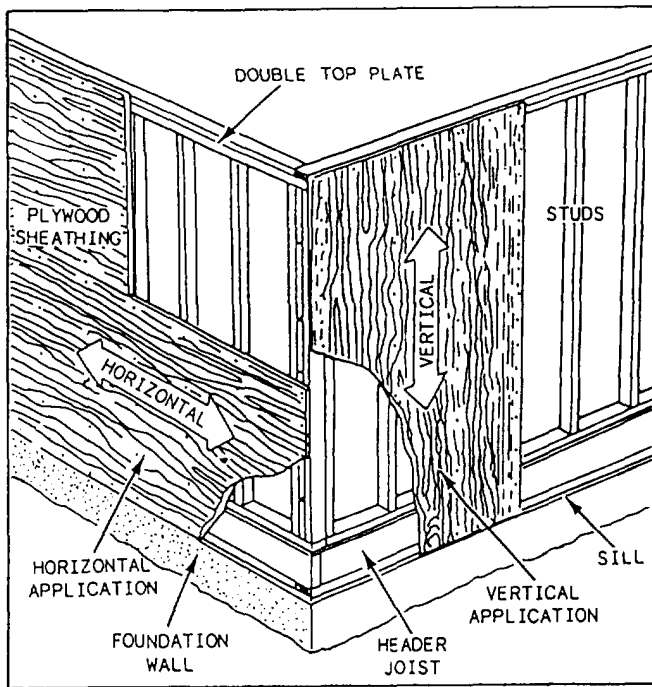


Figure 1-50.—Plywood sheathing.

walls range in size from 4 by 8 feet to 4 by 12 feet with thicknesses from 5/16 inch to 3/4 inch. The panels may be placed with the grain running vertically or horizontally (fig. 1-50). Specifications may require blocking along the long edges of horizontally placed panels.

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

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

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

Plywood sheathing can be applied when the squared wall is still lying on the subfloor. However, problems can occur after the wall is raised if the floor is not perfectly straight and level. For this reason, some Builders prefer to place the plywood after the entire building has been framed.

Nonveneered Panels

Although plywood is the most commonly used material for wall sheathing, specs sometimes call for

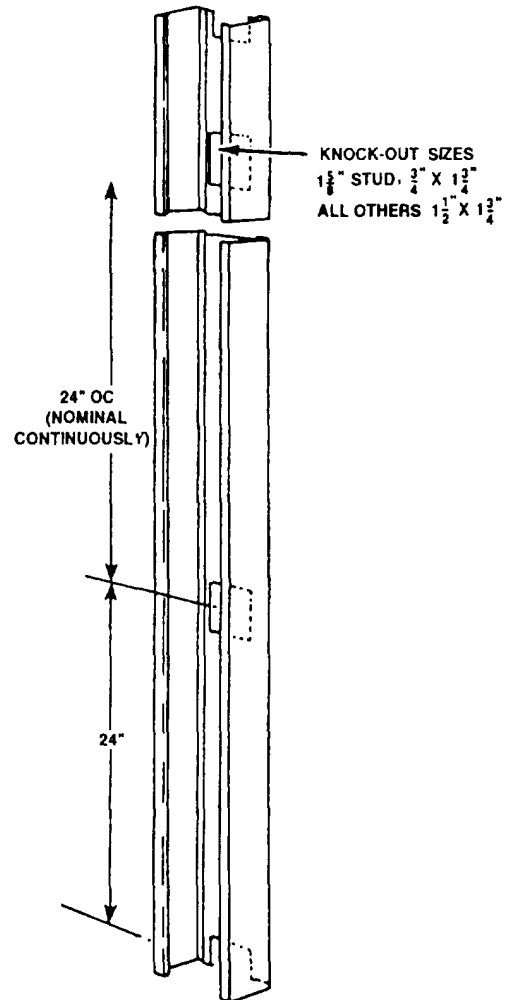


Figure 1-51.—Typical metal stud construction.

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

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

METAL FRAMING

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

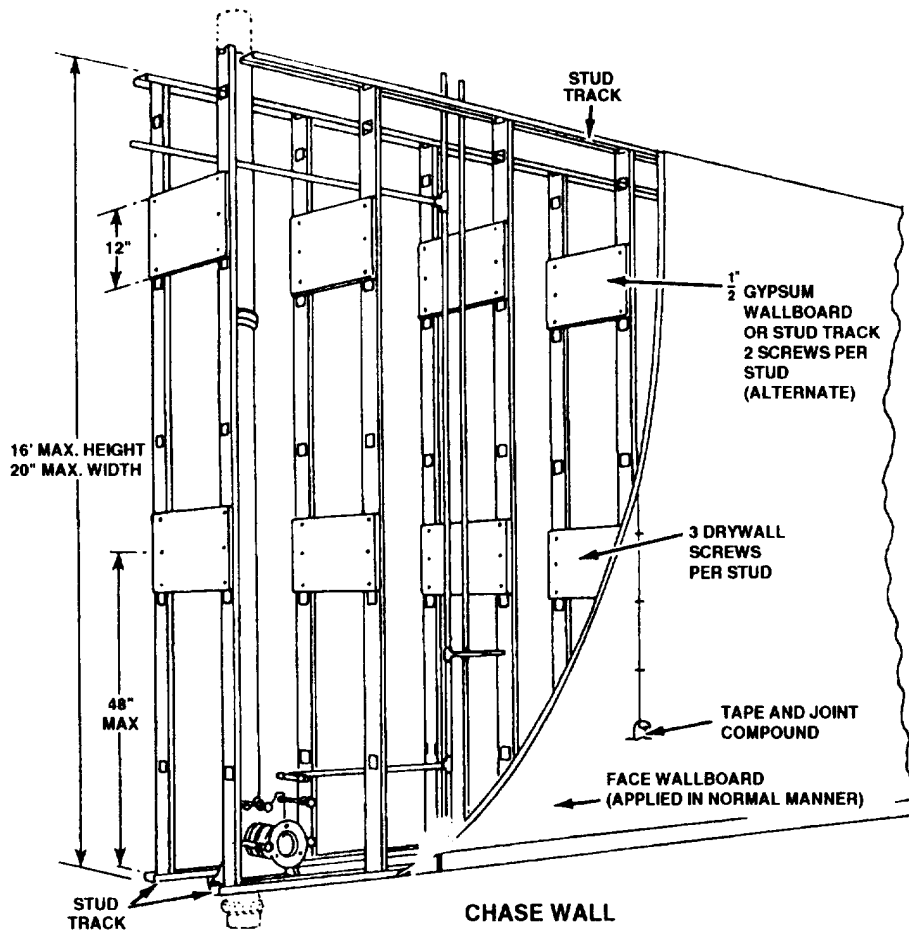


Figure 1-52.—Chase wall construction.

buildings are framed in a combination of metal and wood.

The metal framing members generally used are cold-formed steel, electrogalvanized to resist corrosion. Thicknesses range from 18 gauge to 25 gauge, the latter being most common. Most metal studs have notches at each end and knockouts located about 24 inches OC (fig. 1-51) to facilitate pipe and conduit installation. The size of the knockout, not the size of the stud, determines the maximum size of pipe or other material that can be passed through horizontally.

Chase (or double stud) walls (fig. 1-52) are often used when large pipes, ducts, or other items must pass vertically or horizontally in the walls. Studs are generally available in thicknesses of 1 5/8, 2 1/2, 3 5/8, 4, and 6 inches. The metal runners used are also 25-gauge (or specified gauge) steel or aluminum, sized to complement the studs. Both products have features advantageous to light-frame construction. The metal studs and runners do not shrink swell, twist, or warp. Termites cannot affect them, nor are they susceptible to

dry rot. Also, when combined with proper covering material, they have a high fire-resistance rating.

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

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

Door frames for both the interior partitions and exterior walls are integral with the system. They are preprinted and may come complete with necessary

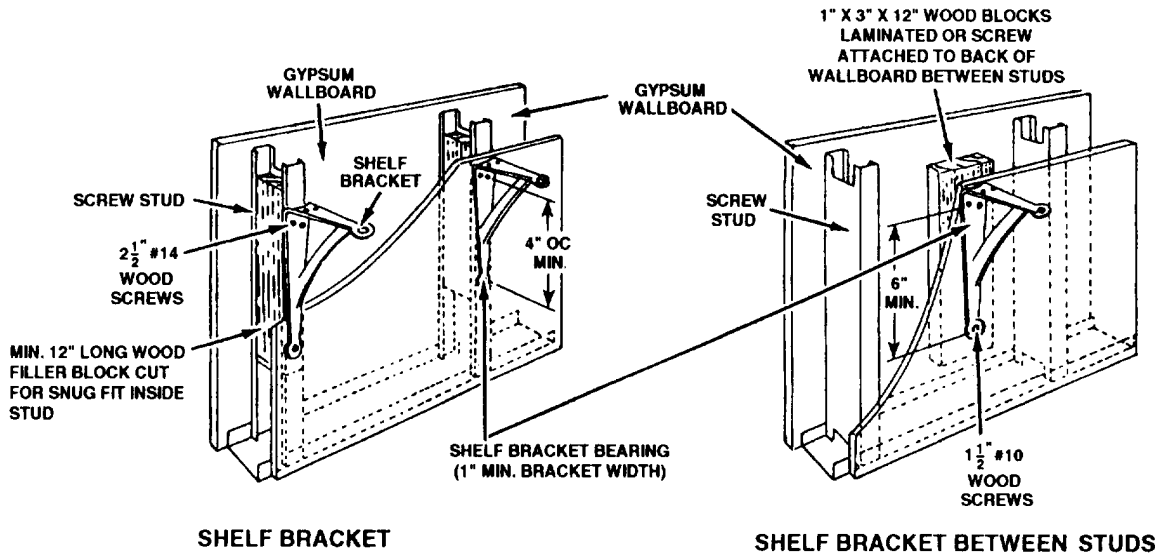


Figure 1-53.—Wood blocking for ceiling or wall-mounted fixtures.

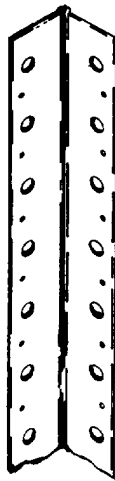


Figure 1-54.—Standard corner bead.



Figure 1-55.—Multiflex tape bead.

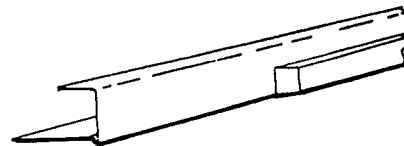


Figure 1-56.—Casing and trim beads.

hinges, locks, rubber stops, and weather stripping. The windows are also integral to the system, prefabricated and painted. These units may include interior and exterior trim designed to accept 1/2-inch wallboard and 1/2-inch sheathing plus siding on the outside.

Plumbing is installed in prepunched stud webs. Wiring is passed through insulated grommets inserted in the prepunched webs of the studs and plates. Wall and ceiling fixtures are mounted by attaching wood blocking spaced between the flanges of the wall studs or trusses

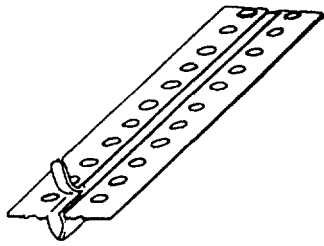


Figure 1-57.—Expansion joint.

(fig. 1-53). Friction-tight insulation is installed by placing the batts (bundles of insulating material) between the studs on the exterior walls. Studs are spaced 12, 16, or 24 inches OC as specified in the blueprints.

Corner and Casing Beads

Standard wallboard corner bead is manufactured from galvanized steel with perforated flanges, as shown in figure 1-54. It provides a protective reinforcement of straight corners. The corner bead is made with 1-inch by 1-inch flanges for 3/8- or 1/2-inch single-layer wallboard; 1 inch by 1 1/4 inches for 1/2-inch

or 5/8-inch single-layer wallboard; 1 1/4 inches by 1 1/4 inches for two-layer wallboard application. It is available in 10-foot lengths.

Multiflex tape bead consists of two continuous metal strips on the undersurface of 2 1/8-inch-wide reinforcing tape (fig. 1-55). This protects corners formed at any angle. Multiflex tape bead comes in 100-foot rolls.

Casing and trim beads (examples are shown in fig. 1-56) are used as edge protection and trim around window and door openings and as moldings at ceiling angles. They are made from galvanized steel in three styles to fit 3/8-inch, 1/2-inch, and 5/8-inch wallboard and come in 10-foot lengths.

Expansion Joints

Expansion joints are vinyl extrusions used as control joints in drywall partitions and ceilings. A typical form is shown in figure 1-57.

Figure 1-58 shows a typical metal frame layout and use of corner and casing beads for corners, partition intersections, and partition ends. It also shows a typical

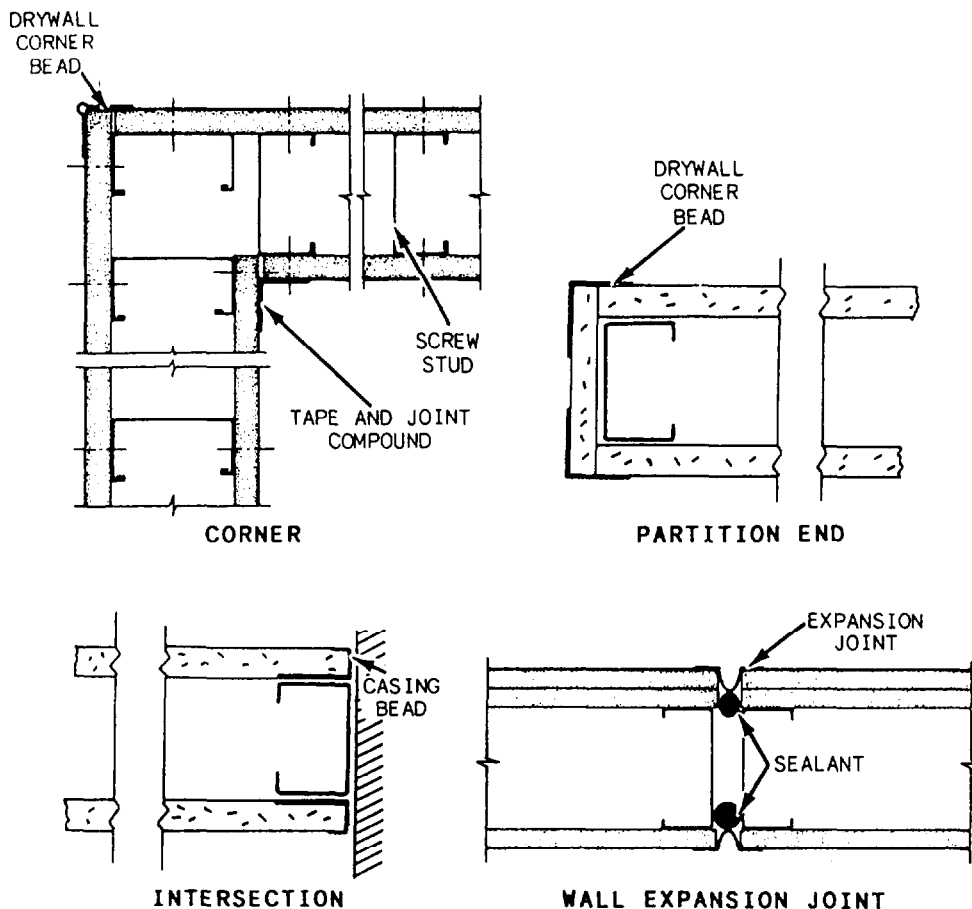


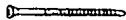


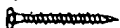








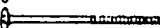
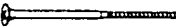
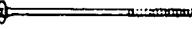







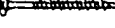
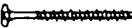

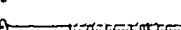



Figure 1-58.—Metal frame layout with various beads and joints.

	HEAD	LENGTH	FASTENING APPLICATION
	LOW PROFILE	$\frac{1}{2}$ "	METAL-TO-METAL, REDUCES DRYWALL BULGE OVER SCREW.*
	TRIM	1"	BATTEN TO METAL STUD.*
	TRIM	$1\frac{5}{8}$ "	WOOD TRIM ON SINGLE LAYER DRYWALL TO METAL FRAMING.*
	TRIM	$2\frac{1}{4}$ "	WOOD TRIM ON DOUBLE LAYER DRYWALL TO METAL FRAMING.*
	WASHER HEAD	$\frac{1}{2}$ "	METAL LATH TO STEEL FRAMING.*
	BUGLE	$1\frac{1}{2}$ "	BOARD-TO-BOARD DURING LAMINATION.
	BUGLE	$1\frac{1}{4}$ "	DRYWALL OR CHANNELS TO WOOD FRAMING.
	PAN	$\frac{3}{8}$ "	METAL-TO-METAL*
	PAN	$\frac{1}{2}$ "	METAL STUDS TO RUNNERS. DOOR FRAME CLIPS TO METAL STUDS.*
	PAN	$\frac{3}{8}$ "	METAL STUDS TO METAL RUNNERS SPLICING STUDS.
	BUGLE	1"	$\frac{1}{2}$ " OR $\frac{5}{8}$ " DRYWALL TO METAL FRAMING.*
	BUGLE	$1\frac{1}{4}$ "	METAL LATH TO METAL STUDS.*
	BUGLE	$1\frac{5}{8}$ "	DOUBLE LAYER $\frac{1}{2}$ " OR $\frac{5}{8}$ " DRYWALL TO METAL FRAMING.*
	BUGLE	$1\frac{7}{8}$ "	MULTI-LAYER DRYWALL TO METAL FRAMING.*
	BUGLE	2"	LAMINATED DRYWALL UP TO $1\frac{5}{8}$ " THICK TO METAL FRAMING.*
	BUGLE	$2\frac{1}{4}$ "	DOUBLE LAYER 1" SHAFTLINER TO METAL FRAMING.*
	BUGLE	$2\frac{5}{8}$ "	LAMINATED DRYWALL UP TO $2\frac{1}{4}$ " THICK TO FRAMING.*
	BUGLE	3"	MULTI-LAYER DRYWALL UP TO $2\frac{1}{2}$ " THICK TO FRAMING.*
	TRIM	1"	BATTEN OVER DRYWALL TO METAL STUD.
	TRIM	$1\frac{5}{8}$ "	WOOD TRIM OVER DRYWALL TO METAL STUD.
	TRIM	$2\frac{1}{4}$ "	WOOD TRIM OVER DOUBLE LAYER DRYWALL TO METAL STUD.
	BUGLE	1"	$\frac{1}{2}$ " OR $\frac{5}{8}$ " DRYWALL TO METAL STUD UP TO 20 GAUGE. STEEL CHANNELS TO WOOD FRAMING.
	BUGLE	$1\frac{1}{8}$ "	$\frac{5}{8}$ " DRYWALL CEILING ATTACHMENTS.
	BUGLE	$1\frac{1}{4}$ "	$\frac{5}{8}$ " DRYWALL CEILING ON RESILIENT FURRING CHANNELS.
	BUGLE	$1\frac{5}{8}$ "	DOUBLE LAYER $\frac{5}{8}$ " DRYWALL TO METAL STUD.
	BUGLE	$1\frac{7}{8}$ "	$\frac{1}{2}$ " DRYWALL THROUGH SHAFTLINER TO METAL RUNNERS.
	BUGLE	$2\frac{1}{4}$ "	$\frac{5}{8}$ " DRYWALL THROUGH SHAFTLINER TO METAL RUNNERS.
	BUGLE	$2\frac{5}{8}$ "	DOUBLE LAYER 1" SHAFTLINER TO METAL STUD.
	BUGLE	3"	$\frac{1}{2}$ " DRYWALL OVER 2 LAYERS OF 1" SHAFTLINER TO METAL FRAMING.

*FRAMING NOT EXCEEDING .1084 THICKNESS (12 GAUGE).

Figure 1-59.—Drywall screws and fastening application.

cross section of a metal frame stud wall control joint. Figure 1-59 lists the different types of fasteners used in metal frame construction and explains the application of each type.

CEILING FRAMING

LEARNING OBJECTIVE: Upon completing this section, you should be able to state the purpose of ceiling frame members and describe layout and installation procedures.

Ceiling construction begins after all walls have been plumbed, aligned, and secured. One type of ceiling

supports an attic area beneath a sloping (pitched) roof. Another type serves as the framework of a flat roof. When a building has two or more floors, the ceiling of a lower story is the floor of the story above.

One of the main structural functions of a ceiling frame is to tie together the outside walls of the building. When located under a pitched roof, the ceiling frame also resists the outward pressure placed on the walls by the roof rafters (fig. 1-60). The tops of interior partitions are fastened to the ceiling frame. In addition to supporting the attic area beneath the roof, the ceiling frame supports the weight of the finish ceiling materials, such as gypsum board or lath and plaster.

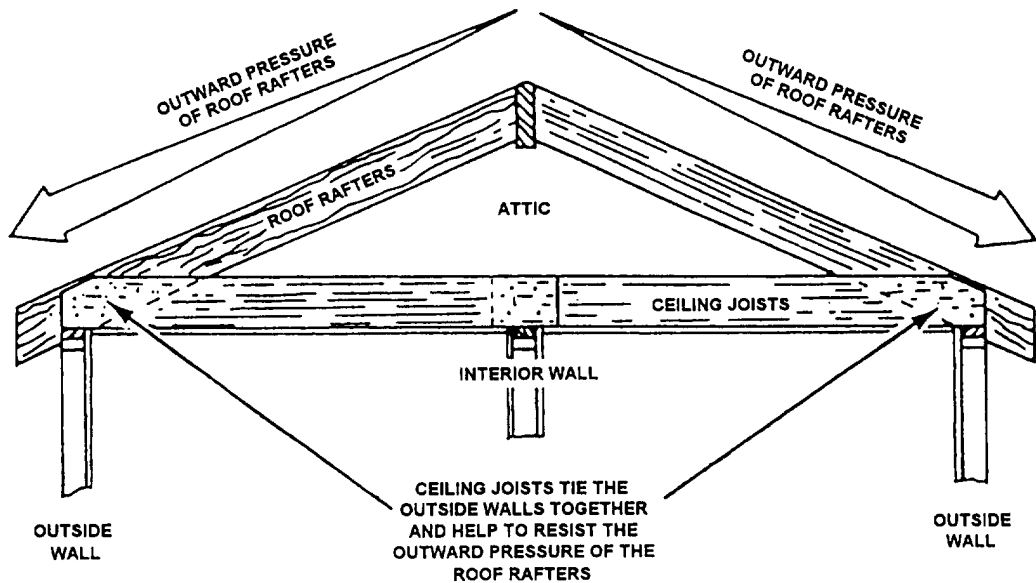


Figure 1-60.—Ceiling frame tying exterior walls together.

JOISTS

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

Interior Support

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

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

Roof Rafters

Whenever possible, the ceiling joists should run in the same direction as the roof rafters. Nailing the outside end of each ceiling joist to the heel of the rafter as well as to the wall plates (fig. 1-61) strengthens the tie between the outside walls of the building.

A building maybe designed so that the ceiling joists do not run parallel to the roof rafters. The rafters are therefore pushing out on walls not tied together by ceiling joists. In this case, 2 by 4 pieces are added to run

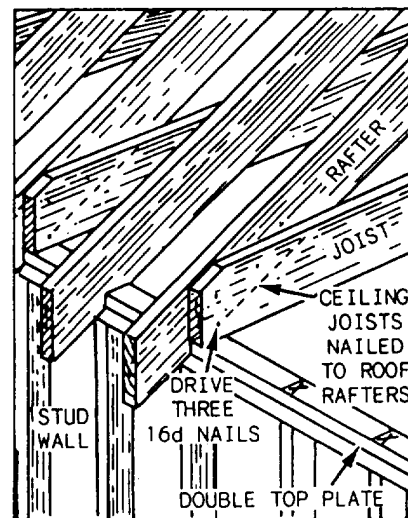


Figure 1-61.—Nailing of ceiling joists.

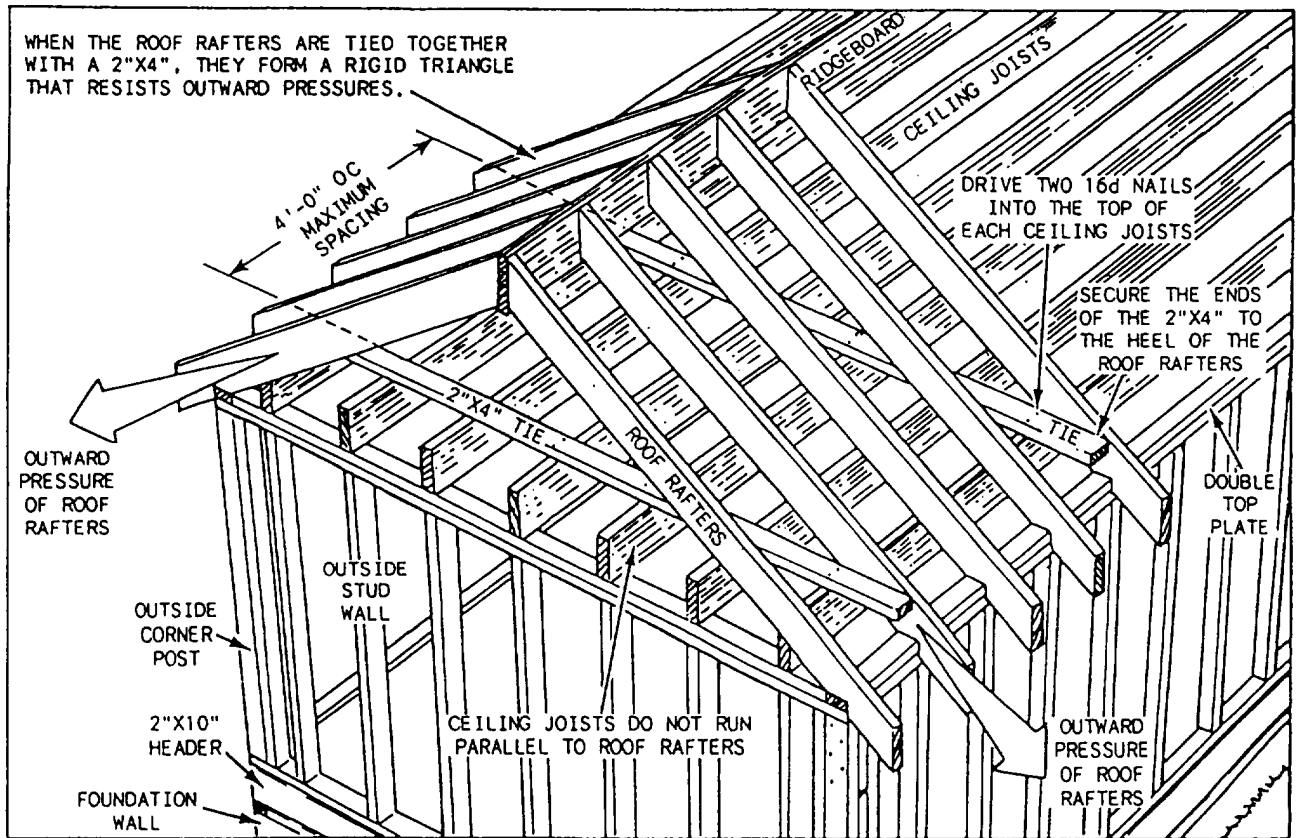


Figure 1-62.—2 by 4 ties.

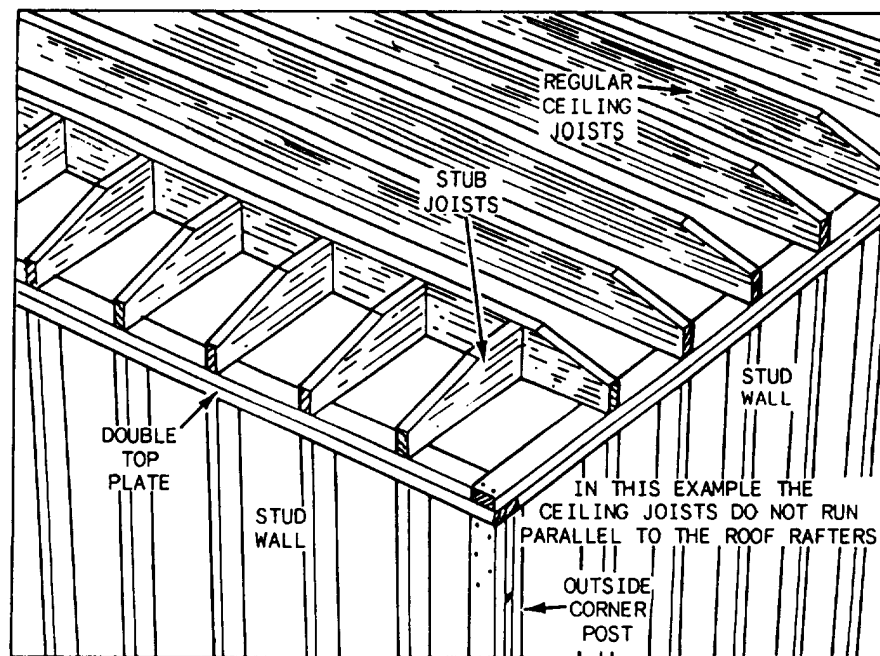


Figure 1-63.—Stub joists.

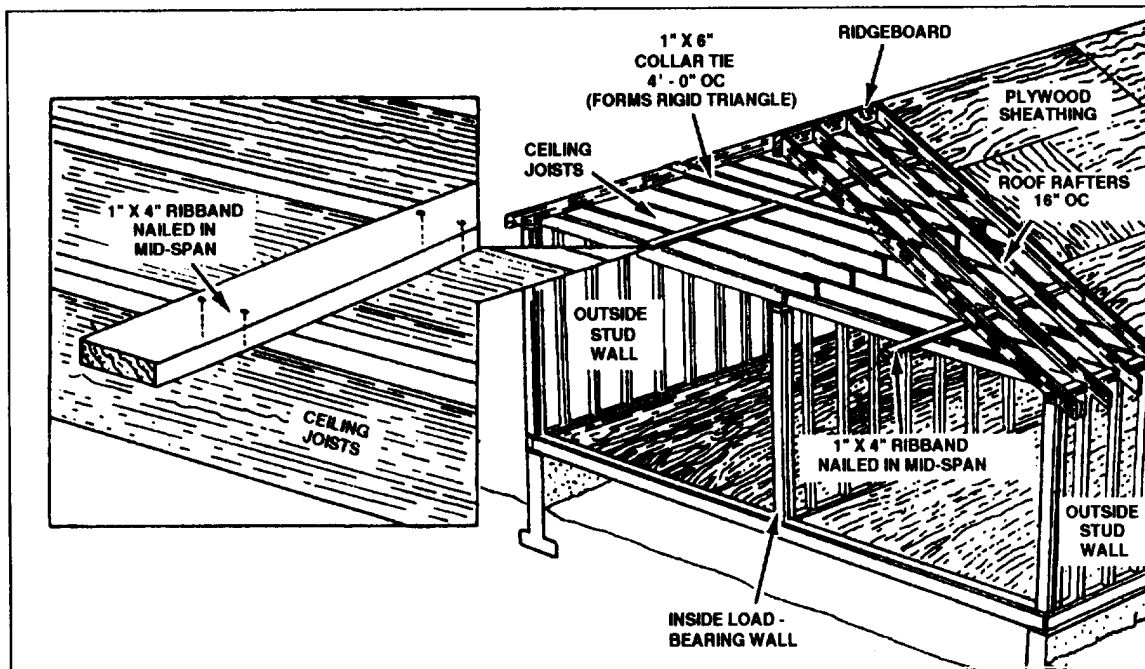


Figure 1-64.—Ribband installation.

in the same direction as the rafters, as shown in figure 1-62. The 2 by 4s should be nailed to the top of each ceiling joist with two 16d nails. The 2 by 4 pieces should be spaced no more than 4 feet apart, and the ends secured to the heels of the rafters or to blocking over the outside walls.

Roof Slope

When ceiling joists run in the same direction as the roof rafters, the outside ends must be cut to the slope of the roof. Ceiling frames are sometimes constructed with stub joists (fig. 1-63). Stub joists are necessary when, in certain sections of the roof, rafters and ceiling joists do not run in the same direction. For example, a low-pitched hip roof requires stub joists in the hip section of the roof.

Ribbands and Strongbacks

Ceiling joists not supporting a floor above require no header joists or blocking. Without the additional header joists, however, ceiling joists may twist or bow at the centers of their span. To help prevent this, nail a 1 by 4 piece called a ribband at the center of the spans (fig. 1-64). The ribband is laid flat and fastened to the top of each joist with two 8d nails. The end of each ribband is secured to the outside walls of the building.

A more effective method of preventing twisting or bowing of the ceiling joists is to use a strongback. A strongback is made of 2 by 6 or 2 by 8 material nailed to the side of a 2 by 4 piece. The 2 by 4 piece is fastened

with two 16d nails to the top of each ceiling joist, as shown in figure 1-65. The strongbacks are blocked up and supported over the outside walls and interior partitions. Each strongback holds a ceiling joist in line and also helps support the joist at the center of its span.

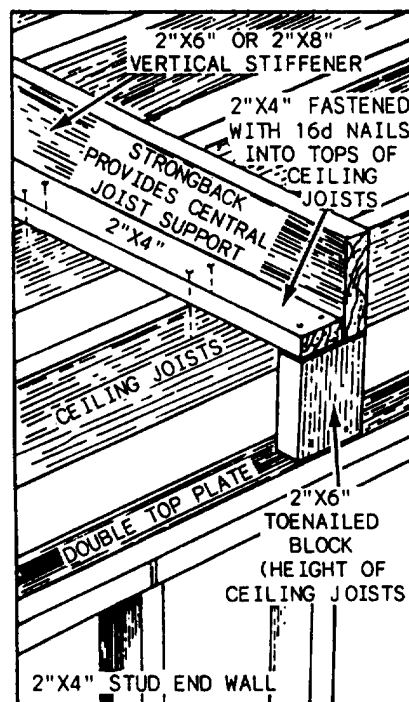


Figure 1-65.—Strongback.

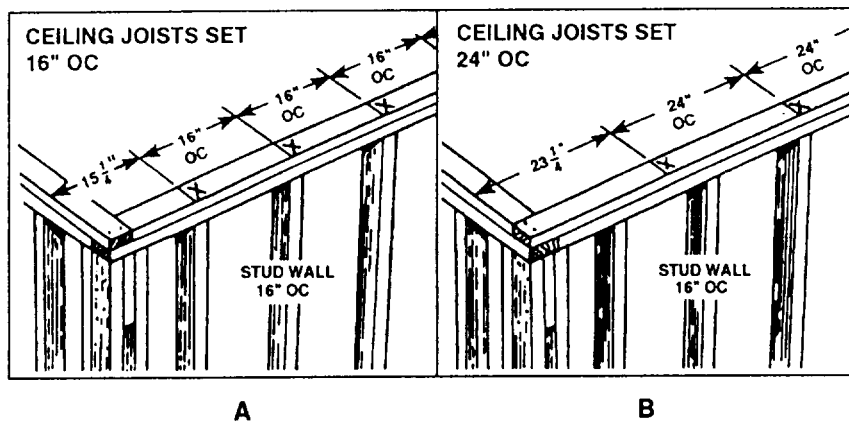


Figure 1-66.—Ceiling joist spacing.

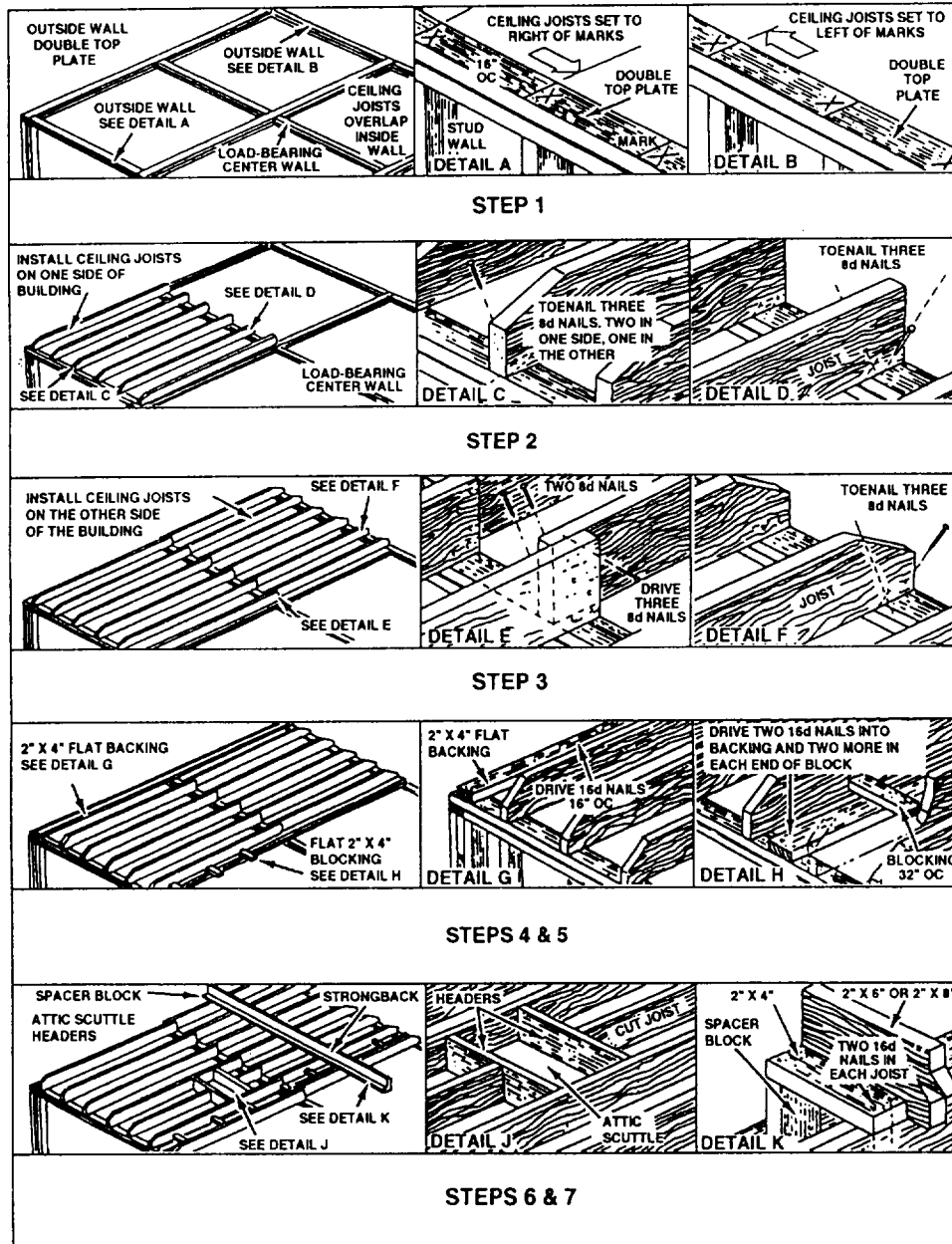


Figure 1-67.—Constructing a typical ceiling frame.

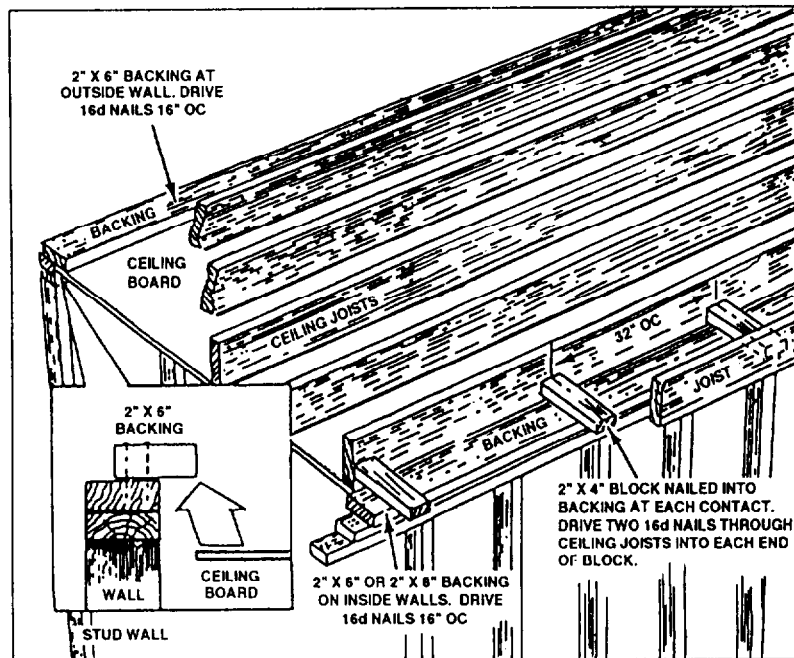


Figure 1-68.—Backing for nailing joists to ceiling frame.

Layout

Ceiling joists should be placed directly above the studs when the spacing between the joists is the same as between the studs. This arrangement makes it easier to install pipes, flues, or ducts running up the wall and through the roof. However, for buildings with walls having double top plates, most building codes do not require ceiling joists to line up with the studs below.

If the joists are being placed directly above the studs, they follow the same layout as the studs below (fig. 1-66, view A). If the joist layout is different from that of the studs below (for example, if joists are laid out 24 inches OC over a 16 inch OC stud layout), mark the first joist at 23 1/4 inches and then at every 24 inches OC (fig. 1-66, view B).

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

FRAME

All the joists for the ceiling frame should be cut to length before they are placed on top of the walls. On structures with pitched roofs, the outside ends of the joists should also be trimmed for the roof slope. This

angle must be cut on the crown (top) side of the joist. The prepared joists can then be handed up to the Builders working on top of the walls. The joists are spread in a flat position along the walls, close to where they will be nailed. Figure 1-67 shows one procedure for constructing the ceiling frame. In this example, the joists lap over an interior partition. Refer to the figure as you study the following steps:

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

Fastening Walls

The tops of walls running in the same direction as the ceiling joists must be securely fastened to the ceiling frame. The method most often used is shown in figure 1-68. Blocks, 2 inches by 4 inches, spaced 32 inches OC, are laid flat over the top of the partition. The ends of

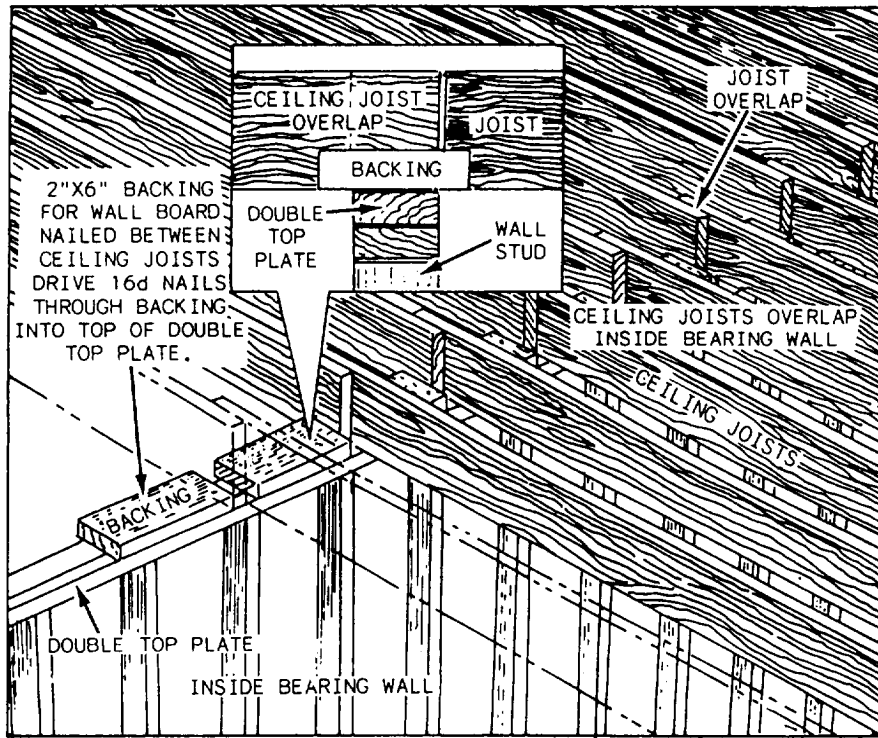


Figure 1-69.—Backing for interior wall plates.

each block are fastened to the joists with two 16d nails. Two 16d nails are also driven through each block into the top of the wall.

Applying Backing

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

Figure 1-68 shows backing placed on top of walls. The 2 by 4 pieces nailed to the exterior wall projects from one side of the wall. The interior wall requires a 2 by 6 or 2 by 8 piece extending from both sides of the wall. Backing is fastened to the top plates with 16d nails spaced 16 inches OC. Backing is also used where joists run at right angles to the partition (fig. 1-69).

Attic Scuttle

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

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

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

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

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

Exterior and Interior Trim, John E. Ball, Delmar Publishers, Inc., Albany, N.Y., 1975.

CHAPTER 2

ROOF FRAMING

In this chapter, we will introduce you to the fundamentals of roof design and construction. But, before discussing roof framing, we will first review some basic terms and definitions used in roof construction; we will then discuss the framing square and learn how it's used to solve some basic construction problems. Next, we'll examine various types of roofs and rafters, and techniques for laying out, cutting, and erecting rafters. We conclude the chapter with a discussion of the types and parts of roof trusses.

TERMINOLOGY

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of roofs and define common roof framing terms.

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

TYPES OF ROOFS

The most commonly used types of pitched roof construction are the gable, the hip, the intersecting, and the shed (or lean-to). An example of each is shown in figure 2-1.

Gable

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

Hip

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

Intersecting

The intersecting roof consists of a gable and valley, or hip and valley. The valley is formed where the two different sections of the roof meet, generally at a 90° angle. This type of roof is more complicated than the

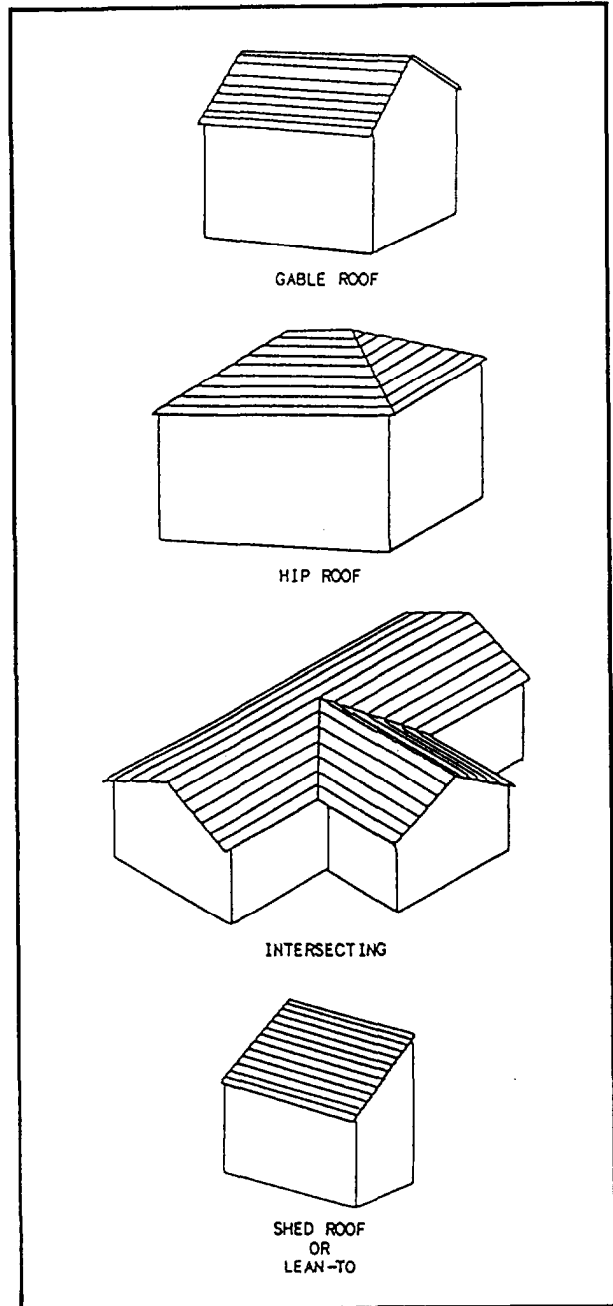
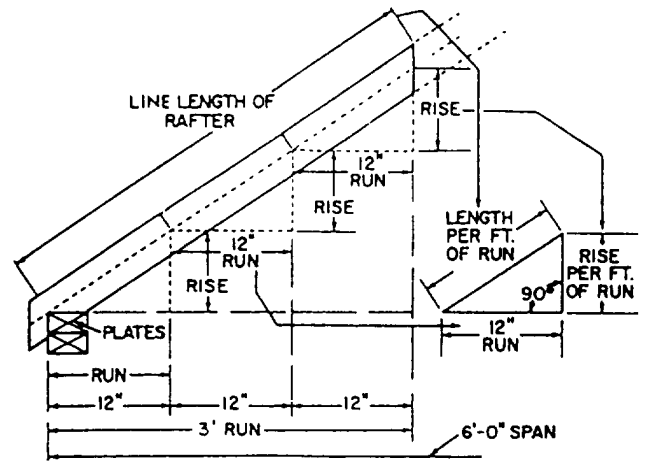


Figure 2-1.—Most common types of pitched roofs.

other types and requires more time and labor to construct.

Shed

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



FRAMING TERMS

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

Roof

Features associated with basic roof framing terms are shown in figure 2-2. Refer to the figure as you study the terms discussed in the next paragraphs.

Span is the horizontal distance between the outside top plates, or the base of two abutting right triangles.

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

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

Pitch is the ratio of unit of rise to the unit of span. It describes the slope of a roof. Pitch is expressed as a fraction, such as 1/4 or 1/2 pitch. The term "pitch" is gradually being replaced by the term "cut." Cut is the angle that the roof surface makes with a horizontal plane. This angle is usually expressed as a fraction in which the numerator equals the unit of rise and the denominator equals the unit of run (12 inches), such as 6/12 or 8/12. This can also be expressed in inches per foot; for example, a 6- or 8-inch cut per foot. Here, the unit of run (12 inches) is understood. Pitch can be converted to cut by using the following formula: $unit\ of\ span\ (24\ in.) \times pitch = unit\ of\ rise$. For example,

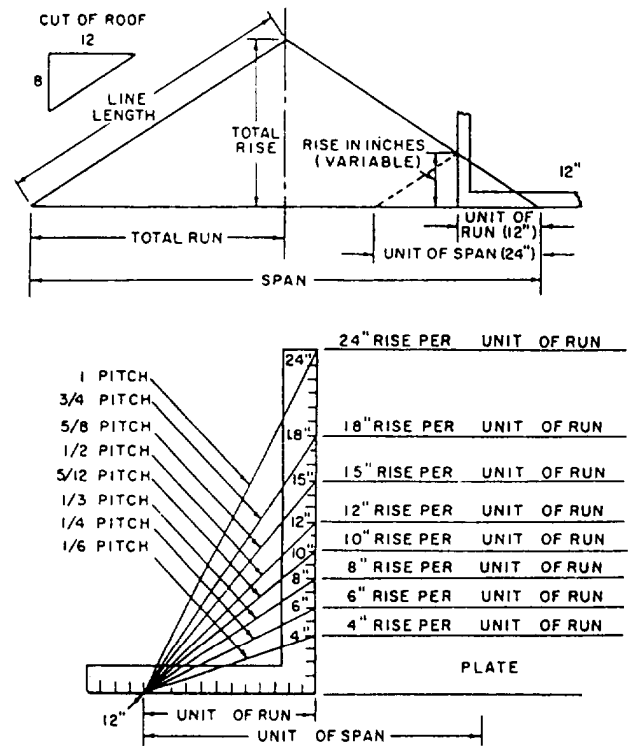
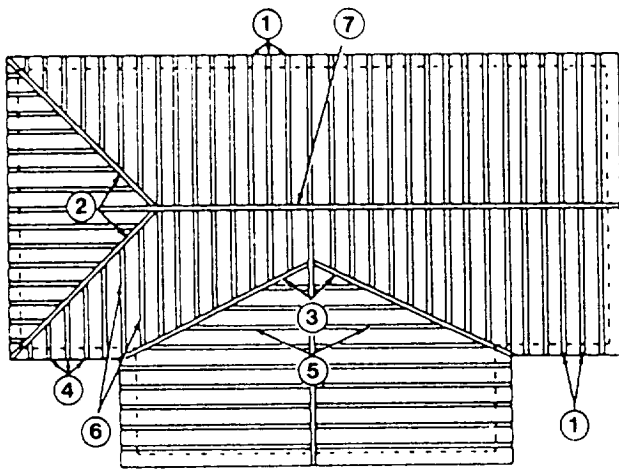


Figure 2-2.—Roof framing terms.

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

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



- | | |
|-------------------|------------------|
| 1. Common rafters | 5. Valley jacks |
| 2. Hip rafters | 6. Cripple jacks |
| 3. Valley rafters | 7. Ridgeboard |
| 4. Hip jack | |

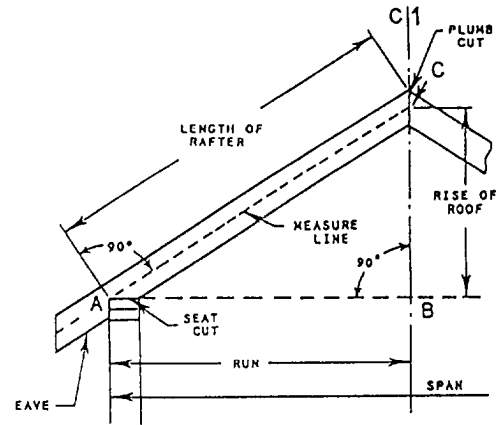
Figure 2-3.-Rafter terms.

Rafter

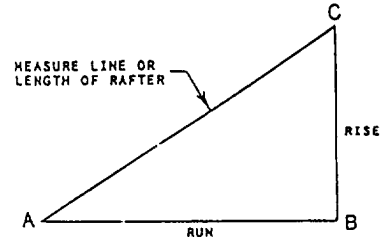
The members making up the main body of the framework of all roofs are called rafters. They do for the roof what the joists do for the floor and what the studs do for the wall. Rafters are inclined members spaced from 16 to 48 inches apart. They vary in size, depending on their length and spacing. The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

The structural relationship between the rafters and the wall is the same in all types of roofs. The rafters are not framed into the plate, but are simply nailed to it. Some are cut to fit the plate, whereas others, in hasty construction, are merely laid on top of the plate and nailed in place. Rafters usually extend a short distance beyond the wall to form the eaves (overhang) and protect the sides of the building. Features associated with various rafter types and terminology are shown in figure 2-3.

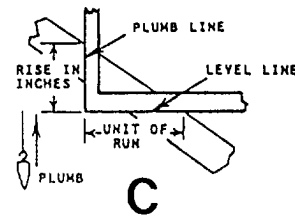
Common rafters extend from the plate to the ridgeboard at right angles to both. Hip rafters extend diagonally from the outside corner formed by perpendicular plates to the ridgeboard. Valley rafters extend from the plates to the ridgeboard along the lines where two roofs intersect. Jack rafters never extend the



A



B



C

Figure 2-4.—Rafter layout.

full distance from plate to ridgeboard. Jack rafters are subdivided into the hip, valley, and cripple jacks.

In a hip jack, the lower ends rest on the plate and the upper ends against the hip rafter. In a valley jack the lower ends rest against the valley rafters and the upper ends against the ridgeboard. A cripple jack is nailed between hip and valley rafters.

Rafters are cut in three basic ways (shown in fig. 2-4, view A). The top cut, also called the plumb cut, is made at the end of the rafter to be placed against the ridgeboard or, if the ridgeboard is omitted, against the opposite rafters. A seat, bottom, or heel cut is made at the end of the rafter that is to rest on the plate. A side cut (not shown in fig. 2-4), also called a cheek cut, is a bevel cut on the side of a rafter to make it fit against another frame member.

Rafter length is the shortest distance between the outer edge of the top plate and the center of the ridge line. The cave, tail, or overhang is the portion of the

rafter extending beyond the outer edge of the plate. A measure line (fig. 2-4, view B) is an imaginary reference line laid out down the middle of the face of a rafter. If a portion of a roof is represented by a right triangle, the measure line corresponds to the hypotenuse; the rise to the altitude; and, the run to the base.

A plumb line (fig. 2-4, view C) is any line that is vertical (plumb) when the rafter is in its proper position. A level line (fig. 2-4, view C) is any line that is horizontal (level) when the rafter is in its proper position.

FRAMING SQUARE

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe and solve roof framing problems using the framing square.

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

DESCRIPTION

The framing square (fig. 2-5, view A) consists of a wide, long member called the blade and a narrow, short member called the tongue. The blade and tongue form a right angle. The face of the square is the side one sees when the square is held with the blade in the left hand, the tongue in the right hand, and the heel pointed away from the body. The manufacturer's name is usually stamped on the face. The blade is 24 inches long and 2 inches wide. The tongue varies from 14 to 18 inches long and is 1 1/2 inches wide, measured from the outer corner, where the blade and the tongue meet. This corner is called the heel of the square.

The outer and inner edges of the tongue and the blade, on both face and back, are graduated in inches. Note how inches are subdivided in the scale on the back of the square. In the scales on the face, the inch is subdivided in the regular units of carpenter's measure (1/8 or 1/16 inch). On the back of the square, the outer edge of the blade and tongue is graduated in inches and twelfths of inches. The inner edge of the tongue is graduated in inches and tenths of inches. The inner edge of the blade is graduated in inches and thirty-seconds of

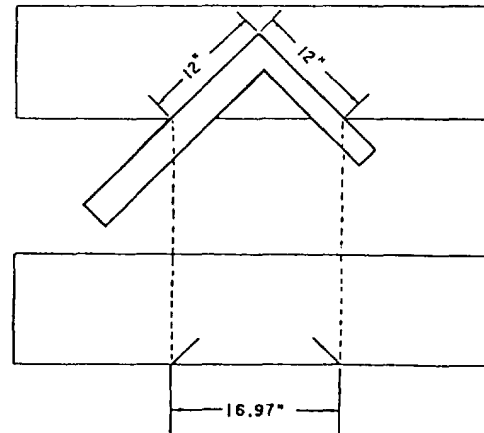
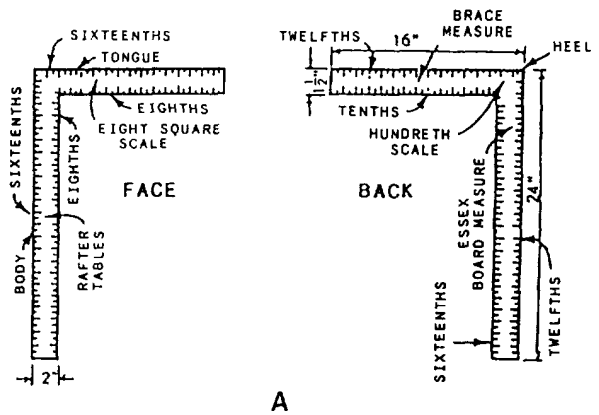


Figure 2-5.—Framing square: A. Nomenclature; B. Problem solving.

inches on most squares. Common uses of the twelfths scale on the back of the framing square will be described later. The tenths scale is not normally used in roof framing.

SOLVING BASIC PROBLEMS WITH THE FRAMING SQUARE

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

Figure 2-5, view B, shows you how the framing square is used to determine the length of the hypotenuse of a right triangle with the other sides each 12 inches long. Place a true straightedge on a board and set the square on the board so as to bring the 12-inch mark on

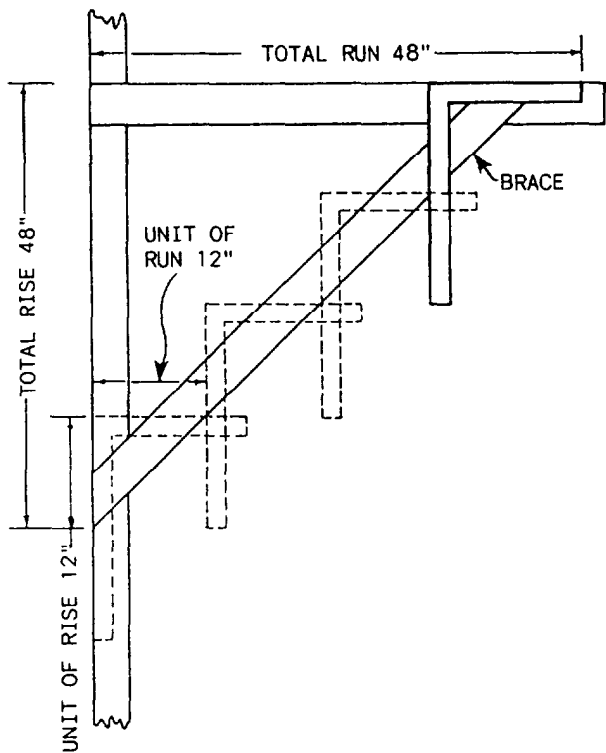


Figure 2-6.—"Stepping off" with a framing square.

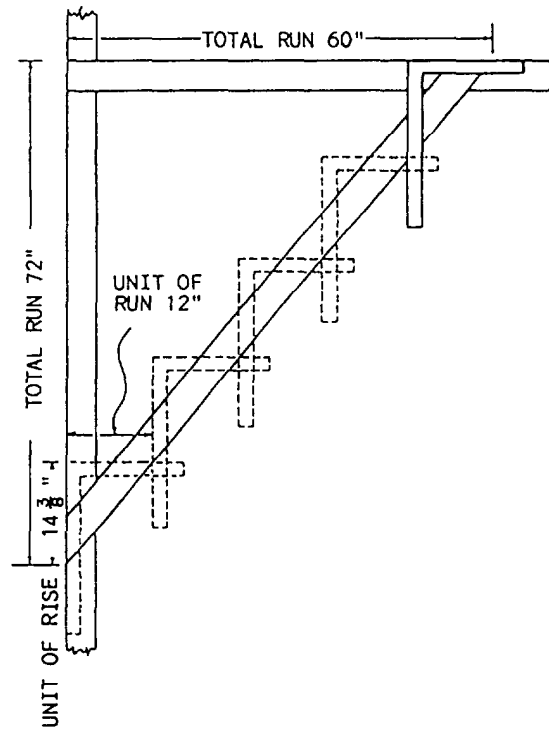


Figure 2-7.—"Stepping off" with a square when the unit of run and unit of rise are different.

the tongue and the blade even with the edge of the board. Draw the pencil marks as shown. The distance between these marks, measured along the edge of the board, is the length of the hypotenuse of a right triangle with the other sides each 12 inches long. You will find that the distance, called the bridge measure, measures just under 17 inches—16.97 inches, as shown in the figure. For most practical Builder purposes, though, round 16.97 inches to 17 inches.

Solving for Unit and Total Run and Rise

In figure 2-5, the problem could be solved by a single set (called a cut) of the framing square. This was due to the dimensions of the triangle in question lying within the dimensions of the square. Suppose, though, you are trying to find the length of the hypotenuse of a right triangle with the two known sides each being 48 inches long. Assume the member whose length you are trying to determine is the brace shown in figure 2-6. The total run of this brace is 48 inches, and the total rise is also 48 inches.

To figure the length of the brace, you first reduce the triangle in question to a similar triangle within the dimensions of the framing square. The length of the vertical side of this triangle is called unit of rise, and the length of the horizontal side is called the unit of run. By

a general custom of the trade, unit of run is always taken as 12 inches and measured on the tongue of the framing square.

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

To get the length of the brace, set the framing square to the unit of run (12 inches) on the tongue and to the unit of rise (also 12 inches) on the blade, as shown in figure 2-6. Then, "step off" this cut as many times as the unit of run goes into the total run. In this case, $48/12$, or 4 times, as shown in the figure.

In this problem, the total run and total rise were the same, from which it followed that the unit of run and unit of rise were also the same. Suppose now that you want to know the length of a brace with a total run of 60 inches and a total rise of 72 inches, as in figure 2-7. Since the unit of run is 12 inches, the unit of rise must be the value of x in the proportional equation $60:72::12:x$. That is, the proportion $60:72$ is the same as the proportion $12:x$. Working this out, you find the unit of rise is

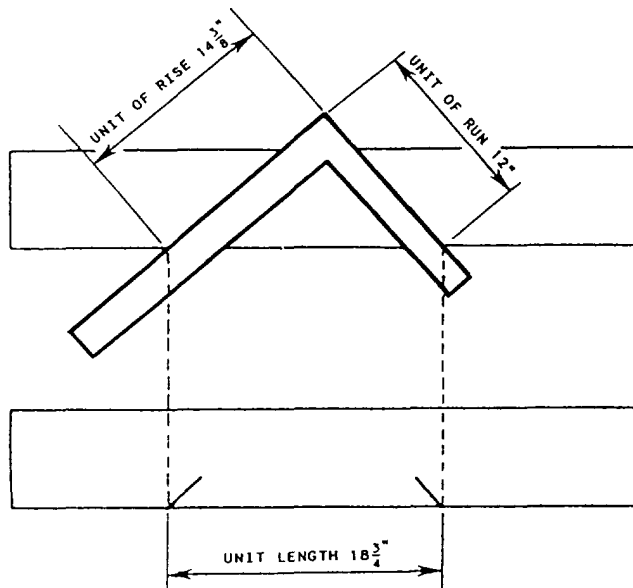


Figure 2-8.-Unit length.

14.4 inches. For practical purposes, you can round this to 14 3/8.

To lay out the full length of the brace, set the square to the unit of rise (14 3/8 inches) and the unit of run (12 inches), as shown in figure 2-7. Then, step off this cut as many times as the unit of run goes into the total run (60/12, or 5 times).

Determining Line Length

If you do not go through the stepping-off procedure, you can figure the total length of the member in question by first determining the bridge measure. The bridge measure is the length of the hypotenuse of a right triangle with the other sides equal to the unit of run and unit of rise. Take the situation shown above in figure 2-7. The unit of run here is 12 inches and the unit of rise is 14 3/8 inches. Set the square to this cut, as shown in figure 2-8, and mark the edges of the board as shown. If you measure the distance between the marks, you will find it is 18 3/4 inches. Bridge measure can also be found by using the Pythagorean theorem: ($a^2 + b^2 = c^2$). Here, the unit of rise is the altitude (a), the unit of run is the base (b), and the hypotenuse (c) is the bridge measure.

To get the total length of the member, you simply multiply the bridge measure in inches by the total run in feet. Since that is 5, the total length of the member is 18 3/4 x 5, or 93 3/4 inches. Actually, the length of the hypotenuse of a right triangle with the other sides 60 and

72 inches long is slightly more than 93.72 inches, but 93 3/4 inches is close enough for practical purposes.

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

SCALES

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

Twelfths Scale

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

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

Suppose now that you know the unit of run, unit of rise, and total run of a rafter, and you want to find the total rise and the total length. Use the unit of run (12 inches) and unit of rise (8 inches), and total run of 8 feet 9 inches. Set the square to the unit of rise on the tongue and unit of run on the blade (fig. 2-9, top view). Then, slide the square to the right until the 8 9/12-inch mark on the blade (representing the total run of 8 feet 9 inches) comes even with the edge of the board, as shown in the second view. The figure of 5 10/12 inches, now indicated on the tongue, is one-twelfth of the total rise. The total rise is, therefore, 5 feet 10 inches. The distance between pencil marks (10 7/12 inches) drawn along the tongue and the blade is one-twelfth of the total length. The total length is, therefore, 10 feet 7 inches.

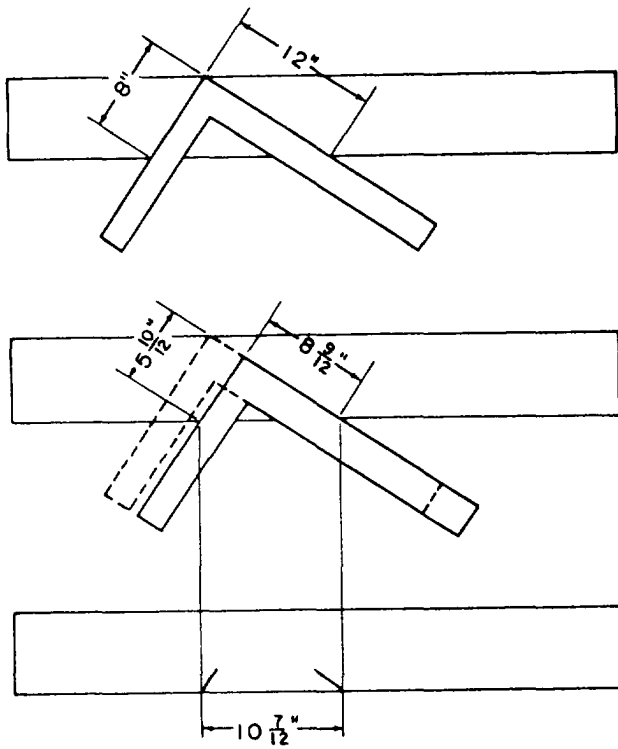


Figure 2-9.-Finding total rise and length when unit of run, unit of rise, and total run are known.

The twelfths scale may also be used to determine dimensions by inspection for proportional reductions or enlargements. Suppose you have a panel 10 feet 9 inches long by 7 feet wide. You want to cut a panel 7 feet long with the same proportions. Set the square, as shown in figure 2-9, but with the blade at 10 9/12 inches and the tongue at 7 inches. Then slide the blade to 7 inches and read the figure indicated on the tongue, which will be 4 7/12 inches if done correctly. The smaller panel should then be 4 feet 7 inches wide.

Hundredths Scale

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

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

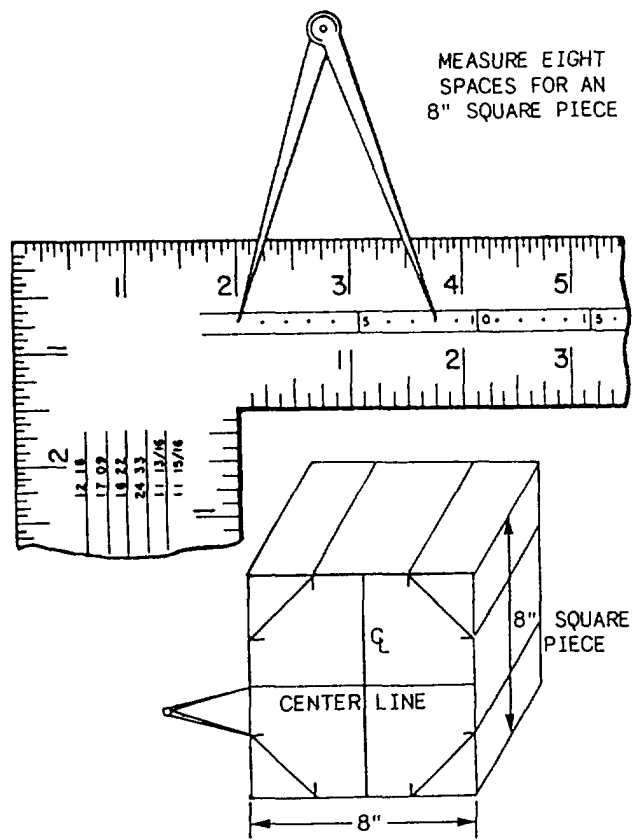


Figure 2-10.—Using the octagon square.

Octagon Scale

The octagon scale (sometimes called the eight-square scale) is located in the middle of the face of the tongue. The octagon scale is used to lay out an octagon (eight-sided figure) in a square of given even-inch dimensions.

Let's say you want to cut an 8-inch octagonal piece for a stair newel. First, square the stock to 8 by 8 inches and smooth the end section. Then, draw crossed center lines on the end section, as shown in figure 2-10. Next, set a pair of dividers to the distance from the first to the eighth dot on the octagon scale, and layoff this distance on either side of the centerline on the four slanting sides of the octagon. This distance equals one-half the length of a side of the octagon.

When you use the octagon scale, set one leg of the dividers on the first dot and the other leg on the dot whose number corresponds to the width in inches of the square from which you are cutting the piece.

FRAMING SQUARE TABLES

There are three tables on the framing square: the unit length rafter table, located on the face of the blade; the

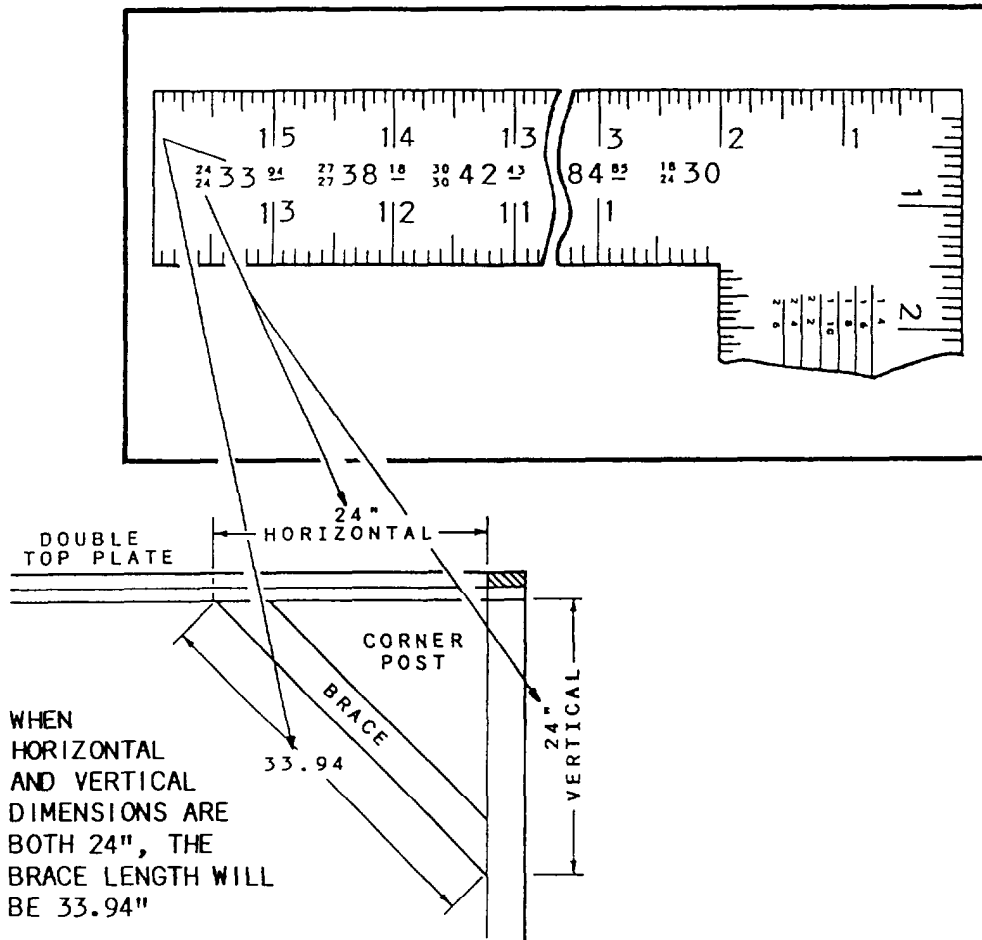


Figure 2-11.-Brace table.

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

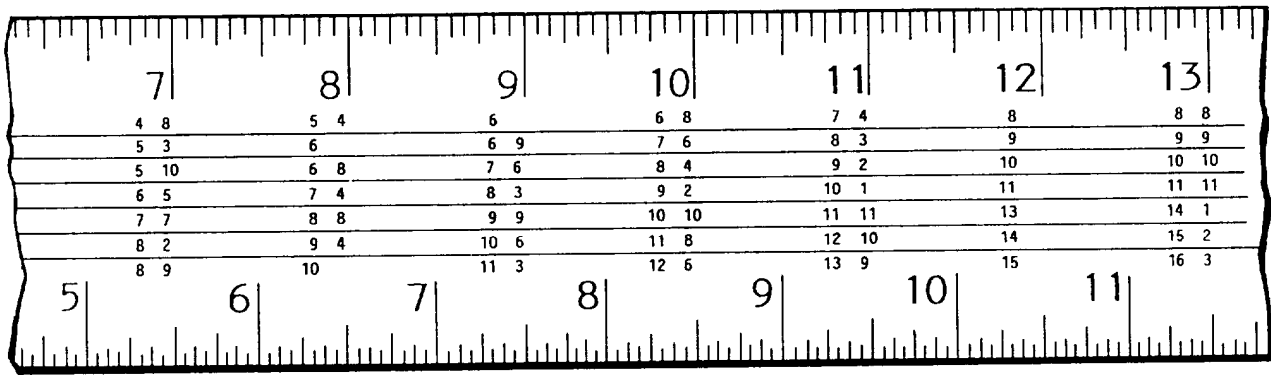
Brace

The brace table sets forth a series of equal runs and rises for every three-units interval from 24/24 to 60/60, together with the brace length, or length of the hypotenuse, for each given run and rise. The table can be used to determine, by inspection, the length of the hypotenuse of a right triangle with the equal shorter sides of any length given in the table. For example, in the segment of the brace table shown in figure 2-11, you can see that the length of the hypotenuse of a right triangle with two sides 24 units long is 33.94 units; with

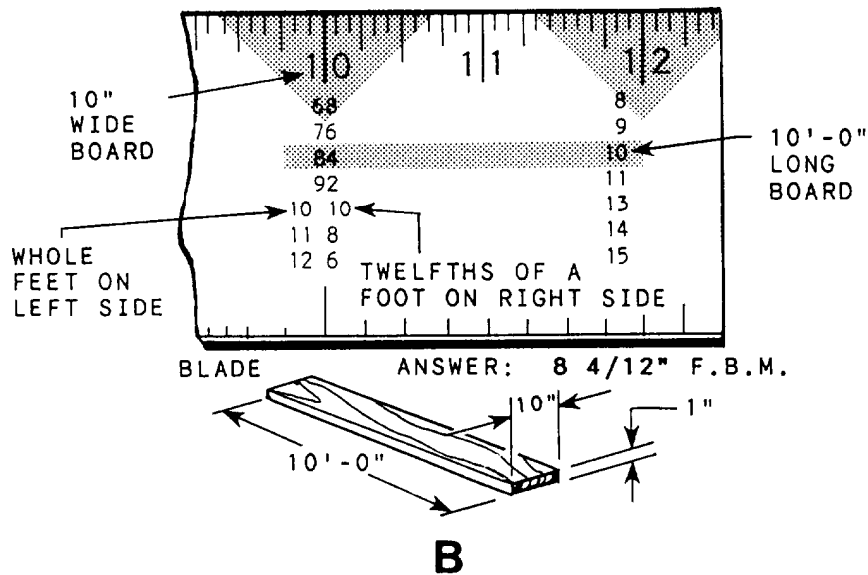
two sides 27 units long, 38.18 units; two sides 30 units long, 42.43 units; and so on.

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

Suppose you want to find the length of the hypotenuse of a right triangle with two sides 40 inches each. The sides of similar triangles are proportional, and any right triangle with two equal sides is similar to any other right triangle with two equal sides. The brace table shows that a right triangle with the two shorter sides



A



B

Figure 2-12.-Segment of Essex board measure table.

being 30 inches long has a hypotenuse of 42.43 inches. The length of the hypotenuse of a right triangle with the two shorter sides being 40 inches long must be the value of x in the proportional equation $30:42.43::40:x$, or about 56.57 inches.

Notice that the last item in the brace table (the one farthest to the right in fig. 2-11) gives you the hypotenuse of a right triangle with the other proportions 18:24:30. These proportions are those of the most common type of unequal-sided right triangle, with sides in the proportions of 3:4:5.

Essex Board

The primary use of the Essex board measure table is for estimating the board feet in lumber of known

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

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

Let's take an example. Suppose you want to figure the board measure of a piece of lumber 10 feet long by 10 inches wide by 1 inch thick. Scan down the column (fig. 2-12, view B) headed by the 12-inch graduation to 10, and then go horizontally to the left to the figure directly below the 10-inch graduation. You will find the figure to be 84, or 8 4/12 board feet. For easier calculating purposes, you can convert 8 4/12 to a decimal (8.33).

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

$$\begin{array}{r}
 \$1.15 \\
 \times 8.33 \\
 \hline
 \$9.5795 \text{ (rounded off to } \$9.58\text{)}.
 \end{array}$$

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

The board measure scale can be read only for lumber from 8 to 15 feet in length. If your piece is longer than 15 feet, you can proceed in one of two ways. If the length of the piece is evenly divisible by one of the lengths in the table, you can read for that length and multiply the result by the number required to equal the piece you are figuring. Suppose you want to find the number of board feet in a piece 33 feet long by 7 inches wide by 1 inch thick. Since 33 is evenly divisible by 11, scan down the 12-inch column to 11 and then go left to the 7-inch column. The figure given there (which is 65/12, or 6.42 bd. ft.) is one-third of the total board feet. The total number of board feet is 6 5/12 (or 6.42) x 3, or 19 3/12 (or 19.26) board feet.

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

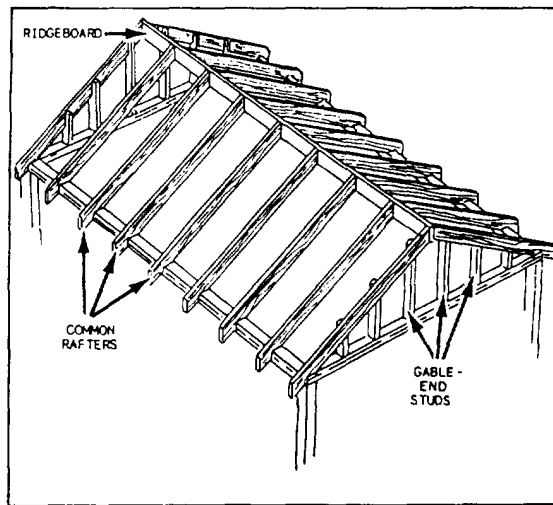


Figure 2-13.—Framework of a gable roof.

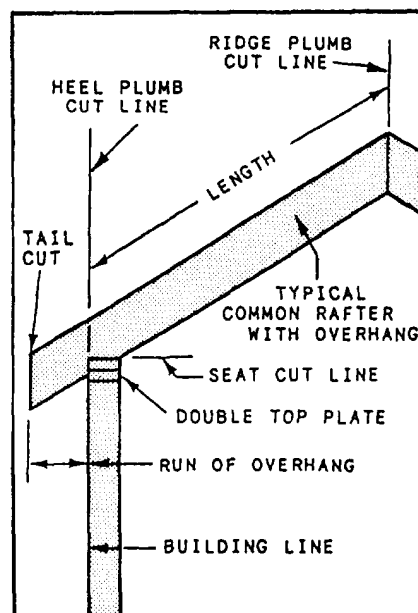


Figure 2-14.—Typical common rafter with an overhang.

DESIGNS

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe procedures for the layout and installation of members of gable, hip, intersecting, and shed roof designs.

As we noted earlier, the four most common roof designs you will encounter as a Builder are gable, hip, intersecting, and shed. In this section, we will examine

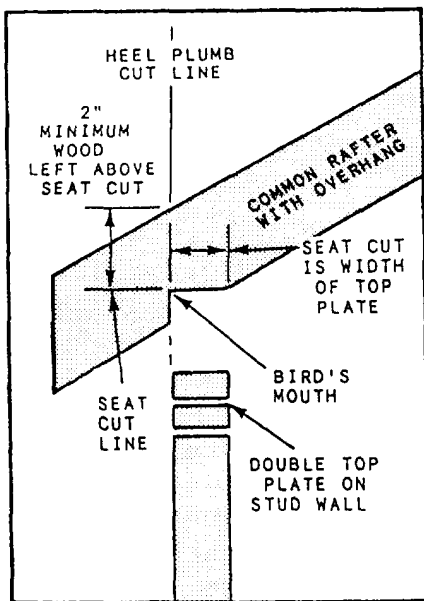


Figure 2-15.—A “bird’s-mouth” is formed by the heel plumb line and seat line.

various calculations, layouts, cutting procedures, and assembly requirements required for efficient construction.

GABLE

Next to the shed roof, which has only one slope, the gable roof is the simplest type of sloping roof to build because it slopes in only two directions. The basic structural members of the gable roof are the ridgeboard, the common rafters, and the gable-end studs. The framework is shown in figure 2-13.

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

Common Rafters

All common rafters for a gable roof are the same length. They can be precut before the roof is assembled. Today, most common rafters include an overhang. The overhang (an example is shown in fig. 2-14) is the part of the rafter that extends past the building line. The run of the overhang, called the projection, is the horizontal distance from the building line to the tail cut on the rafter. In figure 2-14, note the plumb cuts at the ridge, heel, and tail of the rafter. A level seat cut is placed where the rafter rests on the top plate. The notch formed by the seat and heel cut line (fig. 2-15) is often called the bird’s-mouth.

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

CALCULATING LENGTHS OF COMMON RAFTERS.— The length of a common rafter is based on the unit of rise and total run of the roof. The unit of rise and total run are obtained from the blueprints. Three different procedures can be used to calculate common rafter length: use a framing square printed with a rafter table; use a book of rafter tables; or, use the step-off method where rafter layout is combined with calculating length.

Framing squares are available with a rafter table printed on the face side (fig. 2-16). The rafter table makes it possible to find the lengths of all types of rafters for pitched roofs, with unit of rises ranging from 2 inches to 18 inches. Let’s look at two examples:

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

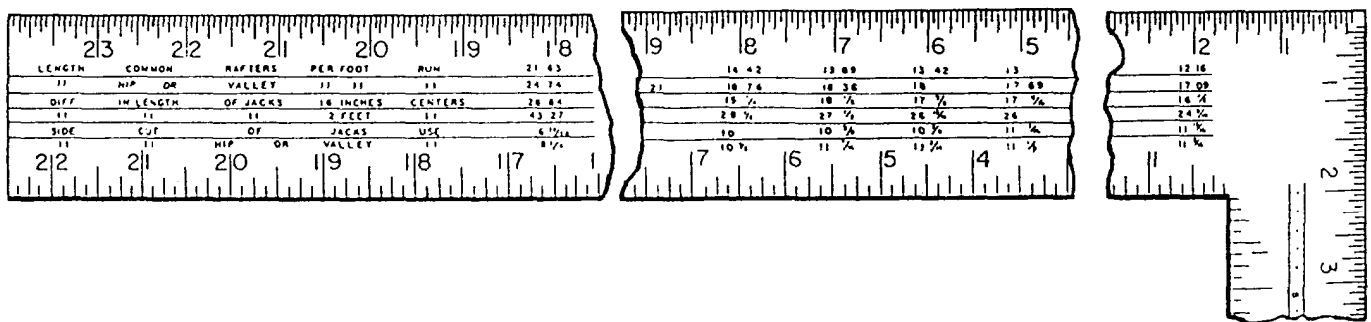


Figure 2-16.—Rafter table on face of a steel square.

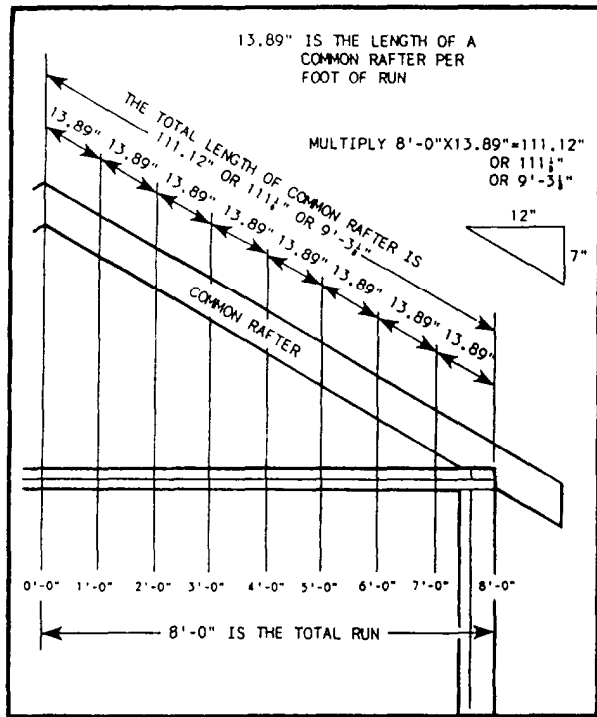


Figure 2-17.—Rafter length.

Look at the first line of the rafter table on a framing square to find LENGTH COMMON RAFTERS PER FOOT RUN (also known as the bridge measure). Since the roof in this example has a 7-inch unit of rise, locate the number 7 at the top of the square. Directly beneath the number 7 is the number 13.89. This means that a common rafter with a 7-inch unit of rise will be 13.89 inches long for every unit of run. To find the length of the rafter, multiply 13.89 inches by the number of feet in the total run. (The total run is always one-half the span.) The total run for a roof with a 16-foot span is 8 feet; therefore, multiply 13.89 inches by 8 to find the rafter length. Figure 2-17 is a schematic of this procedure.

If a framing square is not available, the bridge measure can be found by using the Pythagorean theorem using the same cut of 7/12: $7^2 + 12^2 = 193^2$; the square root of 193 is 13.89.

Two steps remain to complete the procedure.

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

$$\begin{array}{r} 13.89 \text{ inches} \\ \times 8 \\ \hline 111.12 \text{ inches} \end{array}$$

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

$$\begin{array}{r} .12 \\ \times 16 \\ \hline 1.92 \end{array}$$

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

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

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

$$\frac{6}{12} = \frac{1}{2} \quad (1/2 \text{ foot} = 6 \text{ inches}).$$

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

$$\frac{1}{2} = .5 \quad (.5 \text{ foot} = 6 \text{ inches}).$$

Step 3. Multiply the total run (12.5) by the length of the common rafter per foot of run (13.42 inches) (fig. 2-16):

$$\begin{array}{r} 12.5 \\ \times 13.42 \\ \hline 167.75 \text{ inches.} \end{array}$$

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

$$.75 \times 16 = 12$$

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

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

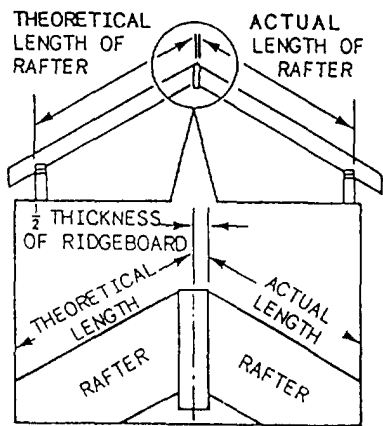


Figure 2-18.—The actual (versus theoretical) length of a common rafter.

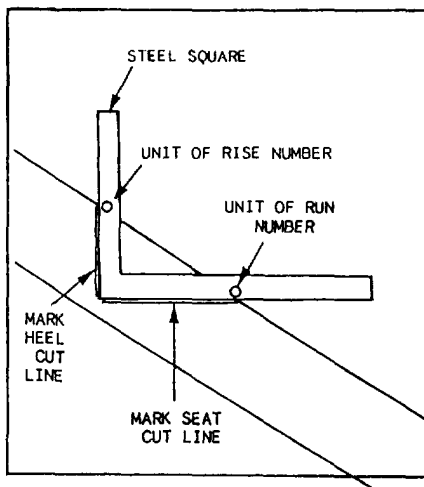


Figure 2-19.—Steel square used to lay out plumb and seat cuts.

SHORTENING.— Rafter length found by any of the methods discussed here is the measurement from the heel plumb line to the center of the ridge. This is known as the theoretical length of the rafter. Since a ridgeboard,

usually 1 1/2 inches thick, is placed between the rafters, one-half of the ridgeboard (3/4 inch) must be deducted from each rafter. This calculation is known as shortening the rafter. It is done at the time the rafters are laid out. The actual length (as opposed to the theoretical length) of a rafter is the distance from the heel plumb line to the shortened ridge plumb line (fig. 2-18).

LAYING OUT.— Before the rafters can be cut, the angles of the cuts must be marked. Layout consists of marking the plumb cuts at the ridge, heel, and tail of the rafter, and the seat cut where the rafter will rest on the wall. The angles are laid out with a framing square, as shown in figure 2-19. A pair of square gauges is useful in the procedure. One square gauge is secured to the tongue of the square next to the number that is the same as the unit of rise. The other gauge is secured to the blade of the square next to the number that is the same as the unit of run (always 12 inches). When the square is placed on the rafter stock, the plumb cut can be marked along the tongue (unit of rise) side of the square. The seat cut can be marked along the blade (unit of run) side of the square.

Rafter layout also includes marking off the required overhang, or tail line length, and making the shortening calculation explained earlier. Overhang, or tail line length, is rarely given and must be calculated before laying out rafters. Projection, the horizontal distance from the building line to the rafter tail, must be located from drawings or specifications. To determine tail line length, use the following formula: bridge measure (in inches) times projection (in feet) equals tail line length (in inches). Determine the bridge measure by using the rafter table on the framing square or calculate it by using the Pythagorean theorem. Using figure 2-20 as a guide, you can see there are four basic steps remaining.

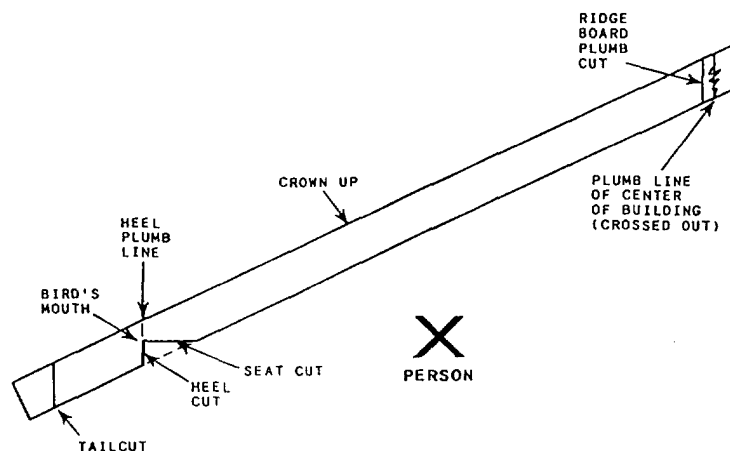


Figure 2-20.—Laying out a common rafter for a gable roof.

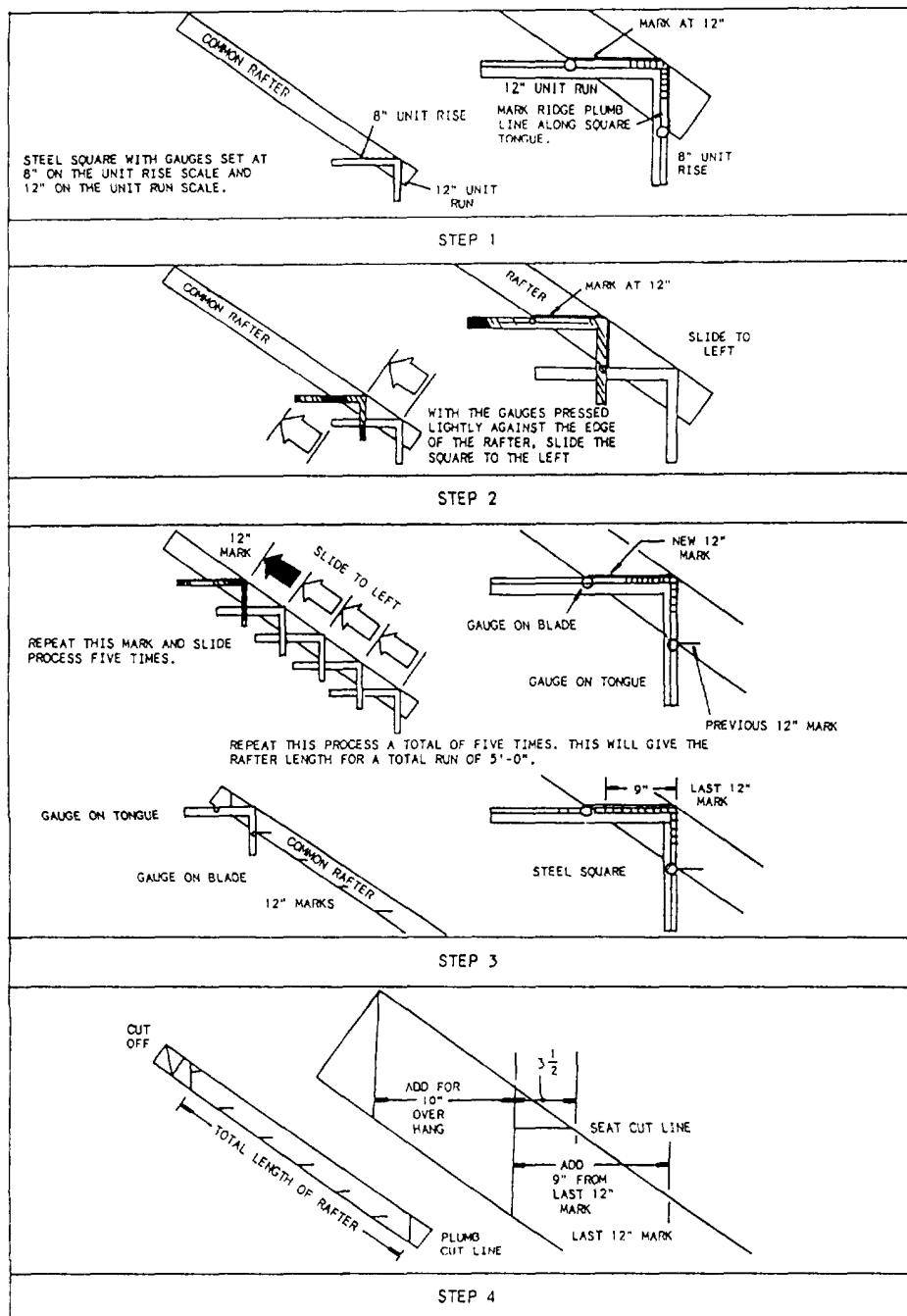


Figure 2-21. Step-off method for calculating common rafter length.

Step 1. Lay out the rafter line length. Hold the framing square with the tongue in your right hand, the blade in the left, and the heel away from your body. Place the square as near the right end of the rafter as possible with the unit of rise on the tongue and the unit of run on the blade along the edge of the rafter stock. Strike a plumb mark along the tongue on the wide part of the material. This mark represents

the center line of the roof. From either end of this mark, measure the line length of the rafter and mark the edge of the rafter stock. Hold the framing square in the same manner with the 6 on the tongue on the mark just made and the 12 on the blade along the edge. Strike a line along the tongue, this mark represents the plumb cut of the heel.

- Step 2.** Lay out the bird's-mouth. Measure 1 1/2 inches along the heel plumb line up from the bottom of the rafter. Set the blade of the square along the plumb line with the heel at the mark just made and strike a line along the tongue. This line represents the seat of the bird's-mouth.
- Step 3.** Lay out the tail line length. Measure the tail line length from the bird's-mouth heel plumb line. Strike a plumb line at this point in the same manner as the heel plumb line of the common rafter.
- Step 4.** Lay out the plumb cut at the ridgeboard. Measure and mark the point along the line length half the thickness of the ridgeboard. (This is the ridgeboard shortening allowance.) Strike a plumb line at this point. This line represents the plumb cut of the ridgeboard.

Step-Off Calculations and Layout

The step-off method for rafter layout is old but still practiced. It combines procedures for laying out the rafters with a procedure of stepping off the length of the rafter (see fig. 2-21). In this example, the roof has an 8-inch unit of rise, a total run of 5 feet 9 inches, and a 10-inch projection.

First, set gauges at 8 inches on the tongue and 12 inches on the blade. With the tongue in the right hand, the blade in the left hand, and the heel away

from the body, place the square on the right end of the rafter stock. Mark the ridge plumb line along the tongue. Put a pencil line at the 12-inch point of the blade.

Second, with the gauges pressed lightly against the rafter, slide the square to the left. Line the tongue up with the last 12-inch mark and make a second 12-inch mark along the bottom of the blade.

Third, to add the 9-inch remainder of the total run, place the tongue on the last 12-inch mark. Draw another mark at 9 inches on the blade. This will be the total length of the rafter.

Last, lay out and cut the plumb cut line and the seat cut line.

Roof Assembly

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

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

The ridgeboard like the common rafters, should be precut. The rafter locations are then copied on the ridgeboard from the markings on the wall plates (fig. 2-22). The ridgeboard should be the length of the building plus the overhang at the gable ends.

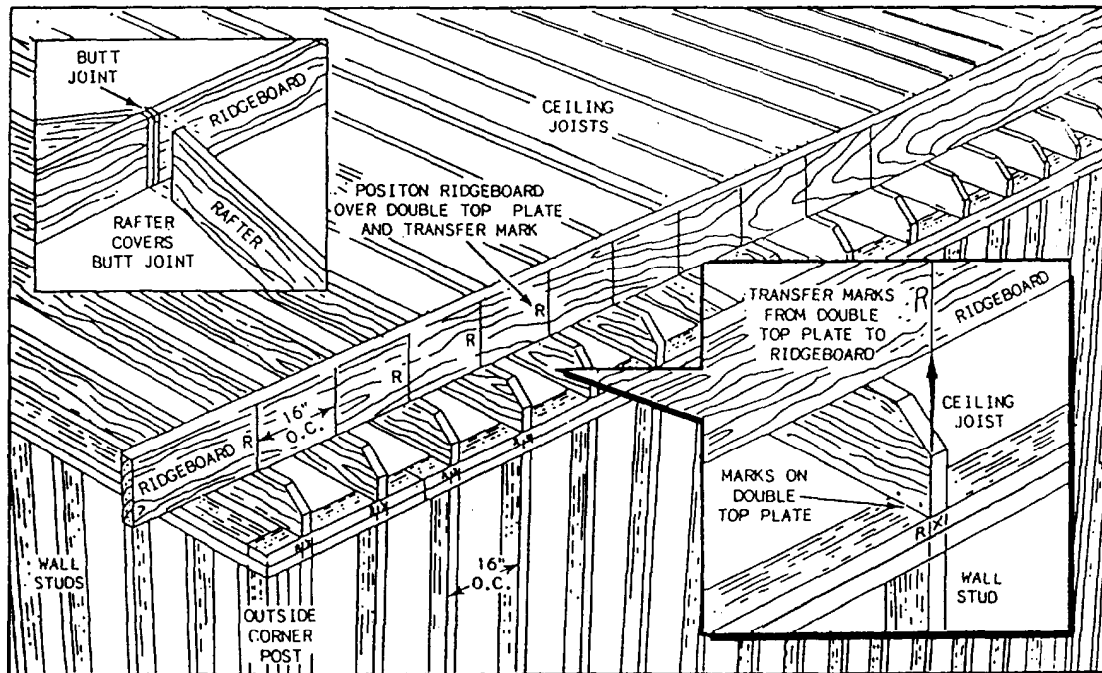


Figure 2-22.—Ridgeboard layout.

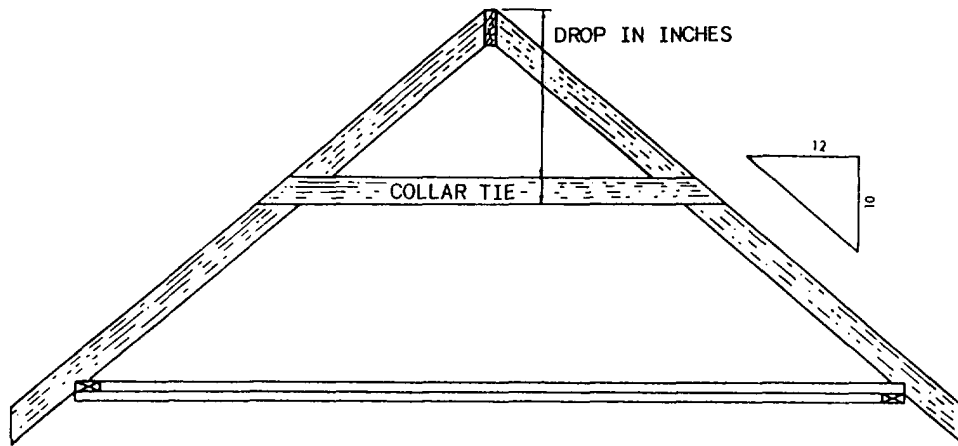


Figure 2-23.—Calculation for a collar tie.

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

One pair of rafters should be cut and checked for accuracy before the other rafters are cut. To check the first pair for accuracy, set them in position with a

1/2-inch piece of wood fitted between them. If the rafters are the correct length, they should fit the building. If, however, the building walls are out of line, adjustments will have to be made on the rafters.

After the first pair of rafters is checked for accuracy (and adjusted if necessary), one of the pair can be used as a pattern for marking all the other rafters. Cutting is usually done with a circular or radial-arm saw.

COLLAR TIE.— Gable or double-pitch roof rafters are often reinforced by horizontal members

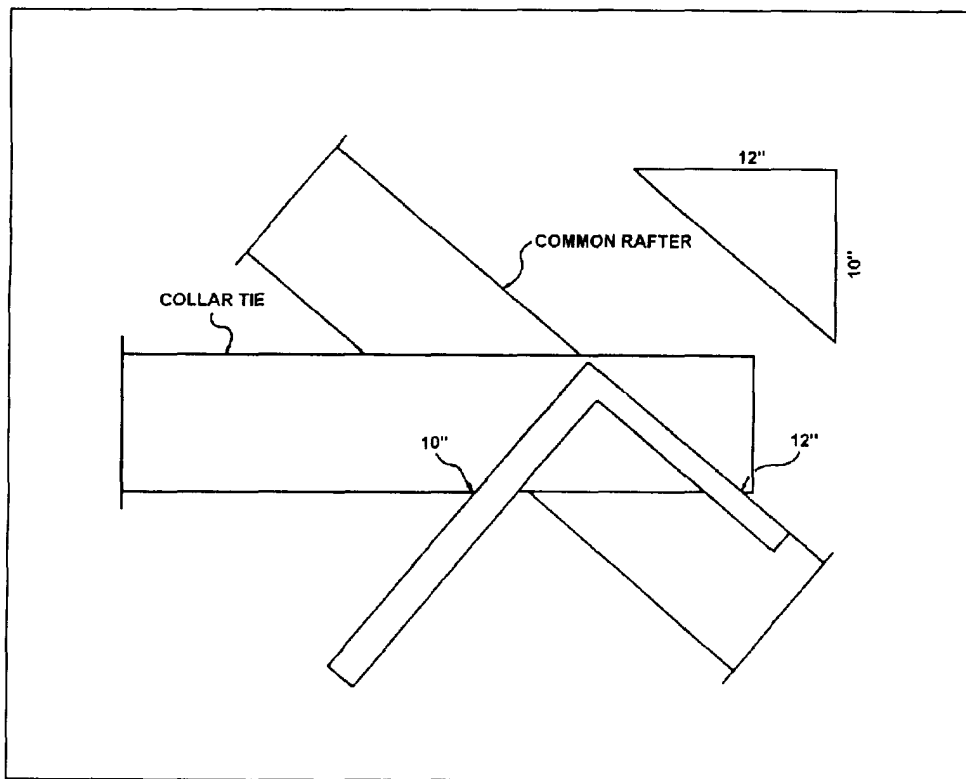


Figure 2-24.—Laying out end cut on a collar tie.

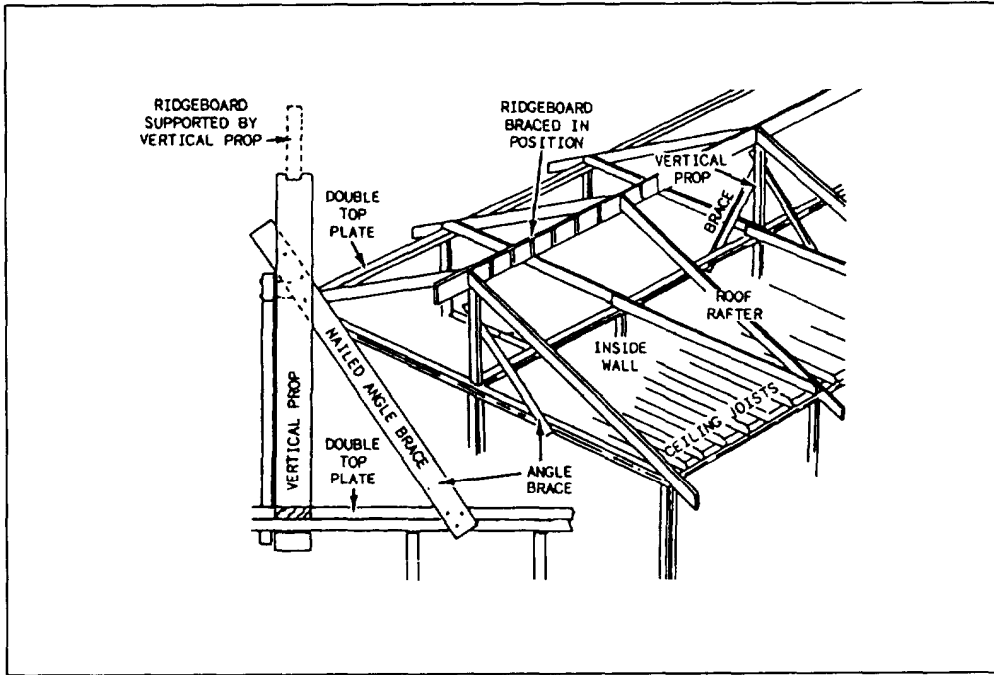


Figure 2-25.-Setting up and bracing a ridgeboard when only a few workers are available.

called collar ties (fig. 2-23). In a finished attic, the ties may also function as ceiling joists.

To find the line length of a collar tie, divide the amount of drop of the tie in inches by the unit of rise of the common rafter. This will equal one-half the length of the tie in feet. Double the result for the actual length. The formula is as follows: Drop in inches times 2, divided by unit or rise, equals the length in feet.

The length of the collar tie depends on whether the drop is measured to the top or bottom edge of the collar tie (fig. 2-23). The tie must fit the slope of the roof. To obtain this angle, use the framing square. Hold the unit of run and the unit of rise of the common rafter. Mark and cut on the unit of run side (fig. 2-24).

METHODS OF RIDGE BOARD ASSEMBLY.— Several different methods exist for setting up the ridgeboard and attaching the rafters to it. When only a few Builders are present, the most convenient procedure is to set the ridgeboard to its required height (total rise) and hold it in place with temporary vertical props (fig. 2-25). The rafters can then be nailed to the ridgeboard and the top wall plates.

Plywood panels should be laid on top of the ceiling joists where the framing will take place. The panels provide safe and comfortable footing. They also provide a place to put tools and materials.

Common rafter overhang can be laid out and cut before the rafters are set in place. However, many Builders prefer to cut the overhang after the rafters are fastened to the ridgeboard and wall plates. A line is snapped from one end of the building to the other, and the tail plumb line is marked with a sliding T-bevel, also called a bevel square. These procedures are shown in figure 2-26. The rafters are then cut with a circular saw.

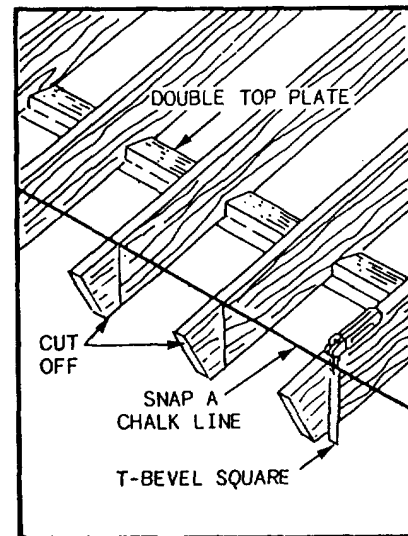


Figure 2-26.-Snapping a line and marking plumb cuts for a gable-end overhang.

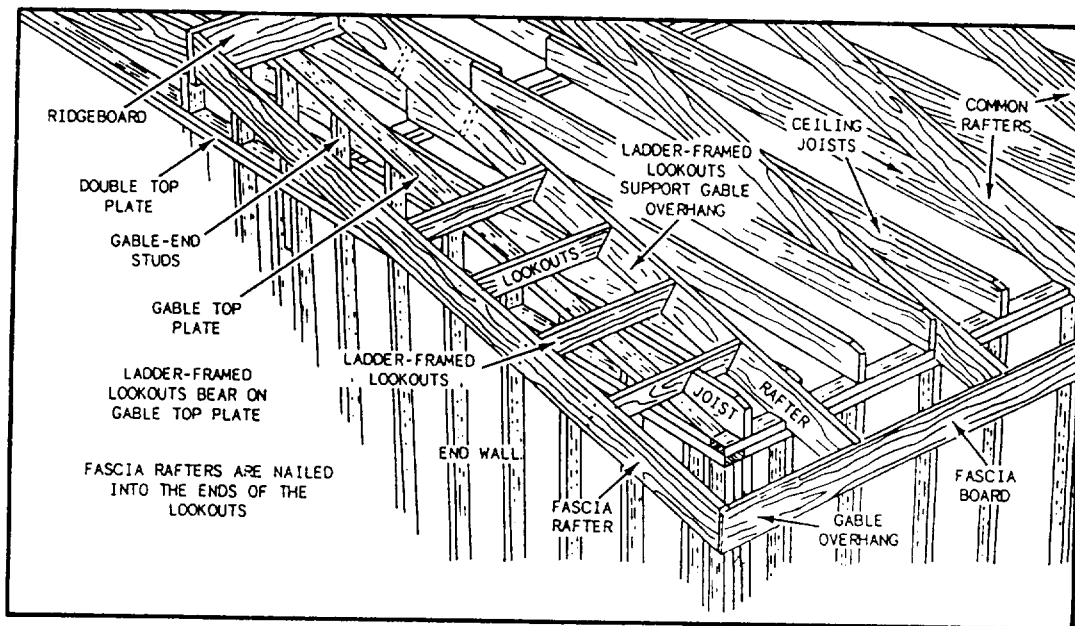


Figure 2-27.-Gable-end overhang with the end wall framed under the overhang.

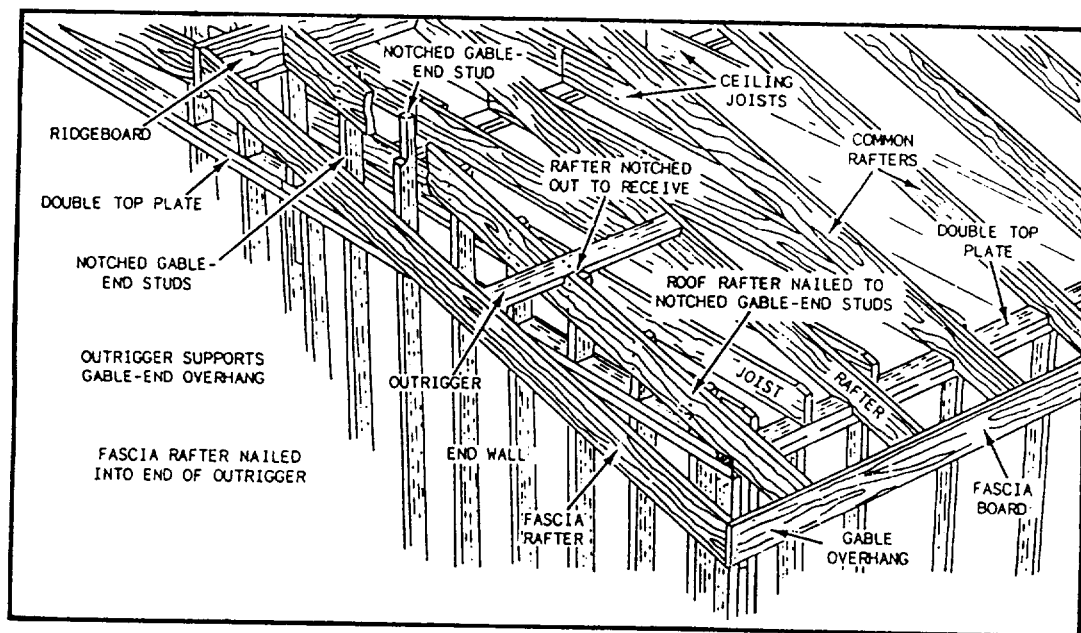


Figure 2-28.-Gable-end overhang with the end wall framed directly beneath the rafters.

This method guarantees that the line of the overhang will be perfectly straight, even if the building is not.

Over each gable end of the building, another overhang can be framed. The main framing members of the gable-end overhang are the fascia, also referred to as “fly” (or “barge”) rafters. They are tied to the ridgeboard at the upper end and to the fascia board at the lower end. Fascia boards are often nailed to the tail ends of the common rafters to serve as a finish piece at the edge of the roof. By extending past the gable ends

of the house, common rafters also help to support the basic rafters.

Figures 2-27 and 2-28 show different methods used to frame the gable-end overhang. In figure 2-27, a fascia rafter is nailed to the ridgeboard and to the fascia board. Blocking (not shown in the figures) rests on the end wall and is nailed between the fascia rafter and the rafter next to it. This section of the roof is further strengthened when the roof sheathing is nailed to it. In figure 2-28, two common rafters are placed directly over the gable

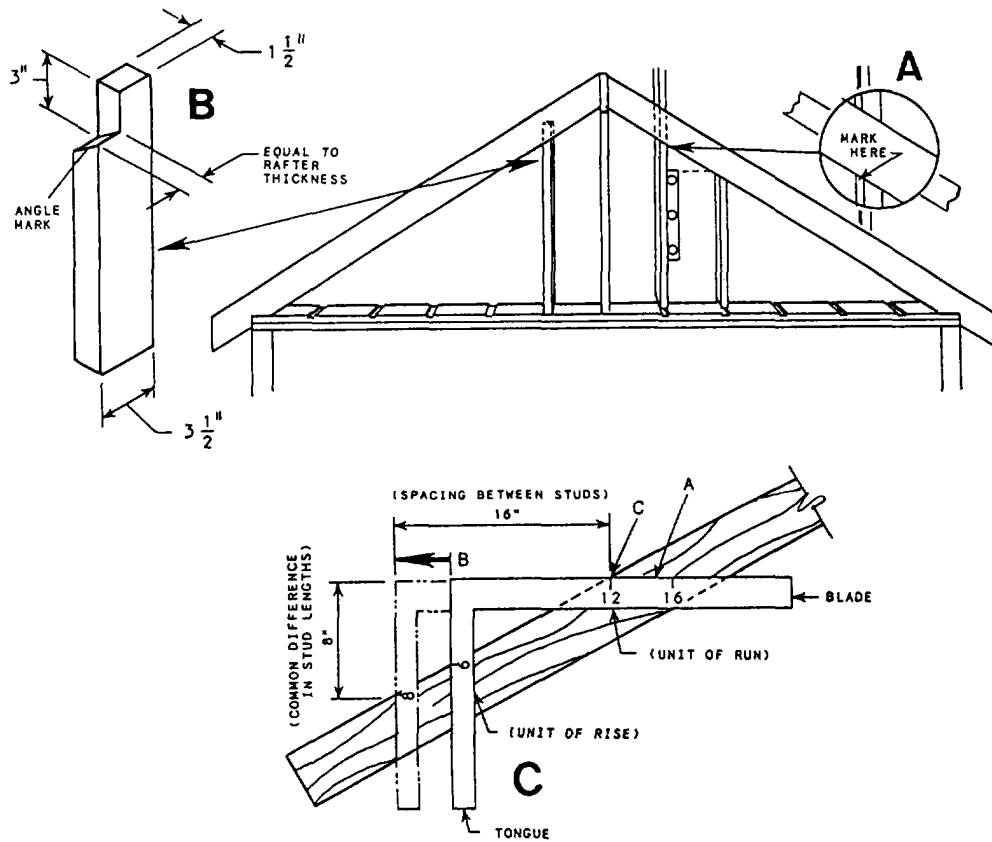


Figure 2-29.—Calculating common difference of gable-end studs.

ends of the building. The fascia rafters (fly rafters) are placed between the ridgeboard and the fascia boards. The gable studs should be cut to fit against the rafter above.

End Framing

Gable-end studs rest on the top plate and extend to the rafter line in the ends of a gable roof. They may be placed with the edge of the stud even with the outside wall and the top notched to fit the rafter (as shown in fig. 2-28), or they may be installed flatwise with a cut on the top of the stud to fit the slope of the rafter.

The position of the gable-end stud is located by squaring a line across the plate directly below the center of the gable. If a window or vent is to be installed in the gable, measure one-half of the opening size on each side of the center line and make a mark for the first stud. Starting at this mark layout the stud spacing (that is, 16 or 24 inches on center [OC]) to the outside of the building. Plumb the gable-end stud on the first mark and mark it where it contacts the bottom of the rafter, as shown in figure 2-29, view A. Measure and mark 3 inches above this mark and notch the stud to the depth equal to the thickness of the rafter, as shown in view B.

The lengths of the other gable studs depend on the spacing.

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

$$\frac{24 \text{ inches (OC spacing)}}{12 \text{ inches (unit of run)}} = 2$$

and, 2 x 6 inches (unit of rise) or 12 inches (common difference).

The common difference in the length of the gable studs may also be laid out directly with the framing square (fig. 2-29, view C). Place the framing square on the stud to the cut of the roof (6 and 12 inches for this example). Draw a line along the blade at A. Slide the square along this line in the direction of the arrow at B until the desired spacing between the studs (16 inches for this example) is at the intersection of the line drawn at A and the edge of the stud. Read the dimension on the tongue aligned with the same edge of the stud (indicated by C). This is the common difference (8 inches for this example) between the gable studs.

Toenail the studs to the plate with two 8d nails in each side. As the studs are nailed in place, care must be taken not to force a crown into the top of the rafter.

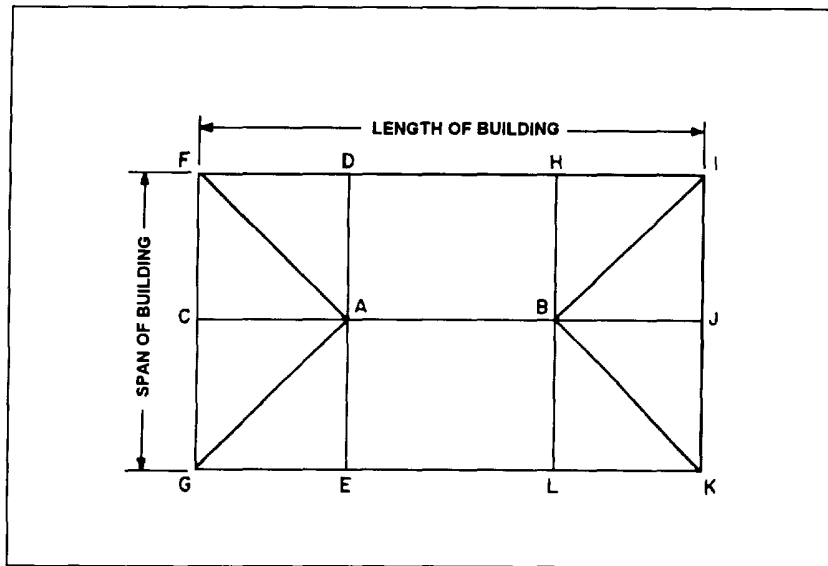


Figure 2-30.—Equal-pitch hip roof framing diagram.

HIP

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

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

Figure 2-30 shows part of a roof framing diagram for an equal-pitch hip roof. A roof framing diagram may be included among the working drawings; if not, you should lay one out for yourself. Determine what scale will be used, and lay out all framing members to scale. Lay the building lines out first. You can find the span and the length of the building on the working drawings. Then, draw a horizontal line along the center of the span.

In an equal-pitch hip roof framing diagram, the lines indicating the hip rafters (AF, AG, BI, and BK in figure 2-30) form 45° angles with the building lines. Draw these lines at 45°, as shown. The points where they meet the center line are the theoretical ends of the ridge piece.

The ridge-end common rafters AC, AD, AE, BH, BJ, and BL join the ridge at the same points.

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

Let's suppose, for example, that the span of the building is 30 feet. Then, one-half the span, which is the same as the total run of a common rafter, is 15 feet. Applying the Pythagorean theorem, the total run of a hip rafter is:

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

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

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

$$\sqrt{(21.21^2 + 10^2)} = 23.45 \text{ feet, or about } 23 \text{ feet } 5 \frac{3}{8} \text{ inches.}$$

To find the length of a hip rafter on the basis of bridge measure, you must first determine the bridge measure. As with a common rafter, the bridge measure of a hip rafter is the length of the hypotenuse of a triangle with its altitude and base equal to the unit of run and unit of rise of the rafter. The unit of rise of a hip rafter is always the same as that of a common rafter, but the unit of run of a hip rafter is a fixed unit of measure, always 16.97.

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

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

If the unit of run of a hip rafter is 16.97 and the unit of rise (in this particular case) is 8, the bridge measure of the hip rafter must be:

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

This means that for every unit of run (16.97) the rafter has a line length of 18.76 inches. Since the total run of the rafter is 21.21 feet, the length of the rafter must be the value of x in the proportional equation $16.97:18.76::21.21:x$, or 23.45 feet.

Like the unit length of a common rafter, the bridge measure of a hip rafter can be obtained from the unit length rafter table on the framing square. If you turn back to figure 2-16, you will see that the second line in the table is headed LENGTH HIP OR VALLEY PER FT RUN. This means "per foot run of a common rafter in the same roof." Actually, the unit length given in the tables is the unit length for every 16.97 units of run of the hip rafter itself. If you go across to the unit length given under 8, you will find the same figure, 18.76 units, that you calculated above.

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

case, is 15 feet. The length of the hip rafter is therefore 18.76×15 , or 281.40 inches—23.45 feet once converted.

You step off the length of an equal-pitch hip roof just as you do the length of a common rafter, except that you set the square to a unit of run of 16.97 inches instead of to a unit of run of 12 inches. Since 16.97 inches is the same as 16 and 15.52 sixteenths of an inch, setting the square to a unit of run of 17 inches is close enough for most practical purposes. Bear in mind that for any plumb cut line on an equal-pitch hip roof rafter, you set the square to the unit of rise of a common rafter and to a unit of run of 17.

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

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

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

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

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

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

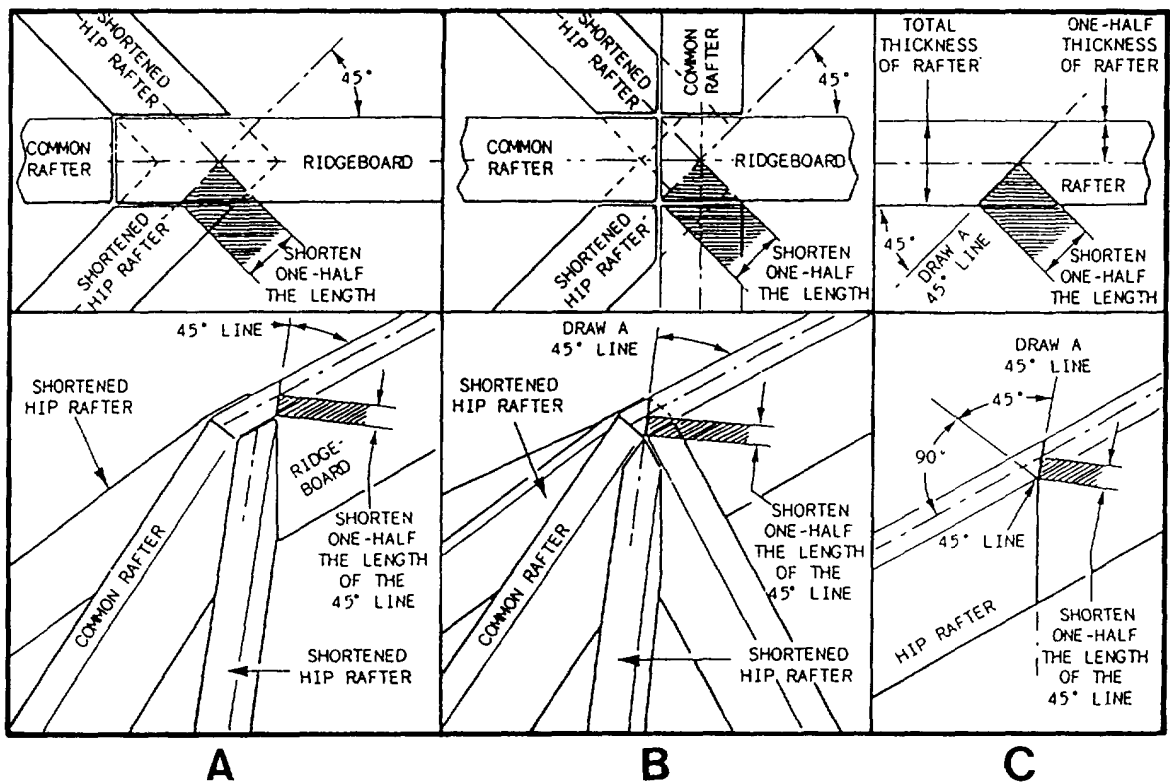


Figure 2-31.-Shortening a hip rafter.

Rafter Shortening Allowance

As in the case with a common rafter, the line length of a hip rafter does not take into account the thickness of the ridge piece. The size of the ridge-end shortening allowance for a hip rafter depends upon the way the ridge end of the hip rafter is joined to the other structural members. As shown in figure 2-31, the ridge end of the hip rafter can be framed against the ridgeboard (view A) or against the ridge-end common rafters (view B). To calculate the actual length, deduct one-half the 45° thickness of the ridge piece that fits between the rafters from the theoretical length.

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

If the hip rafter is framed against the ridge piece, the shortening allowance is one-half of the 45° thickness of

the ridge piece (fig. 2-31, view C). The 45° thickness of stock is the length of a line laid at 45° across the thickness dimension of the stock. If the hip rafter is framed against the common rafter, the shortening allowance is one-half of the 45° thickness of a common rafter.

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

Rafter Projection

A hip or valley rafter overhang, like a common rafter overhang, is figured as a separate rafter. The projection, however, is not the same as the projection of a common rafter overhang in the same roof. The projection of the hip or valley rafter overhang is the hypotenuse of a right triangle whose shorter sides are each equal to the run of a common rafter overhang (fig. 2-32). If the run of the common rafter overhang is

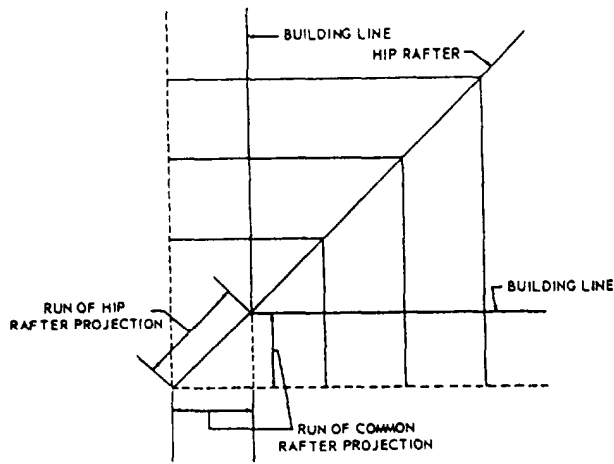


Figure 2-32.—Run of hip rafter projection.

18 inches for a roof with an 8-inch unit of rise, the length of the hip or valley rafter tail is figured as follows:

1. Find the bridge measure of the hip or valley rafter on the framing square (refer to figure 2-16). For this roof, it is 18.76 inches.
2. Multiply the bridge measure (in inches) of the hip or valley rafter by the projection (in feet) of the common rafter overhang:

$$\begin{array}{r}
 18.76 \text{ inches (bridge measure)} \\
 \times 1.5 \text{ feet (projection of the common rafter)} \\
 \hline
 28.14, \text{ or } 28 \frac{1}{8} \text{ inches.}
 \end{array}$$

3. Add this product to the theoretical rafter length.

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

Rafter Side Cuts

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

The angle of the side cut is laid out as shown in figure 2-33. Place the tongue of the framing square

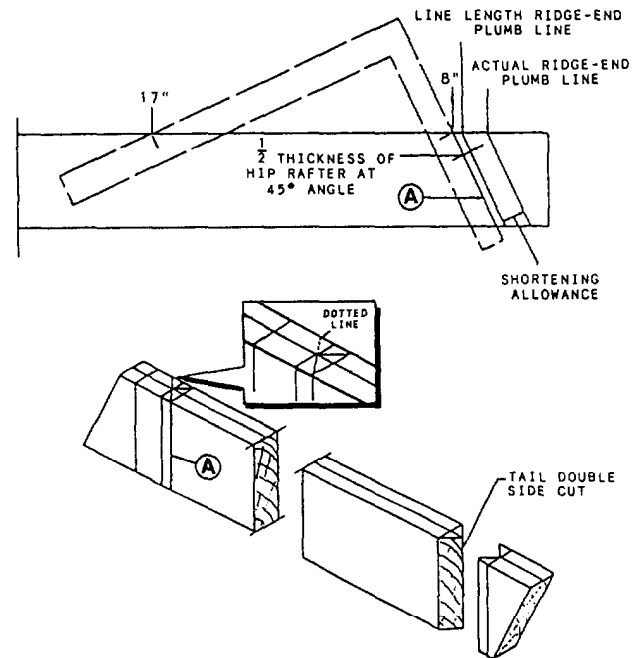


Figure 2-33.—Laying out hip rafter side cut.

along the ridge cut line, as shown, and measure off one-half the thickness of the hip rafter along the blade. Shift the tongue to the mark, set the square to the cut of the rafter (17 inches and 8 inches), and draw the plumb line marked "A" in the figure. Then, turn the rafter edge-up, draw an edge centerline, and draw in the angle of the side cut, as indicated in the lower view of figure 2-33. For a hip rafter to be framed against the ridge, there will be only a single side cut, as indicated by the dotted line in the figure. For one to be framed against the ridge ends of the common rafters, there will be a double side cut, as shown in the figure. The tail of the rafter must have a double side cut at the same angle, but in the reverse direction.

The angle of the side cut on a hip rafter may also be laid out by referring to the unit length rafter table on the framing square. (Look ahead to figure 2-41.) You will see that the bottom line in the table is headed SIDE CUT HIP OR VALLEY USE. If you follow this line over to the column headed by the figure 8 (for a unit of rise of 8), you will find the figure 10 7/8. If you place the framing square faceup on the rafter edge with the tongue on the ridge-end cut line, and set the square to a cut of 10 7/8 inches on the blade and 12 inches on the tongue, you can draw the correct side-cut angle along the tongue.

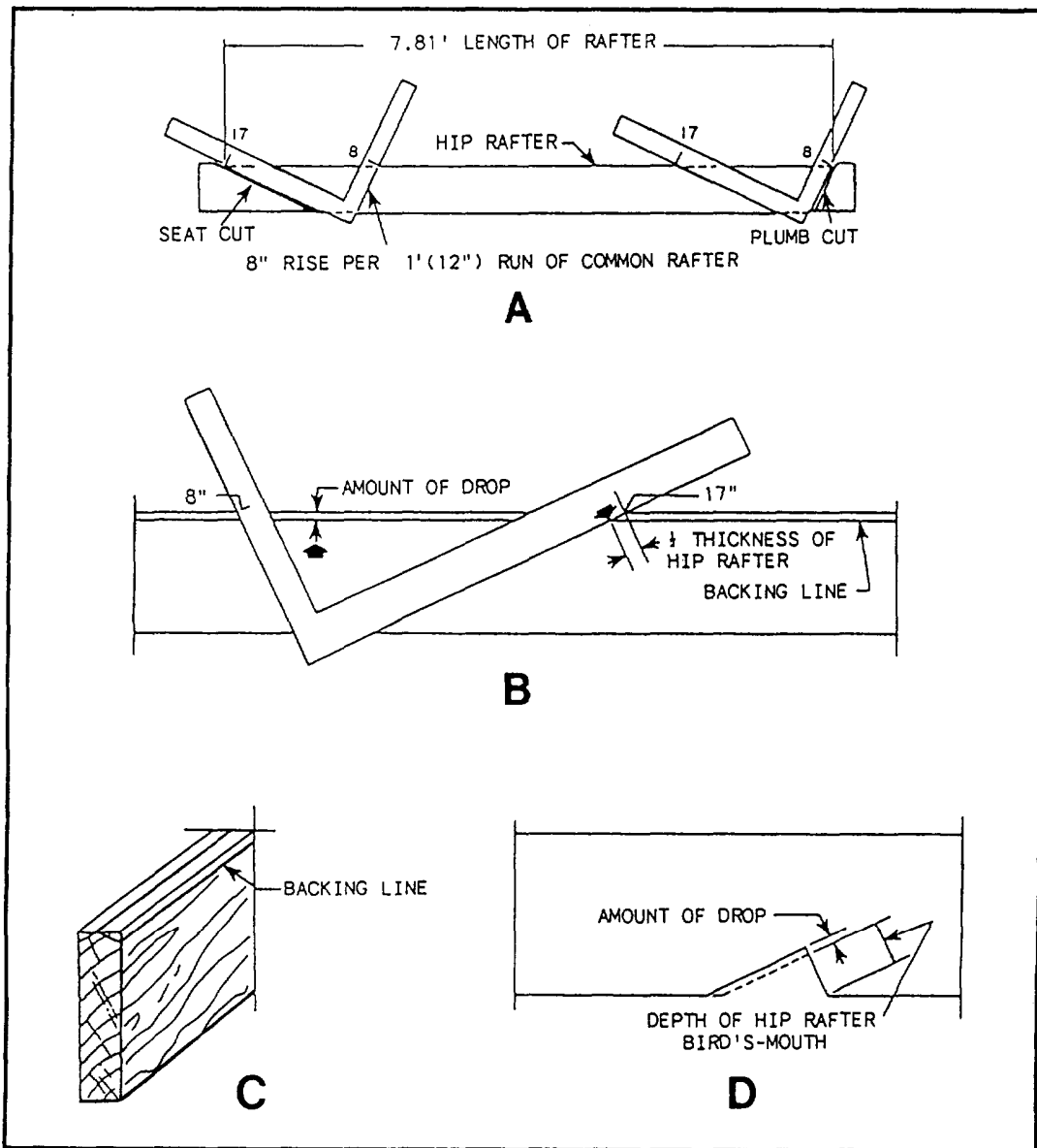


Figure 2-34. Backing or dropping a hip rafter: A. Marking the top (plumb) cut and the seat (level) cut of a hip rafter; B. Determining amount of backing or drop; C. Bevel line for backing the rafter; D. Deepening the bird's-mouth for dropping the rafter.

Bird's-Mouth

Laying out the bird's-mouth for a hip rafter is much the same as for a common rafter. However, there are a couple of things to remember. When the plumb (heel) cut and level (seat) cut lines are laid out for a bird's-mouth on a hip rafter, set the body of the square at 17 inches and the tongue to the unit of rise (for example, 8 inches—depending on the roof pitch) (fig. 2-34, view A). When laying out the depth of the heel for the bird's-mouth, measure along the heel plumb

line down from the top edge of the rafter a distance equal to the same dimension on the common rafter. This must be done so that the hip rafter, which is usually wider than a common rafter, will be level with the common rafters.

If the bird's-mouth on a hip rafter has the same depth as the bird's-mouth on a common rafter, the edge of the hip rafter will extend above the upper ends of the jack rafters. You can correct this by either backing or dropping the hip rafter. Backing means to bevel the top edges of the hip rafter (see fig. 2-35). The amount of backing is taken at a right angle to the roof surface on

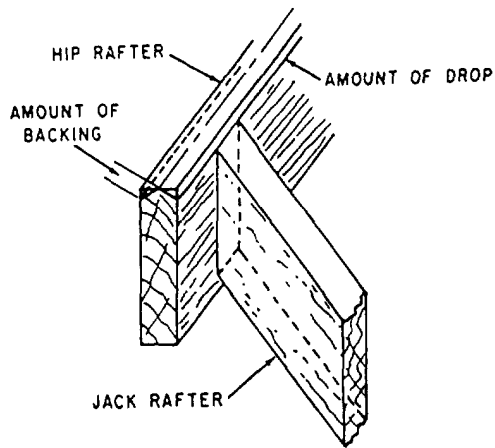


Figure 2-35.-Backing or dropping a hip rafter.

the top edge of the hip rafters. Dropping means to deepen the bird's-mouth so as to bring the top edge of the hip rafter down to the upper ends of the jacks. The amount of drop is taken on the heel plumb line (fig. 2-34, view D).

The backing or drop required is calculated, as shown in figure 2-34, view B. Set the framing square to the cut of the rafter (8 inches and 17 inches) on the upper edge, and measure off one-half the thickness of the rafter from the edge along the blade. A line drawn through this

mark and parallel to the edge (view C) indicates the bevel angle if the rafter is to be backed. The perpendicular distance between the line and the edge of the rafter is the amount of the drop. This represents the amount the depth of the hip rafter bird's-mouth should exceed the depth of the common rafter bird's-mouth (view D).

INTERSECTING

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

The two sections of an intersecting roof may not be the same width. If they are the same width, the roof is said to have equal spans. If they are not the same width, the roof is said to have unequal spans.

Spans

In a roof with equal spans, the height (total rise) is the same for both ridges (fig. 2-36). That is, both sections are the same width, and the ridgeboards are the same height. A pair of valley rafters is placed where the slopes of the roof meet to form a valley between the two sections. These rafters go from the inside corners formed by the two sections of the building to the corners

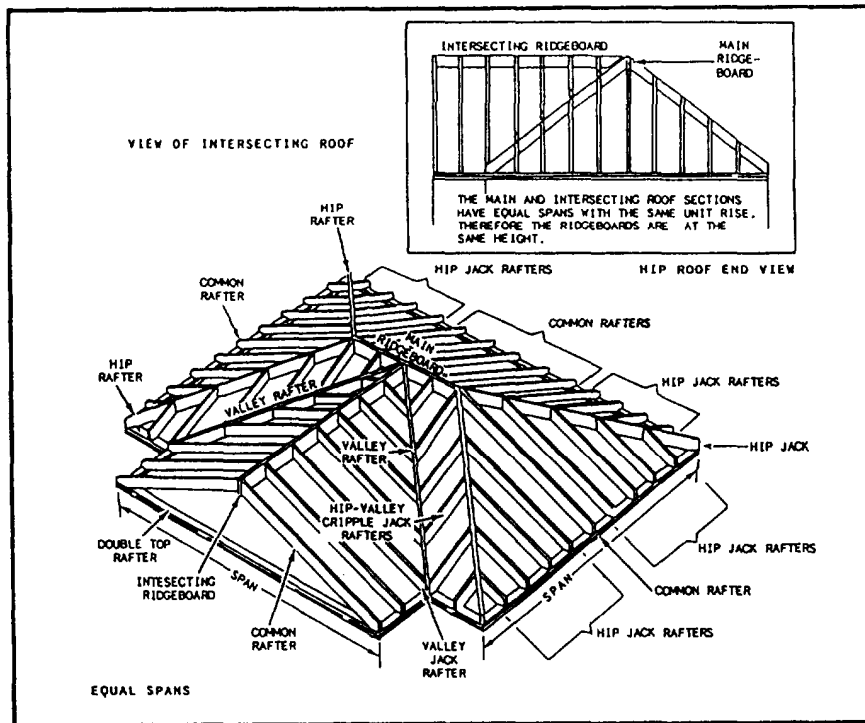


Figure 2-36.-Intersecting roof with equal spans.

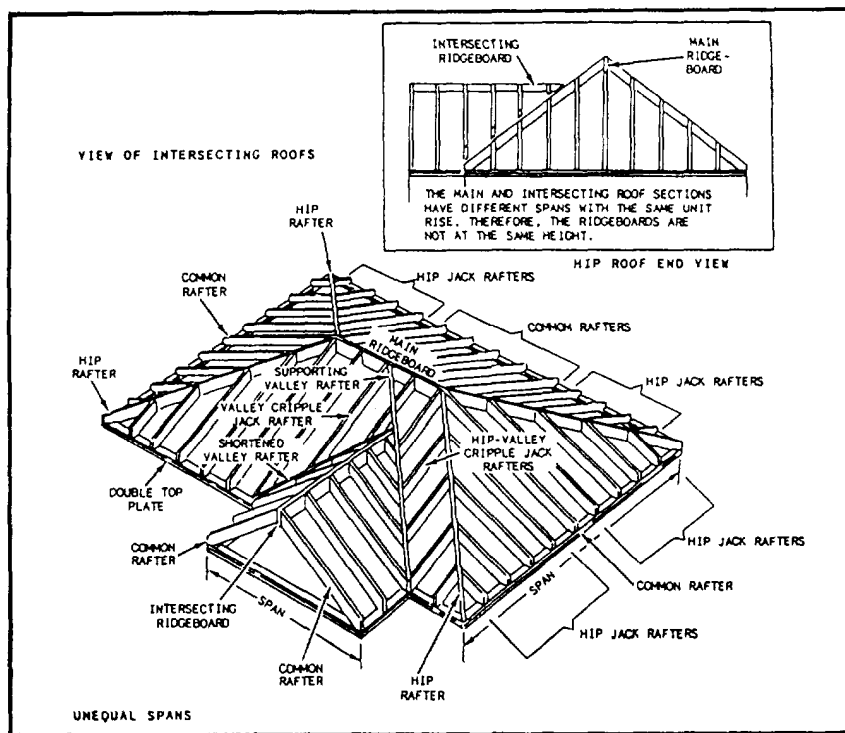


Figure 2-37.—Intersecting roof with unequal spans.

formed by the intersecting ridges. Valley jack rafters run from the valley rafters to both ridges. Hip-valley cripple jack rafters are placed between the valley and hip rafters.

An intersecting roof with unequal spans requires a supporting valley rafter to run from the inside corner formed by the two sections of the building to the main ridge (fig. 2-37). A shortened valley rafter runs from the other inside corner of the building to the supporting valley rafter. Like an intersecting roof with equal spans, one with unequal spans also requires valley jack rafters and hip-valley cripple jack rafters. In addition, a valley cripple jack rafter is placed between the supporting and shortened valley rafters. Note that the ridgeboard is lower on the section with the shorter span.

Valley Rafters

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

A valley rafter follows the line of intersection between a main-roof surface and a gable-roof addition or a gable-roof dormer surface. Most roofs having valley rafters are equal-pitch roofs, in which the pitch of the addition or dormer roof is the same as the pitch of the main roof. There are unequal-pitch valley-rafter

roofs, but they are quite rare and require special framing methods.

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

Figure 2-38 shows an equal-span framing situation, in which the span of the addition is the same as the span of the main roof. Since the pitch of the addition roof is the same as the pitch of the main roof, equal spans bring the ridge pieces to equal heights.

Looking at the roof framing diagram in the figure, you can see the total run of a valley rafter (indicated by AB and AC in the diagram) is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter in the main roof. The unit of run of a valley rafter is therefore 16.97, the same as the unit of run for a hip rafter. It follows that figuring the length of an equal-span valley rafter is the same as figuring the length of an equal-pitch hip roof rafter.

A valley rafter, however, does not require backing or dropping. The projection, if any, is figured just as it is for a hip rafter. Side cuts are laid out as they are for a

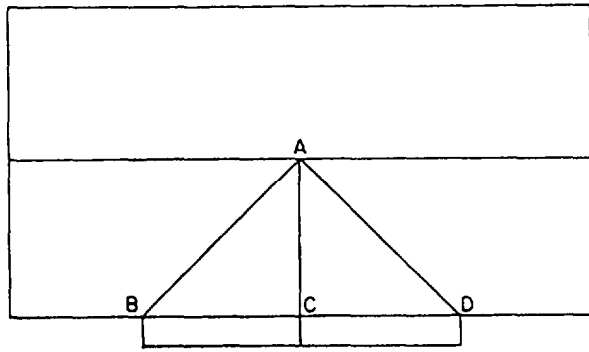
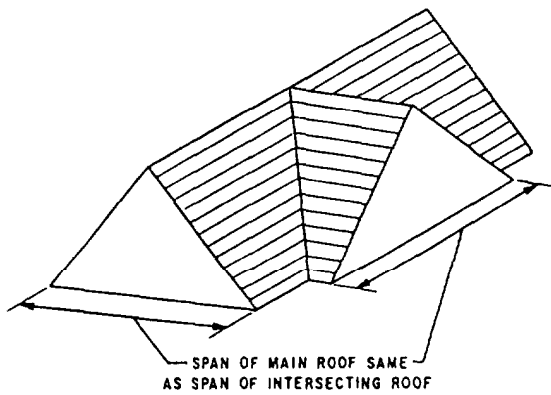


Figure 2-38.-Equal-span intersecting roof.

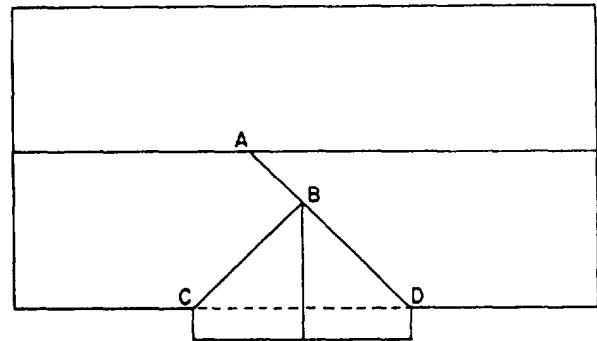
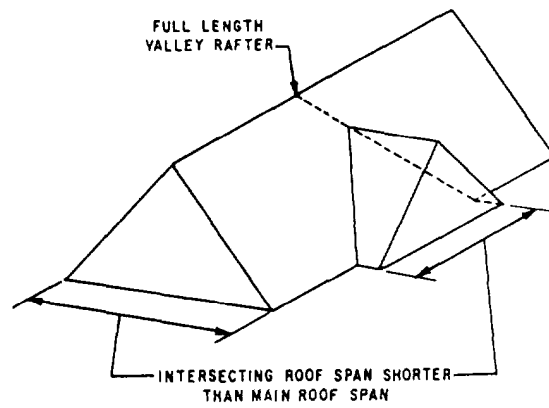


Figure 2-40.-Equal pitch but unequal span framing.

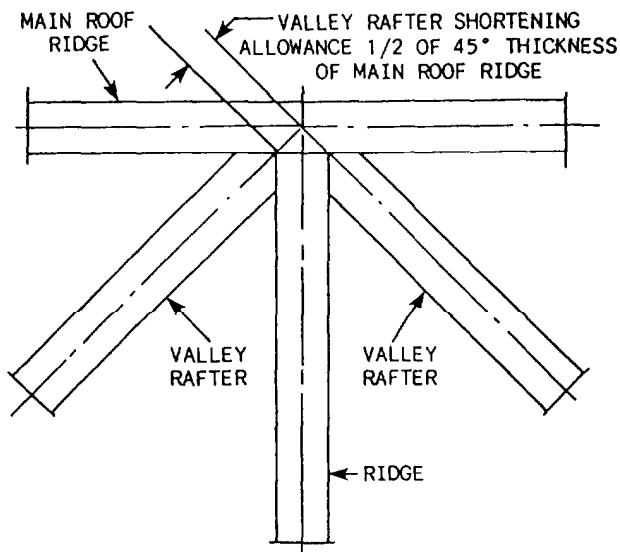


Figure 2-39.-Ridge-end shortening allowance for equal-span intersecting valley rafter.

hip rafter. The valley-rafter tail has a double side cut (like the hip-rafter tail) but in the reverse direction. This is because the tail cut on a valley rafter must form an inside, rather than an outside, corner. As indicated in figure 2-39, the ridge-end shortening allowance in this framing situation amounts to one-half of the 45° thickness of the ridge.

Figure 2-40 shows a framing situation in which the span of the addition is shorter than the span of the main roof. Since the pitch of the addition roof is the same as the pitch of the main roof, the shorter span of the addition brings the addition ridge down to a lower level than that of the main-roof ridge.

There are two ways of framing an intersection of this type. In the method shown in figure 2-40, a full-length valley rafter (AD in the figure) is framed between the top plate and the main-roof ridgeboard. A shorter valley rafter (BC in the figure) is then framed to the longer one. If you study the framing diagram, you can see that the total run of the longer valley rafter is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter in the main roof. The total run of the shorter valley rafter, on the other hand, is the hypotenuse of a right triangle with the altitude and base equal to the total run of a common rafter in the addition. The total run of a common rafter in the main roof is equal to one-half the span of the main roof. The total run of a common rafter in the addition is equal to one-half the span of the addition.

Knowing the total run of a valley rafter, or of any rafter for that matter, you can always find the line length by applying the bridge measure times the total run.

23	22	21	20	19	18	
LENGTH	COMMON	RAFTERS	PER FOOT	RUN		21 63
	HIP OR	VALLEY				24 74
DIFF	IN LENGTH	OF JACKS	16 INCHES	CENTERS		28 84
			2 FEET			43 27
SIDE	CUT	OF	JACKS	USE		6 1/16
		HIP OR	VALLEY			8 1/4
22	21	20	19	18	17	

9	8	13
15 00	14 42	13
19 21	18 76	18
20	19 23	17
30	28 84	16
9 1/4	10	
10 1/4	10 7/8	
8	7	6

Figure 2-41.-Rafter table method.

Suppose, for example, that the span of the addition in figure 2-40 is 30 feet and that the unit of rise of a common rafter in the addition is 9. The total run of the shorter valley rafter is:

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

Referring to the unit length rafter table in figure 2-41, you can see the bridge measure for a valley rafter in a roof with a common rafter unit of rise of 9 is 19.21. Since the unit of run of a valley rafter is 16.97, and the total run of this rafter is 21.21 feet, the line length must be the value of x in the proportional equation $16.97:19.21::21.21:x$, or 24.01 feet.

An easier way to find the length of a valley rafter is to multiply the bridge measure by the number of feet in one-half the span of the roof. The length of the longer valley rafter in figure 2-40, for example, would be 19.21 times one-half the span of the main roof. The length of the shorter valley rafter is 19.21 times one-half the span

of the addition. Since one-half the span of the addition is 15 feet, the length of the shorter valley rafter is $15 \times 9.21 = 288.15$ inches, or approximately 24.01 feet.

Figure 2-42 shows the long and short valley rafter shortening allowances. Note that the long valley rafter has a single side cut for framing to the main-roof ridge piece, whereas the short valley rafter is cut square for framing to the long valley rafter.

Figure 2-43 shows another method of framing an equal-pitch unequal-span addition. In this method, the inboard end of the addition ridge is nailed to a piece that hangs from the main-roof ridge. As shown in the framing diagram, this method calls for two short valley rafters (AB and AC), each of which extends from the top plate to the addition ridge.

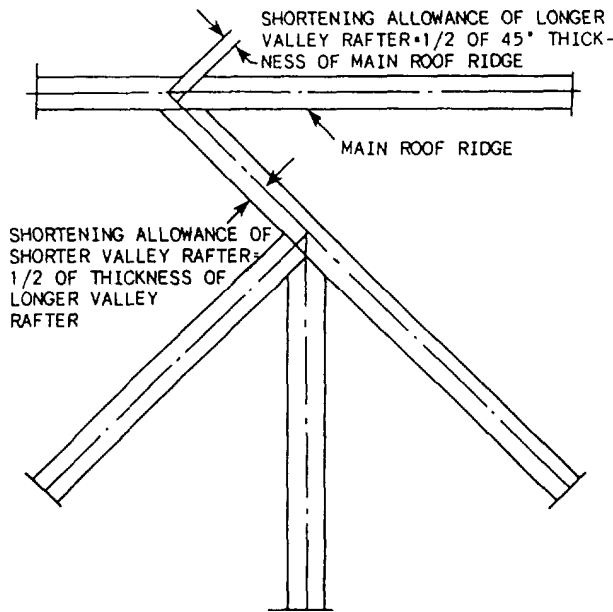


Figure 2-42.-Long and short valley rafter shortening allowance.

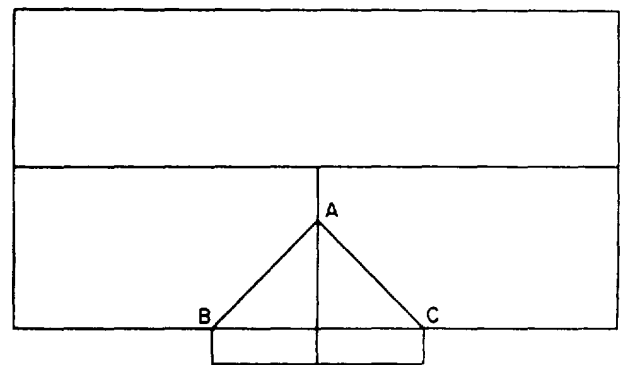
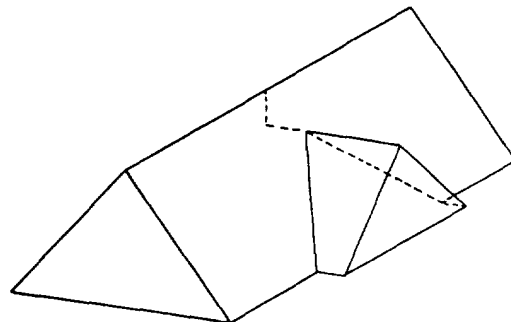


Figure 2-43.-Another method of framing equal-pitch unequal-span intersection.

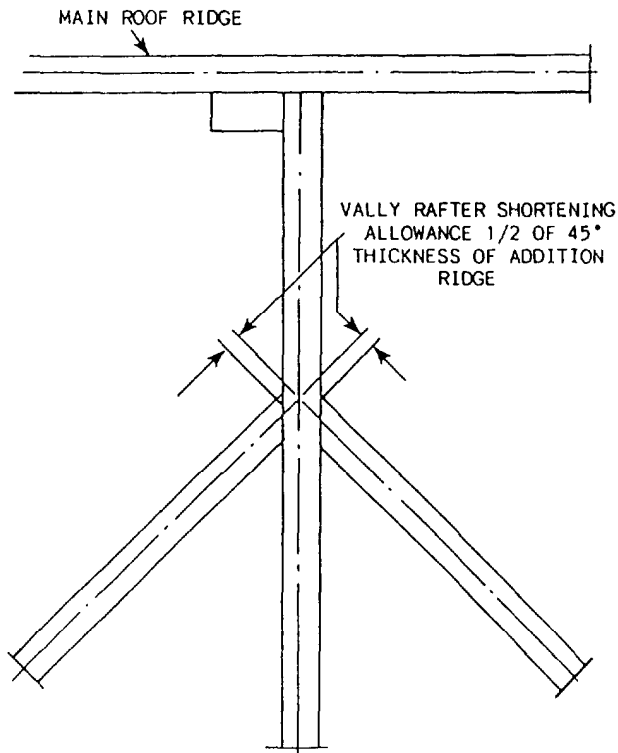


Figure 2-44.—Shortening allowance of valley rafters suspended ridge method of intersecting roof framing.

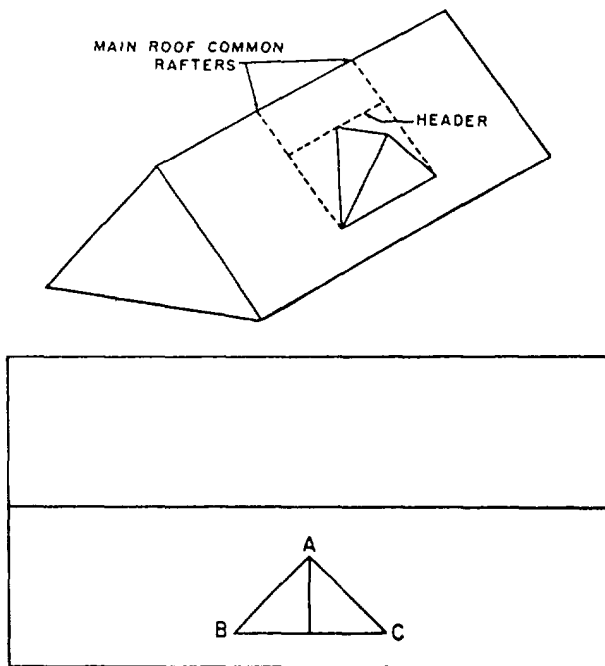


Figure 2-45.—Method of framing dormer without sidewalk.

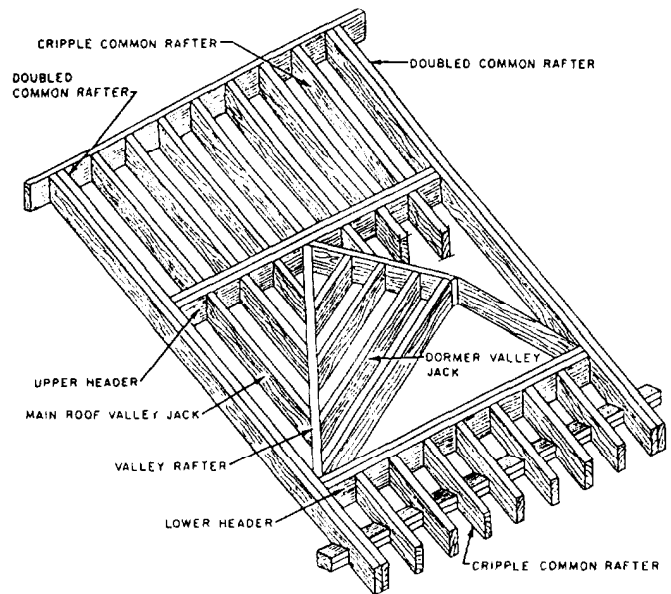


Figure 2-46.—Arrangement and names of framing members for dormer without sidewalls.

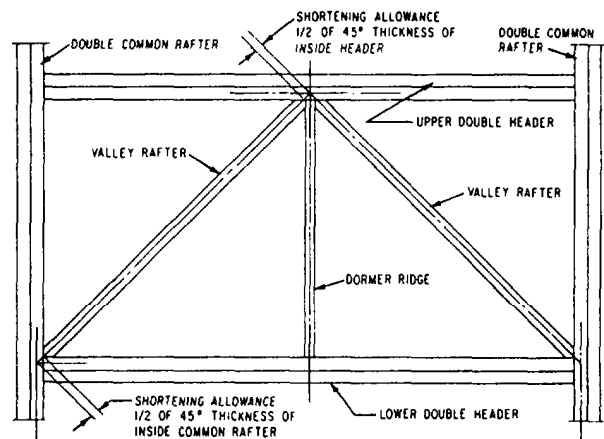


Figure 2-47.—Valley rafter shortening allowance for dormer without sidewalls.

As indicated in figure 2-44, the shortening allowance of each of the short valley rafters is one-half the 45° thickness of the addition ridge. Each rafter is framed to the addition ridge with a single side cut.

Figure 2-45 shows a method of framing a gable dormer without sidewalls. The dormer ridge is framed to a header set between a pair of doubled main-roof common rafters. The valley rafters (AB and AC) are framed between this header and a lower header. As indicated in the framing diagram, the total run of a valley rafter is the hypotenuse of a right triangle with the shorter sides equal to the total run of a common rafter in the dormer. Figure 2-46 shows the arrangement and names of framing members in this type of dormer framing.

The upper edges of the header must be beveled to the cut of the main roof. Figure 2-47 shows that in this

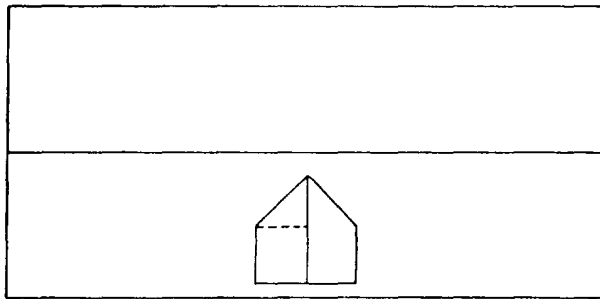
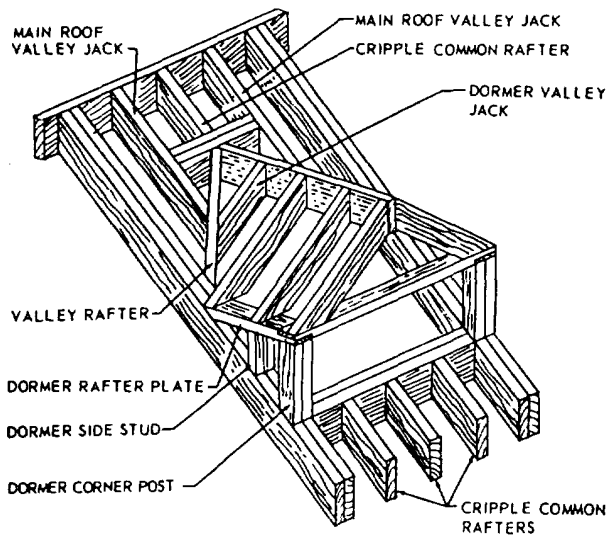


Figure 2-48.—Method of framing gable dormer with sidewalls.

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

Figure 2-48 shows a method of framing a gable dormer with sidewalls. As indicated in the framing diagram, the total run of a valley rafter is again the hypotenuse of a right triangle with the shorter sides each equal to the run of a common rafter in the dormer. You figure the lengths of the dormer corner posts and side studs just as you do the lengths of gable-end studs, and you lay off the lower end cutoff angle by setting the square to the cut of the main roof.

Figure 2-49 shows the valley rafter shortening allowance for this method of framing a dormer with sidewalls.

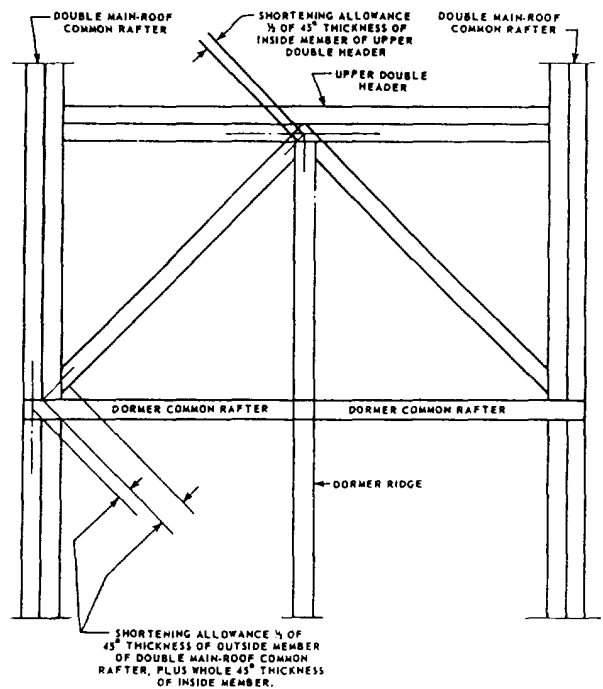


Figure 2-49.—Valley rafter shortening allowance for dormers with sidewalls.

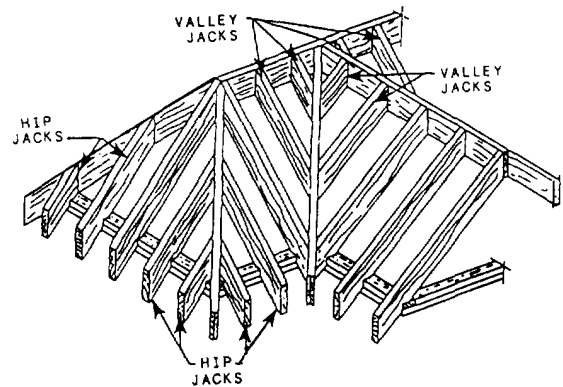


Figure 2-50.—Types of jack rafters.

Jack Rafters

A jack rafter is a part of a common rafter, shortened for framing a hip rafter, a valley rafter, or both. This means that, in an equal-pitch framing situation, the unit of rise of a jack rafter is always the same as the unit of rise of a common rafter. Figure 2-50 shows various types of jack rafters.

A hip jack rafter extends from the top plate to a hip rafter. A vane y jack rafter extends from a valley rafter to a ridge. (Both are shown in fig. 2-51.) A cripple jack rafter does not contact either a top plate or a ridge. A

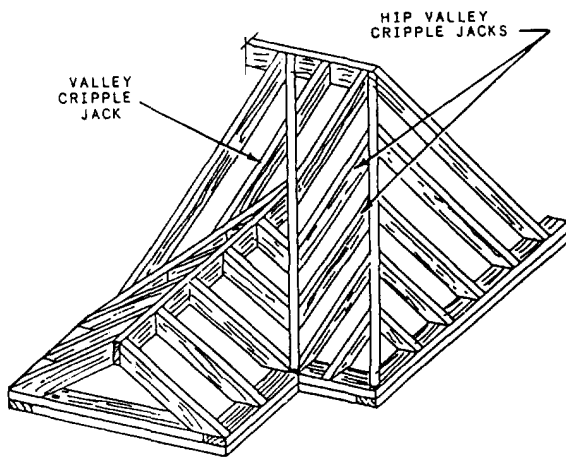


Figure 2-51.—Valley cripple Jack and hip-valley cripple jack.

valley cripple jack extends between two valley rafters in the long and short valley rafter method of framing. A hip-valley cripple jack extends from a hip rafter to a valley rafter.

LENGTHS.— Figure 2-52 shows a roof framing diagram for a series of hip jack rafters. The jacks are always on the same OC spacing as the common rafters.

Now, suppose the spacing, in this instance, is 16 inches OC. You can see that the total run of the shortest jack is the hypotenuse of a right triangle with the shorter sides each 16 inches long. The total run of the shortest jack is therefore:

$$\sqrt{(16^2 + 16^2)} = 22.62 \text{ inches.}$$

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

$$\sqrt{(12^2 + 8^2)} = 14.42 \text{ inches.}$$

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

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

The common difference for hip jacks spaced 16 inches OC, or 24 inches OC, is given in the unit length

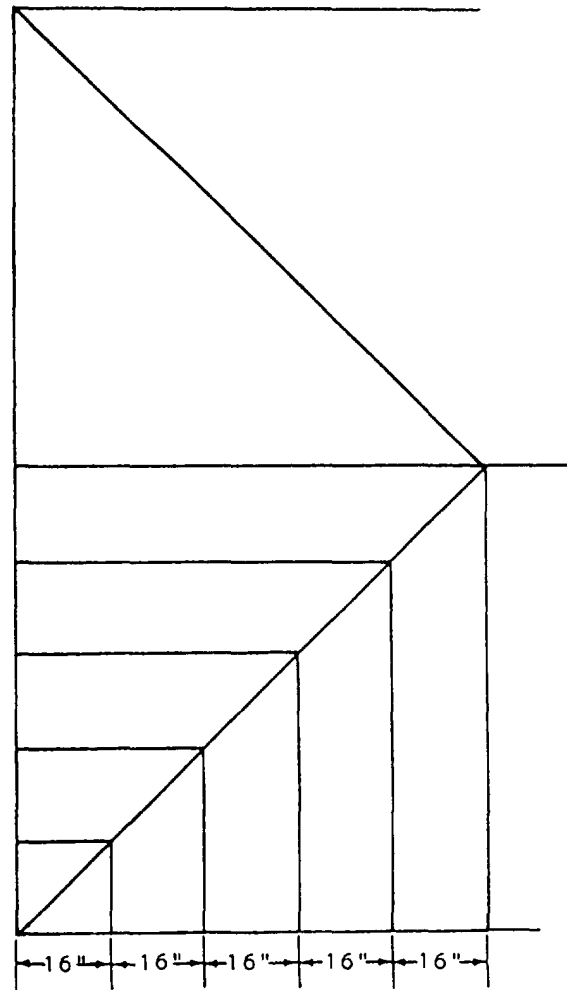


Figure 2-52.—Hip jack framing diagram.

rafter table on the framing square for unit of rise ranging from 2 to 18, inclusive. Turn back to figure 2-41, which shows a segment of the unit length rafter table. Note the third line in the table, which reads DIFF IN LENGTH OF JACKS 16 INCHES CENTERS. If you follow this line over to the figure under 8 (for a unit of rise of 8), you'll find the same unit length (19.23) that you worked out above.

The best way to determine the length of a valley jack or a cripple jack is to apply the bridge measure to the total run. The bridge measure of any jack is the same as the bridge measure of a common rafter having the same unit of rise as the jack. Suppose the jack has a unit of rise of 8. In figure 2-41, look along the line on the unit length rafter tables headed LENGTH COMMON RAFTER PER FOOT RUN for the figure in the column under 8; you'll find a unit length of 14.42. You should know by this time how to apply this to the total run of a jack to get the line length.

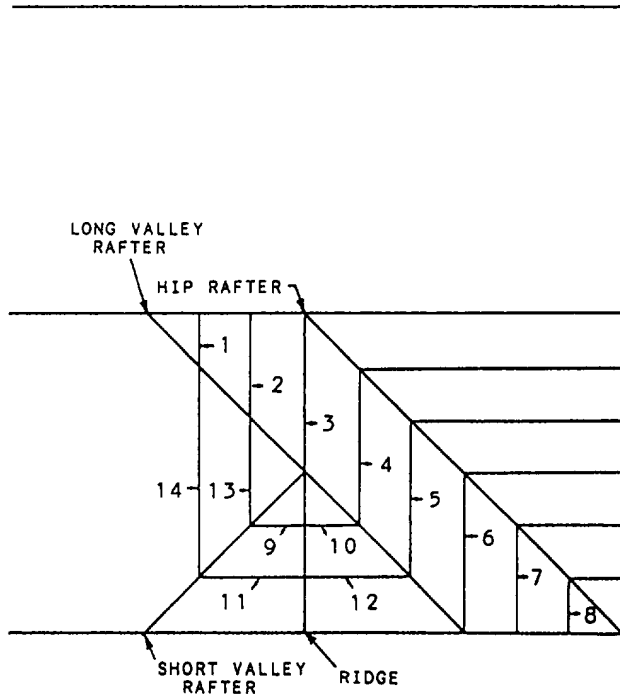


Figure 2-53.—Jack rafter framing diagram.

The best way to figure the total runs of valley jacks and cripple jacks is to lay out a framing diagram and study it to determine what these runs must be. Figure 2-53 shows part of a framing diagram for a main hip roof with a long and short valley rafter gable addition. By studying the diagram, you can figure the total runs of the valley jacks and cripple jacks as follows:

- The run of valley jack No. 1 is obviously the same as the run of hip jack No. 8, which is the run of the shortest hip jack. The length of valley jack No. 1 is therefore equal to the common difference of jacks.
- The run of valley jack No. 2 is the same as the run of hip jack No. 7, and the length is therefore twice the common difference of jacks.
- The run of valley jack No. 3 is the same as the run of hip jack No. 6, and the length is therefore three times the common difference of jacks.
- The run of hip-valley cripple Nos. 4 and 5 is the same as the run of valley jack No. 3.

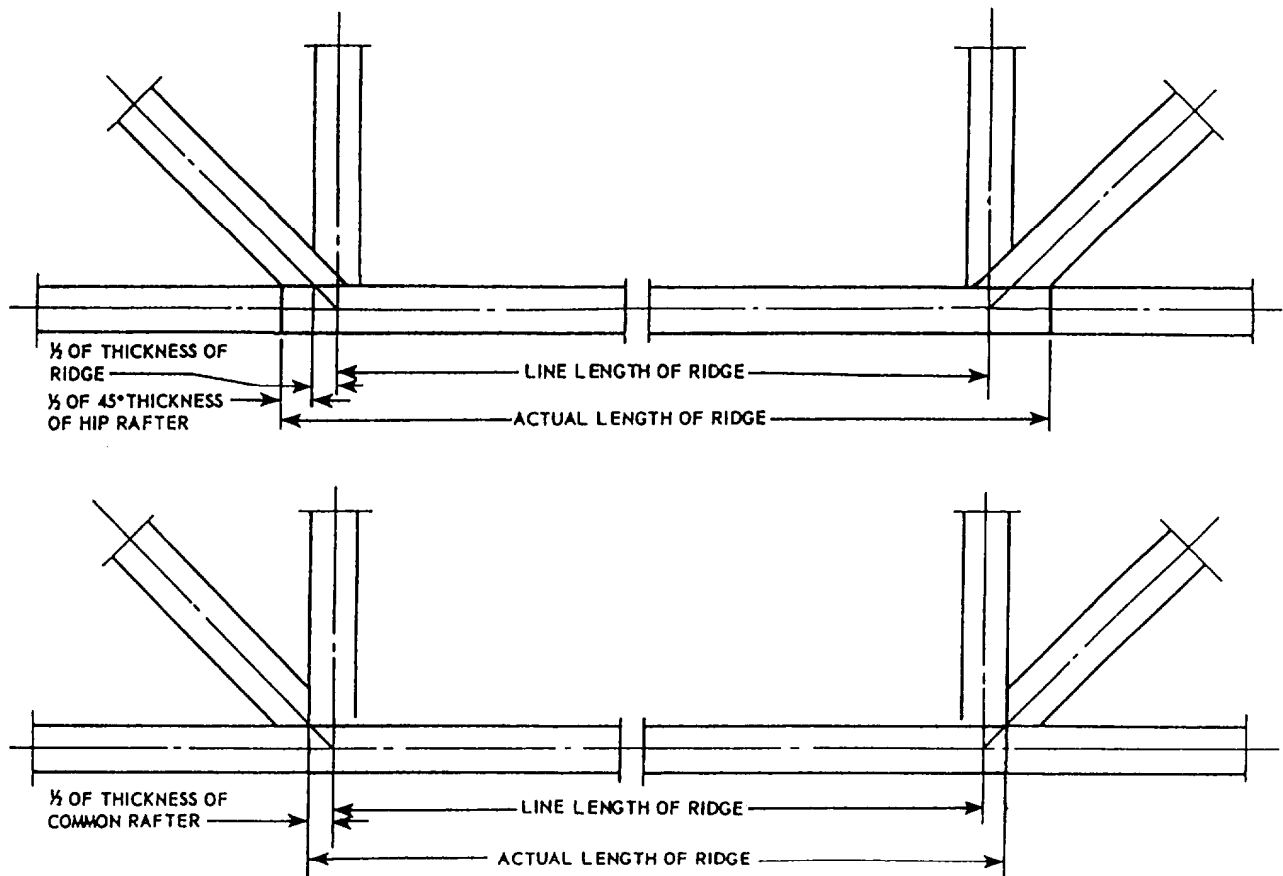


Figure 2-54.—Line and actual lengths of hip roof ridgeboard.

- The run of valley jack Nos. 9 and 10 is equal to the spacing of jacks OC. Therefore, the length of one of these jacks is equal to the common difference of jacks.
- The run of valley jacks Nos. 11 and 12 is twice the run of valley jacks Nos. 9 and 10, and the length of one of these jacks is therefore twice the common difference of jacks.
- The run of valley cripple No. 13 is twice the spacing of jacks OC, and the length is therefore twice the common difference of jacks.
- The run of valley cripple No. 14 is twice the run of valley cripple No. 13, and the length is therefore four times the common difference of jacks.

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

SIDE CUTS.— The side cut on a jack rafter can be laid out using the same method as for laying out the side cut on a hip rafter. Another method is to use the fifth line of the unit length rafter table, which is headed **SIDE CUT OF JACKS USE** (fig. 2-41). If you follow that line over to the figure under 8 (for a unit of rise of 8), you will see that the figure given is 10. To lay out the side cut on a jack set the square faceup on the edge of the rafter to 12 inches on the tongue and 10 inches on the blade, and draw the side-cut line along the tongue.

BIRD'S-MOUTH AND PROJECTION.— A jack rafter is a shortened common rafter; consequently, the bird's-mouth and projection on a jack rafter are laid out just as they are on a common rafter.

Ridge Layout

Laying out the ridge for a gable roof presents no particular problem since the line length of the ridge is equal to the length of the building. The actual length

includes any overhang. For a hip main roof, however, the ridge layout requires a certain amount of calculation.

As previously mentioned, in an equal-pitch hip roof, the line length of the ridge amounts to the length of the building minus the span. The actual length depends upon the way the hip rafters are framed to the ridge.

As indicated in figure 2-54, the line length ends of the ridge are at the points where the ridge centerline and the hip rafter center line cross. In the figure, the hip rafter is framed against the ridge. In this method of framing, the actual length of the ridge exceeds the line length, at each end, by one-half the thickness of the ridge, plus one-half the 45° thickness of the hip rafter. In the figure, the hip rafter is also framed between the common rafters. In this method of framing, the actual length of the ridge exceeds the line length at each end by one-half the thickness of a common rafter.

Figure 2-55, view A, shows that the length of the ridge for an equal-span addition is equal to the length of the addition top plate, plus one-half the span of the building, minus the shortening allowance at the

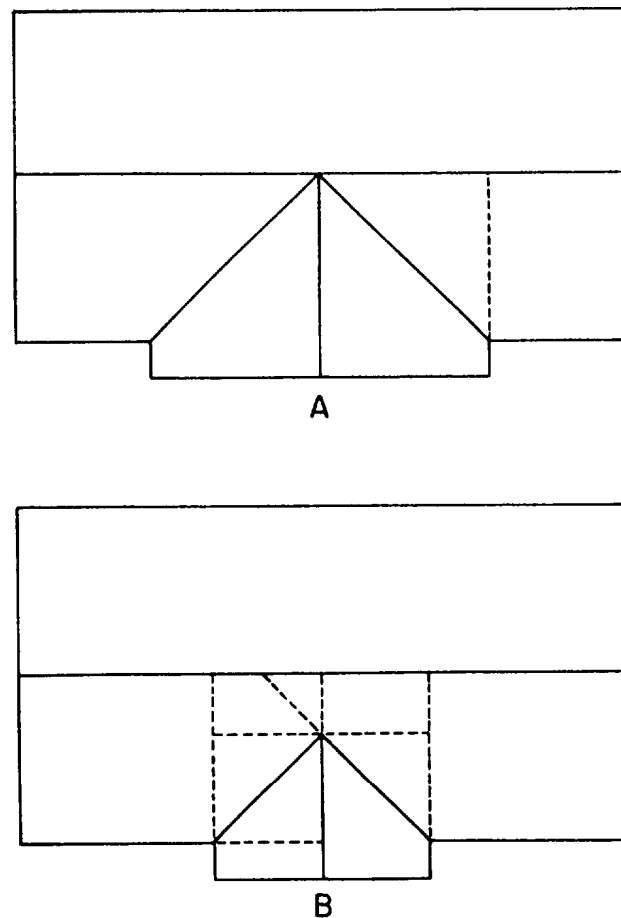
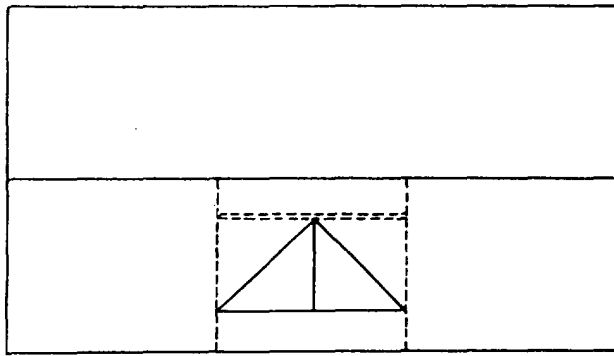
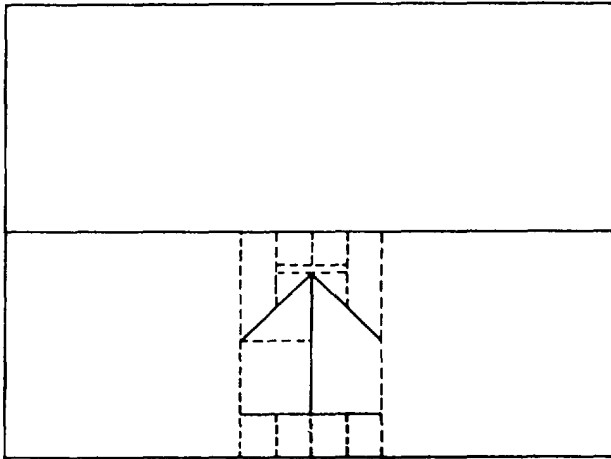


Figure 2-55.—Lengths of addition ridge.



A



B

Figure 2-56.-Lengths of dormer ridge.

main-roof ridge. The shortening allowance amounts to one-half the thickness of the main-roof ridge.

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

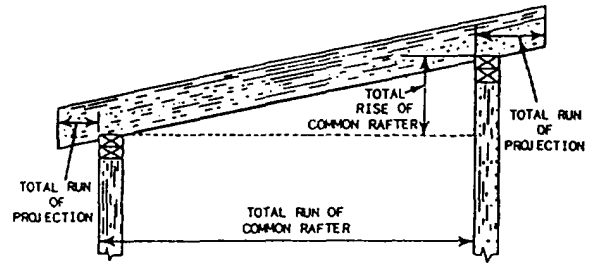
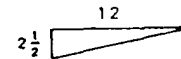


Figure 2-57.-Shed roof framing.

Figure 2-56, view A, shows that the length of the ridge on a dormer without sidewalls is equal to one-half the span of the dormer, less a shortening allowance one-half the thickness of the inside member of the upper double header. View B shows that the length of the ridge on a dormer with sidewalls is the length of the dormer rafter plate, plus one-half the span of the dormer, minus a shortening allowance one-half the thickness of the inside member of the upper double header.

SHED

A shed roof is essentially one-half of a gable roof. Like the full-length rafters in a gable roof, the full-length rafters in a shed roof are common rafters. However, the total run of a shed roof common rafter is equal to the span of the building minus the width of the top plate on the higher rafter-end wall (fig. 2-57). Also, the run of the overhang on the higher wall is measured from the inner edge of the top plate. With these exceptions, shed roof common rafters are laid out like gable roof common rafters. A shed roof common rafter has two bird's-mouths, but they are laid out just like the bird's-mouth on a gable roof common rafter.

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

Figure 2-58 shows a method of framing a shed dormer. This type of dormer can be installed on almost any type of roof. There are three layout problems to be solved here: determining the total run of a dormer rafter; determining the angle of cut on the inboard ends of the dormer rafters; and determining the lengths of the dormer sidewall studs.

To determine the total run of a dormer rafter, divide the height of the dormer end wall, in inches, by the

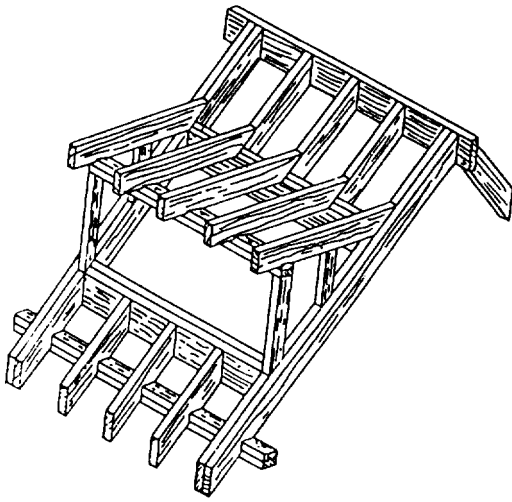


Figure 2-58.-Method of framing a shed dormer.

difference between the unit of rise of the dormer roof and the unit of rise of the main roof. Take the dormer shown in figure 2-59, for example. The height of the dormer end wall is 9 feet, or 108 inches. The unit of rise of the main roof is 8; the unit of rise of the dormer roof is 2 1/2; the difference is 5 1/2. The total run of a dormer rafter is therefore 108 divided by 5 1/2, or 19.63 feet. Knowing the total run and the unit of rise, you can figure the length of a dormer rafter by any of the methods already described.

As indicated in figure 2-59, the inboard ends of the dormer rafters must be cut to fit the slope of the main roof. To get the angle of this cut, set the square on the rafter to the cut of the main roof, as shown in the bottom view of figure 2-59. Measure off the unit of rise of the dormer roof from the heel of the square along the tongue as indicated and make a mark at this point. Draw the cutoff line through this mark from the 12-inch mark.

You figure the lengths of the sidewall studs on a shed dormer as follows: In the roof shown in figure 2-59, a dormer rafter raises 2 1/2 units for every 12 units of run. A main-roof common rafter rises 8 units for every 12 units of run. If the studs were spaced 12 inches OC, the length of the shortest stud (which is also the common difference of studs) would be the difference between 8 and 2 1/2 inches, or 5 1/2 inches. If the stud spacing is 16 inches, the length of the shortest stud is the value of x in the proportional equation $12:5\ 1/2::16:x$, or 7 5/16 inches. The shortest stud, then, will be 7 5/16 inches long. To get the lower end cutoff angle for studs, set the square on the stud to the cut of the main

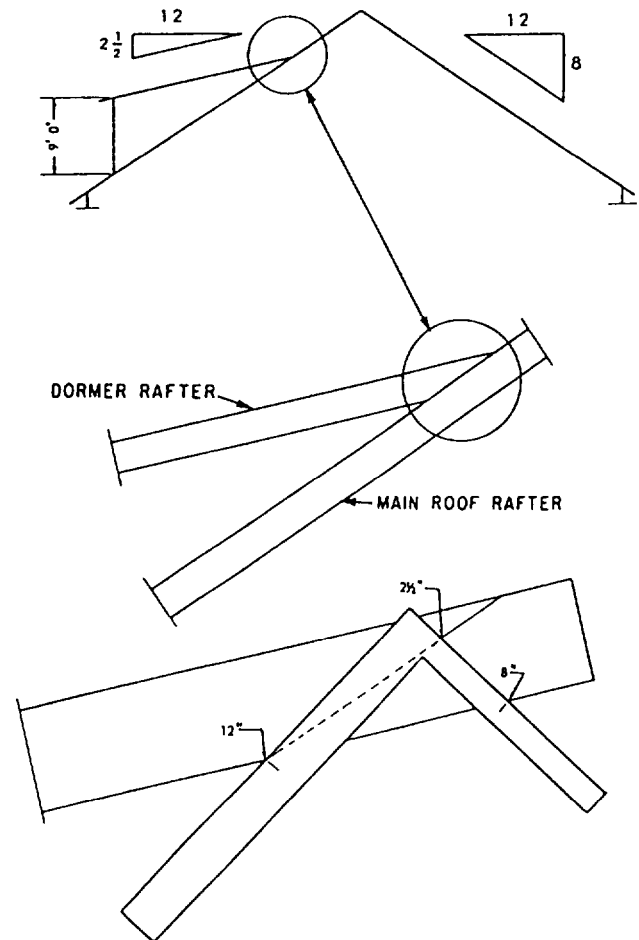


Figure 2-59.-Shed dormer framing calculation.

roof. To get the upper end cutoff angle, set the square to the cut of the dormer roof.

INSTALLATION

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

Rafter Locations

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

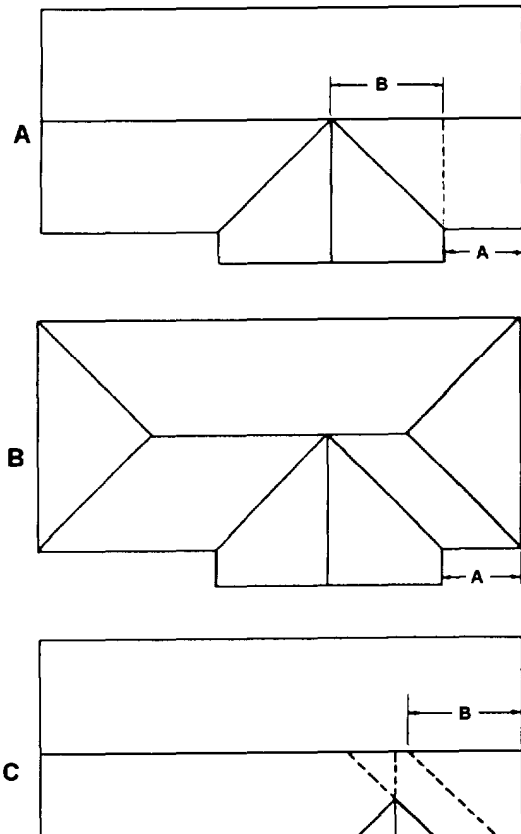


Figure 2-60.-Intersection ridge and valley rafter location layout.

The locations of additional ridge and valley rafters can be determined as indicated in figure 2-60. In an equal-span situation (views A and B), the valley rafter locations on the main-roof ridge lie alongside the addition ridge location. In view A, the distance between the end of the main-roof ridge and the addition ridge location is equal to A plus distance B, distance B being one-half the span of the addition. In view B, the distance between the line length end of the main-roof ridge and the addition ridge location is the same as distance A. In both cases, the line length of the addition ridge is equal to one-half the span of the addition, plus the length of the addition sidewall rafter plate.

Figure 2-60, view C, shows an unequal-span situation. If framing is by the long and short valley rafter method, the distance from the end of the main-roof ridge to the upper end of the longer valley rafter is equal to distance A plus distance B, distance B being one-half the span of the main roof. To determine the location of the inboard valley rafter, first calculate the unit length of the longer valley rafter, or obtain it from the unit length rafter

tables. Let's suppose that the common rafter unit of rise is 8. In that case, the unit length of a valley rafter is 18.76.

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

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

You know that the valley rafter is 18.76 units long for every 16.97 units of run. The length of rafter for 14.14 feet of run must therefore be the value of x in the proportional equation $16.97:18.76::14.14:x$, or 15.63 feet. The location mark for the inboard end of the shorter valley rafter on the longer valley rafter, then, will be 15.63 feet, or 15 feet 7 9/16 inches, from the heel plumb cut line on the longer valley rafter. The length of the additional ridge will be equal to one-half the span of the addition, plus the length of the additional sidewall top plate, minus a shortening allowance one-half the 45° thickness of the longer valley rafter.

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

Roof Frame Erection

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

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

Two crewmembers, one at each end of the scaffold, hold the ridge in position. Another crewmember sets the gable-end rafters in place and toenails them at the rafter plate with 8d nails, one on each side of a rafter. Before we proceed any further, see table 2-1 as to the type and

Table 2-1.—Recommended Schedule for Nailing the Framing and Sheathing of a Wood-Frame Structure

JOINING	NAILING METHOD	NAILS		
		Nr.	Size	Placement
Header to joist	End-nail	3	16d	
Joist to sill or girder	Toenail	2 3	10d or 8d	
Header and stringer joist to sill	Toenail		10d	16 in. OC
Bridging to joist	Toenail each end	2	8d	
Ledger strip to beam, 2 in. thick		3	16d	At each joist
Subfloor, boards: 1 by 6 in. and smaller 1 by 8 in.		2 3	8d 8d	To each joist To each joist
Subfloor, plywood: At edges At intermediate joists			8d 8d	6 in. OC 8 in. OC
Subfloor (2 by 6 in., T&G) to joist or girder	Blind nail (casing) and face-nail	2	16d	
Soleplate to stud, horizontal assembly	End-nail	2	16d	At each stud
Top plate to stud	End-nail	2	16d	
Stud to soleplate	Toenail	4	8d	
Soleplate to joist or blocking	Face-nail		16d	16 in. OC
Doubled studs	Face-nail, stagger		10d	16 in. OC
End stud of intersecting wall to exterior wall stud	Face-nail		16d	16 in. OC
Upper top plate to lower top plate	Face-nail		16d	16 in. OC
Upper top plate, laps and intersections	Face-nail	2	16d	
Continuous header, two pieces, each edge			12d	12 in. OC
Ceiling joist to top wall plates	Toenail	3	8d	
Ceiling joist laps at partition	Face-nail	4	16d	
Rafter to top plate	Toenail	2	8d	
Rafter to ceiling joist	Face-nail	5	10d	
Rafter to valley or hip rafter	Toenail	3	10d	
Ridgeboard to rafter	End-nail	3	10d	
Rafter to rafter through ridgeboard	Toenail Edge-nail	2 4	10d 8d	
Collar tie to rafter: 2-in. member 1-in. member	Face-nail Face-nail	2 3	12d 8d	
1-in. diagonal let-in brace to each stud and plate (four nails at top)		2	8d	
Built-up corner studs: Studs to blocking Intersecting stud to corner studs	Face-nail Face-nail	2	10d 6d	Each side 12 in. OC
Built-up girders and beams, three or more members	Face-nail		20d	32 in. OC, each side
Wall sheathing: 1 by 8 in. or less, horizontal 1 by 6 in. or greater, diagonal	Face-nail Face-nail	2 3	8d 8d	At each stud At each stud

Table 2-1.-Recommended Schedule for Nailing the Framing and Sheathing of a Wood-Frame Structure—Continued

JOINING	NAILING METHOD	NAILS		
		Nr.	Size	Placement
Wall sheathing, vertically applied plywood: 3/8 in. and less thick 1/2 in. and over thick	Face-nail Face-nail		6d 8d	6 in. edge 12 in. intermediate
Wall sheathing, vertically applied fiberboard: 1/2 in. thick 25/32 in. thick	Face-nail Face-nail			1 1/2-in. roofing nail 3 in. from edge and 1 3/4-in. roofing nail 6 in. intermediately spaced
Roof sheathing, boards, 4-, 6-, 8-in. width	Face-nail	2	8d	At each rafter
Roof sheathing, plywood: 3/8 in. and less thick 1/2 in. and over thick	Face-nail Face-nail		6d 8d	6 in. edge and 12 in. intermediate

size nails used in roof framing erection. Each crew-member on the scaffold then end-nails the ridge to the end of the rafter. They then toenail the other rafter to the ridge and to the first rafter with two 10d nails, one on each side of the rafter.

Temporary braces, like those for a wall, should be set up at the ridge ends to hold the rafter approximately plumb, after which the rafters between the end rafters should be erected. The braces should then be released, and the pair of rafters at one end should be plumbed with a plumb line, fastened to a stick extended from the end of the ridge. The braces should then be reset, and they should be left in place until enough sheathing has been installed to hold the rafters plumb. Collar ties, if any, are nailed to common rafters with 8d nails, three to each end of a tie. Ceiling-joist ends are nailed to adjacent rafters with 10d nails.

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

For an addition or dormer, the valley rafters are usually erected first. Valley rafters are toe nailed with 10d nails. Ridges and ridge-end common rafters are erected next, other addition common rafters next, and valley and cripple jacks last. A valley jack should be held in position for nailing, as shown in figure 2-61. When properly nailed, the end of a straightedge laid along the

top edge of the jack should contact the centerline of the valley rafter, as shown.

TRUSSES

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe the types and parts of roof trusses, and explain procedures for fabricating, handling, and erecting them.

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

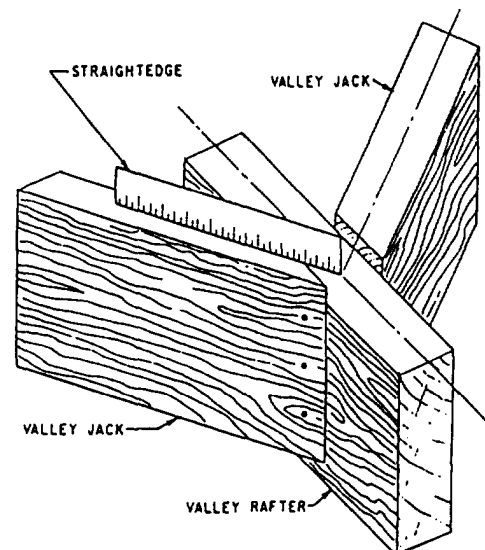


Figure 2-61.-Correct position for nailing a valley jack rafter.

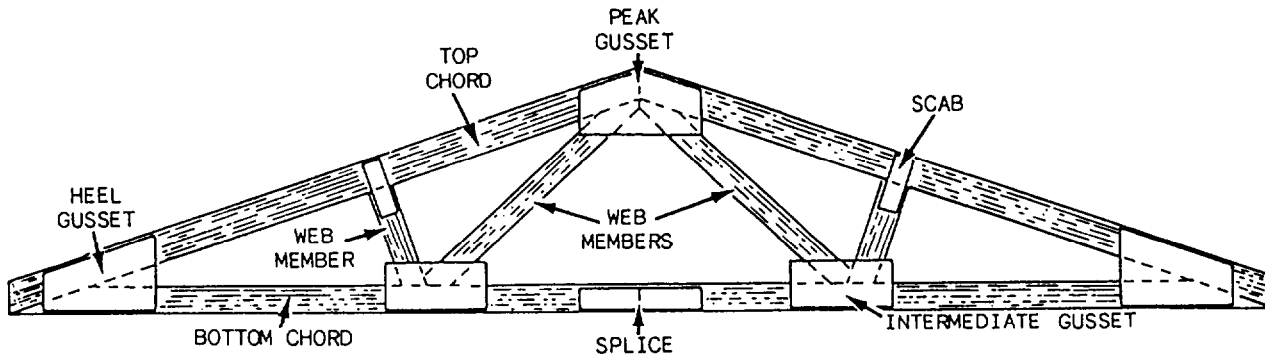


Figure 2-62.—Truss construction.

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

The basic components of a roof truss are the top and bottom chords and the web members (fig. 2-62). The top chords serve as roof rafters. The bottom chords act as ceiling joists. The web members run between the top and bottom chords. The truss parts are usually made of 2- by 4-inch or 2- by 6-inch material and are tied together with metal or plywood gusset plates. Gussets shown in this figure are made of plywood.

TYPES

Roof trusses come in a variety of shapes. The ones most commonly used in light framing are the king post, the W-type (or fink), and the scissors. An example of each is shown in figure 2-63.

King Post

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

W-Type (Fink)

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

Scissors

The scissor truss is used for building with sloping ceilings. Many residential, church, and commercial

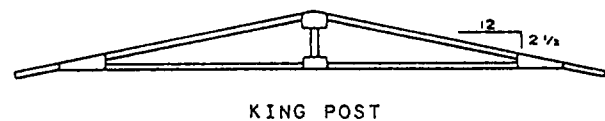
buildings require this type of truss. Generally, the slope of the bottom chord of a scissor truss equals one-half the slope of the top chord.

DESIGN PRINCIPLES

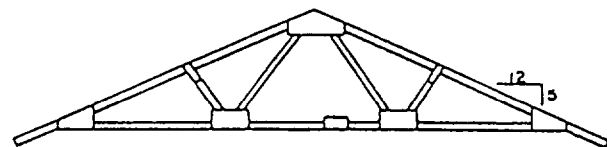
A roof truss is an engineered structural frame resting on two outside walls of a building. The load carried by the truss is transferred to these outside walls.

Weight and Stress

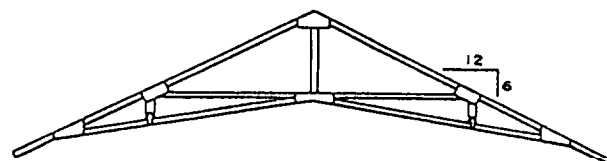
The design of a truss includes consideration of snow and wind loads and the weight of the roof itself. Design also takes into account the slope of the roof. Generally, the flatter the slope, the greater the stresses. Flatter slopes, therefore, require larger members and stronger connections in roof trusses.



KING POST



W-TYPE



SCISSORS

Figure 2-63.—Truss types.

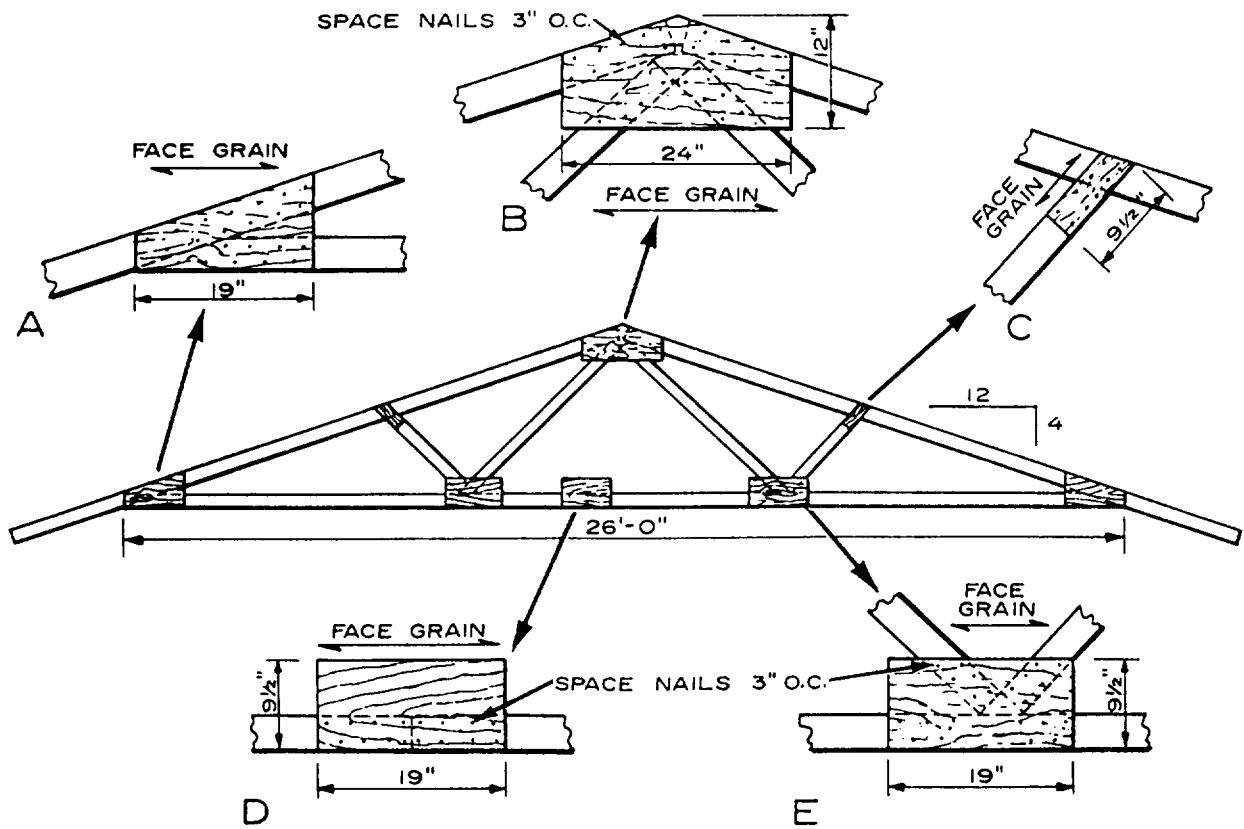


Figure 2-64. Plywood gussets.

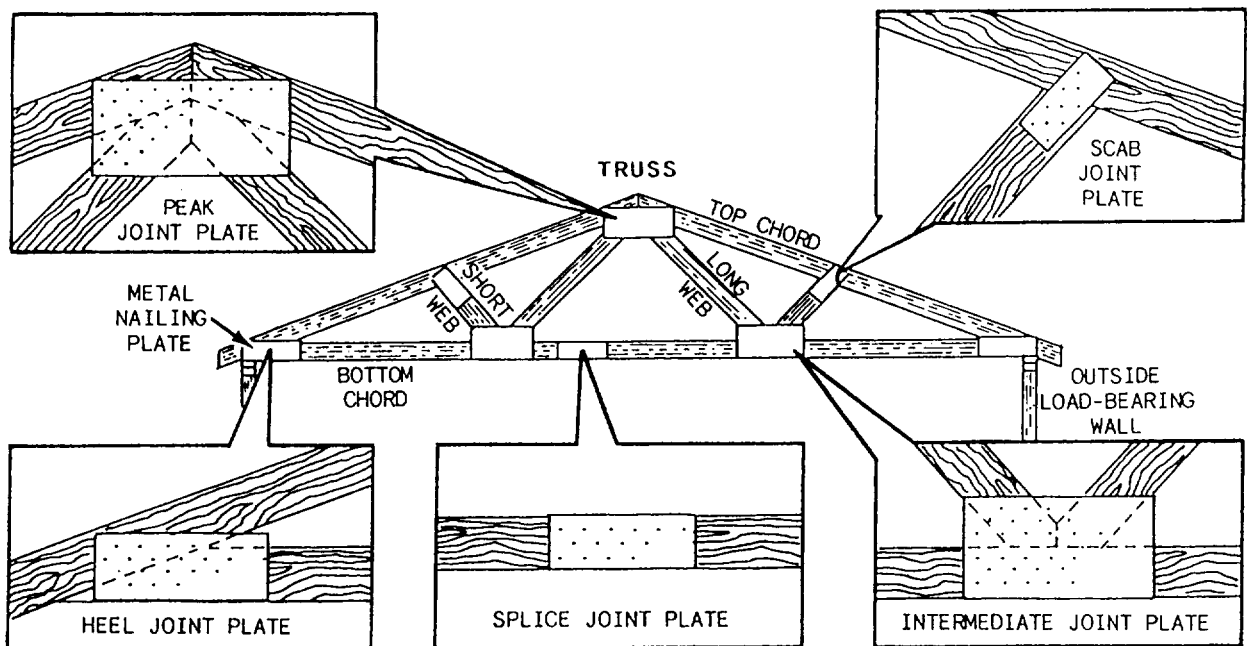


Figure 2-65. Metal gusset plates.

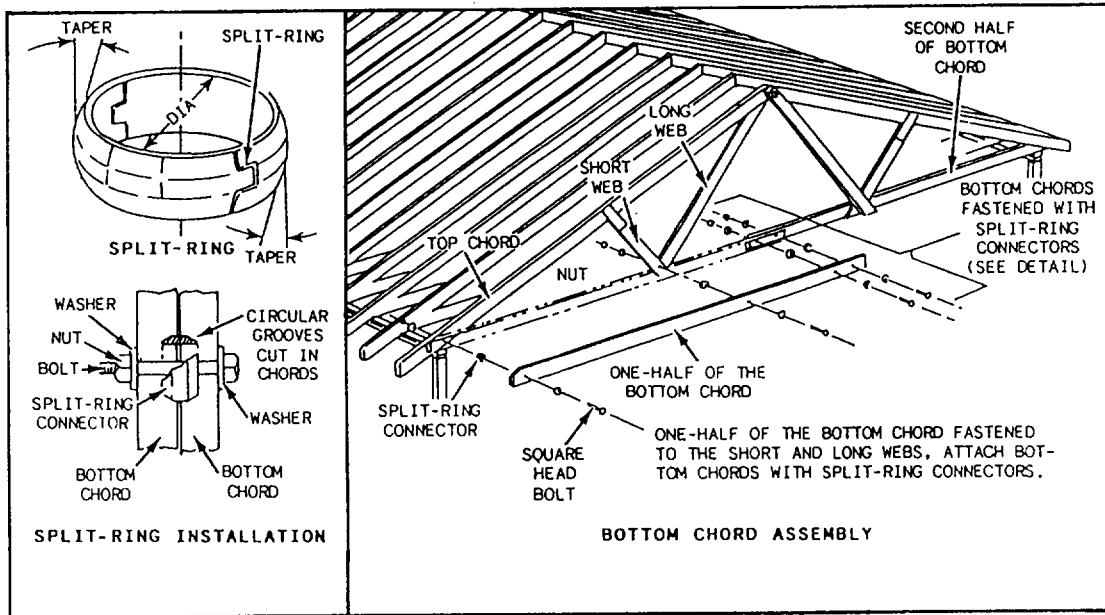


Figure 2-66.—Truss members fastened together with split-ring connectors.

A great majority of the trusses used are fabricated with plywood gussets (fig. 2-64, views A through E), nailed, glued, or bolted in place. Metal gusset plates (fig. 2-65) are also used. These are flat pieces usually manufactured from 20-gauge zinc-coated or galvanized steel. The holes for the nails are prepunched. Others are assembled with split-ring connectors (fig. 2-66) that prevent any movement of the members. Some trusses are designed with a 2- by 4-inch soffit return at the end of each upper chord to provide nailing for the soffit of a wide box cornice.

Tension and Compression

Each part of a truss is in a state of either tension or compression (see fig. 2-67). The parts in a state of tension are subjected to a pulling-apart force. Those under compression are subjected to a pushing-together force. The balance of tension and compression gives the truss its ability to carry heavy loads and cover wide spans.

In view A of figure 2-67, the ends of the two top chords (A-B and A-C) are being pushed together (compressed). The bottom chord prevents the lower ends (B and C) of the top chords from pushing out; therefore, the bottom chord is in a pulling-apart state (tension). Because the lower ends of the top chords cannot pull apart, the peak of the truss (A) cannot drop down.

In view B, the long webs are secured to the peak of the truss (A) and also fastened to the bottom chord at

points D and E. This gives the bottom chord support along the outside wall span. The weight of the bottom chord has a pulling-apart effect (tension) on the long webs.

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

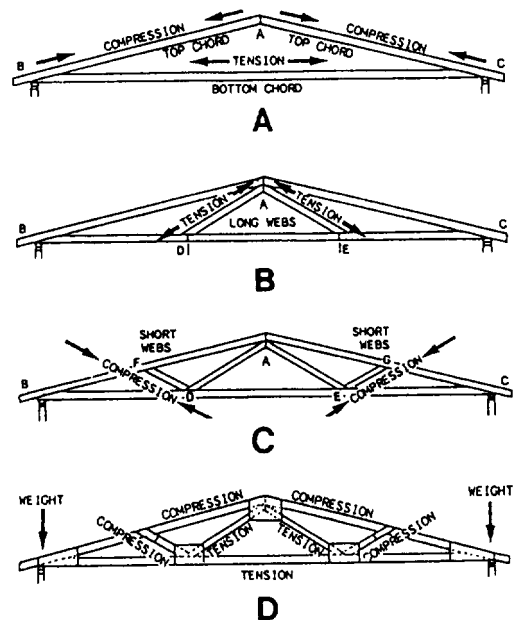


Figure 2-67.—Tension and compression in a truss.

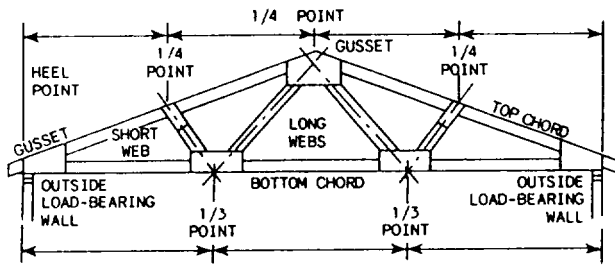


Figure 2-68.-Layout for a W-type (fink) truss.

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

Web members must be fastened at certain points along the top and bottom chords in order to handle the stress and weight placed upon the truss. A typical layout for a W-type (fink) truss is shown in figure 2-68. The points at which the lower ends of the web members fasten to the bottom chord divide the bottom chord into

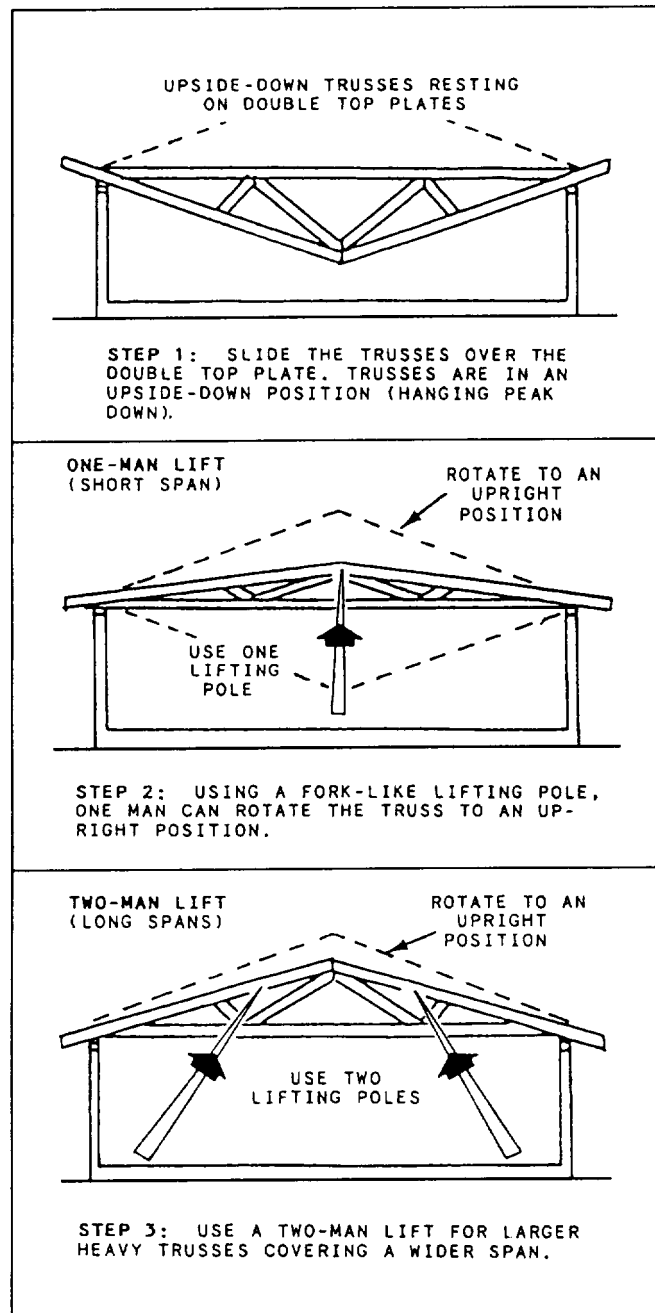


Figure 2-69.—Placing trusses by hand.

three equal parts. Each short web meets the top chord at a point that is one-fourth the horizontal distance of the bottom chord.

FABRICATION

The construction features of a typical W-truss are shown in figure 2-64. Also shown are gusset cutout sizes and nailing patterns for nail-gluing. The span of this truss is 26 feet and roof cut is 4/12. When spaced 24 inches apart and made of good-quality 2- by 4-inch members, the trusses should be able to support a total roof load of 40 pounds per square foot.

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

Plywood-gusset, king-post trusses are limited to spans of 26 feet or less if spaced 24 inches apart and fabricated with 2- by 4-inch members and a 4/12 roof cut. The spans are somewhat less than those allowed for W-trusses having the same-sized members. The shorter span for the king-post truss is due, in part, to the unsupported upper chord. On the other hand, because it has more members than the king-post truss and

distances between connections are shorter, the W-truss can span up to 32 feet without intermediate support, and its members can be made of lower grade lumber.

INSTALLATION

Trusses are usually spaced 24 inches OC. They must be lifted into place, fastened to the walls, and braced. Small trusses can be placed by hand, using the procedure shown in figure 2-69. Builders are required on the two opposite walls to fasten the ends of the trusses. One or two workers on the floor below can push the truss to an upright position. If appropriate equipment is available, use it to lift trusses into place.

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

Bracing

After the truss bundles have been set on the walls, they are moved individually into position, nailed down, and temporarily braced. Without temporary bracing, a truss may topple over, cause damage to the truss, and possibly injure workers. A recommended procedure for bracing trusses as they are being set in place is shown in figure 2-70. Refer to the figure as you study the following steps:

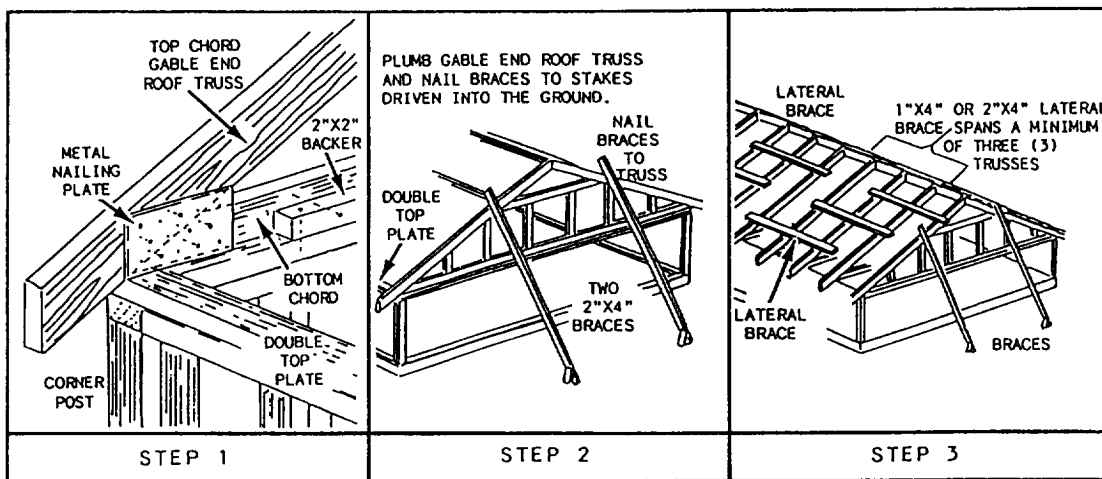


Figure 2-70.—Installing roof trusses and temporary bracing.

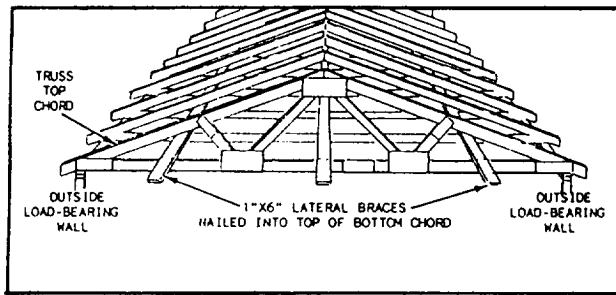


Figure 2-71.—Permanent lateral bracing in a truss.

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

The temporary bracing is removed as the roof sheathing is nailed. Properly nailed plywood sheathing is sufficient to tie together the top chords of the trusses. Permanent lateral bracing of 1- by 4-inch material is recommended at the bottom chords (fig. 2-71). The braces are tied to the end walls and spaced 10 feet OC.

Anchoring Trusses

When fastening trusses, you must consider resistance to uplift stresses as well as thrust. Trusses are fastened to the outside walls with nails or framing anchors. The ring-shank nail provides a simple connection that resists wind uplift forces. Toe nailing is sometimes done, but this is not always the most satisfactory method. The heel gusset and a plywood gusset or metal gusset plate are located at the wall plate and make toenailing difficult. However, two 10d nails on each side of the truss (fig. 2-72, view A) can be used

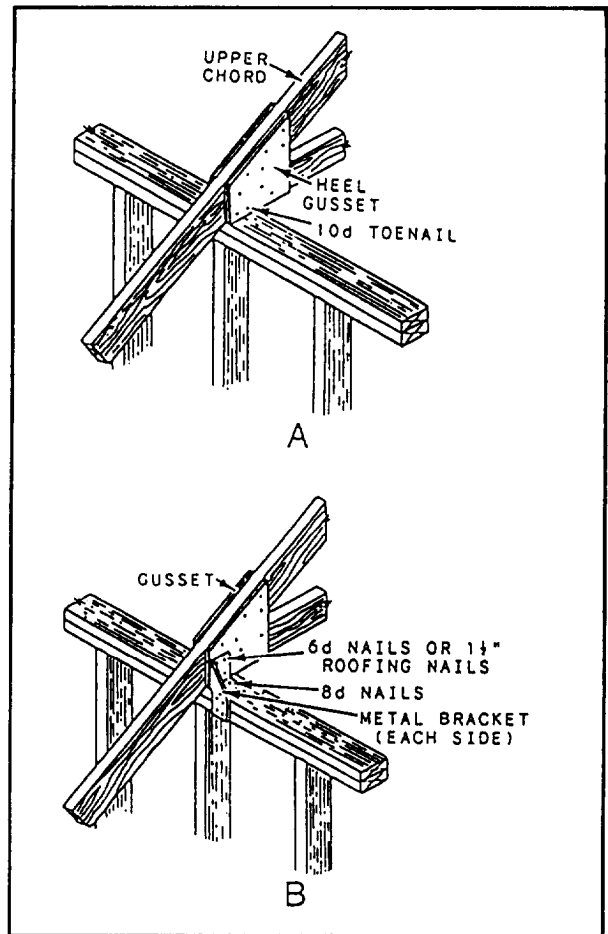


Figure 2-72.—Fastening trusses to the plate: A. Toenailing; B. Metal bracket.

in nailing the lower chord to the plate. Predrilling may be necessary to prevent splitting. Because of the single-member thickness of the truss and the presence of gussets at the wall plates, it is usually a good idea to use some type of metal connector to supplement the toenailings.

The same types of metal anchors (fig. 2-72, view B) used to tie regular rafters to the outside walls are equally effective for fastening the ends of the truss. The brackets are nailed to the wall plates at the side and top with 8d nails and to the lower chords of the truss with 6d or 1 1/2-inch roofing nails.

INTERIOR PARTITION INSTALLATION

Where partitions run parallel to, but between, the bottom truss chords, and the partitions are erected before the ceiling finish is applied, install 2- by 4-inch blocking

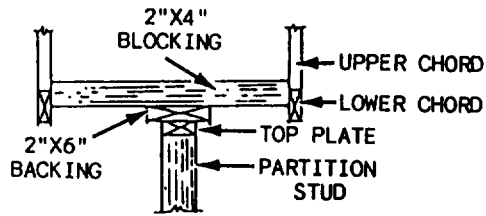


Figure 2-73.-Construction details for partitions that run parallel to the bottom truss chords.

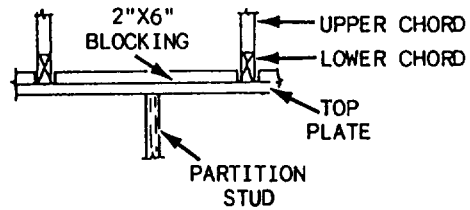


Figure 2-74.-Construction details for partitions that run at right angles to the bottom of the truss chords.

between the lower chords (fig. 2-73). This blocking should be spaced not over 4 feet OC. Nail the blocking to the chords with two 16d nails in each end. To provide nailing for lath or wallboard, nail a 1- by 6-inch or 2- by 6-inch continuous backer to the blocking. Set the bottom face level with the bottom of the lower truss chords.

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

If the partitions run at right angles to the bottom of the truss chords, the partitions are nailed directly to lower chord members. For applying ceiling finish, nail

2- by 6-inch blocking on top of the partition plates between the trusses (fig. 2-74).

RECOMMENDED READING LIST

NOTE

Although the following reference was current when this TRAMAN was published, its continued currency cannot be assured. You therefore need to ensure that you are studying the latest revision.

Basic Roof Framing, Benjamin Barnow, Tab Books, Inc., Blue Ridge Summit, Pa., 1986.

CHAPTER 3

ROOF CONSTRUCTION AND TRIM CARPENTRY

The previous chapters have dealt with framing wood structures, including joists, studs, rafters, and other structural members. These constitute “rough carpentry” and are the main supports of a wood-frame structure. (Subflooring and wall and roof sheathing strengthen and brace the frame.)

The remaining work on the structure involves installing the nonstructural members. This work, referred to as “finish carpentry,” includes installing the roof covering, door and window frames, and the doors and windows themselves. Some nonstructural members are purely ornamental, such as casings on doors and windows, and the moldings on cornices and inside walls. Installation of purely ornamental members is known as trim carpentry.

Finish carpentry is divided into exterior and interior finish. Exterior finish material consist of roof sheathing, exterior trim, roof coverings, outside wall covering, and exterior doors and windows. Exterior finish materials are installed after the rough carpentry has been completed. Examples of interior finish materials include all coverings applied to the rough walls, ceilings, and floors. We will cover these topics in a later chapter.

In this chapter, we'll cover the exterior finishing of roofs. In the next chapter, we'll examine the exterior finishing of walls.

ROOF SHEATHING

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify various types of roof sheathing and describe their installation requirements.

Roof sheathing covers the rafters or roof joists. The roof sheathing is a structural element and, therefore, part of the framing. Sheathing provides a nailing base for the finish roof covering and gives rigidity and strength to the roof framing. Lumber and plywood roof sheathing are the most commonly used materials for pitched roofs. Plank or laminated roof decking is sometimes used in structures with exposed ceilings. Manufactured wood fiber roof decking is also adaptable to exposed ceiling applications.

LUMBER

Roof sheathing boards are generally No. 3 common or better. These are typically softwoods, such as Dougls fir, redwood, hemlock, western larch, fir, and spruce. If you're covering the roof with asphalt shingles, you should use only thoroughly seasoned wood for the sheathing. Unseasoned wood will dry and shrink which may cause the shingles to buckle or lift along the full length of the sheathing board.

Nominal 1-inch boards are used for both flat and pitched roofs. Where flat roofs are to be used for a deck or a balcony, thicker sheathing boards are required. Board roof sheathing, like board wall sheathing and subflooring, can be laid either horizontally or diagonally. Horizontal board sheathing may be closed (laid with no space between the courses) or open (laid with space between the courses). In areas subject to wind-driven snow, a solid roof deck is recommended.

Installation

Roof boards used for sheathing under materials requiring solid, continuous support must be laid closed. This includes such applications as asphalt shingles, composition roofing, and sheet-metal roofing. Closed roof sheathing can also be used for wood shingles. The boards are nominal 1 inch by 8 inches and may be square-edged, dressed and matched, shiplapped, or tongue and groove. Figure 3-1 shows the installation of both closed and open lumber roof sheathing.

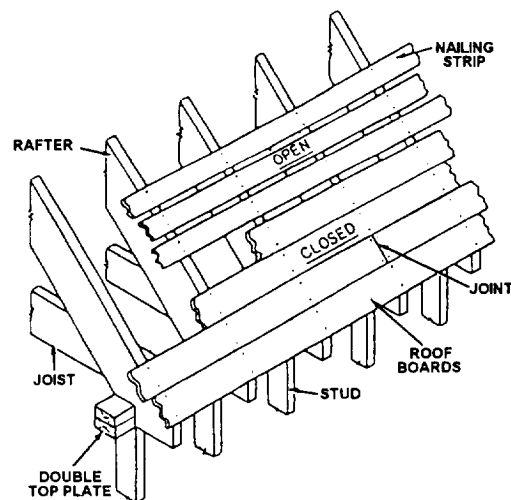


Figure 3-1. Closed and open roof sheathing.

Open sheathing can be used under wood shingles or shakes in blizzard-free areas or damp climates. Open sheathing usually consists of 1- by 4-inch strips with the on-center (OC) spacing equal to the shingle weather exposure, but not over 10 inches. (A 10-inch shingle lapped 4 inches by the shingle above it is said to be laid 6 inches to the weather.) When applying open sheathing, you should lay the boards without spacing to a point on the roof above the overhang.

Nailing

Nail lumber roof sheathing to each rafter with two 8-penny (8d) nails. Joints must be made on the rafters just as wall sheathing joints must be made over the studs. When tongue-and-groove boards are used, joints may be made between rafters. In no case, however, should the joints of adjoining boards be made over the same rafter space. Also, each board should bear on at least two rafters.

PLYWOOD

Plywood offers design flexibility, construction ease, economy, and durability. It can be installed quickly over large areas and provides a smooth, solid base with a minimum number of joints. A plywood deck is equally effective under any type of shingle or built-up roof. Waste is minimal, contributing to the low in-place cost.

Plywood is one of the most common roof sheathing materials in use today. It comes in 4- by 8-foot sheets in a variety of thicknesses, grades, and qualities. For sheathing work a lower grade called CDX is usually used. A large area (32 square feet) can be applied at one time. This, plus its great strength relative to other sheathing materials, makes plywood a highly desirable choice.

The thickness of plywood used for roof sheathing is determined by several factors. The distance between rafters (spacing) is one of the most important. The larger the spacing, the greater the thickness of sheathing that should be used. When 16-inch OC rafter spacing is used, the minimum recommended thickness is 3/8 inch. The type of roofing material to be applied over the sheathing also plays a role. The heavier the roof covering, the thicker the sheathing required. Another factor determining sheathing thickness is the prevailing weather. In areas where there are heavy ice and snow loads, thicker sheathing is required. Finally, you have to consider allowable dead and live roof loads established by calculations and tests.

These are the controlling factors in the choice of roof sheathing materials. Recommended spans and plywood grades are shown in table 3-1.

Installation

Plywood sheathing is applied after rafters, collar ties, gable studs, and extra bracing (if necessary) are in place. Make sure there are no problems with the roof frame. Check rafters for plumb, make sure there are no badly deformed rafters, and check the tail cuts of all the rafters for alignment. The crowns on all the rafters should be in one direction—up.

Figure 3-2 shows two common methods of starting the application of sheathing at the roof eaves. In view A, the sheathing is started flush with the tail cut of the rafters. Notice that when the fascia is placed, the top edge of the fascia is even with the top of the sheathing. In view B, the sheathing overlaps the tail end of the rafter by the thickness of the fascia material. You can see that the edge of the sheathing is flush with the fascia.

If you choose to use the first method (view A) to start the sheathing, measure the two end rafters the width of the plywood panel (48 inches). From the rafter tail ends, and using the chalk box, strike a line on the top edge of all the rafters. If you use the second method,

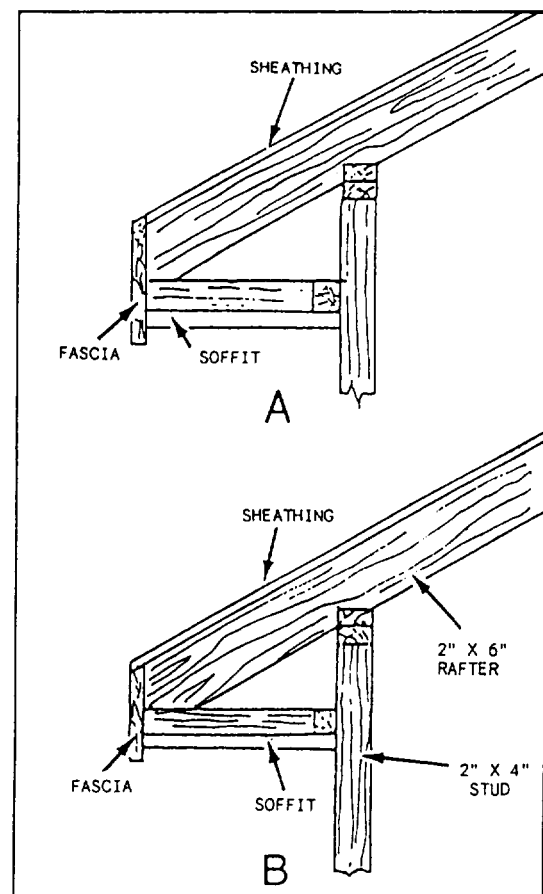


Figure 32.—Two methods of starting the first sheet of roof sheathing at the eaves of a roof: A. Flush with rafter; B. Overlapping rafter.

Table 3-1.-Plywood Roof Sheathing Application Specifications

Plywood roof sheathing ^{1,2,3} (Plywood continuous over two or more spans; grain of face plies across supports)														
PANEL IDENTIFICATION INDEX	PLYWOOD THICKNESS (Inch)	MAX. SPAN (Inches) ⁴	UNSUPPORTED EDGE-MAX. LENGTH (Inches) ⁵	ALLOWABLE ROOF LOADS (psf) ^{6,7}										
				Spacing of Supports (Inches center to center)										
				12	16	20	24	30	32	36	42	48	60	72
12/0	5/16	12	12	100 (130)										
16/0	5/16, 3/8	16	16	130 (170)	55 (75)									
20/0	5/16, 3/8	20	20		85 (110)	45 (55)								
24/0	3/8, 1/2	24	24		150 (160)	75 (100)	45 (60)							
30/12	5/8	30	26			145 (165)	85 (110)	40 (55)						
32/16	1/2, 5/8	32	28				90 (105)	45 (60)	40 (50)					
36/16	3/4	36	30				125 (145)	65 (85)	55 (70)	35 (50)				
42/20	5/8, 3/4 7/8	42	32				80 (105)	65 (90)	45 (60)	(35) (40)				
48/24	3/4, 7/8	48	36					105 (115)	75 (90)	55 (55)	40 (40)			
2-4-1	1 1/8	72	48						175 (175)	105 (105)	80 (80)	50 (50)	30 (35)	
1 1/8 G1&2	1 1/8	72	48						145 (145)	85 (85)	65 (65)	40 (40)	30 (30)	
1 1/4 G3&4	1 1/4	72	48						160 (165)	95 (95)	75 (75)	45 (45)	25 (35)	

- Notes: 1. Applies to Standard, Structural I and II and C-C grades only
2. For applications where the roofing is to be guaranteed by a performance bond, recommendations may differ somewhat from these values. Contact American Plywood Association for bonded roof recommendations
3. Use 6d common smooth, ring-shank or spiral thread nails for plywood 1/2" thick or less, and 8d common smooth, ring-shank or spiral thread for panels over 1/2" but not exceeding 1" thick (if ring-shank or spiral thread nails same diameter as common). Use 8d ring-shank or spiral thread or 10d common smooth shank nails for 2-4-1, 1 1/8" and 1 1/4" panels. Space nails 6" at panel edges and 12" at intermediate supports except those where spans are 48" or more, nails must be 6" at all supports
4. These spans must not be exceeded for any load conditions
5. Provide adequate blocking, tongue-and-groove edges or other suitable edge support, such as ply clips when spans exceed indicated value. Use two ply clips for 48" or greater spans and one for lesser spans
6. Uniform load deflection limitation: 1/180th of the span under live load plus dead load. 1/240th under live load only. In the table, allowable live load is shown above with allowable total load shown below in parentheses
7. Allowable roof loads were established by laboratory tests and calculations assuming evenly distributed loads

measure the width of the panel minus the actual thickness of the fascia material. Use this chalk line to position the upper edge of the sheathing panels. If the roof rafters are at right angles to the ridge and plates, this line will place the sheathing panels parallel to the outer ends of the rafters.

WARNING

Be particularly careful when handling sheet material on a roof during windy conditions. You may be thrown off balance and possibly off the roof entirely. Also, the sheet may be blown off the roof and strike someone.

Placing

Notice in figure 3-2 that sheathing is placed before the trim is applied. Sheathing is always placed from the lower (eaves) edge of the roof up toward the ridge. It can be started from the left side and worked toward the right, or you can start from the right and work toward the left. Usually, it is started at the same end of the house from which the rafters were laid out.

The first sheet of plywood is a full 4- by 8-foot panel. The top edge is placed on the chalk line. If the sheathing is started from the left side of the roof, make sure the right end falls in the middle of a rafter. This must be done so that the left end of the next sheet has a surface upon which it can bear weight and be nailed.

The plywood is placed so that the grain of the top ply is at right angles (perpendicular) to the rafters. Placing the sheathing in this fashion spans a greater number of rafters, spreads the load, and increases the strength of the roof. Figure 3-3 shows plywood panels laid perpendicular to the rafters with staggered joints. Note that a small space is left between sheets to allow for expansion.

The sheets that follow are butted against spacers until the opposite end is reached. If there is any panel hanging over the edge, it is trimmed after the panel is fastened in place. A chalk line is snapped on the sheathing flush with the end of the house, and the panel is then cut with a circular saw. Read the manufacturer's specification stamp and allow proper spacing at the ends and edges of the sheathing. This will compensate for any swelling that might take place with changes in moisture content.

The cutoff piece of sheathing can be used to start the second course (row of sheathing), provided it spans two or more rafters. If it doesn't span two rafters, start the second course with a half sheet (4 by 4) of plywood.

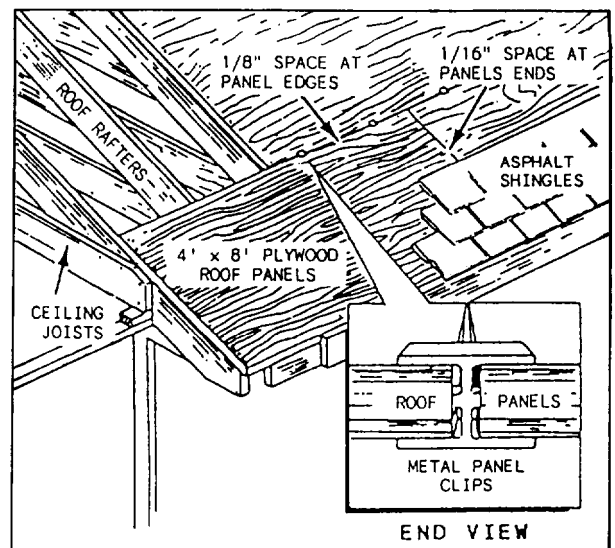


Figure 3-3. Plywood roofing panel installation.

It is important to stagger all vertical joints. All horizontal joints need blocking placed underneath or a metal clip (ply clip). Ply clips (H clips or panel clips) are designed to strengthen the edges of sheathing panels between supports or rafters. The use of clips is determined by the rafter spacing and specifications (see figure 3-3).

The pattern is carried to the ridge. The final course is fastened in place, a chalk line is snapped at the top edge of the rafters, and the extra material cut off. The opposite side of the roof is then sheathed using the same pattern.

Nailing

When nailing plywood sheathing, follow the project specifications for nailing procedures. Use 6d common smooth, ring-shank or spiral thread nails for plywood 1/2 inch thick or less. For plywood more than 1/2 inch but not exceeding 1 inch thick, use 8d common smooth, ring-shank or spiral thread nails. When using a nail gun for roof sheathing, follow all applicable safety regulations.

ROOF DECKING

In this section, we'll discuss the two most common types of roof decking you will encounter as a Builder: plank and wood fiber.

Plank

Plank roof decking, consisting of 2-inch (and thicker) tongue-and-groove planking, is commonly

used for flat or low-pitched roofs in post-and-beam construction. Single tongue-and-groove decking in nominal 2 by 6 and 2 by 8 sizes is available with the V-joint pattern only.

Decking comes in nominal widths of 4 to 12 inches and in nominal thicknesses of 2 to 4 inches. Three- and 4-inch roof decking is available in random lengths of 6 to 20 feet or longer (odd and even).

Laminated decking is also available in several different species of softwood lumber: Idaho white pine, inland red cedar, Idaho white fir, ponderosa pine, Douglas fir, larch, and yellow pine. Because of the laminating feature, this material may have a facing of one wood species and back and interior laminations of different woods. It is also available with all laminations of the same species. For all types of decking, make sure the material is the correct thickness for the span by checking the manufacturer's recommendations. Special load requirements may reduce the allowable spans. Roof decking can serve both as an interior ceiling finish and as a base for roofing. Heat loss is greatly reduced by adding fiberboard or other rigid insulation over the wood decking.

INSTALLATION.— Roof decking applied to a flat roof should be installed with the tongue away from the worker. Roof decking applied to a sloping roof should be installed with the tongue up. The butt ends of the pieces are bevel cut at approximately a 2° angle (fig. 3-4). This provides a bevel cut from the face to the back to ensure a tight face butt joint when the decking is laid in a random-length pattern. If there are three or more supports for the decking, a controlled random laying pattern (shown in figure 3-5) can be used. This is an economical pattern because it makes use of random-plank lengths, but the following rules must be observed:

- Stagger the end joints in adjacent planks as widely as possible and not less than 2 feet.
- Separate the joints in the same general line by at least two courses.
- Minimize joints in the middle one-third of all spans.
- Make each plank bear on at least one support.
- Minimize the joints in the end span.

The ability of the decking to support specific loads depends on the support spacing, plank thickness, and span arrangement. Although two-span continuous layout offers structural efficiency, use of random-length

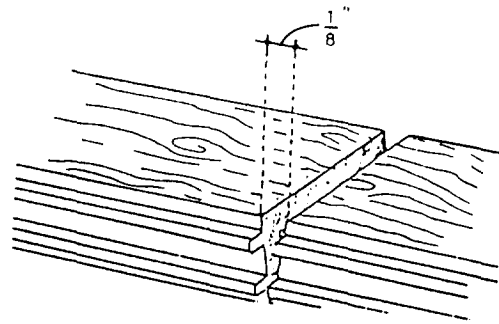
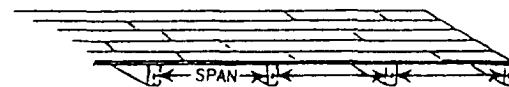


Figure 3-4.—Ends of roof decking cut at a 2° angle.



DOUBLE SPAN



CONTROLLED RANDOM PATTERN

Figure 3-5.—Plank decking span arrangements.

planks is the most economical. Random-length double tongue-and-groove decking is used when there are three or more spans. It is not intended for use over single spans, and it is not recommended for use over double spans (see figure 3-5).

NAILING.— Fasten decking with common nails twice as long as the nominal plank thickness. For widths 6 inches or less, toenail once and face-nail once at each support. For widths over 6 inches, toenail once and face-nail twice. Decking 3 and 4 inches thick must be predrilled and toenailed with 8-inch spikes. Bright common nails may be used, but dipped galvanized common nails have better holding power and reduce the possibility of rust streaks. End joints not over a support should be side-nailed within 10 inches of each plank end. Splines are recommended on end joints of 3- and 4-inch material for better alignment, appearance, and strength.

Wood Fiber

All-wood fiber roof decking combines strength and insulation advantages that make possible quality construction with economy. This type of decking is weather resistant and protected against termites and rot.

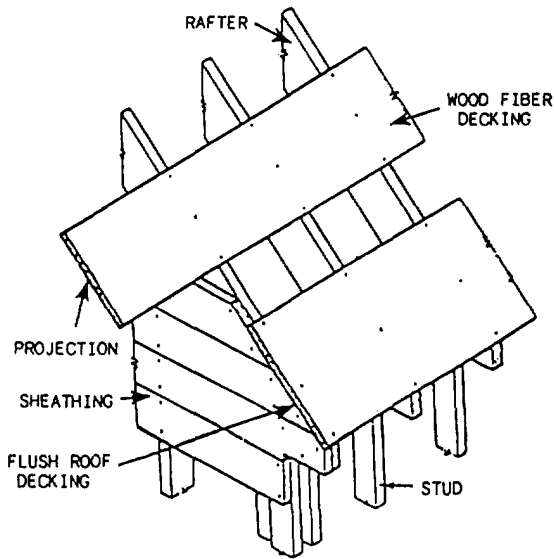


Figure 3-6. Wood fiber roof decking at gable ends.

It is ideally suited for built-up roofing, as well as for asphalt and wood shingles on all types of buildings. Wood fiber decking is available in four thicknesses: 2 3/8 inches, 1 7/8 inches, 1 3/8 inches, and 15/16 inch. The standard panels are 2 inches by 8 feet with tongue-and-groove edges and square ends. The surfaces are coated on one or both sides at the factory in a variety of colors.

INSTALLATION.—Wood fiber roof decking is laid with the tongue-and-groove joint at right angles to the support members. The decking is started at the cave line with the groove edge opposite the applicator. Staple wax paper in position over the rafter before installing the roof deck. The wax paper protects the exposed interior finish of the decking if the beams are to be stained. Caulk the end joints with a nonstaining caulking compound. Butt the adjacent piece up against the caulked joint. Drive the tongue-and-groove edges of each unit firmly together with a wood block cut to fit the grooved edge of the decking. End joints must be made over a support member.

NAILING.— Although the wood fiber roof panels have tongue-and-groove edges, they are nailed through the face into the wood, rafters, or trusses. Face-nail 6 inches OC with 6d nails for 15/16-inch, 8d for 1 3/8-inch, 10d for 1 7/8-inch, and 16d for 2 3/8-inch thicknesses.

If you aren't going to apply the finish roofing material immediately after the roof is sheathed, cover the deck with building felt paper. The paper will protect the sheathing in case of rain. Wet panels tend to separate.

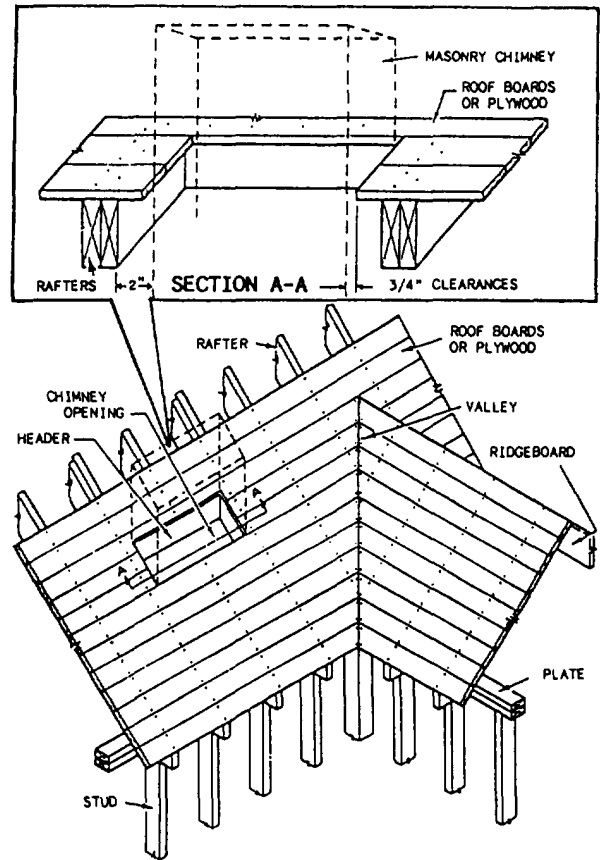



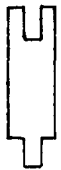

Figure 3-7. Sheathing details at chimney and valley openings.

Roof decking that extends beyond gable-end walls for the overhang should span not less than three rafter spaces. This is to ensure anchorage to the railers and to prevent sagging (see figure 3-6). When the projection is greater than 16 to 20 inches, special ladder framing is used to support the sheathing.

Table 3-2. Determining Roof Area from a Plan

RISE (Inches)	FACTOR	RISE	FACTOR
3"	1.031	8"	1.202
3 1/2"	1.042	8 1/2"	1.225
4"	1.054	9"	1.250
4 1/2"	1.068	9 1/2"	1.275
5"	1.083	10"	1.302
5 1/2"	1.100	10 1/2"	1.329
6"	1.118	11"	1.357
6 1/2"	1.137	11 1/2"	1.385
7"	1.158	12"	1.414
7 1/2"	1.179		

Table 3-3.-Lumber Sheathing Specifications and Estimating Factor

	NOMINAL SIZE	WIDTH		AREA FACTOR
		Dress	Face	
Shiplap 	1 × 6	5 7/16	4 15/16	1.22
	1 × 8	7 1/8	6 5/8	1.21
	1 × 10	9 1/8	8 5/8	1.16
	1 × 12	11 1/8	10 5/8	1.13
Tongue and Groove 	1 × 4	3 7/16	3 3/16	1.26
	1 × 6	5 7/16	5 3/16	1.16
	1 × 8	7 1/8	6 7/8	1.16
	1 × 10	9 1/8	8 7/8	1.13
	1 × 12	11 1/8	10 7/8	1.10
S4S 	1 × 4	3 1/2	3 1/2	1.14
	1 × 6	5 1/2	5 1/2	1.09
	1 × 8	7 1/4	7 1/4	1.10
	1 × 10	9 1/4	9 1/4	1.08
	1 × 12	11 1/4	11 1/4	1.07

Plywood extension beyond the end wall is usually governed by the rafter spacing to minimize waste. Thus, a 16-inch rake (gable) projection is commonly used when rafters are spaced 16 inches OC. Butt joints of the plywood sheets should be alternated so they do not occur on the same rafter.

DETAILS AT CHIMNEY AND VALLEY OPENINGS

Where chimney openings occur in the roof structure, the roof sheathing should have a 3/4-inch clearance on all sides from the finished masonry. Figure 3-7 shows sheathing details at the valley and chimney opening. The detail at the top shows the clearances between masonry and wood-framing members. Framing members should have a 2-inch clearance for fire protection. The sheathing should be securely nailed to the rafters and to the headers around the opening.

Wood or plywood sheathing at the valleys and hips should be installed to provide a tight joint and should be securely nailed to hip and valley rafters. This provides a smooth solid base for metal flashing.

ESTIMATING SHEATHING MATERIAL

To figure the roof area without actually getting on the roof and measuring, find the dimensions of the roof on the plans. Multiply the length times the width of the roof, including the overhang. Then multiply by the factor shown opposite the rise of the roof in table 3-2. The result will be the roof area.

For example, assume a building is 70 feet long and 30 feet wide (including the overhang), and the roof has a rise of 5 1/2 inches: 70 feet x 30 feet = 2,100 square feet. For arise of 5 1/2 inches, the factor on the chart is 1.100:2,100 square feet x 1.100=2,310 square feet. So, the total area to be covered is 2,310 square feet. Use this total area for figuring roofing needs, such as sheathing, felt underpayment, or shingles.

Lumber Sheathing

To decide how much lumber will be needed, first calculate the total area to be covered. Determine the size boards to be used, then refer to table 3-3. Multiply the total area to be covered by the factor from the chart. For example, if 1- by 8-inch tongue-and-groove sheathing

Table 3-4. Plank Decking Estimating Factor

SIZE	AREA FACTOR
2" × 6"	2.40
2" × 8"	2.29
3" × 6"	3.43
4" × 6"	4.57

boards are to be used, multiply the total roof area by 1.16. To determine the total number of board feet needed, add 5 percent for trim and waste.

Plywood Sheathing

To determine how much plywood will be needed, find the total roof area to be covered and divide by 32 (the number of square feet in one 4-by 8-foot sheet of plywood). This gives you the number of sheets required to cover the area. Be sure to add 5 percent for a trim and waste allowance.

Decking or Planking

To estimate plank decking, first determine the area to be covered, then refer to the chart in table 3-4. In the left column, find the size planking to be applied. For example, if 2- by 6-inch material is selected, the factor is 2.40. Multiply the area to be covered by this factor and add a 5 percent trim and waste allowance.

Wood Fiber Roof Decking

To estimate the amount of wood fiber decking required, first find the total roof area to be covered. For every 100 square feet of area, you will need 6.25 panels, 2 by 8 feet in size. So, divide the roof area by 100 and multiply by 6.25. Using our previous example with a roof area of 2,310 square feet, you will need 145 panels.

EXTERIOR TRIM

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of cornices and material used in their construction.

Exterior trim includes door and window trim, cornice trim, fascia boards and soffits, and rake or gable-end trim. Contemporary designs with simple cornices and moldings contain little of this material;

traditional designs have considerably more. Much of the exterior trim, in the form of finish lumber and moldings, is cut and fitted on the job. Other materials or assemblies, such as shutters, louvers, railings, and posts, are shop fabricated and arrive on the job ready to be fastened in place.

The properties desired in materials used for exterior trim are good painting and weathering characteristics, easy working qualities, and maximum freedom from warp. Decay resistance is desirable where materials may absorb moisture. Heartwood from cedar, cypress, and redwood has high decay resistance. Less durable species can be treated to make them decay resistant. Many manufacturers pre-dip materials, such as siding, window sash, door and window frames, and trim, with a water-repellent preservative. On-the-job dipping of end joints or miters cut at the building site is recommended when resistance to water entry and increased protection are desired.

Rust-resistant trim fastenings, whether nails or screws, are preferred wherever they may be in contact with weather. These include galvanized, stainless steel, or aluminum fastenings. When a natural finish is used, nails should be stainless steel or aluminum to prevent staining and discoloration. Cement-coated nails are not rust-resistant.

Siding and trim are normally fastened in place with a standard siding nail, which has a small flathead. However, finish or casing nails might also be used for some purposes. Most of the trim along the shingle line, such as at gable ends and cornices, is installed before the roof shingles are applied.

The roof overhangs (eaves) are the portions of the roof that project past the sidewalls of the building. The cornice is the area beneath the overhangs. The upward slopes of the gable ends are called rakes. Several basic designs are used for finishing off the roof overhangs and cornices. Most of these designs come under the category of open cornice or closed cornice. They not only add to the attractiveness of a building but also help protect the sidewalls of the building from rain and snow. Wide overhangs also shade windows from the hot summer sun.

Cornice work includes the installation of the lookout ledger, lookouts, plancier (soffit), ventilation screens, fascia, frieze, and the moldings at and below the eaves, and along the sloping sides of the gable end (rake). The ornamental parts of a cornice are called cornice trim and consist mainly of molding; the molding running up the side of the rakes of a gable roof is called gable cornice trim. Besides the main roof, the additions and dormers may have cornices and cornice trim.

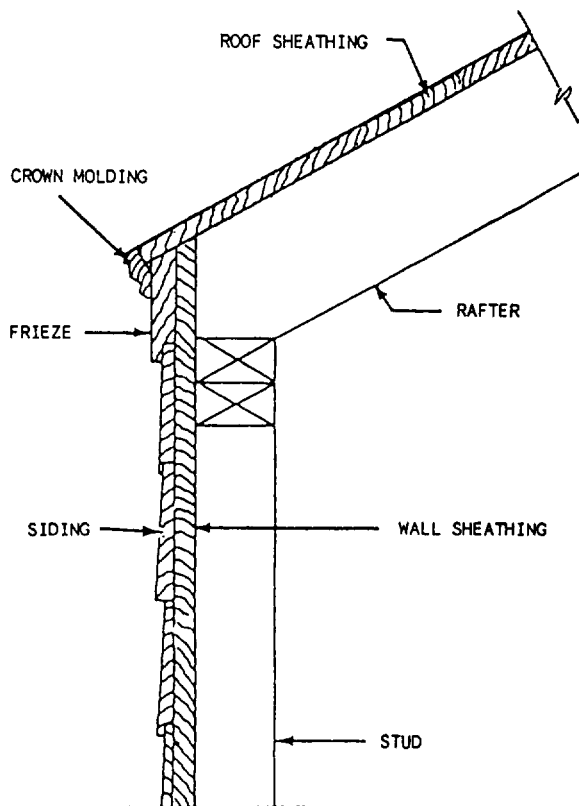


Figure 3-8.-Simple cornice.

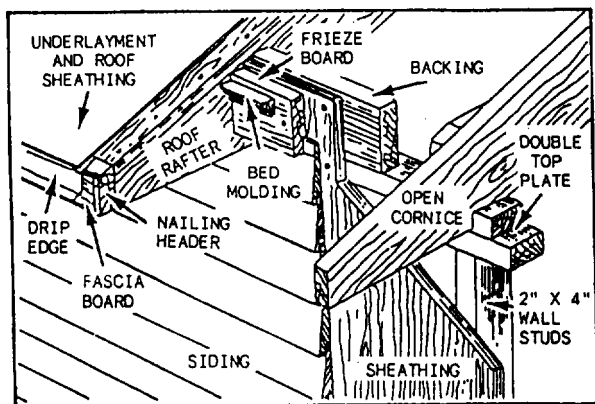
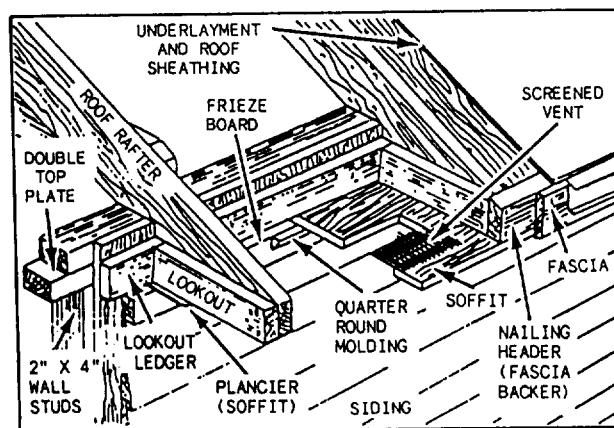


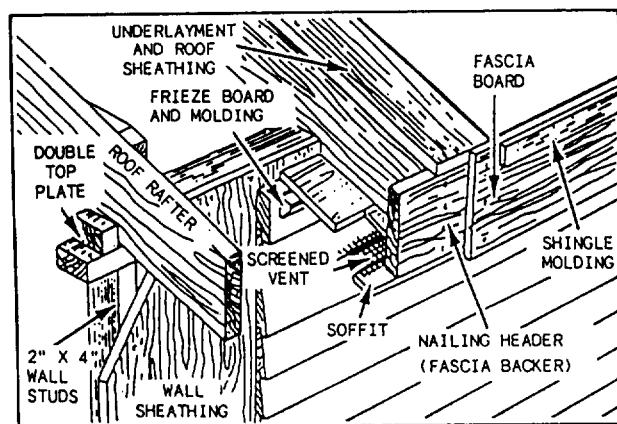
Figure 3-9.-Open cornice.

CORNICES

The type of cornice required for a particular structure is indicated on the wall sections of the drawings, and there are usually cornice detail drawings as well. A roof with no rafter overhang or cave usually has the simple cornice shown in figure 3-8. This cornice consists of a single strip or board called a frieze. It is beveled on the upper edge to fit under the overhang or cave and rabbeted on the lower edge to overlap the upper edge of the top course of siding. If trim is used, it usually consists of molding placed as shown in figure 3-8. Molding trim in this position is called crown molding.



A



B

Figure 3-10.-Closed cornices: A. Flat boxed cornice; B. Sloped boxed cornice.

A roof with a rafter overhang may have an open cornice or a closed (also called a box) cornice. In open-cornice construction (fig. 3-9), the undersides of the rafters and roof sheathing are exposed. A nailing header (fascia backer) is nailed to the tail ends of the rafters to provide a straight and solid nailing base for the fascia board. Most spaces between the rafters are blocked off. Some spaces are left open (and screened) to allow attic ventilation. Usually, a frieze board is nailed to the wall below the rafters. Sometimes the frieze board is notched between the rafters and molding is nailed over it. Molding trim in this position is called bed molding. In closed-cornice construction, the bottom of the roof overhang is closed off. The two most common types of closed cornices are the flat boxed cornice and the sloped boxed cornice (shown in figure 3-10, views A and B, respectively).

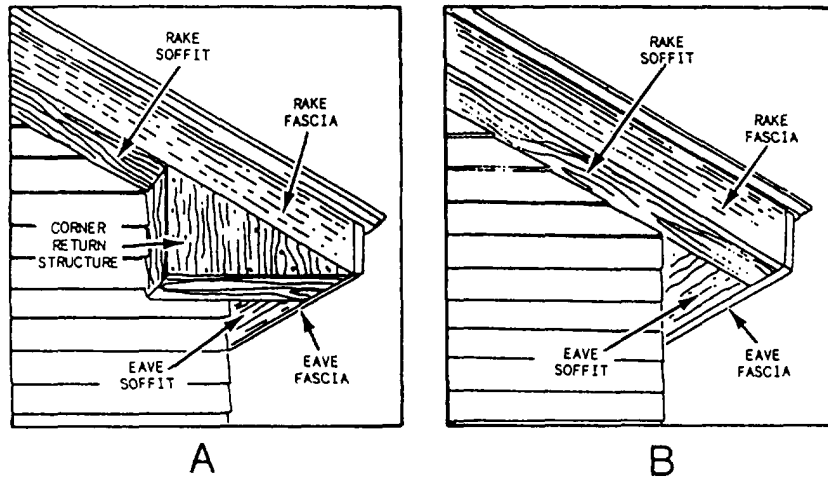


Figure 3-11.-Cornice construction: A. Finish rake for boxed cornice; B. Rake soffit of a sloped box cornice.

The flat boxed cornice requires framing pieces called lookouts. These are toenailed to the wall or to a lookout ledger and face-nailed to the ends of the rafters. The lookouts provide a nailing base for the soffit, which is the material fastened to the underside of the cornice. A typical flat boxed cornice is shown in figure 3-10, view A. For a sloped boxed cornice, the soffit material is nailed directly to the underside of the rafters (fig. 3-10, view B). This design is often used on buildings with wide overhangs.

The basic rake trim pieces are the frieze board, trim molding, and the fascia and soffit material. Figure 3-11, view A, shows the finish rake for a flat boxed cornice. It requires a cornice return where the eave and rake soffits join. View B shows the rake of a sloped boxed cornice. Always use rust-resistant nails for exterior finish work. They may be aluminum, galvanized, or cadmium-plated steel.

PREFABRICATED WOOD AND METAL TRIM

Because cornice construction is time-consuming, various prefabricated systems are available that provide a neat, trim appearance. Cornice soffit panel materials include plywood, hardboard, fiberboard, and metal. Many of these are factory-primed and available in a variety of standard widths (12 to 48 inches) and in lengths up to 12 feet. They also may be equipped with factory-installed screen vents.

When installing large sections of wood fiber panels, you should fit each panel with clearance for expansion. Nail 4d rust-resistant nails 6 inches apart along the edges and intermediate supports (lookouts). Strut nailing at the

end butted against a previously placed panel. First, nail the panel to the main supports and then along the edges. Drive nails carefully so the underside of the head is just flush with the panel surface. Remember, this is finish work; no hammer head marks please. Always read and follow manufacturer's directions and recommended installation procedures. Cornice trim and soffit systems are also available in aluminum and come in a variety of prefinished colors and designs.

Soffit systems made of prefinished metal panels and attachment strips are common. They consist of three basic components wall hanger strips (also called frieze strips); soffit panels (solid, vented, or combination); and fascia covers. Figure 3-12 shows the typical installation configuration of the components. Soffit panels include a vented area and are available in a variety of lengths.

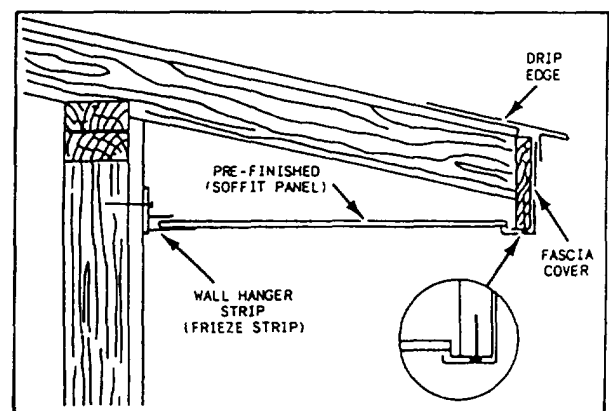


Figure 3-12.-Basic components of prefinished metal soffit system.

To install a metal panel system, first snap a chalk line on the sidewall level with the bottom edge of the fascia board. Use this line as a guide for nailing the wall hanger strip in place. Insert the panels, one at a time, into the wall strip. Nail the outer end to the bottom edge of the fascia board.

After all soffit panels are in place, cut the fascia cover to length and install it. The bottom edge of the cover is hooked over the end of the soffit panels. It is then nailed in place through prepunched slots located along the top edge. Remember to use nails compatible with the type of material being used to avoid electrolysis between dissimilar metals. Again, always study and follow the manufacturer's directions when making an installation of this type.

ROOFING TERMS AND MATERIALS

LEARNING OBJECTIVE: Upon completing this section, you should be able to define roofing terms and identify roofing materials.

The roof covering, or roofing, is a part of the exterior finish. It should provide long-lived waterproof protection for the building and its contents from rain, snow, wind, and, to some extent, heat and cold.

Before we begin our discussion of roof coverings, let's first look at some of the most common terms used in roof construction.

TERMINOLOGY

Correct use of roofing terms is not only the mark of a good worker, but also a necessity for good construction. This section covers some of the more common roofing terms you need to know.

Square

Roofing is estimated and sold by the square. A square of roofing is the amount required to cover 100 square feet of the roof surface.

Coverage

Coverage is the amount of weather protection provided by the overlapping of shingles. Depending on the kind of shingle and method of application, shingles may furnish one (single coverage), two (double coverage), or three (triple coverage) thicknesses of

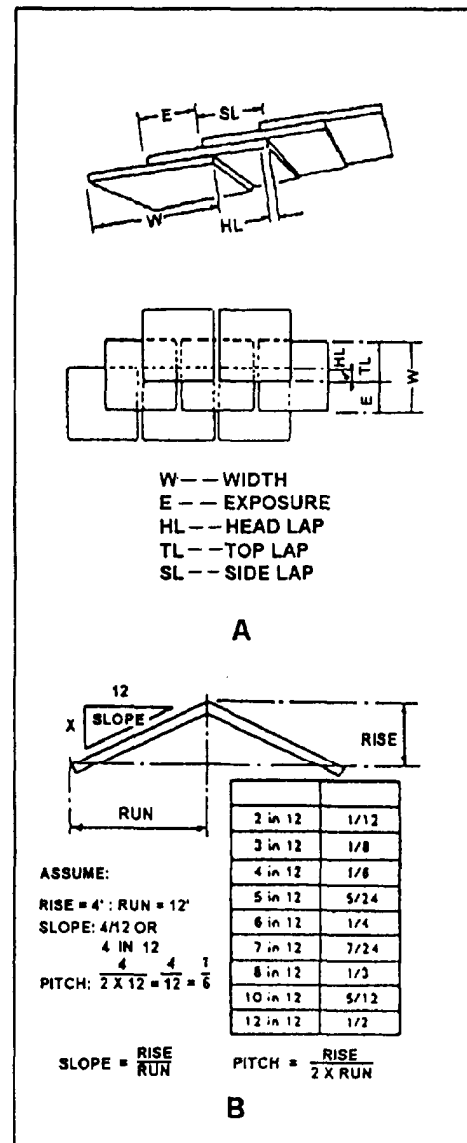


Figure 3-13.-Roofing terminology: A. Surfaces; B. Slope and pitch.

material over the roof surface. Shingles providing single coverage are suitable for re-roofing over existing roofs. Shingles providing double and triple coverage are used for new construction. Multiple coverage increases weather resistance and provides a longer service life.

Shingle Surfaces

The various surfaces of a shingle are shown in view A of figure 3-13. "Shingle width" refers to the total measurement across the top of either a strip type or individual type of shingle. The area that one shingle overlaps a shingle in the course (row) below it is referred to as "top lap." "Side lap" is the area that one shingle

overlaps a shingle next to it in the same course. The area that one shingle overlaps a shingle two courses below it is known as head lap. Head lap is measured from the bottom edge of an overlapping shingle to the nearest top edge of an overlapped shingle. "Exposure" is the area that is exposed (not overlapped) in a shingle. For the best protection against leakage, shingles (or shakes) should be applied only on roofs with a unit rise of 4 inches or more. A lesser slope creates slower water runoff, which increases the possibility of leakage as a result of windblown rain or snow being driven underneath the butt ends of the shingles.

Slope

"Slope" and "pitch" are often incorrectly used synonymously when referring to the incline of a sloped roof. View B of figure 3-13 shows some common roof slopes with their corresponding roof pitches.

"Slope" refers to the incline of a roof as a ratio of vertical rise to horizontal run. It is expressed sometimes as a fraction but typically as X-in-12; for example, a 4-in-12 slope for a roof that rises at the rate of 4 inches for each foot (12 inches) of run. The triangular symbol above the roof in figure 3-13, view B, conveys this information.

Pitch

"Pitch" is the incline of a roof as a ratio of the vertical rise to twice the horizontal run. It is expressed as a fraction. For example, if the rise of a roof is 4 feet and the run 12 feet, the roof is designated as having a pitch of 1/6 ($4/24 = 1/6$).

MATERIALS

In completing roofing projects, you will be working with a number of different materials. In the following section, we will discuss the most common types of underlayments, flashing, roofing cements, and exterior materials you will encounter. We will also talk about built-up roofing.

Materials used for pitched roofs include shingles of asphalt, fiberglass, and wood. Shingles add color, texture, and pattern to the roof surface. To shed water, all shingles are applied to roof surfaces in some overlapping fashion. They are suitable for any roof with enough slope to ensure good drainage. Tile and slate are also popular. Sheet materials, such as roll roofing,

galvanized steel, aluminum, copper, and tin, are sometimes used. For flat or low-pitched roofs, composition or built-up roofing with a gravel topping or cap sheet are frequent combinations. Built-up roofing consists of a number of layers of asphalt-saturated felt mopped down with hot asphalt or tar. Metal roofs are sometimes used on flat decks of dormers, porches, or entryways.

The choice of materials and the method of application are influenced by cost, roof slope, expected service life of the roofing, wind resistance, fire resistance, and local climate. Because of the large amount of exposed surface of pitched roofs, appearance is also important.

Underlayments

There are basically four types of underlayments you will be working with as a Builder: asphalt felt, organic, glass fiber, and tarred.

Once the roof sheathing is in place, it is covered with an asphalt felt underpayment commonly called roofing felt. Roofing felt is asphalt-saturated and serves three basic purposes. First, it keeps the roof sheathing dry until the shingles can be applied. Second, after the shingles have been laid, it acts as a secondary barrier against wind-driven rain and snow. Finally, it also protects the shingles from any resinous materials, which could be released from the sheathing.

Roofing felt is designated by the weight per square. As we mentioned earlier, a square is equal to 100 square feet and is the common unit to describe the amount of roofing material. Roofing felt is commonly available in rolls of 15 and 30 pounds per square. The rolls are usually 36 inches wide. A roll of 15-pound felt is 144 feet long, whereas a roll of 30-pound felt is 72 feet long. After you allow for a 2-inch top lap, a roll of 15-pound felt will cover 4 squares; a roll of 30-pound felt will cover 2 squares.

Underpayment should be a material with low vapor resistance, such as asphalt-saturated felt. Do not use materials, such as coated felts or laminated waterproof papers, which act as a vapor barrier. These allow moisture or frost to accumulate between the underpayment and the roof sheathing. Underpayment requirements for different kinds of shingles and various roof slopes are shown in table 3-5.

Apply the underpayment as soon as the roof sheathing has been completed. For single underpayment, start at the eave line with the 15-pound felt. Roll across

Table 3-5.-Underlayment Recommendations for Shingle Roofs

TYPE OF ROOFING	SHEATHING	TYPE OF UNDERLAYMENT	NORMAL SLOPE		LOW SLOPE	
Asbestos-Cement Shingles	Solid	No. 15 asphalt saturated asbestos (inorganic) felt, OR No. 30 asphalt saturated felt	5/12 and up	Single layer over entire roof	3/12 to 5/12	Double layer over entire roof ¹
Asphalt/Fiberglass Shingles	Solid	No. 15 asphalt saturated felt	4/12 and up	Single layer over entire roof	2/12 to 4/12	Double layer over entire roof ²
Wood Shakes	Spaced	No. 30 asphalt saturated felt (interlayment)	4/12 and up	Underlayment starter course; interlayment over entire roof	Shakes not recommended on slopes less than 4/12 with spaced sheathing	
	Solid ^{3,5}	No. 30 asphalt saturated felt (interlayment)	4/12 and up	Underlayment starter course; interlayment over entire roof	3/12 to 4/12 ⁴	Single layer underlayment over entire roof; interlayment over entire roof
Wood Shingles	Spaced	None required	5/12 and up	None required	3/12 to 5/12 ⁴	None required
	Solid ⁵	No. 15 asphalt saturated felt	5/12 and up	None required ⁶	3/12 to 5/12 ⁴	None required ⁶
<p>Notes: 1. May be single layer on 4/12 slope in areas where outside design temperature is warmer than 0°F</p> <p>2. Square-butt strip shingles only; requires wind-resistant shingles or cemented tabs</p> <p>3. Recommended in areas subject to wind-driven snow</p> <p>4. Requires reduced weather exposure</p> <p>5. May be desirable for added insulation and to minimize air infiltration</p> <p>6. May be desirable for protection of sheathing</p>						

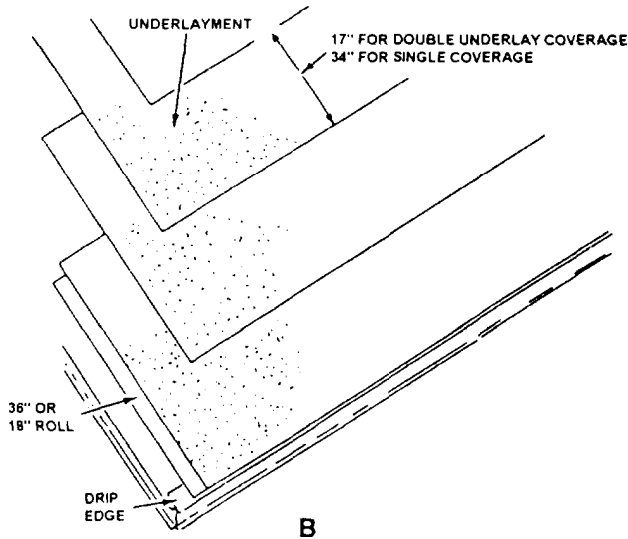
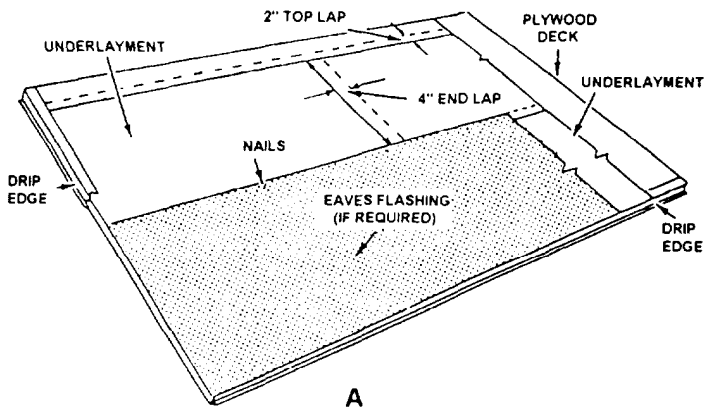


Figure 3-14.-Roofing underlayment: A. Single coverage; B. Double coverage.

the roof with atop lap of at least 2 inches at all horizontal points and a 4-inch side lap at all end joints (fig. 3-14, view A). Lap the underlayment over all hips and ridges 6 inches on each side. A double underpayment can be started with two layers at the cave line, flush with the fascia board or molding. The second and remaining strips have 19-inch head laps with 17-inch exposures (fig. 3-14, view B). Cover the entire roof in this manner. Make sure that all surfaces have double coverage. Use only enough fasteners to hold the underpayment in place until the shingles are applied. Do not apply shingles over wet underpayment.

In areas where moderate-to-severe snowfall is common and ice dams occur, melting snow refreezes at the cave line (fig. 3-15, view A). It is a good practice to apply one course of 55-pound smooth-surface roll roofing as a flashing at the eaves. It should be wide

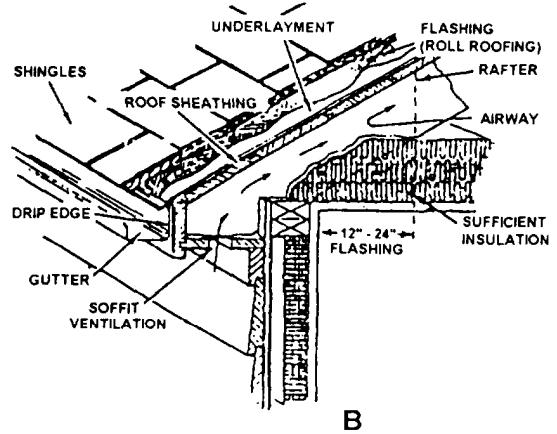
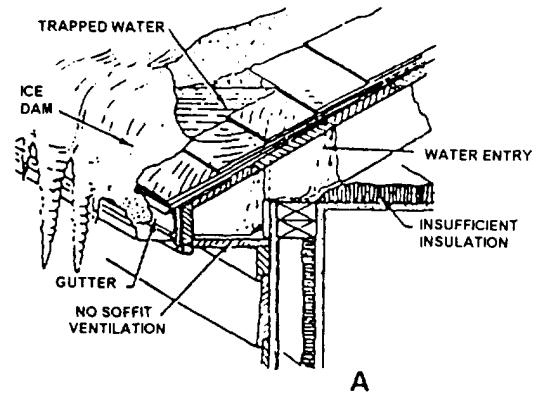


Figure 3-15.-Protection from ice dams A. Refreezing snow and ice; B. Cornice ventilation.

enough to extend from the roof edge to between 12 and 24 inches inside the wall line. The roll roofing should be installed over the underpayment and metal drip edge. This will lessen the chance of melting snow to back up under the shingles and fascia board of closed cornices. Damage to interior ceilings and walls results from this water seepage. Protection from ice dams is provided by cave flashing. Cornice ventilation by means of soffit vents and sufficient insulation will minimize the melting (fig. 3-15, view B).

ASPHALT FELT.— Roofing felts are used as underpayment for shingles, for sheathing paper, and for reinforcements in the construction of built-up roofs. They are made from a combination of shredded wood fibers, mineral fibers, or glass fibers saturated with asphalt or coal-tar pitch. Sheets are usually 36 inches wide and available in various weights from 10 to 50 pounds. These weights refer to weight per square (100 feet).

ORGANIC FELTS.— Asphalt-saturated felts composed of a combination of felted papers and organic

shredded wood fibers are considered felts. They are among the least expensive of roofing felts and are widely used not only as roofing, but also as water and vapor retarders. Fifteen-pound felt is used under wood siding and exterior plaster to protect sheathing or wood studs. It is generally used in roofing for layers or plies in gravel-surfaced assemblies and is available perforated. Perforated felts used in built-up roofs allow entrapped moisture to escape during application. Thirty-pound felt requires fewer layers in a built-up roof. It is usually used as underlayment for heavier cap sheets or tile on steeper roofs.

GLASS-FIBER FELTS.— Sheets of glass fiber, when coated with asphalt, retain a high degree of porosity, assuring a maximum escape of entrapped moisture or vapor during application and maximum bond between felts. Melted asphalt is applied so that the finished built-up roof becomes a monolithic slab reinforced with properly placed layers of glass fibers. The glass fibers, which are inorganic and do not curl, help create a solid mass of reinforced waterproof roofing material.

TARRED FELTS.— Coal-tar pitch saturated organic felts are available for use with bitumens of the same composition. Since coal-tar and asphalt are not compatible, the components in any construction must be limited to one bitumen or the other unless approved by the felt manufacturer.

Flashing

The roof edges along the eaves and rake should have a metal drip edge, or flashing. Flashing is specially constructed pieces of sheet metal or other materials used to protect the building from water seepage. Flashing must be made watertight and be water shedding. Flashing materials used on roofs may be asphalt-saturated felt, metal, or plastic. Felt flashing is generally used at the ridges, hips, and valleys. However, metal flashing, made of aluminum, galvanized steel, or copper, is considered superior to felt. Metal used for flashing must be corrosion resistant. It should be galvanized steel (at least 26 gauge), 0.019-inch-thick aluminum, or 16-ounce copper.

Flashing is available in various shapes (fig. 3-16, view A), formed from 26-gauge galvanized steel. It should extend back approximately 3 inches from the roof edge and bend downward over the edge. This causes the water to drip free of underlying cornice

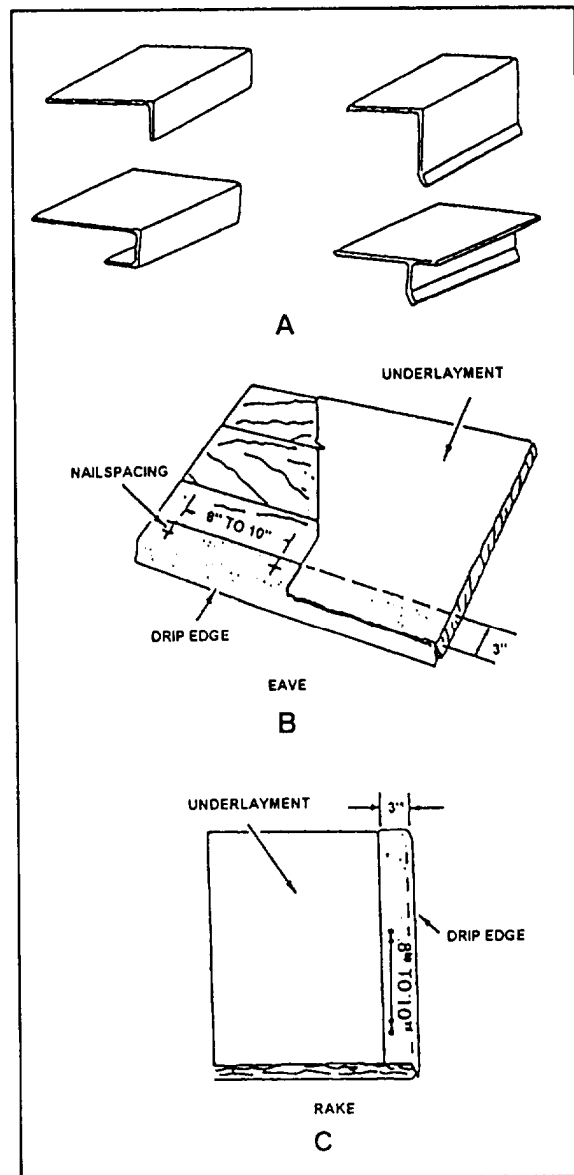


Figure 3-16.-Drip edges A. Basic shapes B. At the eave; C. At the rake.

construction. At the eaves, the underpayment should be laid over the drip edge (view B). At the rake (view C), place the underpayment under the drip edge. Galvanized nails, spaced 8 to 10 inches apart, are recommended for fastening the drip edge to the sheathing.

The shape and construction of different types of roofs can create different types of water leakage problems. Water leakage can be prevented by placing flashing materials in and around the vulnerable areas of the roof. These areas include the point of intersection between roof and soil stack or ventilator, the valley of a roof, around chimneys, and at the point where a wall intersects a roof.

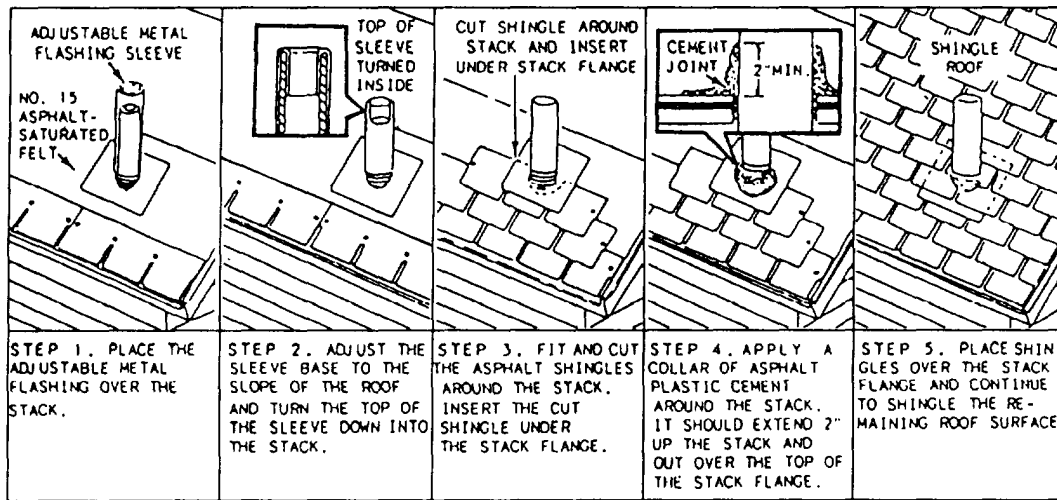


Figure 3-17.-Flashing around a roof projection.

As you approach a soil stack, apply the roofing up to the stack and cut it to fit (fig. 3-17). You then install a corrosion-resistant metal sleeve, which slips over the stack and has an adjustable flange to fit the slope of the roof. Continue shingling over the flange. Cut the shingles to fit around the stack and press them firmly into the cement.

The open or closed method can be used to construct valley flashing. A valley underpayment strip of 15-pound asphalt-saturated felt, 36 inches wide, is applied first. The strip is centered in the valley and secured with enough nails to hold it in place. The horizontal courses of underlayment are cut to overlap this valley strip a minimum of 6 inches.

Open valleys can be flashed with metal or with 90-pound mineral-surfaced asphalt roll roofing. The color can match or contrast with the roof shingles. An 18-inch-wide strip of mineral-surfaced roll roofing is placed over the valley underpayment. It is centered in the valley with the surfaced side down and the lower edge cut to conform to and be flush with the cave flashing. When it is necessary to splice the material, the ends of the upper segments are laid to overlap the lower segments 12 inches and are secured with asphalt plastic cement. This method is shown in figure 3-18. Only enough nails are used 1 inch in from each edge to hold the strip smoothly in place.

Another 36-inch-wide strip is placed over the first strip. It is centered in the valley with the surfaced side up and secured with nails. It is lapped the same way as the underlying 18-inch strip.

Before shingles are applied, a chalk line is snapped on each side of the valley. These lines should start 6 inches apart at the ridge and spread wider apart (at the rate of 1/8 inch per foot) to the eave (fig. 3-18). The

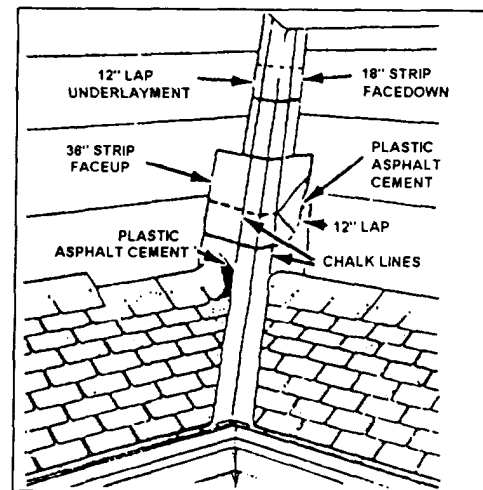


Figure 3-18.-Open valley flashing using roll roofing.

chalk lines serve as a guide in trimming the shingle units to fit the valley and ensure a clean, sharp edge. The upper corner of each end shingle is clipped to direct water into the valley and prevent water penetration between courses. Each shingle is cemented to the valley lining with asphalt cement to ensure a tight seal. No exposed nails should appear along the valley flashing.

Closed (woven) valleys can be used only with strip shingles. This method has the advantage of doubling the coverage of the shingles throughout the length of the valley. This increases the weather resistance at this vulnerable point. A valley lining made from a 36-inch-wide strip of 55-pound (or heavier) roll roofing is placed over the valley underpayment and centered in the valley (fig. 3-19).

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

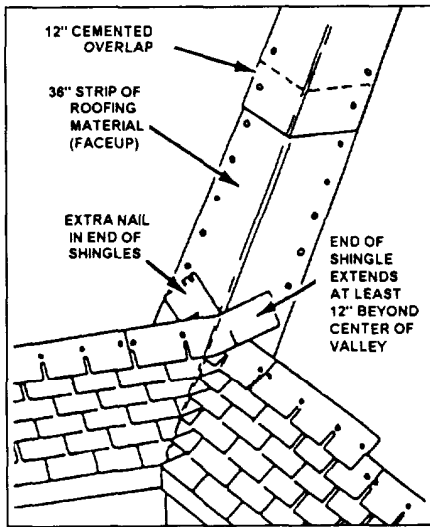


Figure 3-19.-Closed valley flashing.

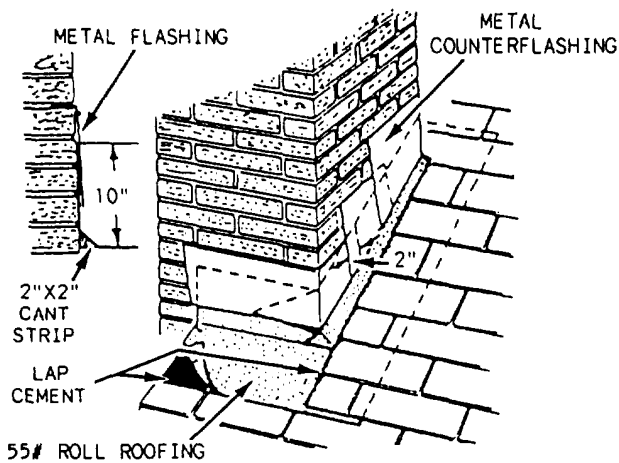


Figure 3-20.-Flashing around a chimney.

- They can be applied on both roof surfaces at the same time with each course, in turn, woven over the valley.
- Each surface can be covered to the point approximately 36 inches from the center of the valley and the valley shingles woven in place later.

In either case, the first course at the valley is laid along the eaves of one surface over the valley lining and extended along the adjoining roof surface for a distance of at least 12 inches. The first course of the adjoining roof surface is then carried over the valley on top of the previously applied shingle. Succeeding courses are then laid alternately, weaving the valley shingles over each other.

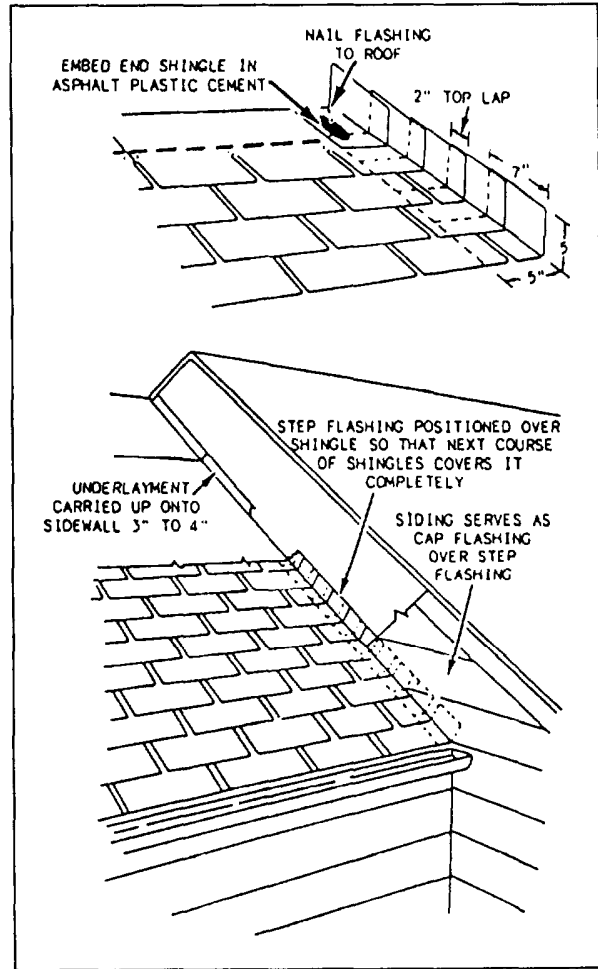


Figure 3-21.-Step flashing.

The shingles are pressed tightly into the valley and nailed in the usual manner. No nail should be located closer than 6 inches to the valley center line, and two nails should be used at the end of each terminal strip.

As you approach a chimney, apply the shingles over the felt up to the chimney face. If 90-pound roll roofing is to be used for flashing, cut wood cant strips and install them above and at the sides of the chimney (fig. 3-20). The roll roofing flashing should be cut to run 10 inches up the chimney. Working from the bottom up, fit metal counterflashing over the base flashing and insert it 1 1/2 inches into the mortar joints. Refill the joints with mortar or roofing cement. The counterflashing can also be installed when the chimney masonry work is done,

Where the roof intersects a vertical wall, it is best to install metal flashing shingles. They should be 10 inches long and 2 inches wider than the exposed face of the regular shingles. The 10-inch length is bent so that it will extend 5 inches over the roof and 5 inches up the wall (see figure 3-21). Apply metal flashing with each

course. This waterproofs the joint between a sloping roof and vertical wall. This is generally called step flashing.

As each course of shingles is laid, a metal flashing shingle is installed and nailed at the top edge as shown. Do not nail flashing to the wall; settling of the roof frame could damage the seal.

Wall siding is installed after the roof is completed. It also serves as a cap flashing. Position the siding just above the roof surface. Allow enough clearance to paint the lower edges.

Roof Cements

Roofing cements are used for installing cave flashing, for flashing assemblies, for cementing tabs of asphalt shingles and laps in sheet material, and for repairing roofs. There are several types of cement, including plastic asphalt cements, lap cements, quick-setting asphalt adhesives, roof coatings, and primers. The type and quality of materials and methods of application on a shingle roof should follow the recommendation of the manufacturer of the shingle roofing.

Exterior

Basically, exterior roof treatment consists of applying various products, including shingles, roll roofing, tiles, slate, and bituminous coverings. Treatment also includes specific construction considerations for ridges, hips, and valleys.

SHINGLES.— The two most common shingle types are asphalt and fiberglass, both of which come in various strip shapes.

Asphalt.— Asphalt (composition) shingles are available in several patterns. They come in strip form or as individual shingles. The shingles are manufactured on a base of organic felt (cellulose) or an inorganic glass mat. The felt or mat is covered with a mineral-stabilized coating of asphalt on the top and bottom. The top side is coated with mineral granules of specified color. The bottom side is covered with sand, talc, or mica.

Fiberglass.— Improved technologies have made the fiberglass mat competitive with organic felt. The weight and thickness of a fiberglass mat is usually less than that of organic felt. A glass fiber mat maybe 0.030 inch thick versus 0.055 inch thick for felt. The popularity of fiberglass-based shingles is their low cost. The mat does not have to be saturated in asphalt. ASTM standards specify 3 pounds per 100 feet. The

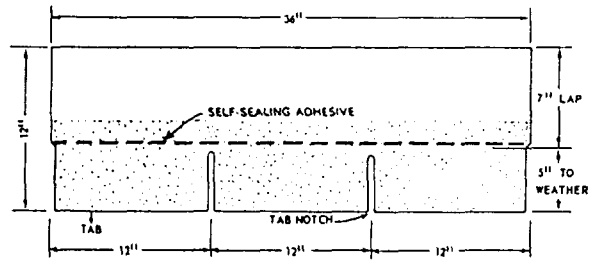


Figure 3-22.-A typical 12- by 36-inch shingle.

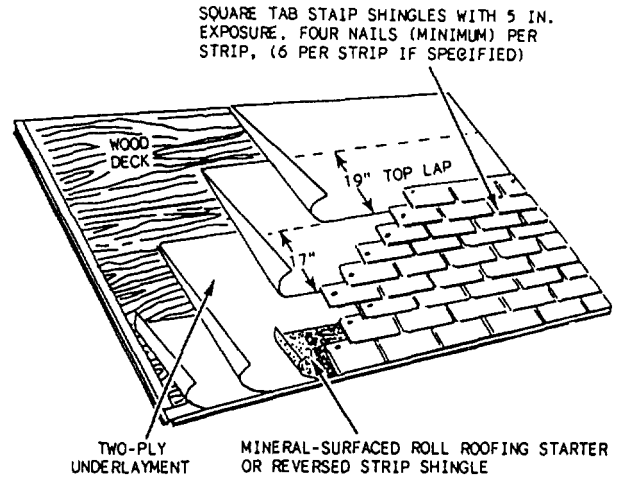


Figure 3-23.-Special shingle application.

combination of glass fiber mats with recently developed resins has significantly lowered the price of composition shingles.

Strip.— One of the most common shapes of asphalt or fiberglass shingles is a 12- by 36-inch strip (fig. 3-22) with the exposed surface cut or scored to resemble three 9-by 12- inch shingles. These are called strip shingles. They are usually laid with 5 inches exposed to the weather. A lap of 2 to 3 inches is usually provided over the upper edge of the shingle in the course directly below. This is called the head lap.

The thickness of asphalt shingles may be uniform throughout, or, as with laminated shingles, slotted at the butts to give the illusion of individual units. Strip shingles are produced with either straight-tab or random-tab design to give the illusion of individual units or to simulate the appearance of wood shakes. Most strip shingles have factory-applied adhesive spaced at intervals along the concealed portion of the strip. These strips of adhesive are activated by the warmth of the sun and hold the shingles firm through wind, rain, and snow.

Strip shingles are usually laid over a single thickness of asphalt-saturated felt if the slope of the roof

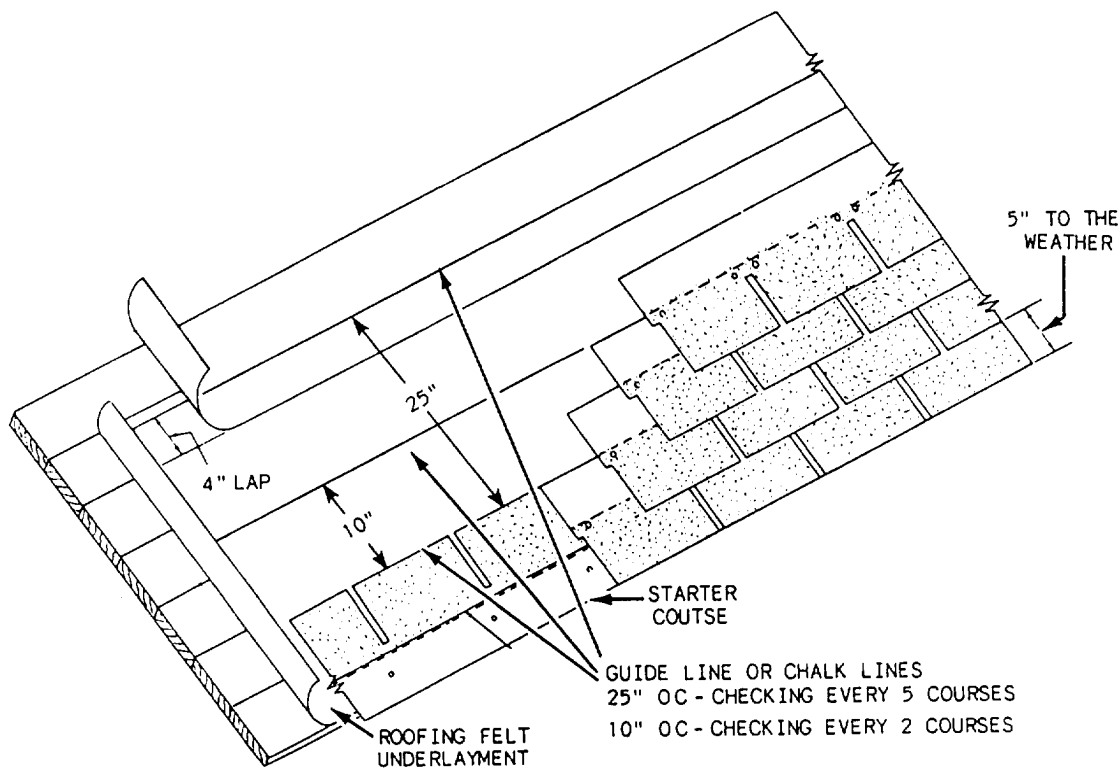


Figure 3-24.-Laying out a shingle roof.

is 4:12 or greater. When special application methods are used, organic- or inorganic-base-saturated or coated-strip shingles can be applied to decks having a slope of 4:12, but not less than 2:12. Figure 3-23 shows the application of shingles over a double layer of underpayment. Double underpayment is recommended under square-tab strip shingles for slopes less than 4:12.

When roofing materials are delivered to the building site, they should be handled with care and protected from damage. Try to avoid handling asphalt shingles in extreme heat or cold. They are available in one-third-square bundles, 27 strip shingles per bundle. Bundles should be stored flat so the strips will not curl after the bundles are open. To get the best performance from any roofing material, always study the manufacturer's directions and install as directed.

On small roofs (up to 30 feet long), strip shingles can be laid starting at either end. When the roof surface is over 30 feet long, it is usually best to start at the center and work both ways. Start from a chalk line perpendicular to the eaves and ridge.

Asphalt shingles will vary slightly in length (plus or minus 1/4 inch in a 36-inch strip). There may also be some variations in width. Thus, chalk lines are required

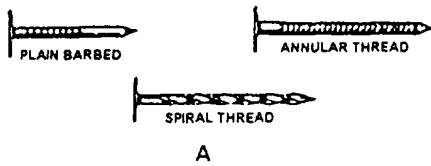
to achieve the proper horizontal and vertical placement of the shingles (fig. 3-24).

The first chalk line from the eave should allow for the starter strip and/or the first course of shingles to overhang the drip edge 1/4 to 3/8 inch.

When laying shingles from the center of the roof toward the ends, snap a number of chalk lines between the eaves and ridge. These lines will serve as reference marks for starting each course. Space them according to the shingle type and laying pattern.

Chalk lines, parallel to the eaves and ridge, will help maintain straight horizontal lines along the butt edge of the shingle. Usually, only about every fifth course needs to be checked if the shingles are skillfully applied. Inexperienced workers may need to set up chalk lines for every second course.

The purpose of a starter strip is to back up the first course of shingles and fill in the space between the tabs. Use a strip of mineral-surfaced roofing 9 inches or wider of a weight and color to match the shingles. Apply the strip so it overhangs the drip edge 1/4 to 3/8 inch above the edge. Space the nails so they will not be exposed at the cutouts between the tabs of the first course of shingles. Sometimes an inverted (tabs to ridge) row of shingles is used instead of the starter strip. When you



APPLICATION	1" SHEATHING	3/8" PLYWOOD
STRIP OR INDIVIDUAL SHINGLE (NEW CONSTRUCTION)	1 1/4"	7/8"
OVER ASPHALT ROOFING (REROOFING)	1 1/2"	1"
OVER WOOD SHINGLES (REROOFING)	1 3/4"	—

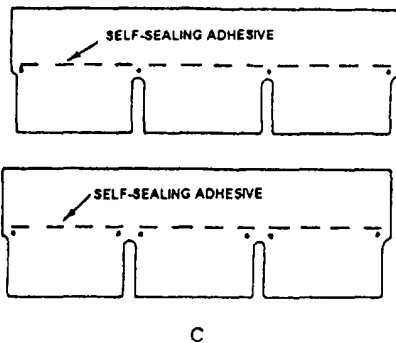


Figure 3-25. Nails suitable for installing strip shingles, recommended nail lengths, and nail placement.

are laying self-sealing strip shingles in windy areas, the starter strip is often formed by cutting off the tabs of the shingles being used. These units are then nailed in place, right side up, and provide adhesive under the tabs of the first course.

Nails used to apply asphalt roofing must have a large head (3/8- to 7/16-inch diameter) and a sharp point. Figure 3-25 shows standard nail designs (view A) and recommended lengths (view B) for nominal 1-inch sheathing. Most manufacturers recommend 12-gauge

galvanized steel nails with barbed shanks. Aluminum nails are also used. The length should be sufficient to penetrate the full thickness of the sheathing or 3/4 inch into the wood.

The number of nails and correct placement are both vital factors in proper application of roofing material. For three-tab square-butt shingles, use a minimum of four nails per strip (fig. 3-25, view C). Specifications may require six nails per shingle (view C). Align each shingle carefully and start the nailing from the end next to the one previously laid. Proceed across the shingle. This will prevent buckling. Drive nails straight so that the edge of the head will not cut into the shingle. The nail head should be driven flush, not sunk into the surface. If, for some reason, the nail fails to hit solid sheathing, drive another nail in a slightly different location.

WOOD SHINGLES AND SHAKES.— Wood shingles are available in three standard lengths: 16, 18, and 24 inches. The 16-inch length is the most popular. It has five-butt thicknesses per 2 inches of width when it is green (designated a 5/2). These shingles are packed in bundles. Four bundles will cover 100 square feet of wall or roof with 5-inch exposure. The 18- or 24-inch-long shingles have thicker butts—five in 2 1/4 inches for the 18-inch shingles and four in 2 inches for 24-inch shingles. The recommended exposures for the standard wood-shingle size are shown in table 3-6.

Figure 3-26 shows the proper method of applying a wood-shingle roof. Underpayment or roofing felt is not required for wood shingles except for protection in ice jam areas. Although spaced or solid sheathing is optional, spaced roof sheathing under wood shingles is most common. Observe the following steps when applying wood shingles:

1. Extend the shingles 1 1/2 inches beyond the cave line and 3/4 inch beyond the rake (gable) edge.

Table 3-6. Recommended Exposure for Wood Shingles

SHINGLE LENGTH	SHINGLE THICKNESS (Green)	MAXIMUM EXPOSURE	
		Slope less than 4 in 12	Slope 5 in 12 and over
Inches		Inches	Inches
16	5 butts in 2"	3 3/4	5
18	5 butts in 2 1/4"	4 1/4	5 1/2
24	4 butts in 2"	5 3/4	7 1/2

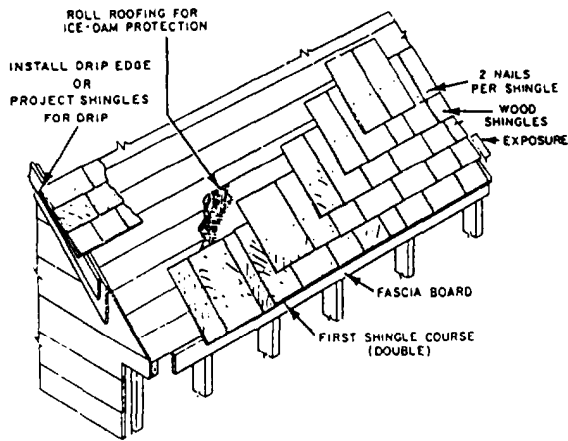


Figure 3-26.-Installation of wood shingles.

2. Use two rust-resistant nails in each shingle. Space them 3/4 inch from the edge and 1 1/2 inches above the butt line of the next course.
3. Double the first course of shingles. In all courses, allow 1/8- to 1/4-inch space between each shingle for expansion when they are wet. Offset the joints between the shingles at least 1 1/2 inches from the joints in the course below. In addition, space the joints in succeeding courses so that they do not directly line up with joints in the second course below.
4. Where valleys are present, shingle away from them. Select and precut wide valley shingles.
5. Use metal edging along the gable end to aid in guiding the water away from the sidewalls.
6. Use care when nailing wood shingles. Drive the nails just flush with the surface. The wood in shingles is soft and can be easily crushed and damaged under the nail heads.

Wood shakes are usually available in several types, but the split-and-resawed type is the most popular. The sawed face is used as the back face and is laid flat on the roof. The butt thickness of each shake ranges between 3/4 inch and 1 1/2 inches. They are usually packed in bundles of 20 square feet with five bundles to the square.

Wood shakes are applied in much the same way as wood shingles. Because shakes are much thicker (longer shakes have the thicker butts), use long galvanized nails. To create a rustic appearance, lay the butts unevenly. Because shakes are longer than shingles, they have greater exposure. Exposure distance is usually 7 1/2 inches for 18-inch shakes, 10 inches for 24-inch shakes,

and 13 inches for 32-inch shakes. Shakes are not smooth on both faces, and because wind-driven rain or snow might enter, it is essential to use an underpayment between each course. A layer of felt should be used between each course with the bottom edge positioned above the butt edge of the shakes a distance equal to double the weather exposure. A 36-inch-wide strip of the asphalt felt is used at the cave line. Solid sheathing should be used when wood shakes are used for roofs in areas where wind-driven snow is common.

ROLL ROOFING.— Roll roofing is made of an organic or inorganic felt saturated with an asphalt coating and has a viscous bituminous coating. Finely ground talc or mica can be applied to both sides of the saturated felt to produce a smooth roofing. Mineral granules in a variety of colors are rolled into the upper surface while the final coating is still soft. These mineral granules protect the underlying bitumen from the deteriorating effects of sun rays. The mineral aggregates are nonflammable and increase the fire resistance and improve the appearance of the underlying bitumen. Mineral-surfaced roll roofing comes in weights of 75 to 90 pounds per square. Roll roofing may have one surface completely covered with granules or have a 2-inch plain-surface salvage along one side to allow for laps.

Roll roofing can be installed by either exposed or concealed nailing. Exposed nailing is the cheapest but doesn't last as long. This method uses a 2-inch lap at the side and ends. It is cemented with special cement and nailed with large-headed nails. In concealed-nailing installations, the roll roofing is nailed along the top of the strip and cemented with lap cement on the bottom edge. Vertical joints in the roofing are cemented into place after the upper edge is nailed. This method is used when maximum service life is required.

Double-coverage roll roofing is produced with slightly more than half its surface covered with granules. This roofing is also known as 19-inch salvage edge. It is applied by nailing and cementing with special adhesives or hot asphalt. Each sheet is lapped 19 inches, blind-nailed in the lapped salvage portion, and then cemented to the sheet below. End laps are cemented into place.

TILES.— Roofing tile was originally a thin, solid unit made by shaping moist clay in molds and drying it in the sun or in a kiln. Gradually, the term has come to include a variety of tile-shaped units made of clay, Portland cement, and other materials. Tile designs have come down to us relatively unchanged from the Greeks and Romans. Roofing tiles are durable, attractive, and

Table 3-7.-Weight of Roofing Materials

MATERIAL	LB WEIGHT/SQUARE (100 sq ft)	KG WEIGHT/ 9.29 m ²
Tin	100	45
Roll roofing	100	45
Asphalt shingles	130-320	59-145
Copper	150	68
Corrugated iron	200	91
Wood shingles	300	136
Asbestos-cement shingles	500	227
Portland cement shingles	500-900	227-408
Built-up roof	600	272
Sheet lead	600-800	272-363
Slate		
1/4"	700	318
3/8"	1,000	454
3/4"	1,500	680
Flat clay tile	1200	544
Clay shingles	1,100-1,400	499-635
Spanish clay tile laid in mortar	1,900 2,900	862 1,315

resistant to fire; however, because of their weight (table 3-7), they usually require additional structural framing members and heavier roof decks.

Clay.— The clays used in the manufacture of roofing tile are similar to those used for brick. Unglazed tile comes in a variety of shades, from a yellow-orange to a deep red, and in blends of grays and greens. Highly glazed tiles are often used on prominent buildings and for landmark purposes.

Clay roofing tiles are produced as either flat or roll tile. Flat tile may be English (interlocking shingle) or French. Roll tiles are produced in Greek or Roman pan-and-cover, Spanish or Mission style (fig. 3-27).

Roll Tile.— Roll tile is usually installed over two layers of hot-mopped 15-pound felt. Double-coverage felts, laid shingle fashion, lapped 19 inches, and mopped with hot asphalt, may be required as an underpayment. The individual tiles are nailed to the sheathing through prepunched holes. Special shapes are available for starter courses, rakes, hips, and ridges. Some manufacturers produce tiles in special tile-and-a-half units for exposed locations, such as gables and hips.

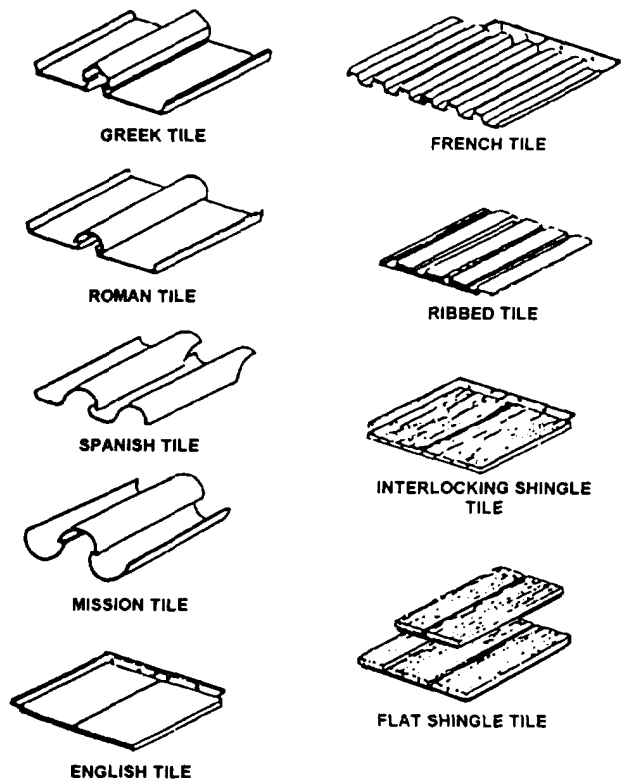


Figure 3-27.-Types of clay roof tiles.

Mission Tile.— Mission tiles are slightly tapered half-round units and are set in horizontal courses. The convex and concave sides are alternated to form pans and covers. The bottom edges of the covers can be laid with a random exposure of 6 to 14 inches to weather. Mission tile can be fastened to the prepared roof deck with copper nails, copper wire, or specially designed brass strips. The covers can be set in portland cement mortar. This gives the roof a rustic appearance, but it adds approximately 10 pounds per square to the weight of the finished roof.

Flat Tile.— Flat tile can be obtained as either flat shingle or interlocking. Single tiles are butted at the sides and lapped shingle fashion. They are produced in various widths from 5 to 8 inches with a textured surface to resemble wood shingles, with smooth colored surfaces, or with highly glazed surfaces. Interlocking shingle tiles have side and top locks, which permit the use of fewer pieces per square. The back of this type of tile is ribbed. This reduces the weight without sacrificing strength. Interlocking flat tile can be used in combination with lines of Greek pan-and-cover tile as accents.

Concrete.— The acceptance of concrete tile as a roofing material has been slow in the United States. However, European manufacturers have invested heavily in research and development to produce a uniformly high-quality product at a reasonable cost. Concrete tile is now used on more than 80 percent of all new residences in Great Britain. Modern high-speed machinery and techniques have revolutionized the industry in the United States, and American-made concrete tiles are now finding a wide market, particularly in the West.

Concrete roof tile, made of Portland cement, sand, and water, is incombustible. It is also a poor conductor of heat. These characteristics make it an ideal roofing material in forested or brushy areas subject to periodic threats of fire. In addition, concrete actually gains strength with age and is unaffected by repeated freezing and thawing cycles.

Color pigments may be mixed with the basic ingredients during manufacture. To provide a glazed surface, cementitious mineral-oxide pigments are sprayed on the tile immediately after it is extruded. This glaze becomes an integral part of the tile. The surface of these tiles may be scored to give the appearance of rustic wood shakes.

Most concrete tiles are formed with side laps consisting of a series of interlocking ribs and grooves.

These are designed to restrict lateral movement and provide weather checks between the tiles. The underside of the tile usually contains weather checks to halt wind-blown water. Head locks, in the form of lugs, overlap wood battens roiled to solid sheathing or strips of spaced sheathing. Nail holes are prepunched. The most common size of concrete tile is 12³/₈ by 17 inches. This provides for maximum coverage with minimum lapping,

Concrete tiles are designed for minimum roof slopes of 2 1/2:12. For slopes up to 3 1/2:12, roof decks are solidly sheathed and covered with roofing felt. For slopes greater than 3 1/2:12, the roof sheathing can be spaced. Roofing felt is placed between each row to carry any drainage to the surface of the next lower course of tile. The lugs at the top of the tiles lock over the sheathing or stripping. Generally, only every fourth tile in every fourth row is nailed to the sheathing, except where roofs are exposed to extreme winds or earthquake conditions. The weight of the tile holds it in place.

Lightweight concrete tile is now being produced using fiberglass reinforcing and a lightweight perlite aggregate. These tiles come in several colors and have the appearance of heavy cedar shakes. The weight of these shingles is similar to that of natural cedar shakes, so roof reinforcing is usually unnecessary.

SLATE.— Slate roofing is hand split from natural rock. It varies in color from black through blue-gray, gray, purple, red and green. The individual slates may have one or more darker streaks running across them. These are usually covered during the laying of the slate. Most slate roofing is available in sizes from 10 by 6 to 26 by 14 inches. The standard thickness is 3/16 inch, but thicknesses of 1/4, 3/8, 1/2, and up to 2 inches can be obtained. Slate may be furnished in a uniform size or in random widths. The surface may be left with the rough hand-split texture or ground to a smoother texture.

The weight of a slate roof ranges from 700 to 1,500 pounds per square, depending upon thickness. The size of framing members supporting a slate roof must be checked against the weight of the slate and method of laying. The type of underpayment used for a slate roof varies, depending on local codes. The requirement ranges from one layer of 15-pound asphalt-saturated felt to 65-pound rolled asphalt roofing for slate over 3/4 inch thick.

Slate is usually laid like shingles with each course lapping the second course below at least 3 inches. The slates can be laid in even rows or at random. Each slate is predrilled with two nail holes and is held in place with

two large-headed slaters' nails. These are made of hard copper wire, cut copper, or cut brass. On hips, ridges, and in other locations where nailing is not possible, the slates are held in place with waterproof elastic slaters' cement colored to match the slate. Exposed nail heads are covered with the same cement.

BITUMENS.— Hot bituminous compounds (bitumens) are used with several types of roofing systems. Both asphalt and coal-tar pitch are bitumens. Although these two materials are similar in appearance, they have different characteristics. Asphalt is usually a product of the distillation of petroleum, whereas coal-tar pitch is a byproduct of the coking process in the manufacture of steel.

Some asphalts are naturally occurring or are found in combination with porous rock. However, most roofing asphalts are manufactured from petroleum crudes from which the lighter fractions have been removed. Roofing asphalts are available in a number of different grades for different roof slopes, climatic conditions, or installation methods.

Roofing asphalts are graded on the basis of their softening points, which range from a low of 135°F (57.2°C) to a high of 225°F (107.2°C). The softening point is not the point at which the asphalt begins to flow, but is determined by test procedures established by the ASTM. Asphalts begin to flow at somewhat lower temperatures than their softening points, depending on the slope involved and the weight of the asphalt and surfacing material.

Generally, the lower the softening point of an asphalt, the better its self-healing properties and the less tendency it has to crack. Dead-flat roofs, where water may stand, or nearly flat roofs, require an asphalt that has the greatest waterproofing qualities and the self-healing properties of low-softening asphalts. A special asphalt known as dead-flat asphalt is used in such cases. As the slope of the roof increases, the need for waterproofing is lessened, and an asphalt that will not flow at expected normal temperatures must be used. For steeper roofing surfaces, asphalt with a softening point of 185°F to 205°F (85°C to 96.1°C) is used. This material is classed as steep asphalt. In hot, dry climates only the high-temperature asphalts can be used.

The softening point of coal-tar pitch generally ranges from 140°F to 155°F (60.0°C to 68.3°C). The softening point of coal-tar pitch limits its usefulness; however, it has been used successfully for years in the eastern and middle western parts of the United States on dead-level or nearly level roofs. In the southwest, where

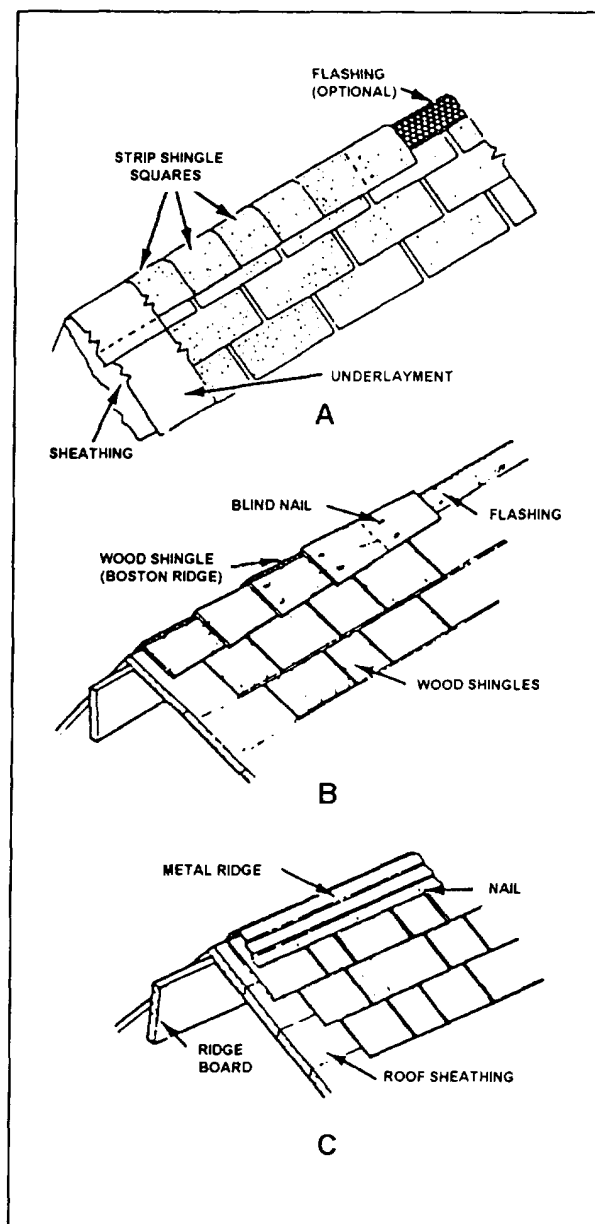


Figure 3-28.—Finish at the ridge: A. Boston ridge with strip shingles; B. Boston ridge with wood shingles; C. Metal ridge.

roof surfaces often reach temperatures of 126°F to 147°F (52.2°C to 63.9°C) in the hot desert sun, the low-softening point of coal-tar pitch makes it unsuitable as a roof surfacing material.

When used within its limitations on flat and low-pitched roofs in suitable climates, coal-tar pitch provides one of the most durable roofing membranes. Coal-tar pitch is also reputed to have cold-flow, or self-healing, qualities. This is because the molecular structure of pitch is such that individual molecules have a physical attraction for each other, so self-sealing is not

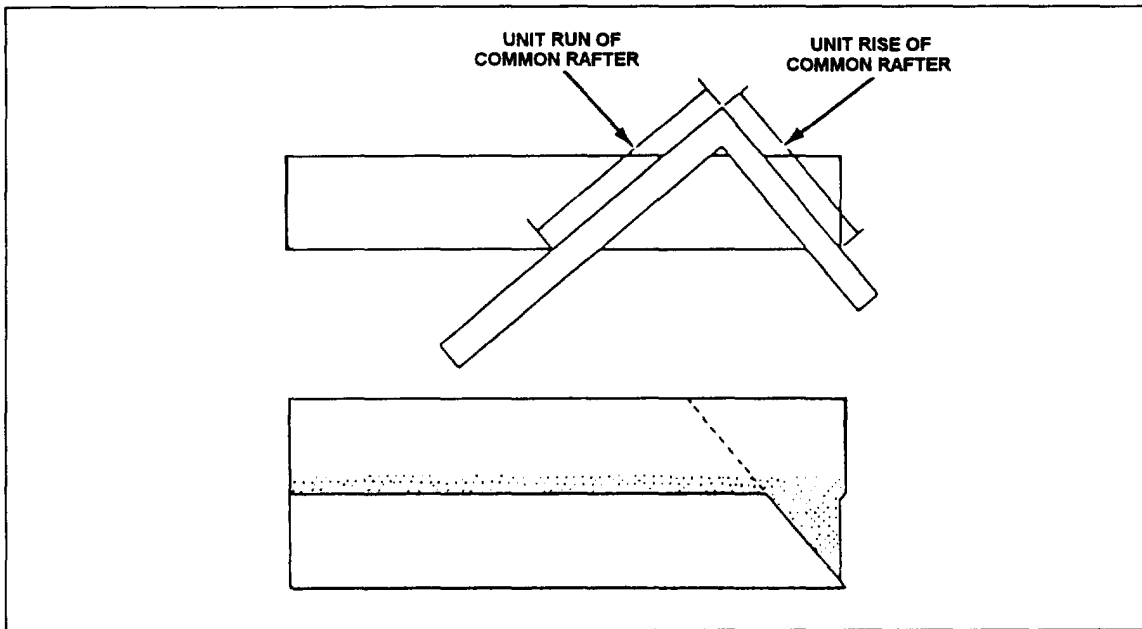


Figure 3-29.-Layout pattern for hip and valley shingles.

dependent on heat. Coal-tar pitch roofs are entirely unaffected by water. When covered by mineral aggregate, standing water may actually protect the volatile oils.

CONSTRUCTION CONSIDERATIONS.—

Laying roofing on a flat surface is a relatively easy procedure. Correctly applying materials to irregular surfaces, such as ridges, hips, and valleys, is somewhat more complex.

Ridge.— The most common type of ridge and hip finish for wood and asphalt shingles is the Boston ridge. Asphalt-shingle squares (one-third of a 12- by 36-inch strip) are used over the ridge and blind-nailed (fig. 3-28, view A). Each shingle is lapped 5 to 6 inches to give double coverage. In areas where driving rains occur, use metal flashing under the shingle ridge to help prevent seepage. The use of a ribbon of asphalt roofing cement under each lap will also help.

A wood-shingle roof should be finished with a Boston ridge (fig. 3-28, view B). Shingles, 6 inches wide, are alternately lapped, fitted, and blind-nailed. As shown, the shingles are nailed in place so that the exposed trimmed edges are alternately lapped. Reassembled hip and ridge units for wood-shingle roofs are available and save both time and money.

A metal ridge can also be used on asphalt-shingle or wood-shingle roofs (fig. 3-28, view C). This ridge is

formed to the roof slope and should be copper, galvanized iron, or aluminum. Some metal ridges are formed so that they provide an outlet ventilating area. However, the design should be such that it prevents rain or snow from blowing in.

Hips and Valleys.— One side of a hip or valley shingle must be cut at an angle to obtain an edge that will match the line of the hip or valley rafter. One way to cut these shingles is to use a pattern. First, select a 3 foot long 1 by 6. Determine the unit length of a common rafter in the roof (if you do not already know it). Set the framing square on the piece to get the unit run of the common rafter on the blade and the unit rise of the common rafter on the tongue (fig. 3-29). Draw a line along the tongue; then saw the pattern along this line. Note: The line cannot be used as a pattern to cut a hip or valley.

Built-up Roofing

A built-up roof, as the name indicates, is built up in alternate plies of roofing felt and bitumen. The bitumen forms a seamless, waterproof, flexible membrane that conforms to the surface of the roof deck and protects all angles formed by the roof deck and projecting surfaces. Without the reinforcement of the felts, the bitumens would crack and alligator and thus lose their volatile oils under solar radiation.

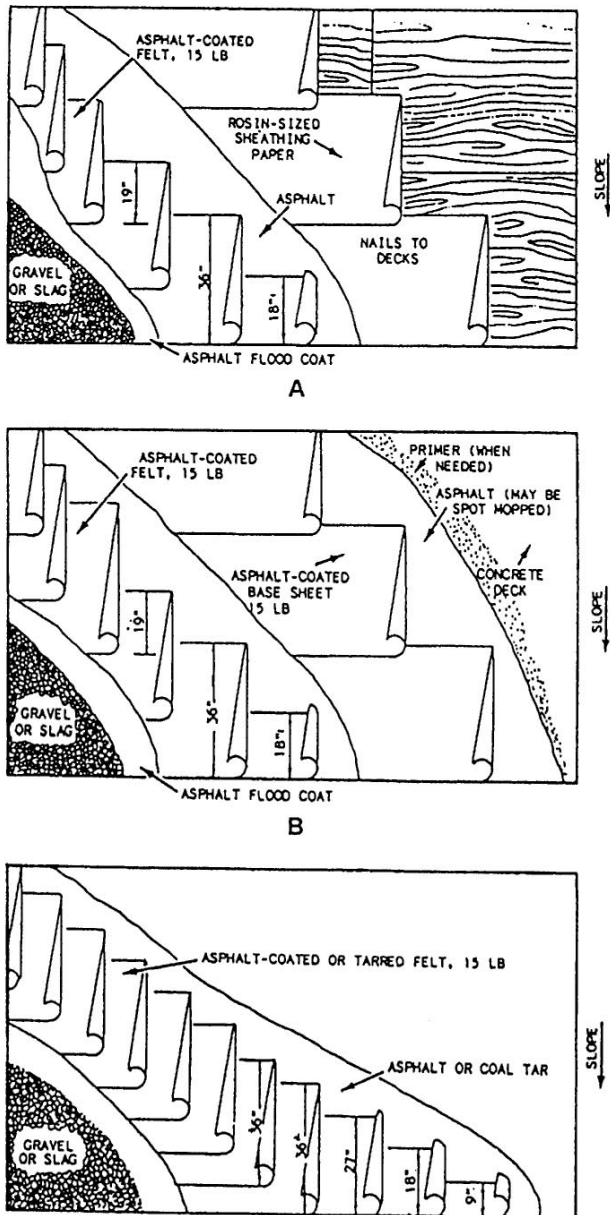


Figure 3-30.-Types of built-up roofing.

APPLICATION OF BITUMENS.—The method of applying roofing depends on the type of roof deck. Some roof decks are nailable and others are not. Figure 3-30 shows examples of wood deck (nailable), concrete deck (not nailable), and built-up roof over insulation. Nailable decks include such materials as wood or fiberboard, poured or precast units of gypsum, and nail able lightweight concrete. Non-nailable decks of concrete or steel require different techniques of roofing. View A of figure 3-30 shows a three-ply built-up roof over a nailable deck, with a gravel or slag surface.

View B shows a three-ply built-up roof over a non-nailable deck with a gravel or slag surface. View C shows a four-ply built-up roof over insulation, with a gravel or slag surface.

The temperatures at which bitumens are applied are very critical. At high temperatures, asphalt is seriously damaged and its life considerably shortened. Heating asphalt to over 500°F (260°C) for a prolonged period may decrease the weather life by as much as 50 percent. Coal-tar pitch should not be heated above 400°F (204°C). Asphalt should be applied to the roof at an approximate temperature of 375°F to 425°F (190.6°C to 218.3°C), and coal-tar pitch should be applied at 275°F to 375°F (135°C to 190°C).

Bitumens are spread between felts at rates of 25 to 35 pounds per square, depending on the type of ply or roofing felt. An asphalt primer must be used over concrete before the hot asphalt is applied. It usually is unnecessary to apply a primer under coal-tar pitch. With wood and other types of nailable decks, the ply is nailed to the deck to seal the joints between the units and prevent dripping of the bitumens through the deck.

Built-up roofs are classed by the number of plies of felt that is used in their construction. The roof maybe three-ply, four-ply, or five-ply, depending on whether the roofing material can be nailed to the deck whether insulation is to be applied underneath it, the type of surfacing desired, the slope of the deck, the climatic conditions, and the life expectancy of the roofing. The ply-and-bitumen membrane of a built-up roof must form a flexible covering that has sufficient strength to withstand normal structure expansion. Most built-up roofs have a surfacing over the last felt ply. This protective surfacing can be applied in several ways.

SURFACING.—Glaze-coat and gravel surfaces are the most commonly seen bituminous roofs.

Glaze Coat.—A coat of asphalt can be flooded over the top layer of felt. This glaze coat protects the top layer of felt from the rays of the sun. The glaze coat is black, but it maybe coated with white or aluminum surfacing to provide a reflective surface.

Gravel.—A flood coat of bitumen (60 pounds of asphalt or 70 pounds of coal-tar pitch per square) is applied over the top ply. Then a layer of aggregate, such as rock gravel, slag, or ceramic granules, is applied while the flood coat is still hot. The gravel weighs

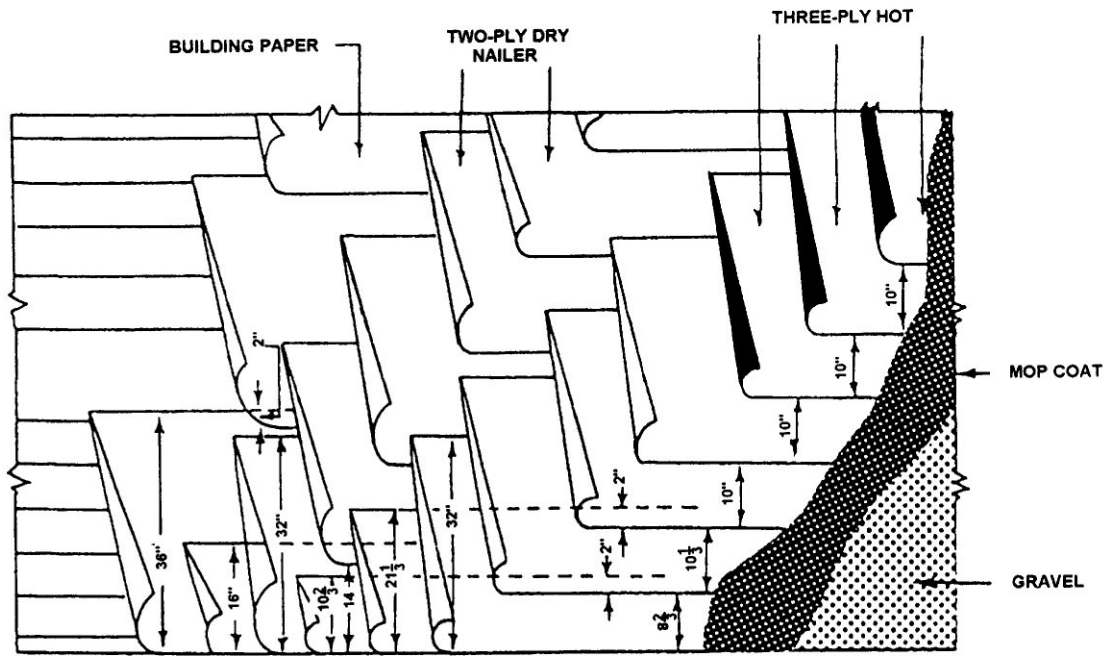


Figure 3-31.-Laying a five-ply built-up roof.

approximately 400 pounds per square and the slag 325 pounds per square. Other aggregates would be applied at a rate consistent with their weight and opacity. The surface aggregate protects the bitumen from the sun and provides a fire-resistant coating.

CAP SHEETS.—A cap sheet surface is similar to gravel-surfaced roofings, except that a mineral-surface is used in place of the flood coat and job-applied gravel. Cap-sheet roofing consists of heavy roofing felts (75 to 105 pounds per square) of organic or glass fibers. Mineral-surfaced cap sheets are coated on both sides with asphalt and surfaced on the exposed side with mineral granules, mica, or similar materials. The cap sheets are applied with a 2-inch lap for single-ply construction or a 19-inch lap if two-ply construction is desired. The mineral surfacing is omitted on the portion that is lapped. The cap sheets are laid in hot asphalt along with the base sheet. Cap sheets are used on slopes between 1/2: 12 and 6:12 where weather is moderate.

COLD-PROCESS ROOFING.—Cold-applied emulsions, cutback asphalts, or patented products can be applied over the top ply of a hot-mopped roof or as an adhesive between plies. If emulsified asphalt is to be used as art adhesive between plies, special plies (such as glass fiber) must be used that are sufficiently porous to allow vapors to escape. Decorative and reflective coatings with asphalt-emulsion bases have been developed to protect and decorate roofing.

DRAINAGE.—When required, positive drainage should be established before the installation of built-up roofing. This can be achieved by the use of lightweight concrete or roofing insulation placed as specified with slopes toward roof drains, gutters, or scuppers.

APPLICATION PROCEDURES.—Built-up roofing consists of several layers of tar-rag-felt, asphalt-rag-felt, or asphalt-asbestos-felt set in a hot binder of melted pitch or asphalt.

Each layer of built-up roofing is called a ply. In a five-ply roof, the first two layers are laid without a binder; these are called the dry nailers. Before the nailers are nailed in place, a layer of building paper is tacked down to the roof sheathing.

A built-up roof, like a shingled roof, is started at the eaves so the strips will overlap in the direction of the watershed. Figure 3-31 shows how 32-inch building paper is laid over a wood-sheathing roof to get five-ply coverage at all points in the roof. There are basically seven steps to the process.

1. Lay the building paper with a 2-inch overlap. Spot-nail it down just enough to keep it from blowing away.
2. Cut a 16-inch strip of saturated felt and lay it along the eaves. Nail it down with nails placed 1 inch from the back edge and spaced 12 inches OC.

3. Nail a full-width (32-inch) strip over the first strip, using the same nailing schedule.
4. Nail the next full-width strip with the outer edge 14 inches from the outer edges of the first two strips to obtain a 2-inch overlap over the edge of the first strip laid. Continue laying full-width strips with the same exposure (14 inches) until the opposite edge of the roof is reached. Finish off with a half-strip along this edge. This completes the two-ply dry nailer.
5. Start the three-ply hot with one-third of a strip, covered by two-thirds of a strip, and then by a full strip, as shown. To obtain a 2-inch overlap of the outer edge of the second full strip over the inner edge of the first strip laid, you must position the outer edge of the second full strip 8 2/3 inches from the outer edges of the first three strips. To maintain the same overlap, lay the outer edge of the third full strip 10 1/3 inches from the outer edge of the second full strip. Subsequent strips can be laid with an exposure of 10 inches. Finish off at the opposite edge of the roof with a full strip, two-thirds of a strip, and one-third of a strip to maintain three plies throughout.
6. Spread a layer of hot asphalt (the flood coat) over the entire roof.
7. Sprinkle a layer of gravel, crushed stone, or slag over the entire roof.

Melt the binder and maintain it at the proper temperature in a pressure fuel kettle. Make sure the kettle is suitably located. Position it broadside to the wind, if possible. The kettle must be set up and kept level. If it is not level, it will heat unevenly, creating a hazard. The first duty of the kettle operator is to inspect the kettle, especially to ensure that it is perfectly dry. Any accumulation of water inside will turn to steam when the kettle gets hot. This can cause the hot binder to bubble over, which creates a serious fire hazard. Detailed procedure for lighting off, operating, servicing, and maintaining the kettle is given in the manufacturer's manual. Never operate the kettle unattended, while the trailer is in transit, or in a confined area.

The kettle operator must maintain the binder at a steady temperature, as indicated by the temperature gauge on the kettle. Correct temperature is designated in binder manufacturer's specifications. For asphalt, it is about 400°F. The best way to keep an even temperature is to add material at the same rate as melted

material is tapped off. Pieces must not be thrown into the melted mass, but placed on the surface, pushed under slowly, and then released. If the material is not being steadily tapped off, it may eventually overheat, even with the burner flame at the lowest possible level. In that case, the burner should be withdrawn from the kettle and placed on the ground to be reinserted when the temperature falls. Prolonged overheating causes flashing and impairs the quality of the binder.

Asphalt or pitch must not be allowed to accumulate on the exterior of the kettle because it creates a fire hazard. If the kettle catches fire, close the lid immediately, shut off the pressure and burner valves, and, if possible, remove the burner from the kettle. Never attempt to extinguish a kettle fire with water. Use sand, dirt, or a chemical fire extinguisher.

A hot roofing crew consists of a mopper and as many felt layers, broomers, nailers, and carriers as the size of the roof requires. The mopper is in charge of the roofing crew. It is the mopper's personal responsibility to mop on only binder that is at the proper temperature. Binder that is too hot will burn the felt, and the layer it makes will be too thin. A layer that is too thin will eventually crack and the felt may separate from the binder. Binder that is too cold goes on too thick so more material is used than is required.

The felt layer must get the felt down as soon as possible after the binder has been placed. If the interval between mopping and felt laying is too long, the binder will cool to the point where it will not bond well with the felt. The felt layer should follow the mopper at an interval of not more than 3 feet. The broomer should follow immediately behind the felt layer, brooming out all air bubbles and embedding the felt solidly in the binder.

Buckets of hot binder should never be filled more than three-fourths full, and they should never be carried any faster than a walk. Whenever possible, the mopper should work downwind from the felt layer and broomer to reduce the danger of spattering. The mopper must take every precaution against spattering at all times. The mopper should lift the mop out of the bucket, not drag it across the rim. Dragging the mop over the rim may upset the bucket, and the hot binder may quickly spread to the feet, or worse still to the knees, of nearby members of the roofing crew.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Basic Roof Framing, Benjamin Barnow, Tab Books, Inc., Blue Ridge Summit, Pa., 1986.

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

Exterior and Interior Trim, John E. Ball, Delmar Pub., Albany, N.Y., 1975.

Manual of Built-up Roof Systems, C. W. Griffin, McGraw-Hill Book Co., New York, 1982.

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

CHAPTER 4

EXTERIOR FINISH OF WALLS

In this chapter, we'll continue our discussion of exterior finishing. In chapter 3, we covered roof finishing; here, we'll examine the exterior finishing of walls, including exterior doors, windows, and glass.

EXTERIOR WALL COVERINGS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of exterior wall coverings and describe procedures for installing siding.

Because siding and other types of exterior wall covering affect the appearance and the maintenance of a structure, the material and pattern should be selected carefully. Wood siding can be obtained in many different patterns and can be finished naturally, stained, or painted. Wood shingles, plywood, wood siding (paneling), fiberboard, and hardboard are some of the types of material used as exterior coverings. Masonry, veneers, metal or plastic siding, and other nonwood materials are additional choices. Many prefinished sidings are available, and the coatings and films applied to several types of base materials may eliminate the need of refinishing for many years.

WOOD SIDING

One of the materials most used for structure exteriors is wood siding. The essential properties required for siding are good painting characteristics, easy working qualities, and freedom from warp. Such properties are present to a high degree in cedar, eastern white pine, sugar pine, western white pine, cypress, and redwood; to a good degree in western hemlock, spruce, and yellow poplar; and to a fair degree in Douglas fir and yellow pine.

Material

The material used for exterior siding that is to be painted should be of a high grade and free from knots, pitch, pockets, and uneven edges. Vertical grain and mixed grain (both vertical and flat) are available in some species, such as redwood and western red cedar. The moisture content at the time of application should be the same as what it will attain in service. To minimize seasonal movement

due to changes in moisture content, choose vertical-grain (edge-grain) siding. While this is not as important for a stained finish, the use of edge-grain siding for a paint finish will result in longer paint life. A 3-minute dip in a water-repellent preservative before siding is installed will result in longer paint life and resist moisture entry and decay. Some manufacturers supply siding with this treatment. Freshly cut ends should be brush-treated on the job.

Patterns

Some wood siding patterns are used only horizontally and others only vertically. Some may be used in either manner if adequate nailing areas are provided. A description of each of the general types of horizontal siding follows.

PLAIN BEVEL.— Plain bevel siding (fig. 4-1) can be obtained in sizes from 1/2 by 4 inches to 1/2 by

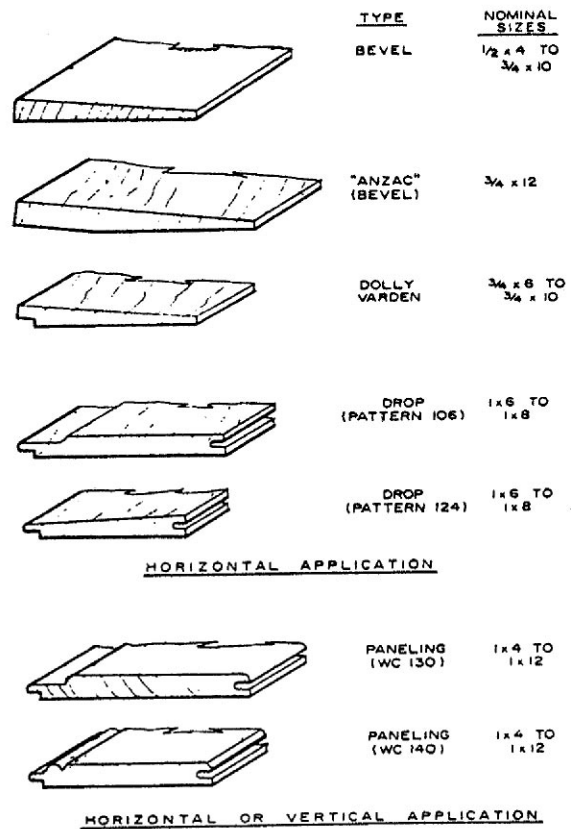


Figure 4-1.-Types of wood siding.

8 inches and also in sizes of 3/4 by 8 inches and 3/4 by 10 inches. "Anzac" siding is 3/4 by 12 inches in size. Usually, the finished width of bevel siding is about one-half inch less than the size listed. One side of beveled siding has a smooth planed surface, whereas the other has a rough resawn surface. For a stained finish, the rough or sawn side is exposed because wood stain works best and lasts longer on rough wood surfaces.

DOLLY VARDEN.— Dolly Varden siding is similar to true bevel siding except that it has shiplap edges. The shiplap edges have a constant exposure distance (fig. 4-1). Because it lays flat against the studs, it is sometimes used for garages and similar buildings without sheathing. Diagonal bracing is therefore needed to stiffen the building and help the structure withstand strong winds and other twist and strain forces.

DROP SIDING.— Regular drop siding can be obtained in several patterns, two of which are shown in figure 4-1. This siding, with matched or shiplap edges, is available in 1- by 6-inch and 1- by 8-inch sizes. It is commonly used for low-cost dwellings and for garages, usually without sheathing. Tests have shown that the tongue-and-grooved (matched) patterns have greater resistance to the penetration of wind-driven rain than the shiplap patterns, when both are treated with a water-repellent preservative.

Fiberboard and Hardboard

Fiberboard and hardboard sidings are also available in various forms. Some have a backing to provide rigidity and strength, whereas others are used directly over sheathing. Plywood horizontal lap siding, with a medium-density overlaid surface, is also available as an exterior covering material. It is usually 3/8 inch thick and 12 or 16 inches wide. It is applied in much the same manner as wood siding, except that a shingle wedge is used behind each vertical joint.

A number of siding or paneling patterns can be used horizontally or vertically (fig. 4-1). These are manufactured in nominal 1-inch thicknesses and in widths from 4 to 12 inches. Both dressed and matched and shiplapped edges are available. The narrow and medium-width patterns are usually more satisfactory under moderate moisture content changes. Wide patterns are more successful if they are vertical-grained (to keep shrinkage to a minimum). The correct moisture content is necessary in tongue-and-groove material to prevent shrinkage and tongue exposure.

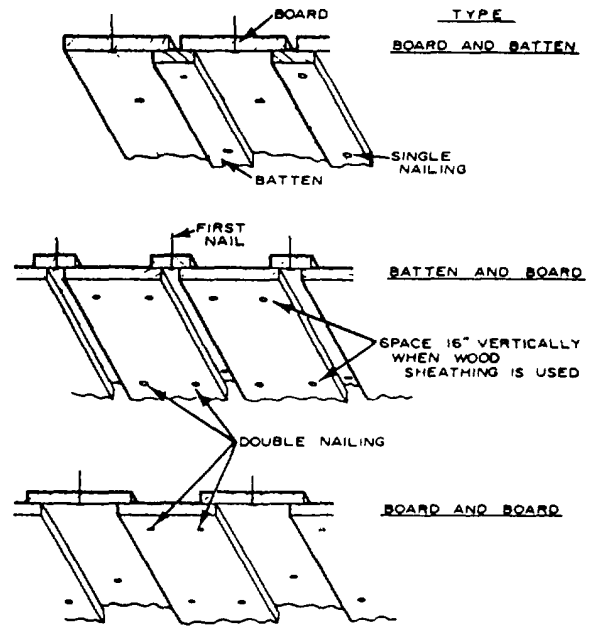


Figure 4-2.-Vertical board siding.

Treatment

Treating the edges of drop, matched, and shiplapped sidings with water-repellent preservative helps prevent wind-driven rain from penetrating the joints exposed to the weather. In areas under wide overhangs or in porches or other protected sections, the treatment is not as important. Some manufacturers provide siding with this treatment already applied.

Applications

A method of siding application, popular for some architectural styles, uses rough-sawn boards and battens applied vertically. These can be arranged in three ways: board and batten, batten and board, and board and board (fig. 4-2).

Sheet Materials

A number of sheet materials are now available for use as siding. These include plywood in a variety of face treatments and species, and hardboard. Plywood or paper-overlaid plywood, also known as panel siding, is sometimes used without sheathing. Paper-overlaid plywood has many of the advantages of plywood besides providing a satisfactory base for paint. A medium-density overlaid plywood is not common. Stud spacing of 16 inches requires a minimum thickness of panel siding of three-eighths inch. However, 1/2- or

5/8-inch-thick sheets perform better because of their greater thickness and strength.

Standard siding sheets are 4 by 8 feet; larger sizes are available. They must be applied vertically with intermediate and perimeter nailing to provide the desired rigidity. Most other methods of applying sheet materials require some type of sheathing beneath. Where horizontal joints are necessary, they should be protected by simple flashing.

An exterior-grade plywood should always be used for siding and can be obtained in grooved, brushed, and saw-textured surfaces. These surfaces are usually finished with stain. If shiplap or matched edges are not provided, the joints should be waterproofed. Waterproofing often consists of caulking and a batten at each joint and a batten at each stud if closer spacing is desired for appearance. An edge treatment of water-repellent preservative will also aid in reducing moisture penetration. When plywood is being installed in sheet form, allow a 1/16-inch edge and end spacing.

Exterior-grade particle board might also be considered for panel siding. Normally, a 5/8-inch thickness is required for 16-inch stud spacing and 3/4-inch thickness for 24-inch stud spacing. The finish must be an approved paint, and the stud wall behind must have corner bracing.

Medium-density fiberboards might also be used in some areas as exterior coverings over certain types of sheathing. Many of these sheet materials resist the passage of water vapor. Hence, when they are used, it is important that a good vapor barrier, well insulated, be used on the warm side of the insulated walls.

NONWOOD SIDING

Nonwood materials are used in some types of architectural design. Stucco or a cement-plaster finish, preferably over a wire mesh base, is common in the Southwest and the West Coast areas. Masonry veneers can be used effectively with wood siding in various finishes to enhance the beauty of both materials.

Some structures require an exterior covering with minimum maintenance. Although nonwood materials are often chosen for this reason, the paint industry is providing comparable long-life coatings for wood-base materials. Plastic films on wood siding and plywood are also promising because little or no refinishing is necessary for the life of the building.

Installation

Siding can be installed only after the window and doorframes are installed. In order to present a uniform appearance, the siding must line up properly with the drip caps and the bottom of the window and door sills. At the same time, it must lineup at the corners. Siding must be properly lapped to increase wind resistance and watertightness. In addition, it must be installed with the proper nails and in the correct nailing sequence.

Fasteners

One of the most important factors in the successful performance of various siding materials is the type of fasteners used. Nails are the most common, and it is poor economy to use them sparingly. Galvanized, aluminum, and stainless steel corrosive-resistant nails may cost more, but their use will ensure spot-free siding under adverse conditions. Ordinary steel-wire nails should not be used to attach siding since they tend to rust in a short time and stain the face of the siding. In some cases, the small-head nails will show rust spots through the putty and paint. Noncorrosive nails that will not cause rust are readily available.

Two types of nails are commonly used with siding: the small-head finishing nail and the moderate-size flathead siding nail.

The small-head finishing nail is set (driven with a nail set) about 1/16 inch below the face of the siding. The hole is filled with putty after the prime coat of paint has been applied. The more commonly used flathead siding nail is nailed flush with the face of the siding and the head later covered with paint.

If the siding is to be natural finished with a water-repellent preservative or stain, it should be fastened with stainless steel or aluminum nails. In some types of prefinished sidings, nails with color-matched heads are supplied.

Nails with modified shanks are available. These include the annularly (ring) threaded shank nail and the spirally threaded shank nail. Both have greater withdrawal resistance than the smooth-shank nail, and, for this reason, a shorter nail is often used.

In siding, exposed nails should be driven flush with the surface of the wood. Overdriving may not only show the hammer mark, but may also cause objectionable splitting and crushing of the wood. In sidings with prefinished surfaces or overlays, the nails should be driven so as not to damage the finished surface.

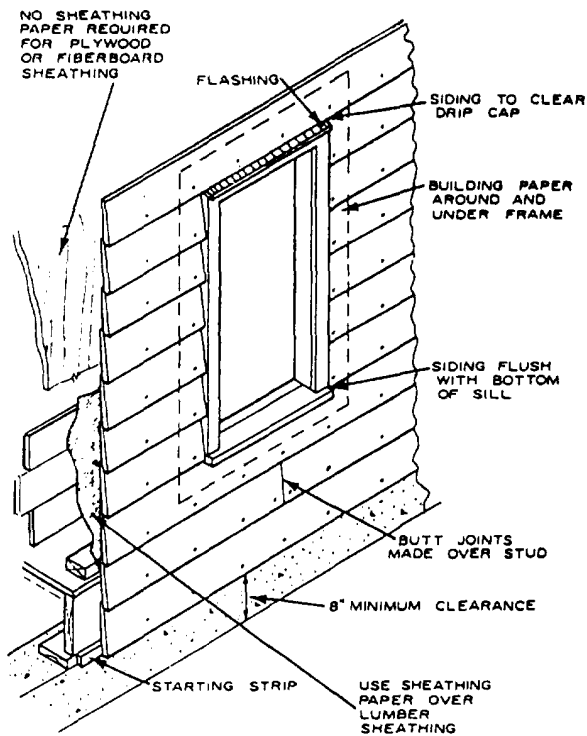


Figure 4-3. Installation of bevel siding.

Exposure

The minimum lap for bevel siding is 1 inch. The average exposure distance is usually determined by the distance from the underside of the window sill to the top of the drip cap (fig. 4-3). From the standpoint of weather resistance and appearance, the butt edge of the first course of siding above the window should coincide with the top of the window drip cap. In many one-story structures with an overhang, this course of siding is often replaced with a frieze board. It is also desirable that the bottom of a siding course be flush with the underside of the window sill. However, this may not always be possible because of varying window heights and types that might be used in a structure.

One system used to determine the siding exposure width so that it is approximately equal above and below the window sill is as follows:

1. Divide the overall height of the window frame by the approximate recommended exposure distance for the siding used (4 inches for 6-inch-wide siding, 6 inches for 8-inch-wide siding, 8 inches for 10-inch-wide siding, and 10 inches for 12-inch-wide siding). This result will be the number of courses between the top and the bottom of the window. For example, the overall height of our sample window from the

top of the drip cap to the bottom of the sill is 61 inches. If 12-inch-wide siding is used, the number of courses would be $61/10 = 6.1$, or six courses. To obtain the exact exposure distance, divide 61 by 6 and the result would be $10 \frac{1}{6}$ inches.

2. Determine the exposure distance from the bottom of the sill to just below the top of the foundation wall. If this distance is 31 inches, use three courses of $10 \frac{1}{3}$ inches each. Thus, the exposure distance above and below the window would be almost the same (fig. 4-3).

When this system is not satisfactory because of big differences in the two areas, it is preferable to use an equal exposure distance for the entire wall height and notch the siding at the window sill. The fit should be tight to prevent moisture from entering.

Installation

Siding may be installed starting with a bottom course. It is normally blocked out with a starting strip the same thickness as the top of the siding board (fig. 4-3). Each succeeding course overlaps the upper edge of the course below it. Siding should be nailed to each stud or on 16-inch centers. When plywood, wood sheathing, or spaced wood nailing strips are used over nonwood sheathing, 7d or 8d nails may be used for 3/4-inch-thick siding. However, if gypsum or fiberboard sheathing is used, 10d nails are recommended to properly penetrate the stud. For 1/2-inch-thick siding, nails may be 1/4 inch shorter than those used for 3/4-inch siding.

The nails should be located far enough up from the butt to miss the top of the lower siding course (fig. 4-4). The clearance distance is usually 1/8 inch. This allows for slight movement of the siding because of moisture changes without causing splitting. Such an allowance is especially required for the wider (8 to 12 inch) siding.

Joints

It is good construction practice to avoid butt joints whenever possible. Use the longer sections of siding under windows and other long stretches, and use the shorter lengths for areas between windows and doors. When a butt joint is necessary, it should be made over a stud and staggered between courses.

Siding should be square cut to provide good joints. Open joints permit moisture to enter and often lead to paint deterioration. It is a good practice to brush or dip

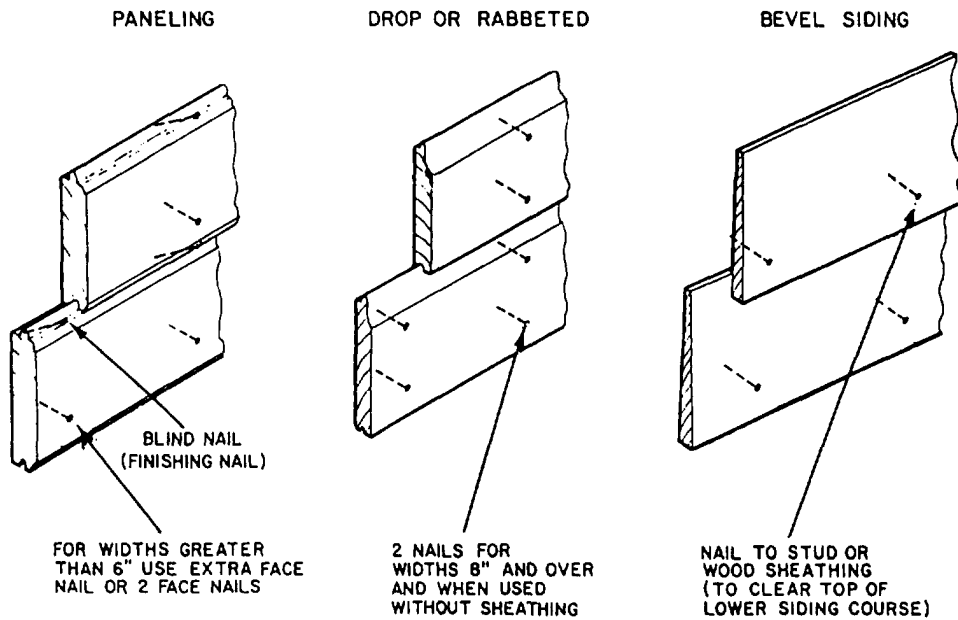


Figure 4-4.-Nailing the siding.

the fresh cut ends of the siding in a water-repellent preservative before boards are roiled in place. After the siding is in place, it is helpful to use a small finger-actuated oil can to apply the water-repellent preservative to the ends and butt joints.

Drop siding is installed in much the same way as lap siding except for spacing and nailing. Drop, Dolly Varden, and similar sidings have a constant exposure distance. The face width is normally 5 1/4 inches for 1- by 6-inch siding and 7 1/4 inches for 1- by 8-inch siding. Normally, one or two nails should be used at each stud, depending on the width (fig. 4-4). The length of the nail depends on the type of sheathing used, but penetration into the stud or through the wood backing should be at least 1 1/2 inches.

Application

There are two ways to apply nonwood siding: horizontally and vertically. Note that these are manufactured items. Make sure you follow the recommended installation procedures.

HORIZONTALLY.— Horizontally applied matched paneling in narrow widths should be blind-nailed at the tongue with a corrosion-resistant finishing nail (fig. 4-4). For widths greater than 6 inches, an additional nail should be used as shown.

Other materials, such as plywood, hardboard, or medium-density fiberboard, are used horizontally in

widths up to 12 inches. They should be applied in the same manner as lap or drop siding, depending on the pattern. Prepackaged siding should be applied according to the manufacturer's directions.

VERTICALLY.— Vertically applied siding and sidings with interlapping joints should be nailed in the same manner as those applied horizontally. However, they should be nailed to blocking used between studs or to wood or plywood sheathing. Blocking should be spaced from 16 to 24 inches OC. With plywood or nominal 1-inch board sheathing, nails should be spaced on 16-inch centers only.

When the various combinations of boards and battens are used, they should also be nailed to blocking spaced from 16 to 24 inches OC between studs, or closer for wood sheathing. The first boards or battens should be fastened with nails at each blocking to provide at least 1 1/2 inches of penetration. For wide underboards, two nails spaced about 2 inches apart maybe used rather than the single row along the center (fig. 4-2). Nails of the top board or batten should always miss the underboards and should not be nailed through them (fig. 4-2). In such applications, double nails should be spaced closely to prevent splitting if the board shrinks. It is also a good practice to use sheathing paper, such as 15-pound asphalt felt, under vertical siding.

Exterior-grade plywood, paper-overlaid plywood, and similar sheet materials used for siding are usually applied vertically. The nails should be driven over the

studs, and the total effective penetration into the wood should be at least 1 1/2 inches. For example, 3/8-inch plywood siding over 3/4-inch wood sheathing would require a 7d nail (which is 2 1/4 inches long). This would result in a 1 1/8-inch penetration into the stud, but a total effective penetration of 1 7/8 inches into the wood sheathing.

The joints of all types of sheet material should be caulked with mastic unless the joints are of the interlapping or matched type of battens. It is a good practice to place a strip of 15-pound asphalt felt under joints.

CORNER COVERINGS

The outside corners of a wood-framed structure can be finished in several ways. Siding boards can be miter-joined at the corners. Shingles can be edge-lapped alternately. The ends of siding boards can be butted at the corners and then covered with a metal cap.

Corner Boards

A type of corner finish that can be used with almost any kind of outside-wall covering is called a corner board. This corner board can be applied to the corner with the siding or shingles end-or-edge-butted against the board.

A corner board usually consists of two pieces of stock: one piece 3 inches wide and the other 4 inches wide if an edge-butt joint between the corner boards is used. The boards are cut to a length that will extend from the top of the water table to the bottom of the frieze. They are edge-butted and nailed together before they are nailed to the corner. This procedure ensures a good tight joint (fig. 4-5). A strip of building paper should be tacked over the corner before the corner board is nailed in position (always allow an overlap of paper to cover the subsequent crack formed where the ends of the siding butts against the corner board).

Interior Corners

Interior corners (fig. 4-6, view A) are butted against a square corner board of nominal 1 1/4- or 1 3/8-inch size, depending on the thickness of the siding.

Mitered Corners

Mitering the corners (fig. 4-6, view B) of bevel and similar sidings is often not satisfactory, unless it is carefully done to prevent openings. A good joint must

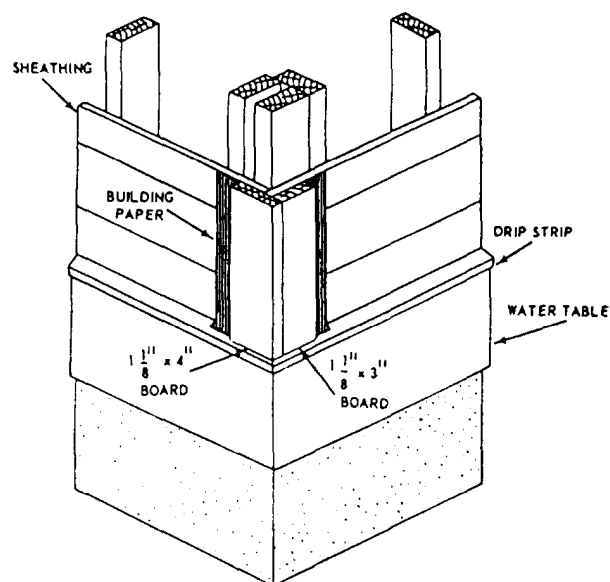


Figure 4-5.-Corner board.

fit tightly the **full depth of the miter**. You should also treat the ends with a water-repellent preservative before nailing.

Metal Corners

Metal corners (fig. 4-6, view C) are perhaps more commonly used than the mitered corner and give a mitered effect. They are easily placed over each corner as the siding is installed. The metal corners should fit tightly and should be nailed on each side to the sheathing or corner stud beneath. When made of galvanized iron, they should be cleaned with a mild acid wash and primed with a metal primer before the structure is painted to prevent early peeling of the paint. Weathering of the metal will also prepare it for the prime paint coat.

corner boards (fig. 4-5) of various types and sizes may be used for horizontal sidings of all types. They also provide a satisfactory termination for plywood and similar sheet materials. Vertical applications of matched paneling or of boards and battens are terminated by lapping one side and nailing into the edge of this member, as well as to the nailing members beneath. corner boards are usually 1 1/8 or 1 3/8 inches wide. To give a distinctive appearance, they should be quite narrow. Plain outside casing, commonly used for window and doorframes, can be adapted for corner boards.

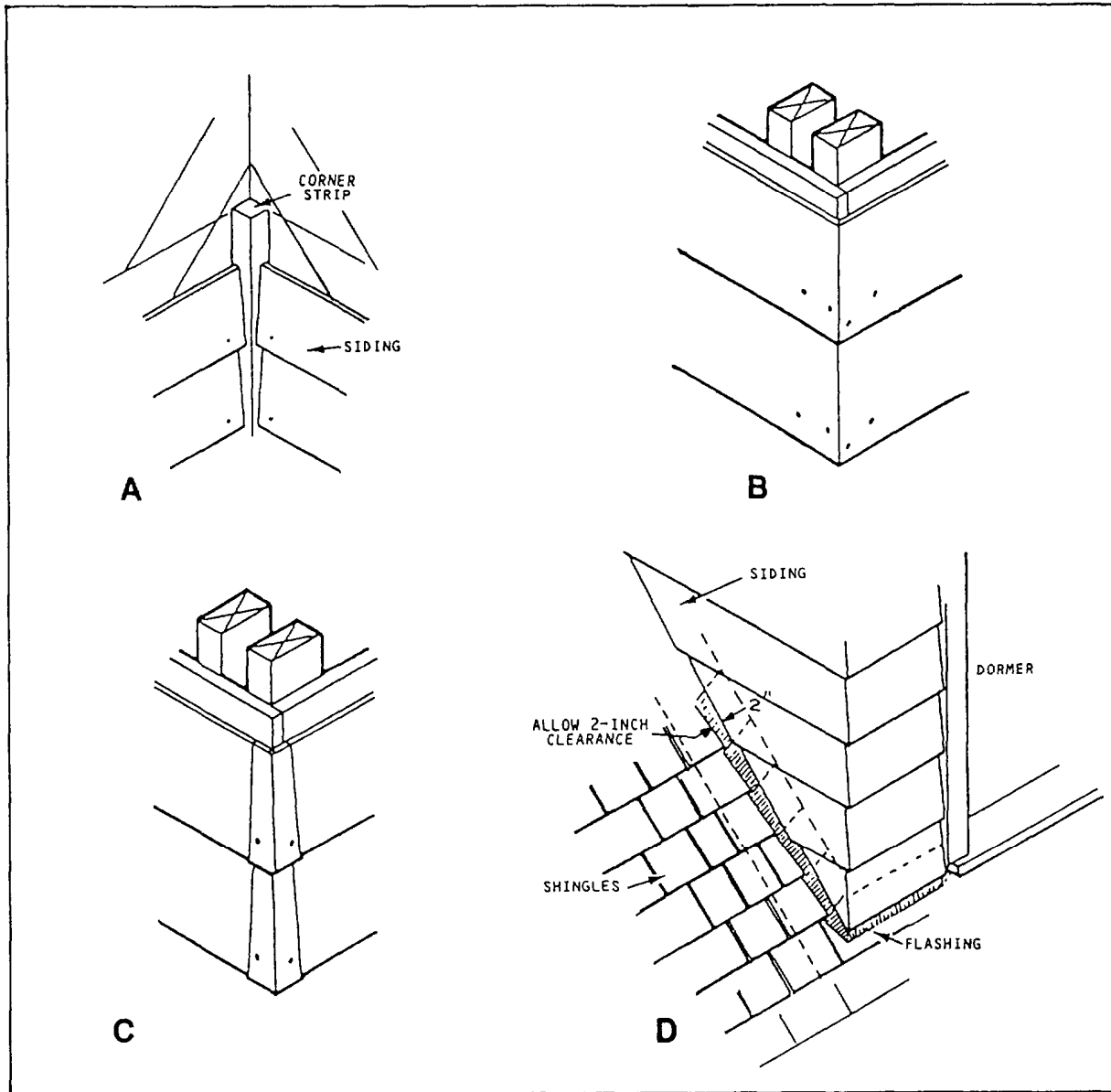


Figure 4-6.-Siding details: A. Interior corners; B. Mitered corners; C. Metal corners; D. Siding return of roof.

Shingles and Shakes

Prefinished shingle or shake exteriors are sometimes used with color-matched metal corners. They can also be lapped over the adjacent corner shingle, alternating each course. This kind of corner treatment, called lacing, usually requires that flashing be used beneath.

When siding returns against a roof surface, such as at the bottom of a dormer wall, there should be a 2-inch clearance (fig. 4-6, view D). Siding that is cut for a tight fit against the shingles retains moisture after rains and usually results in peeling paint. Shingle flashing

extending well up on the dormer wall will provide the necessary resistance to entry of wind-driven rain. Here again, a water-repellent preservative should be used on the ends of the siding at the roof line.

GABLE ENDS

At times, the materials used in the gable ends and in the walls below differ in form and application. The details of construction used at the juncture of the two materials should be such that good drainage is assured. For example, when vertical boards and battens are used at the gable end and horizontal siding below, a drip cap

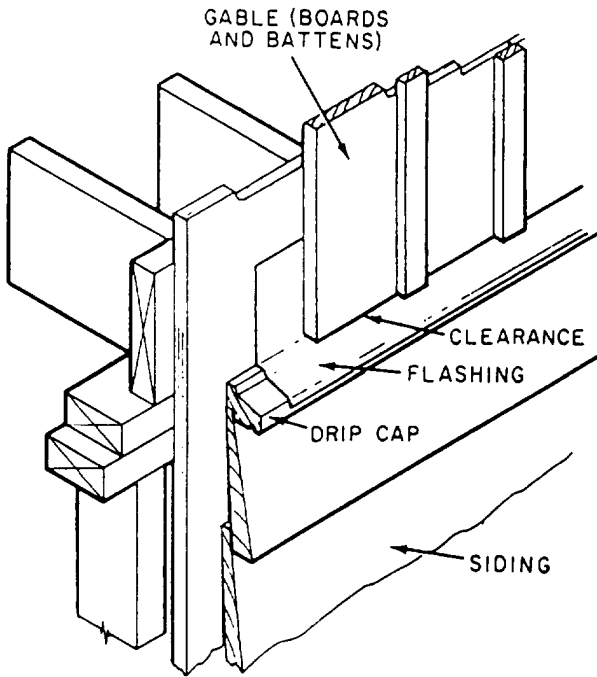


Figure 4-7.-Cable-end finish (material transition).

or similar molding should be used (fig. 4-7). Flashing should be used over and above the drip cap so that moisture cannot enter this transition area.

PATTERNS

Wood shingles and shakes are applied in a single- or double-course pattern. They may be used over wood or plywood sheathing. When sheathing with 3/8-inch plywood, use threaded nails. For nonwood sheathing, 1-by 3-inch or 1- by 4-inch wood nailing strips are used as a base.

In the single-course method, one course is simply laid over the other as lap siding is applied. The shingles can be second grade because only one-half or less of the butt portion is exposed (fig. 4-8). Shingles should not be soaked before application but should usually be laid with about 1/8- to 1/4-inch space between adjacent shingles to allow for expansion during rainy weather. When a siding effect is desired, shingles should be laid so that they are in contact, but only lightly. Pre-stained or treated shingles provide the best results.

In a double-course system, the undercourse is applied over the wall, and the top course is nailed directly over a 1/4-to 1/2-inch projection of the butt (fig. 4-9). The first course should be nailed only enough to hold it in place while the outer course is being applied.

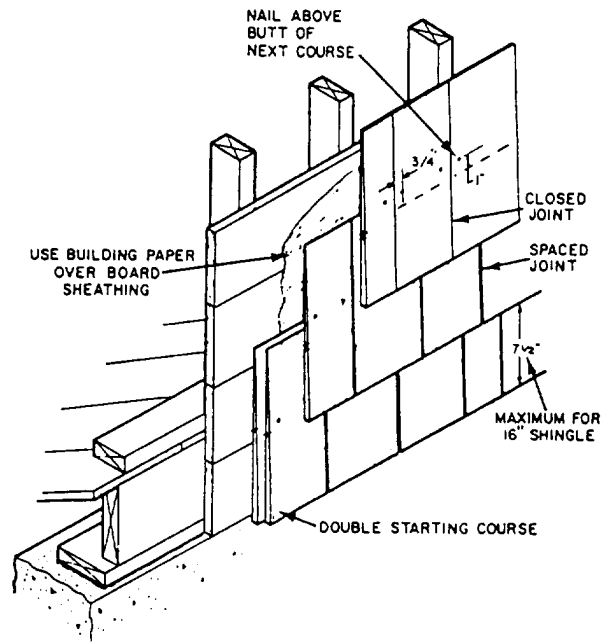


Figure 4-8.-Single coursing of sidewalls (wood shingles and shakes).

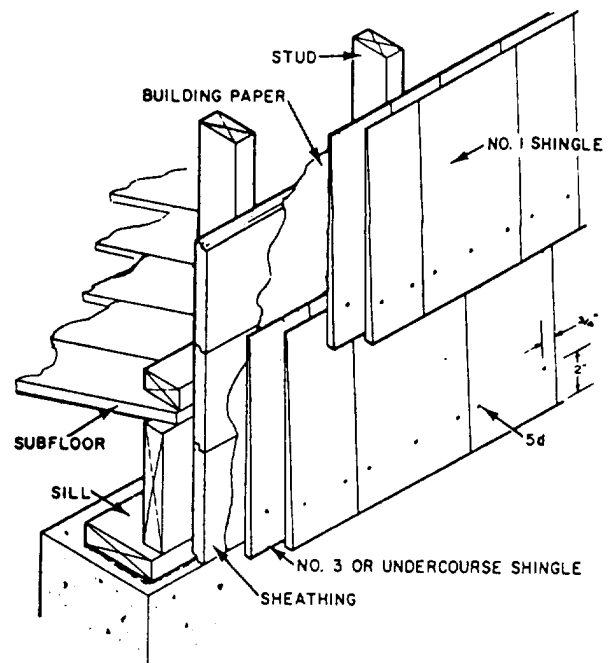


Figure 4-9.-Double coursing of side walls (wood shingles and shakes).

The first shingles can be a lower quality. Because much of the shingle length is exposed, the top course should be first-grade shingles.

Shingles and shakes should be applied with rust-resistant nails long enough to penetrate into the

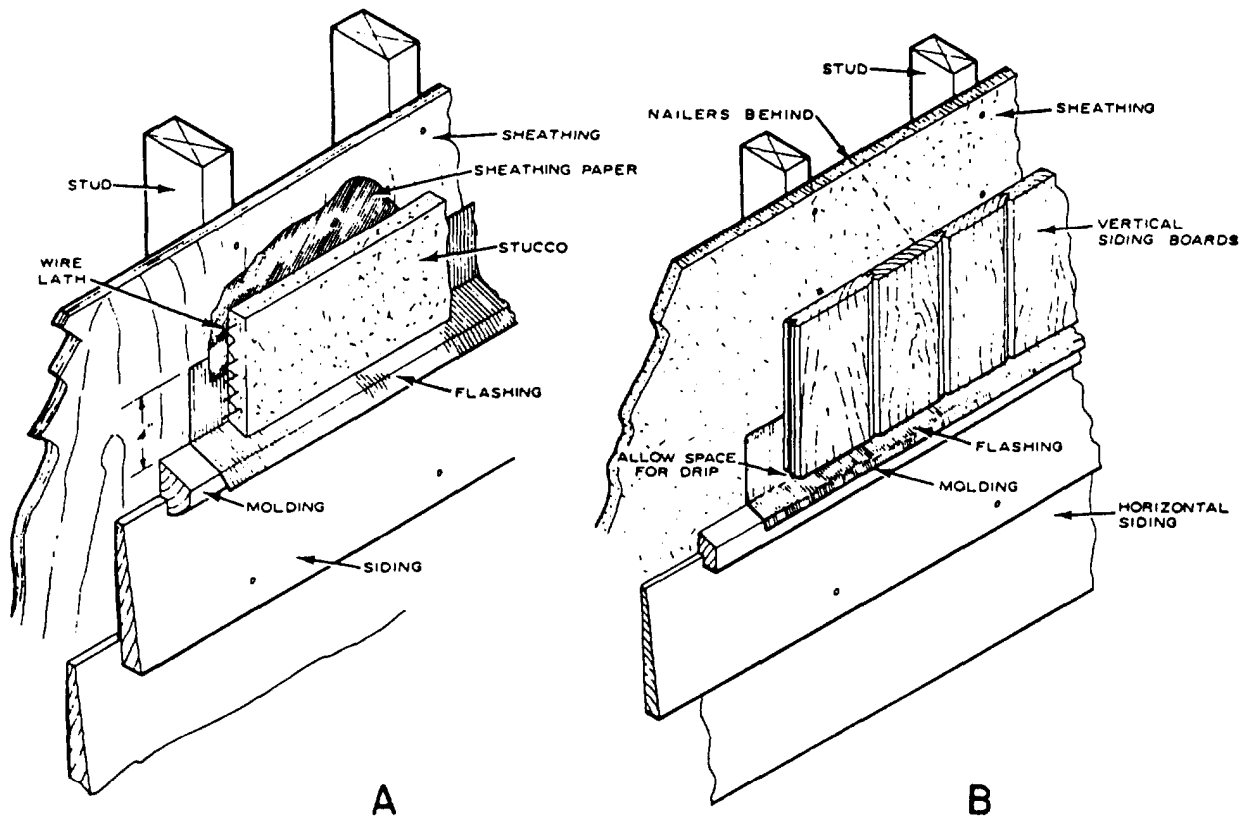


Figure 4-10.-Flashing of material changes: A. Stucco above, siding below, B. Vertical siding above, horizontal below.

wood backing strips or sheathing. In a single course, a 3d or 4d zinc-coated shingle nail is commonly used. In a double course, where nails are exposed, a 5d zinc-coated nail with a small flat head is used for the top course, and a 3d or 4d size for the undercourse. Use building paper over lumber sheathing.

FLASHING

Flashing should be installed at the junction of material changes, chimneys, and roof-wall intersections. It should also be used overexposed doors and windows, roof ridges and valleys, along the edge of a pitched roof, and any other place where rain and melted snow may penetrate.

To prevent corrosion or deterioration where unlike metals come together, use fasteners made of the same kind of metal as the flashing. For aluminum flashing, use only aluminum or stainless steel nails, screws, hangers, and clips. For copper flashing, use copper nails and fittings. Galvanized sheet metal or terneplate should be fastened with galvanized or stainless steel fasteners. (Terneplate is a steel plate coated with an alloy of lead and a small amount of tin.)

One wall area that requires flashing is at the intersection of two types of siding materials. For example, a stucco-finish gable end and a wood-siding lower wall should be flashed (fig. 4-10, view A). A wood molding, such as a drip cap, separates the two materials and is covered by the flashing, which extends at least 4 inches above the intersection. When sheathing paper is used, it should lap the flashing (fig. 4-10, view A).

When a wood-siding pattern change occurs on the same wall, the intersection should also be flashed. A vertical board-sided upper wall with horizontal siding below usually requires some type of flashing (fig. 4-10, view B). A small space above the molding provides a drip for rain. This will prevent paint peeling, which could occur if the boards were in tight contact with the molding. A drip cap (fig. 4-7) is sometimes used as a terminating molding.

DOOR AND WINDOW FLASHING

The same type of flashing as shown in figure 4-10, view A, should be used over door and window openings exposed to driving rain. However, window and door heads protected by wide overhangs in a single-story structure with a hip roof do not ordinarily require the

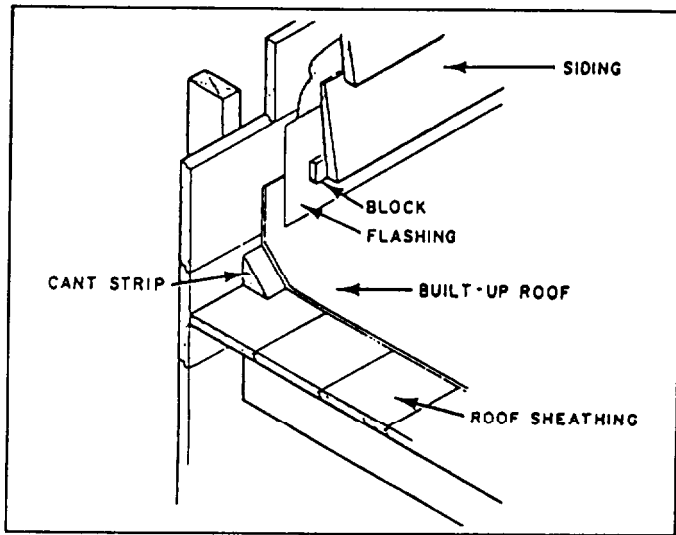


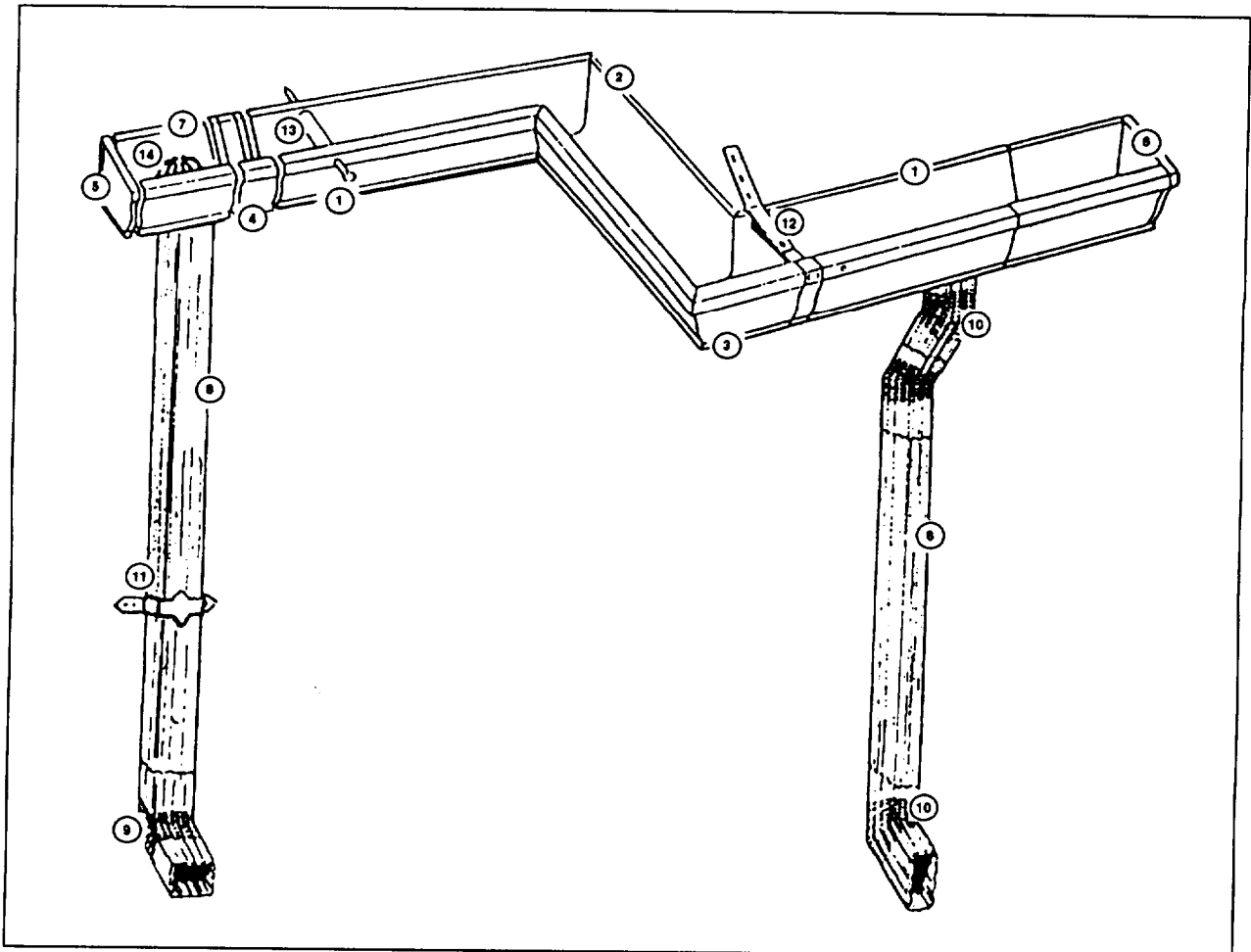
Figure 4-11-Flashing at the intersection of an exterior wall and a flat or low-pitched roof.

flashing. When building paper is used on the sidewalls, it should lap the top edge of the flashing. To protect the walls behind the window sill in a brick veneer exterior, extend the flashing under the masonry sill up the underside of the wood sill.

Flashing is also required at the junctions of an exterior wall and a flat or low-pitched built-up roof (fig. 4-11). Where a metal roof is used, the metal is turned up on the wall and covered by the siding. A clearance should be allowed at the bottom of the siding to protect against melted snow and rain.

GUTTERS AND DOWNSPOUTS

Several types of gutters are available to carry the rainwater to the downspouts and away from the



- | | | | | |
|------------------|--------------------------|-------------------|-------------------|--------------------------|
| 1. Gutter | 4. Slip joint connectors | 7. "D" end pieces | 10. "B" elbows | 13. 7" spike, 5" ferrule |
| 2. Inside miter | 5. End cap "L" | 8. Downspout | 11. Leader straps | 14. Strainer basket |
| 3. Outside miter | 6. End cap "R" | 9. "A" elbows | 12. Hangers | |

Figure 4-12.-Parts of a metal gutter system.

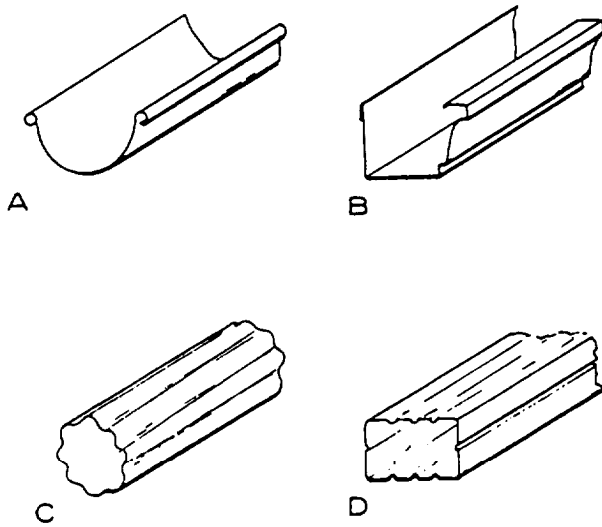


Figure 4-13.-Gutters and downspouts: A. Half-round gutter; B. "K" style gutter C. Round downspout; D. Rectangular downspout.

foundation. On flat roofs, water is often drained from one or more locations and carried through an inside wall to an underground drain. All downspouts connected to an underground drain should be fitted with basket strainers (fig. 4-1 2) at the junctions of the gutter.

Perhaps the most commonly used gutter is the type hung from the edge of the roof or fastened to the edge of the cornice fascia. Metal gutters may be the half-round (fig. 4-13, view A) or "K" style (view B) and may be made of galvanized metal, copper, or aluminum. Some have a factory-applied enamel finish.

Downspouts are round or rectangular (fig. 4-13, views C and D). The round type is used for the half-round gutters. They are usually corrugated to provide extra stiffness and strength. Corrugated patterns are less likely to burst when plugged with ice.

On long runs of gutters, such as required around a hip-roof structure, at least four downspouts are desirable. Gutters should be installed with a pitch of 1 inch per 16 feet toward the downspouts. Formed or half-round gutters are suspended with flat metal hangers (fig. 4-14, views A and B). Spike and ferrule hangers are also used with formed gutters (view C). Gutter hangers should be spaced 3 feet OC.

Gutter splices, corner joints, and downspout connections should be watertight. Downspouts should be fastened to the wall by leaderstraps (fig. 4-12) or hooks. One strap should be installed at the top, one at the bottom, and one at each intermediate joint. An elbow is used at the bottom to guide the water to a splash block

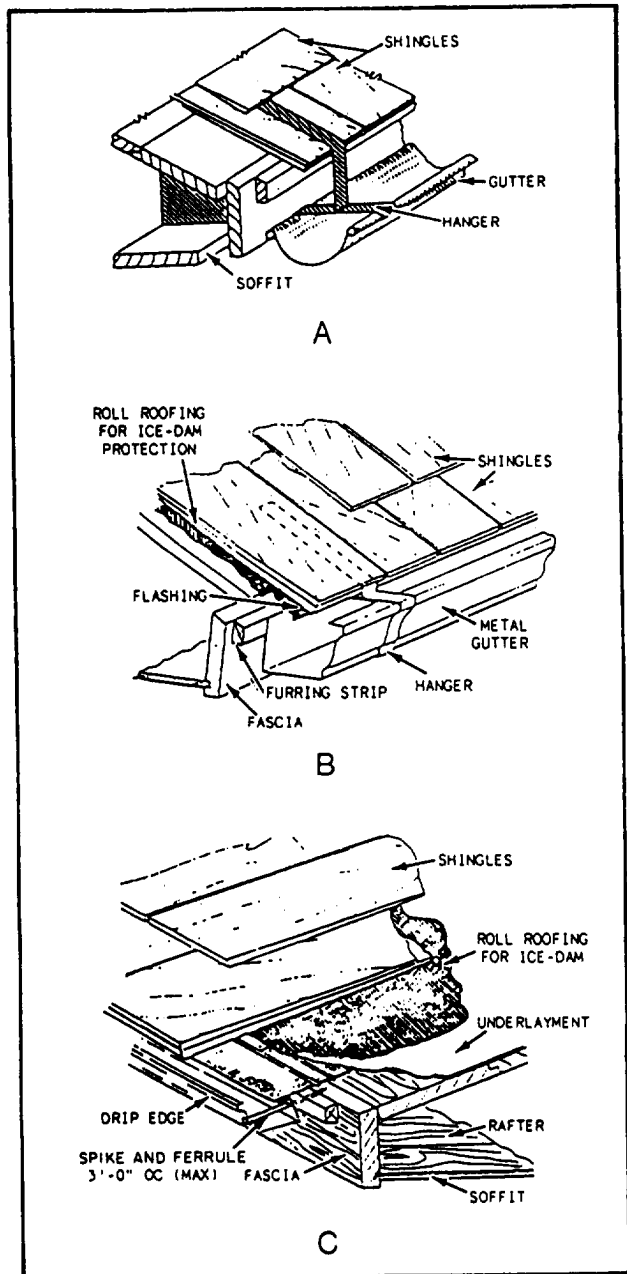


Figure 4-14.-Gutter hangers: A. Flat metal hanger with half-round gutter; B. Flat metal hanger with "K" style metal gutter; C. Spike and ferrule with formed gutter.

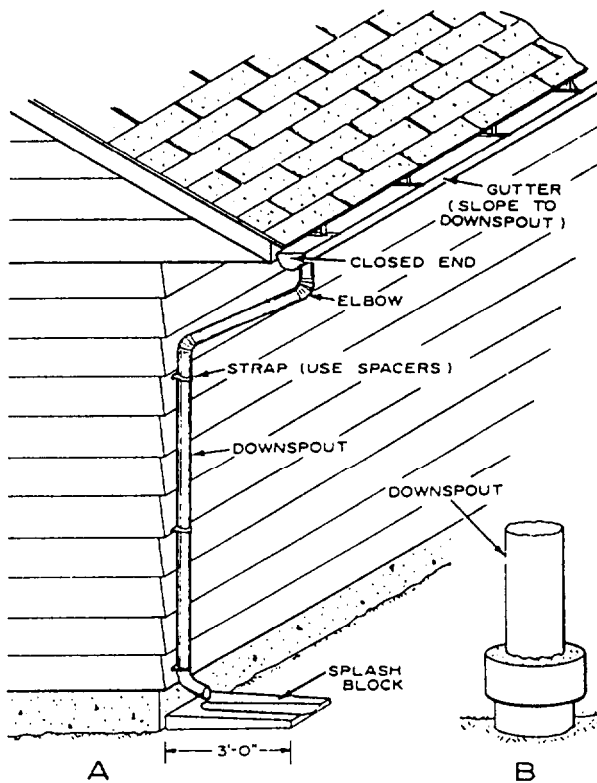


Figure 4-15.-Downspout installation: A. Downspout with splash block; B. Drain to storm sewer.

(fig. 4-15, view A), which carries the water away from the foundation. The minimum length of a splash block should be 3 feet. In some areas, the downspout drains directly into a tile line, which carries the water to a storm sewer (view B).

EXTERIOR DOORS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of exterior doors and describe basic exterior doorjamb installation procedures.

Many types of exterior doors are available to provide access, protection, safety, and privacy. Wood, metal, plastic, glass, or a combination of these materials are used in the manufacture of doors. The selection of door type and material depends on the degree of protection or privacy desired, architectural compatibility, psychological effect, fire resistance, and cost.

DOOR TYPES

Better quality exterior doors are of solid-core construction. The core is usually fiberglass, or the door

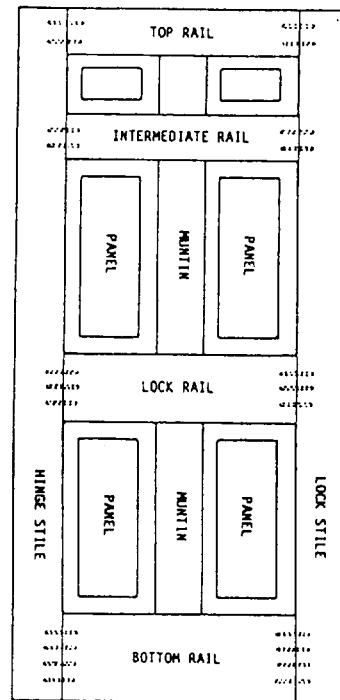


Figure 4-16.-Parts of a Six-panel door.

is metal-faced with an insulated foam core. Solid-core doors are used as exterior doors because of the heavy service and the additional fireproofing. Hollow-core doors are normally used for interior applications. Wood doors are classified by design and method of construction as panel or flush doors.

Panel Doors

A panel door, or stile-and-rail door, consists of vertical members called stiles and horizontal members called rails. The stiles and rails enclose panels of solid wood, plywood, louvers, or glass (fig. 4-16). The stiles extend the full height at each side of the door. The vertical member at the hinged side of the door is called the hinge, or hanging, stile, and the one to which the latch, lock, or push is attached is called the closing, or lock, stile. Three rails run across the full width of the door between the stiles: the top rail, the intermediate or lock rail, and the bottom rail. Additional vertical or horizontal members, called muntins, may divide the door into any number of panels. The rails, stiles, and muntins maybe assembled with either glued dowels or mortise-and-tenon joints.

Sash Doors

Panel doors in which one or more panels are glass are classed as sash (glazed) doors. Fully glazed panel

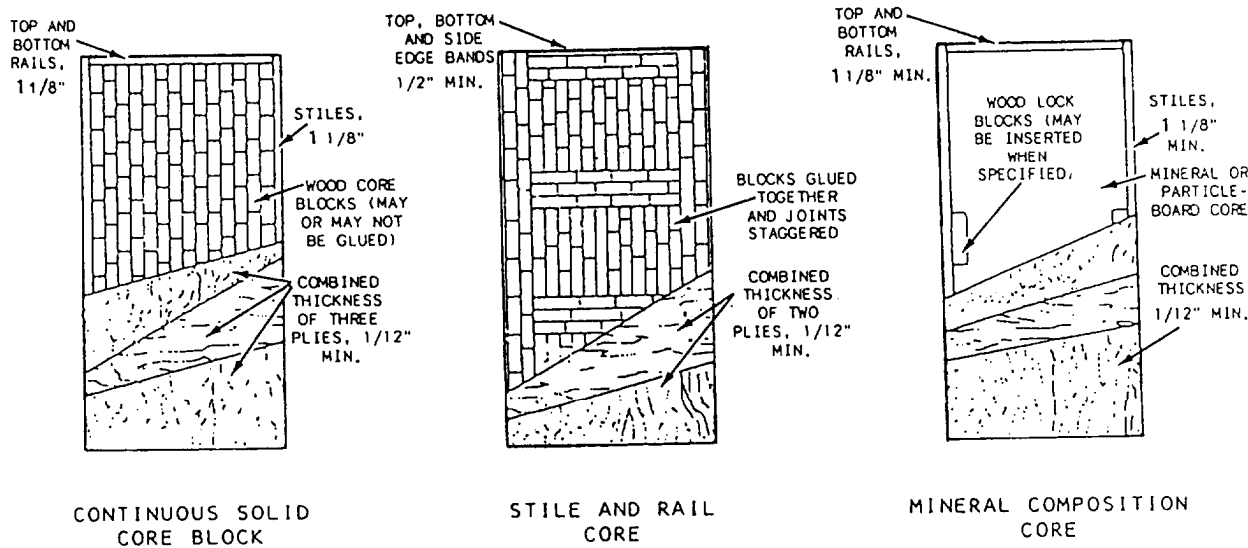


Figure 4-17. Three types of solid-core doors.

doors with only top and bottom rail, without horizontal or vertical muntins, are referred to as “casement” or “French doors.” Storm doors are lightly constructed glazed doors. They are used in conjunction with exterior doors to improve weather resistance. Combination doors consist of interchangeable or hinged glass and screen panels.

Flush Doors

Flush doors are usually made up of thin sheets of veneer over a core of wood, particle board, or fiberboard. The veneer faces act as stressed-skin panels and tend to stabilize the door against warping. The face veneer may be of ungraded hardwood suitable for a plain finish or selected hardwood suitable for a natural finish. The appearance of flush doors may be enhanced by the application of plant-on decorative panels. Both hollow-core and solid-core doors usually have solid internal rails and stiles so that hinges and other hardware may be set in solid wood.

Two types of solid wood cores are widely used in flush-door construction (fig. 4-17). The first type, called a continuous-block, strip- or wood-stave core, consists of low-density wood blocks or strips that are glued together in adjacent vertical rows, with the end joints staggered. This is the most economical type of solid core. However, it is subject to excessive expansion and contraction unless it is sealed with an impervious skin, such as a plastic laminate.

The second type is the stile-and-rail core, in which blocks are glued up as panels inside the stiles and rails.

This type of core is highly resistant to warpage and is more dimensionally stable than the continuous-block core.

In addition to the solid lumber cores, there are two types of composition solid cores. Mineral cores (see fig. 4-17) consist of inert mineral fibers bonded into rigid panels. The panels are framed within the wood rails and stiles, resulting in a core that is light in weight and little affected by moisture. Because of its low density, this type of door should not be used where sound control is important.

The other type (not shown) has particleboard, flakeboard, or waferboard cores, consisting of wood chips or vegetable fibers mixed with resins or other binders, formed under heat and pressure into solid panels. This type of core requires a solid-perimeter frame. Since particleboard has no grain direction, it provides exceptional dimensional stability and freedom from warpage. Because of its low screw-holding ability, it is usually desirable to install wood blocks in the core at locations where hardware will be attached.

DOORJAMBS

The doorjamb is the part of the frame that fits inside the masonry opening or rough frame opening. Jambs may be wood or metal. The jamb has three parts: the two side jambs and the head jamb across the top. Exterior doorjambs have a stop as part of the jamb. The stop is the portion of the jamb that the face of the door closes against. The jamb is 1 1/4 inches thick with a 1/2-inch rabbet serving as a stop.

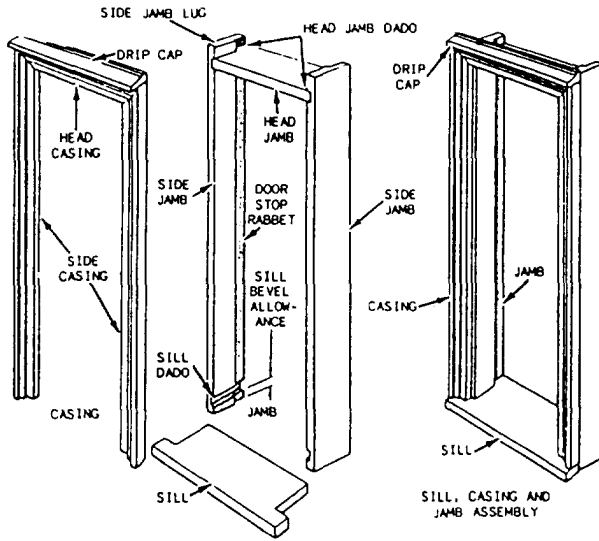


Figure 4-18.-Parts of an exterior doorframe.

Wood

Wood jambs are manufactured in two standard widths: 5 1/4 inches for lath and plaster and 4 1/2 inches for drywall. Jambs may be easily cut to fit walls of any

thickness. If the jamb is not wide enough, strips of wood are nailed on the edges to form an extension. Jambs may also be custom made to accommodate various wall thicknesses.

Metal

Standard metal jambs are available for lath and plaster, concrete block, and brick veneer in 4 3/4-, 5 3/4-, 6 3/4-, and 8 3/4-inch widths. For drywall construction, the common widths available are 5 1/2 and 5 5/8 inches.

The sill is the bottom member in the doorframe. It is usually made of oak for wear resistance. When softer wood is used for the sill, a metal nosing and wear strips are generally included.

The brick mold or outside casings are designed and installed to serve as stops for the screen or combination door. The stops are provided for by the edge of the jamb and the exterior casing thickness (fig. 4-1 8).

Doorframes can be purchased knocked down (K. D.) or preassembled with just the exterior casing or brick mold applied. In some cases, they come preassembled with the door hung in the opening. When the doorframe is assembled on the job, nail the side

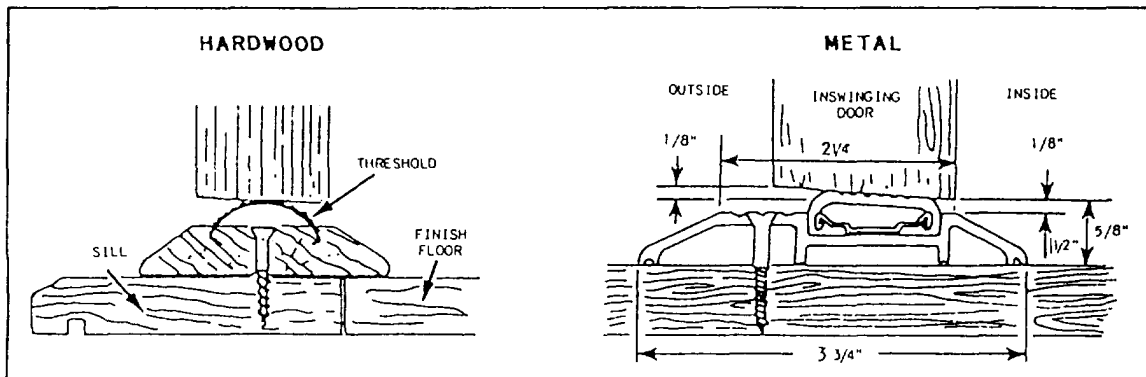


Figure 4-19.-Thresholds.

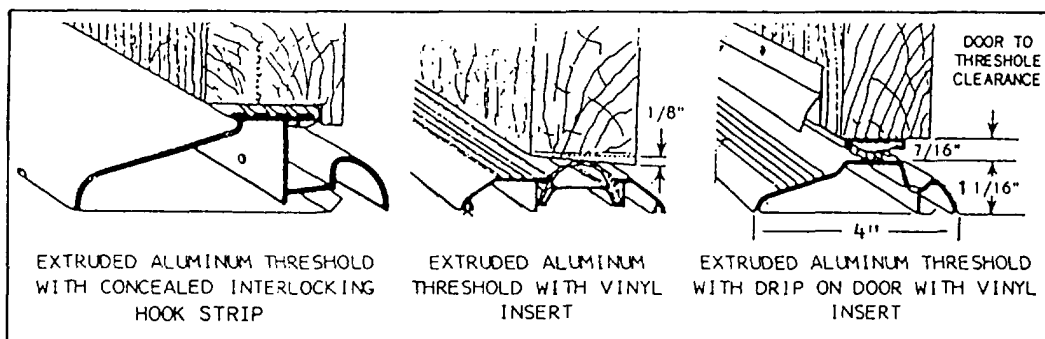


Figure 4-20.-Thresholds providing weatherproof seats.

jamb to the head jamb and sill with 10d casing nails. Then nail the casings to the front edges of the jambs with 10d casing nails spaced 16 inches OC.

Exterior doors are 1 3/4 inches thick and not less than 6 feet 8 inches high. The main entrance door is 3 feet wide, and the side or rear service door is 2 feet 8 inches wide. A hardwood or metal threshold (fig. 4-19) covers the joint between the sill and the finished floor,

The bottom of an exterior door may be equipped with a length of hooked metal that engages with a specially shaped threshold to provide a weatherproof seal. Wood and metal thresholds are available with flexible synthetic rubber tubes that press tightly against the bottom of the door to seal out water and cold or hot air. These applications are shown in figure 4-20. Manufacturers furnish detailed instruction for installation.

DOOR SWINGS

Of the various types of doors, the swinging door is the most common (fig. 4-21). The doors are classed as either right hand or left hand, depending on which side is hinged. Stand outside the door. If the hinges are on your left-hand side, it is a left-hand door. If the hinges are on your right, it is a right-hand door. For a door to swing freely in an opening, the vertical edge opposite the hinges must be beveled slightly. On a left-hand door that swings away from the viewer, a left-hand regular bevel is used; if the door opens toward the viewer, it has a left-hand reverse bevel. Similarly, if the hinges are on the right and the door swings toward the viewer, it has a right-hand reverse bevel.

A door that swings both ways through an opening is called a double-acting door. Two doors that are hinged on opposite sides of a doorway and open from the center are referred to as "double doors"; such doors are frequently double acting. One leaf of a double door may be equipped with an astragal—an extended lip that fits over the crack between the two doors. A Dutch door is one that is cut and hinged so that top and bottom portions open and close independently.

INSTALLING THE EXTERIOR DOORFRAME

Before installing the exterior doorframe, prepare the rough opening to receive the frame. The opening should be approximately 3 inches wider and 2 inches higher than the size of the door. The sill should rest firmly on the floor framing, which normally must be notched to accommodate the sill. The subfloor, floor joists, and stringer or header joist must be cut to a depth

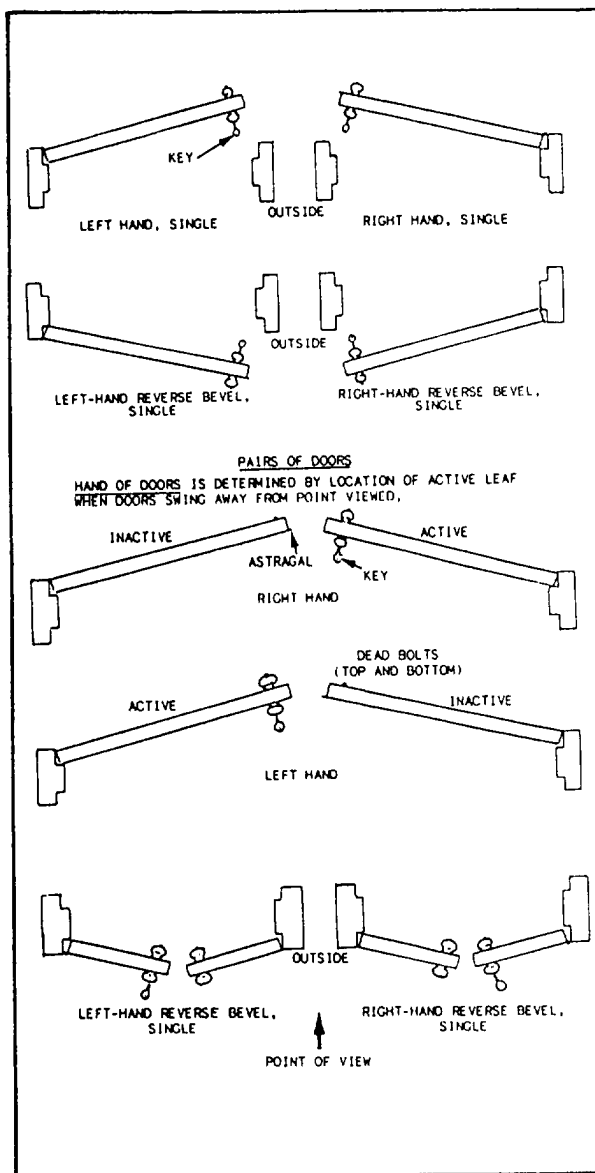


Figure 4-21.—Determining door swings.

that places the top of the sill flush with the finished floor surface.

Line the rough opening with a strip of 15-pound asphalt felt paper, 10 or 12 inches wide. In some structures, it may be necessary to install flashing over the bottom of the opening. The assembled frame is then set into the opening. Set the sill of the assembled doorframe on the trimmed-out area in the floor framing, tip the frame into place, center it horizontally, and then secure it with temporary braces.

Using blocking and wedges, you should level the sill and bring it to the correct height (even with the finished floor). Be sure the sill is level and well supported. For masonry wall and slab floors, the sill is usually placed on a bed of mortar.

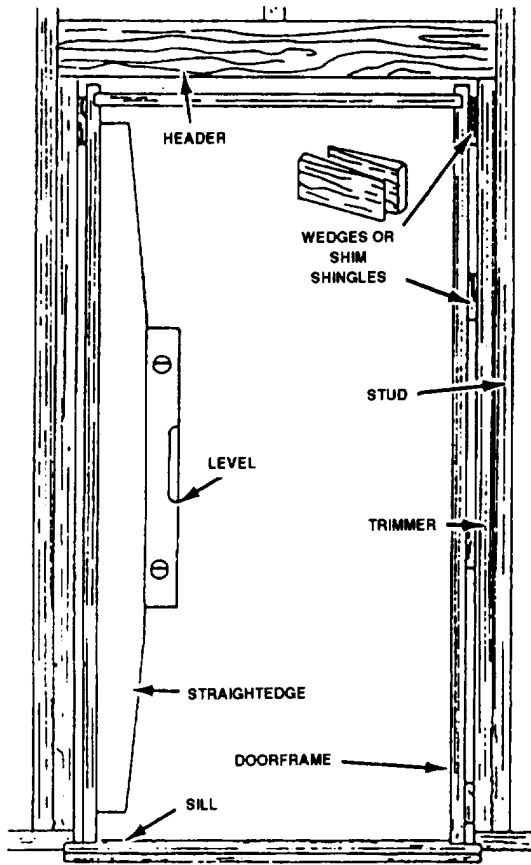


Figure 4-22. Plumbing an exterior doorjamb.

With the sill level, drive a 16d casing nail through the side casing into the wall frame at the bottom of each side. Insert blocking or wedges between the trimmer studs and the top of the jambs. Adjust the wedges until the frame is plumb. Use a level and straightedge for this procedure (fig. 4-22).

NOTE

When setting doorframes, never drive any of the nails completely into the wood until all nails are in place and a final check has been made to make sure that no adjustments are necessary.

Place additional wedges between the jambs and stud frame in the approximate location of the lock strike plate and hinges. Adjust the wedges until the side jambs are well supported and straight. Then secure the wedges by driving a 16d casing nail through the jamb, wedge, and into the trimmer stud. Finally, nail the casing in place with 16d casing nails. These nails should be placed 3/4 inch from the outer edges of the casing and spaced 16 inches OC.

After the installation is complete, a piece of 1/4- or 3/8- inch plywood should be lightly tacked over the sill to protect it during further construction work. At this time, many Builders prefer to hang a temporary door so the interior of the structure can be secured and provide a place to store tools and materials.

Hanging the door and installing door hardware are a part of the interior finishing operation and will be described later in this TRAMAN.

PREHUNG EXTERIOR DOOR UNITS

A variety of prehung exterior door units are available. They include single doors, double doors, and doors with sidelights. Millwork plants provide detailed instructions for installing their products.

First, check the rough opening. Make sure the size is correct and that it is plumb, square, and level. Apply a double bead of caulking compound to the bottom of the opening, and set the unit in place. Spacer shims, located between the frame and door, should not be removed until the frame is firmly attached to the rough opening.

Insert shims between the side jambs and trimmer studs. They should be located at the top, bottom, and midpoint of the door. Drive 16d finishing nails through the jambs, shims, and into the structural frame members. Manufacturers usually recommend that at least two of the screws in the top hinge be replaced with 2 1/4-inch screws. Finally, adjust the threshold so that it makes smooth contact with the bottom edge of the door. After a prehung exterior door unit is installed, the door should be removed from the hinges and carefully stored. A temporary door can be used until final completion of the project.

WINDOWS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of windows used in frame structures, and describe installation procedures.

The primary purpose of windows is to allow the entry of light and air, but they may also be an important part of the architectural design of a building. Windows and their frames are millwork units that are usually fully assembled at the factory, ready for use in buildings. These units often have the sash fitted and weather stripped, frame assembled, and exterior casing in place. Standard combination storms and screens or separate units can also be included. Wood components are treated with a water-repellent preservative at the factory to

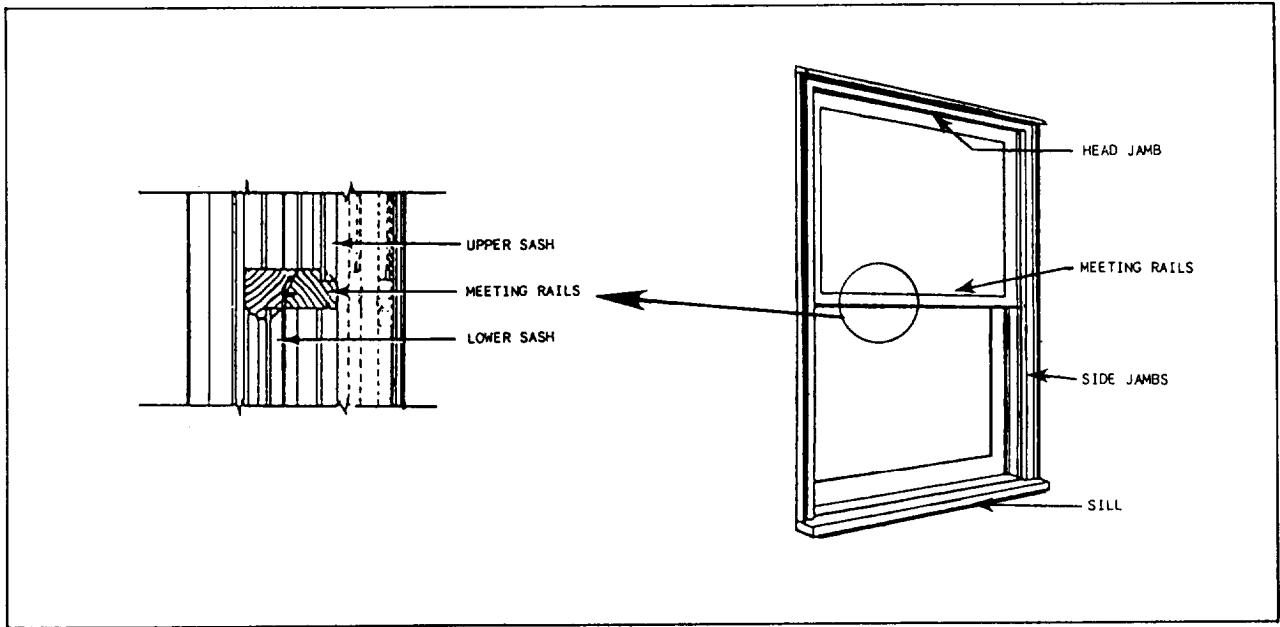


Figure 4-23.-Typical double-hung window.

provide protection before and after they are placed in the walls.

Insulated glass, used both for stationary and moveable sash, consists of two or more sheets of spaced glass with hermetically sealed edges. It resists heat loss more than a single thickness of glass and is often used without a storm sash.

Window frames and sashes should be made from a clear grade of decay-resistant heartwood stock, or from wood that has been given a preservative treatment. Examples include pine, cedar, cypress, redwood, and spruce.

Frames and sashes are also available in metal. Heat loss through metal frames and sash is much greater than through similar wood units. Glass blocks are sometimes used for admitting light in places where transparency or ventilation is not required.

Windows are available in many types. Each type has its own advantage. The principal types are double-hung, casement, stationary, awning, and horizontal sliding. In this chapter, we'll cover just the first three.

DOUBLE-HUNG WINDOWS

The double-hung window is perhaps the most familiar type of window. It consists of upper and lower sashes (fig. 4-23 detail) that slide vertically in separate grooves in the side jambs or in full-width metal weather stripping. This type of window provides a maximum face opening for ventilation of one-half the total window area. Each sash is provided with springs, balances, or compression weather stripping to hold it in place in any

location. Compression weather stripping, for example, prevents air infiltration, provides tension, and acts as a counterbalance. Several types allow the sash to be removed for easy painting or repair.

The jambs (sides and top of the frames) are made of nominal 1-inch lumber; the width provides for use with drywall or plastered interior finish. Sills are made from nominal 2-inch lumber and sloped at about 3 inches in 12 inches for good drainage. Wooden sash is normally 1 3/8 inches thick. Figure 4-24 shows an assembled window stool and apron.

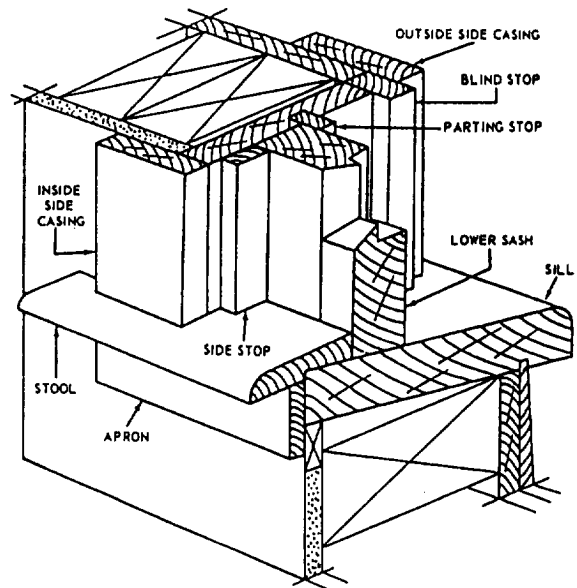


Figure 4-24.-Window stool with apron.

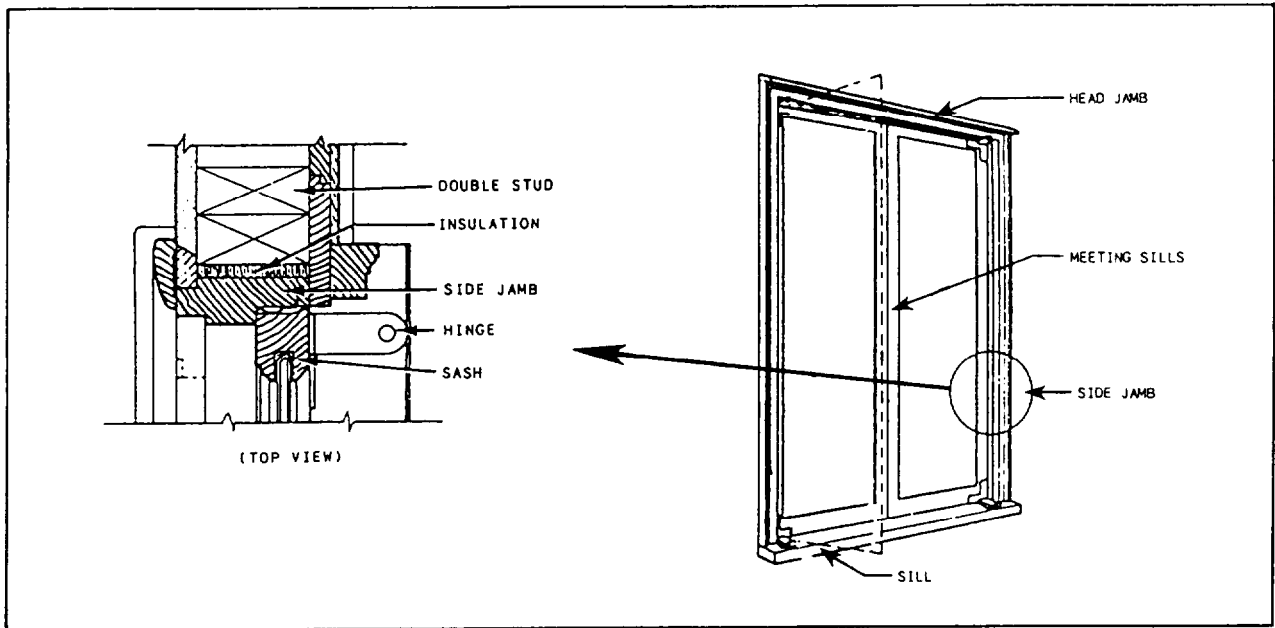


Figure 4-25.-Out-swinging casement sash.

Sash may be divided into a number of lights (glass panes or panels) by small wood members called muntins. Some manufacturers provide preassembled dividers, which snap in place over a single light, dividing it into six or eight lights. This simplifies painting and other maintenance.

Assembled frames are placed in the rough opening over strips of building paper put around the perimeter to minimize air infiltration. The frame is plumbed and nailed to side studs and header through the casings or the blind stops at the sides. Where nails are exposed, such as on the casing, use the corrosion-resistant type.

Hardware for double-hung windows includes the sash lifts that are fastened to the bottom rail. These are sometimes eliminated by providing a finger groove in the rail. Other hardware consists of sash locks or fasteners located at the meeting rail. They lock the window and draw the sash together to provide a wind-tight fit.

Double-hung windows can be arranged in a number of ways—as a single unit, doubled (or mullion), or in groups of three or more. One or two double-hung windows on each side of a large stationary insulated window are often used to create a window wall. Such large openings must be framed with headers large enough to carry roof loads.

CASEMENT WINDOWS

Casement windows consist of side-hinged sash, usually designed to swing outward (fig. 4-25). This type can be made more weathertight than the in-swinging style. Screens are located inside these out-swinging windows, and winter protection is obtained with a storm sash or by using insulated glass in the sash. One advantage of the casement window over the double-hung type is that the entire window area can be opened for ventilation.

Weather stripping is also provided for this type of window, and units are usually received from the factory entirely assembled with hardware in place. Closing hardware consists of a rotary operator and sash lock. As in the double-hung units, casement sash can be used in a number of ways—as a pair or in combinations of two or more pairs. Style variations are achieved by divided lights. Snap-in muntins provide a small, multiple-pane appearance for traditional styling.

Metal sash is sometimes used but, because of low-insulating value, should be installed carefully to prevent condensation and frosting on the interior surfaces during cold weather. A full storm-window unit is sometimes necessary to eliminate this problem in cold climates.

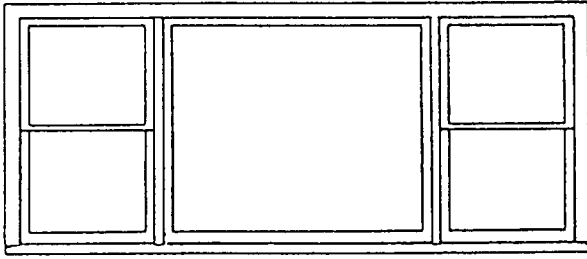


Figure 4-26.-Typical use of stationary window in combination with other types.

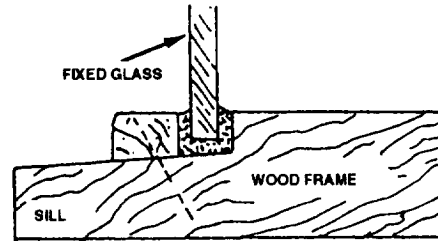
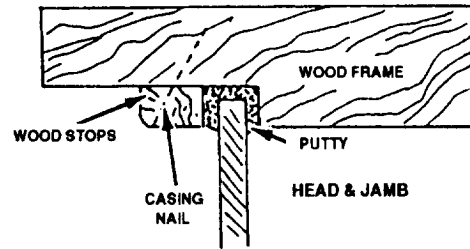


Figure 4-27.-Fixed glass in wood stops.

STATIONARY WINDOWS

Stationary windows, used alone or in combination with double-hung or casement windows (fig. 4-26), usually consist of a wood sash with a large single pane of insulated glass. They are designed to provide light, as well as be attractive, and are fastened permanently into the frame. Because of their size (sometimes 6 to 8 feet wide), stationary windows require a 1 3/4-inch-thick sash to provide strength. This thickness is required because of the thickness of the insulating glass.

Other types of stationary windows may be used without a sash. The glass is set directly into rabbeted frame members and held in place with stops. As with all window-sash units, back puttying and face puttying of the glass (with or without a stop) will assure moisture-resistance windows (fig. 4-27).

GLASS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the different types of glass, glazing materials, and describe procedures for cutting, glazing, and installing glass.

It is surprising how many types of glass and glass-like materials are used in construction. Each has its own characteristics, advantages, and best uses. In this section, we'll cover the various types of glass and materials, and the methods used in assembling glass features ("glazing").

TYPES

The "Glass and Glazing" section of construction specifications contains a wide range of materials. These may include sheet glass, plate glass, heat- and glare-reducing glass, insulating glass, tempered glass, laminated glass, and various transparent or translucent

plastics. Also included may be ceramic-coated, corrugated, figured, and silvered and other decorative glass. Additional materials may include glazier's points, setting pads, glazing compounds, and other installation materials.

Sheet/Window

Sheet or window glass is manufactured by the flat or vertically drawn process. Because of the manufacturing process, a wave or draw distortion runs in one direction through the sheet. The degree of distortion controls the usefulness of this type of glass. For best appearance, window glass should be drawn horizontally or parallel with the ground. To ensure this, the width dimension is given first when you are ordering.

Plate

Plate glass is similar to window and heavy-sheet glass. The surface, rather than the composition or thickness, is the distinguishing feature. Plate glass is manufactured in a continuous ribbon and then cut into large sheets. Both sides of the sheet are ground and polished to a perfectly flat plane. Polished plate glass is furnished in thicknesses or from 1/8 inch to 1 1/4 inches. Thicknesses 5/16 inch and over are termed "heavy polished plate." Regular polished plate is available in three qualities: silvering, mirror glazing, and glazing. The glazing quality is generally used where ordinary glazing is required. Heavy polished plate is generally available in commercial quality only.

Heat Absorbing

Heat-absorbing glass contains controlled quantities of a ferrous iron admixture that absorbs much of the energy of the sun. Heat-absorbing glass is available in plate, heavy plate, sheet, patterned, tempered, wired, and laminated types. Heat-absorbing glass dissipates much of the heat it absorbs, but some of the heat is retained. Thus, heat-absorbing glass may become much hotter than ordinary plate glass.

Because of its higher rate of expansion, heat-absorbing glass requires careful cutting, handling, and glazing. Sudden heating or cooling may induce edge stresses, which can result in failure if edges are improperly cut or damaged. Large lights made of heat-absorbing glass that are partially shaded or heavily draped are subject to higher working stresses and require special design consideration.

Glare Reducing

Glare-reducing glass is available in two types. The first type is transparent with a neutral gray or other color tint, which lowers light transmission but preserves true color vision. The second type is translucent, usually white, which gives wide light diffusion and reduces glare. Both types absorb some of the sun's radiant energy and therefore have heat-absorbing qualities. The physical characteristics of glare-reducing glass are quite similar to those of plate glass. Although glare-reducing glass absorbs heat, it does not require the special precautions that heat-absorbing glass does.

Insulating

Insulating glass units consist of two or more sheets of glass separated by either 3/16-, 7/32-, or 1/4-inch air space. These units are factory-sealed. The captive air is dehydrated at atmospheric pressure. The edge seal can be made either by fusing the edges together or with metal spacing strips. A mastic seal and metal edge support the glass.

Insulating glass requires special installation precautions. Openings into which insulating glass is installed must be plumb and square. Glazing must be free of paint and paper because they can cause a heat trap that may result in breakage. There must be no direct contact between insulating glass and the frame into which it is installed. The glazing compound must be a nonhardening type that does not contain any materials that will attack the metal-to-glass seal of the insulating glass. Never use putty. Resilient setting blocks and

spacers should be provided for uniform clearances on all units set with face stops. Use metal glazing strips for 1/2-inch-thick sash without face stops. Use a full bed of glazing compound in the edge clearance on the bottom of the sash and enough at the sides and top to make a weathertight seal. It is essential that the metal channel at the perimeter of each unit be covered by at least 1/8 inch of compound. This ensures a lasting seal.

Tempered

Tempered glass is plate or patterned glass that has been reheated to just below its melting point and then cooled very quickly by subjecting both sides to jets of air. This leaves the outside surfaces, which cool faster, in a state of compression. The inner portions of the glass are in tension. As a result, fully tempered glass has three to five times the strength against impact forces and temperature changes than untempered glass has. Tempered glass chipped or punctured on any edge or surface will shatter and disintegrate into small blunt pieces. Because of this, it cannot be cut or drilled.

Heat Strengthened

Heat-strengthened glass is plate glass or patterned glass with a ceramic glaze fused to one side. Preheating the glass to apply the ceramic glaze strengthens the glass considerably, giving it characteristics similar to tempered glass. Heat-strengthened glass is about twice as strong as plate glass. Like tempered glass, it cannot be cut or drilled.

Heat-strengthened glass is available in thicknesses of 1/4 and 5/16 inch and in limited standard sizes. It is opaque and is most often used for spandrel glazing in curtain wall systems. Framing members must be sturdy and rigid enough to support the perimeter of the tempered glass panels. Each panel should rest on resilient setting blocks. When used in operating doors and windows, it must not be handled or opened until the glazing compound has set.

Wired

Wired glass is produced by feeding wire mesh into the center of molten glass as it is passed through a pair of rollers. A hexagonal, diamond-shaped square, or rectangular pattern weld or twisted wire mesh may be used. To be given a fire rating, the mesh must be at least 25 gauge, with openings no larger than 1 1/8 inches. Also, the glass must be no less than 1/4 inch thick. Wired glass may be etched or sandblasted on one or both sides

to soften the light or provide privacy. It may be obtained with a pattern on one or both sides.

Patterned

Patterned glass has the same composition as window and plate glass. It is semitransparent with distinctive geometric or linear designs on one or both sides. The pattern can be impressed during the rolling process or sandblasted or etched later. Some patterns are also available as wired glass. Patterned glass allows entry of light while maintaining privacy. It is also used for decorative screens and windows. Patterned glass must be installed with the smooth side to the face of the putty.

Laminated

Laminated glass is composed of two or more layers of either sheet or polished plate glass with one or more layers of transparent or pigmented plastic sandwiched between the layers. A vinyl plastic, such as plasticized polyvinyl resin butyl 0.015 to 0.025 inch thick, is generally used. Only the highest quality sheet or polished plate glass is used in making laminated glass. When this type of glass breaks, the plastic holds the pieces of glass and prevents the sharp fragments from shattering. When four or more layers of glass are laminated with three or more layers of plastic, the product is known as bullet-resisting glass. Safety glass has only two layers of glass and one of plastic.

Safety

Safety glass is available with clear or pigmented plastic, and either clear or heat-absorbing and glare-reducing glass. Safety glass is used where strong impact may be encountered and the hazard of flying glass must be avoided. Exterior doors with a pane area greater than 6 square feet and shower tubs and enclosures are typical applications.

Glazing compounds must be compatible with the layers of laminated plastic. Some compounds cause deterioration of the plastic in safety glass.

Mirrors

Mirrors are made with polished plate, window, sheet, and picture glass. The reflecting surface is a thin coat of metal, generally silver, gold, copper, bronze, or chromium, applied to one side of the glass. For special mirrors, lead, aluminum, platinum, rhodium, or other metals may be used. The metal film can be semi-transparent or opaque and can be left unprotected or

protected with a coat of shellac, varnish, paint, or metal (usually copper). Mirrors used in building construction are usually either polished plate glass or tempered plate glass.

Proper installation requires that the weight of the mirror be supported at the bottom. Mastic installation is not recommended because it may cause silver spoilage.

Plexiglas®

Sheets made of thermoplastic acrylic resin (Plexiglas® and Luciteo, both trade names) are available in flat and corrugated sheets. This material is readily formed into curved shapes and, therefore, is often used in place of glass. Compared with glass, its surface is more readily scratched; hence, it should be installed in out-of-reach locations. This acrylic plastic is obtainable in transparent, translucent, or opaque sheets and in a wide variety of colors.

GLAZING MATERIALS

In this section, we'll discuss the various types of sealers you'll need to install, hold fast, and seal a window in its setting.

Wood-Sash Putty

Wood-sash putty is a cement composed of fine powdered chalk (whiting) or lead oxide (white lead) mixed with boiled or raw linseed oil. Putty may contain other drying oils, such as soybean or perilla. As the oil oxides, the putty hardens. Litharge (an oxide of lead) or special driers may be added if rapid hardening is required. Putty is used in glazing to set sheets of glass into frames. Special putty mixtures are available for interior and exterior glazing of aluminum and steel window sash.

A good grade of wood-sash putty resists sticking to the putty knife or glazier's hands, yet it should not be too dry to apply to the sash. In wood sash, apply a suitable primer, such as priming paints or boiled linseed oil.

Putty should not be painted until it has thoroughly set. Painting forms an airtight film, which slows the drying. This may cause the surface of the paint to crack. All putty should be painted for proper protection.

Metal-Sash Putty

Metal-sash putty differs from wood putty in that it is formulated to adhere to nonporous surfaces. It is used

for glazing aluminum and steel sash either inside or outside. It should be applied as recommended by the manufacturer. Metal-sash putty should be painted within 2 weeks after application, but should be thoroughly set and hard before painting begins.

There are two grades of metal-sash putty: one for interior and one for exterior glazing. Both wood-sash putty and metal-sash putty are known as oleoresinous caulking compounds. The advantage of these materials is their low cost; their disadvantages include high shrinkage, little adhesion, and an exposed life expectancy of less than 5 years.

Elastic Compounds

Elastic glazing compounds are specially formulated from selected processed oils and pigments, which remain plastic and resilient over a longer period than the common hard putties. Butyl and acrylic compounds are the most common elastics. Butyl compounds tend to stain masonry and have a high shrinkage factor. Acrylic-based materials require heating to 110°F before application. Some shrinkage occurs during curing. At high temperatures, these materials sag considerably in vertical joints. At low temperatures, acrylic-based materials become hard and brittle. They are available in a wide range of colors and have good adhesion qualities.

Polybutane Tape

Polybutane tape is a nondrying mastic, which is available in extruded ribbon shapes. It has good adhesion qualities, but should not be used as a substitute or replacement for spacers. It can be used as a continuous bed material in conjunction with a polysulfide sealer compound. This tape must be pressure applied for proper adhesion.

Polysulfide Compounds

Polysulfide-base products are two-part synthetic rubber compounds based on a polysulfide polymer. The consistency of these compounds after mixing is similar to that of a caulking compound. The activator must be thoroughly mixed with the base compound at the job. The mixed compound is applied with either a caulking gun or spatula. The sealing surfaces must be extremely clean. Surrounding areas of glass should be protected before glazing. Excess and spilled material must be removed and the surfaces cleaned promptly. Once polysulfide elastomer glazing compound has cured, it is very difficult to remove. Any excess material left on the surfaces after glazing should be cleaned during the

working time of the material (2 to 3 hours). Toluene and xylene are good solvents for this purpose.

Rubber Materials

Rubber compression materials are molded in various shapes. They are used as continuous gaskets and as intermittent spacer shims. A weathertight joint requires that the gasket be compressed at least 15 percent. Preformed materials reduce costs because careful cleaning of the glass is not necessary, and there is no waste of material.

MEASURING AND CUTTING GLASS

Always measure the length and width of the opening in which the glass is to fit at more than one place. Windows are often not absolutely square. If there is a difference between two measurements, use the smaller and then deduct 1/8 inch from the width and length to allow for expansion and contraction. Otherwise, the glass may crack with changes of temperature. This is especially true with steel casement windows.

Cutting glass is a matter of confidence-and experience. You can gain both by practicing on scrap glass before trying to cut window glass to size. Equipment required for glass cutting consists of a glass cutter, a flat, solid table, a tape measure, and a wood or metal T-square or straightedge. Look at figure 4-28. You should lightly oil the cutting wheel (view A) with a thin machine oil or lubricating fluid. Hold the cutter by resting your index finger on the flat part of the handle, as shown in view B.

To cut a piece of glass, lay a straightedge along the proposed cut, as shown in view C. Hold it down firmly with one hand and with the glass cutter in the other, make one continuous smooth stroke along the surface of the glass with the side of the cutter pressed against the straightedge (view D). The objective is to score the glass, not cut through it. You should be able to hear the cutter bite into the glass as it moves along. Make sure the cut is continuous and that you have not skipped any section. Going over a cut is a poor practice as the glass is sure to break away at that point. Snap the glass immediately after cutting by placing a pencil or long dowel under the score line and pressing with your hands on each side of the cut (view E). Frosted or patterned glass should be cut on the smooth side. Wire-reinforced glass can be cut the same as ordinary glass, except that you will have to separate the wires by flexing the two pieces up and down until the wire breaks or by cutting the wires with side-cutting pliers.

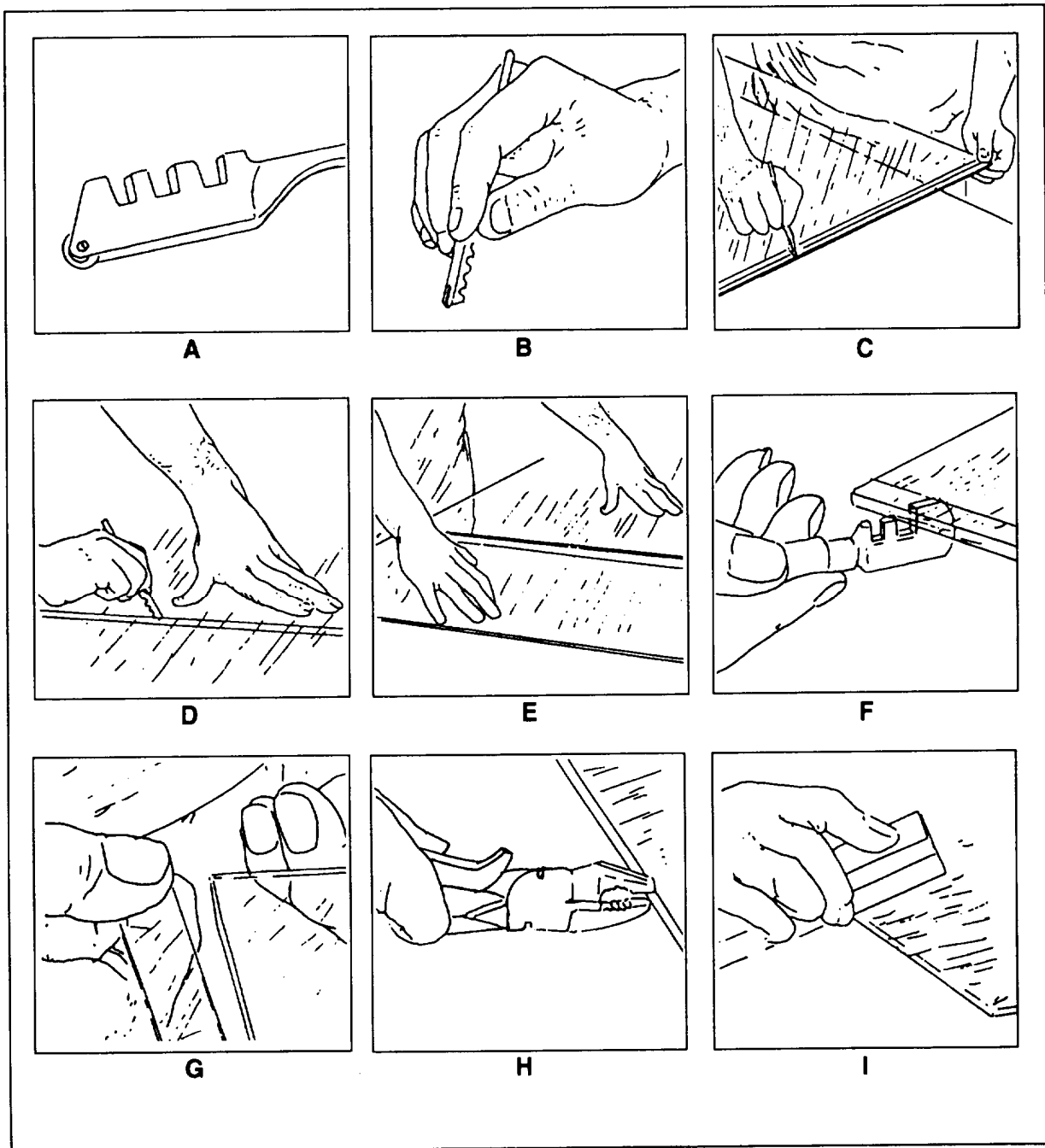


Figure 4-28. Glass cutting.

To cut a narrow strip from a large piece of glass, score a line and then tap gently underneath the score line with the cutter to open up an inch or so of the score line (view F). Next, grasp the glass on each side of the line and gently snap off the waste piece (view G). Press downward away from the score mark. If the strip does not break off cleanly, nibble it off with the pliers (view H) or the notches in the cutter. Slivers less than 1/2 inch wide are cut off by scoring the line and then nibbling off

the waste. Do not nibble without first scoring a line. You can smooth off the edges of glass intended for shelving or tabletops with an oilstone dipped in water, as shown in view I. Rub the stone back and forth from end to end with the stone at a 45° angle to the glass. Rub the stone side to side only, not up and down.

No attempt should be made to change the size of heat-strengthened, tempered, or doubled-glazed units, since any such effort will result in permanent damage.

Table 4-1.-Weight and Maximum Sizes of Sheet Glass

THICKNESS (in.)	THICKNESS (mm)	WEIGHT (oz/sq ft)	WEIGHT (kg/m ²)	MAX. SIZE (in.)	MAX. SIZE (mm)
Window Glass					
SS 3/32	2.4	19	5.8	40 × 50	1,020 × 1,270
DS 1/8	3.2	26	7.9	60 × 80	1,520 × 2,030
Thick Sheet Glass					
3/16	4.8	40	12.2	120 × 84	3,050 × 2,130
7/32	5.6	45	13.7	120 × 84	3,050 × 2,130
1/4	6.3	52	15.9	120 × 84	3,050 × 2,130
3/8	9.5	77	23.5	160 × 84	4,060 × 2,130
7/16*	11.1	86	26.2	60 × 84	1,520 × 2,130
*Used for glass shelving and table tops					

Table 4-2.-Grades of Sheet Glass

GRADE	USE
AA	For uses where superior quality is required
A	For selected glazing
B	For general glazing
Silvering quality A	For silvering mirror applications; seldom used for glazing
Silvering quality B	For mirror applications; seldom used for glazing
Greenhouse quality	For greenhouse glazing or similar applications where appearance is not critical

All heat-absorbing glass must be clean cut. Nibbling to remove flares or to reduce oversized dimensions of heat-absorbing glass is not permitted.

SHEET GLASS SIZES AND GRADES

Sheet glass is produced in a number of thicknesses, but only 3/32- and 1/8-inch sheets are commonly used as a window glass. These thicknesses are designated, respectively, as single strength (SS) and double strength (DS). Thick sheet glass, manufactured by the same method as window glass, is used in openings that exceed window-glass-size recommendations. Table 4-1 lists the thicknesses, weights, and recommended maximum sizes. Sheet glass comes in six grades (table 4-2).

The maximum size glass that may be used in a particular location is governed to a great extent by wind load. Wind velocities, and consequently wind pressures, increase with height above the ground. Various building codes or project specifications determine the maximum allowable glass area for wind load.

SASH PREPARATION

Attach the sash so that it will withstand the design load and comply with the specifications. Adjust, plumb, and square the sash to within 1/8 inch of nominal dimensions on shop drawings. Remove all rivets, screws, bolts, nail heads, welding fillets, and other projections from specified clearances. Seal all sash

corners and fabrication intersections to make the sash watertight. Put a coat of primer paint on all sealing surfaces of wood sash and carbon steel sash. Use appropriate solvents to remove grease, lacquers, and other organic-protecting finishes from sealing surfaces of aluminum sash.

Wood

On old wood sashes, you must clean all putty runs of broken glass fragments and glazier's points—triangular pieces of zinc or galvanized steel driven into the rabbet. Remove loose paint and putty by scraping. Wipe the surface clean with a cloth saturated in mineral spirits or turpentine; prime the putty runs and allow them to dry.

On new wood sashes, you should remove the dust, prime the putty runs, and allow them to dry. All new wood sashes should be pressure treated for decay protection.

Metal

On old metal sashes, you must remove loose paint or putty by scraping. Use steel wool or sandpaper to remove rust. Clean the surfaces thoroughly with a cloth saturated in mineral spirits or turpentine. Prime bare metal and allow it to dry thoroughly.

On new metal sashes, you should wipe the sash thoroughly with a cloth saturated in mineral spirits or turpentine to remove dust, dirt, oil, or grease. Remove any rust with steel wool or sandpaper. If the sash is not already factory-primed, prime it with rust-inhibitive paint and allow it to dry thoroughly.

GLAZING

“Glazing” refers to the installation of glass in prepared openings of windows, doors, partitions, and curtain walls. Glass may be held in place with glazier's points, spring clips, or flexible glazing beads. Glass is kept from contact with the frame with various types of shims. Putty, sealants, or various types of caulking compounds are applied to make a weathertight joint between the glass and the frame.

Wood Sash

Most wood sash is face-glazed. The glass is installed in rabbets, consisting of L-shaped recesses cut

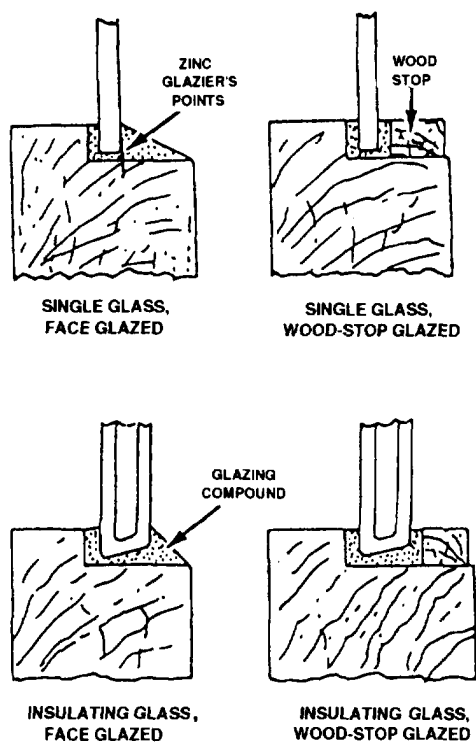


Figure 4-29.-Types of wood-sash glazing.

into the sash or frame to receive and support panes of glass. The glass is held tightly against the frame by glazier's points. The rabbet is then filled with putty. The putty is pressed firmly against the glass and beveled back against the wood frame with a putty knife. A priming paint is essential in glazing wood sash. The priming seals the pores of the wood, preventing the loss of oil from the putty. Wood frames are usually glazed from the outside (fig. 4-29).

As we noted earlier, wood-sash putty is generally made with linseed oil and a pigment. Some putties contain soybean oil as a drying agent. Putty should not be painted until it is thoroughly set. A bead of putty or glazing compound is applied between the glass and the frame as a bedding. The bedding is usually applied to the frame before the glass is set. Back puttying is then used to force putty into spaces that may have been left between the frame and the glass.

Metal Windows and Doors

Glass set in metal frames must be prevented from making contact with metal. This may be accomplished by first applying a setting bed of metal-sash putty or glazing compound. Metal-sash putty differs from wood-sash putty in that it is formulated to adhere to a

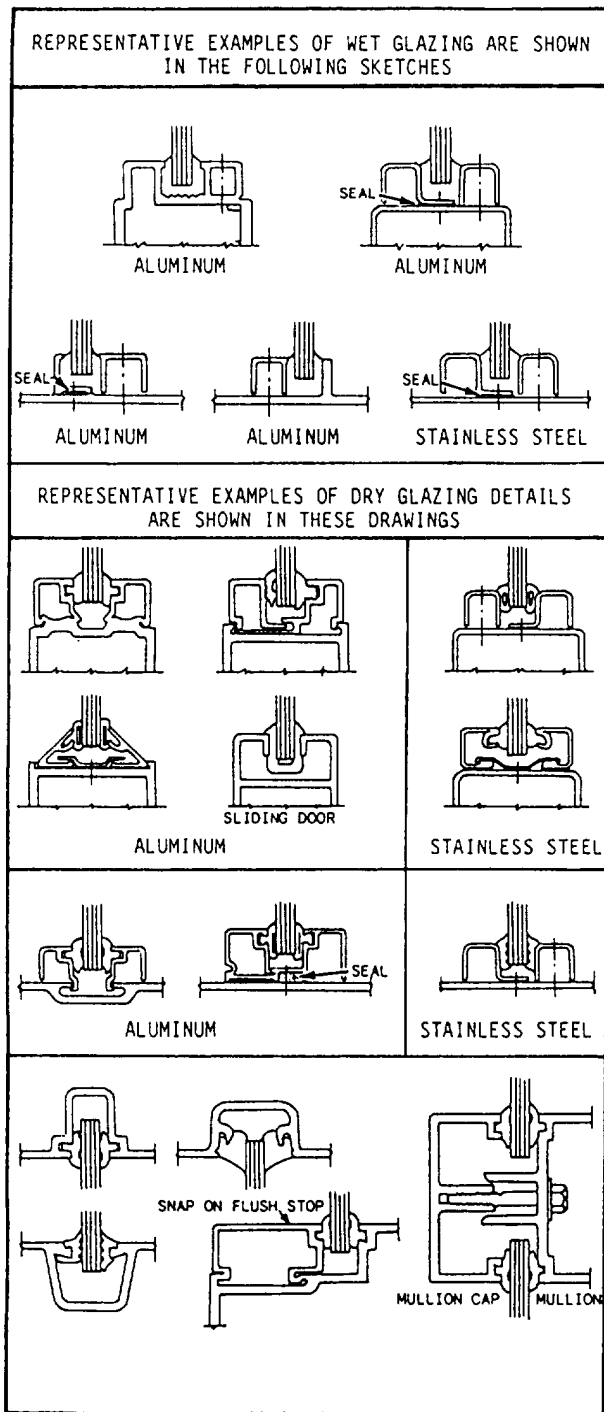


Figure 4-30.-Types of metal-sash glazing.

nonporous surface. Figure 4-30 shows examples of the types of metal-sash putty. Elastic glazing compounds may be used in place of putty. These compounds are produced from processed oils and pigments and will remain plastic and resilient over a longer period than will putty. A skin quickly forms over the outside of the

compound after it is placed, while the interior remains soft. This type of glazing compound is used in windows or doors subject to twisting or vibration. It may be painted as soon as the surface has formed.

For large panes of glass, setting blocks may be placed between the glass edges and the frame to maintain proper spacing of the glass in the openings. The blocks may be of wood, lead, neoprene, or some flexible material. For large openings, flexible shims must be set between the face of the glass and the glazing channel to allow for movement. Plastics and heat-absorbing or reflective glass require more clearance to allow for greater expansion. The shims may be in the form of a continuous tape of a butyl-rubber-based compound, which has been extruded into soft, tacky, ready-to-use tape that adheres to any clean, dry surface. The tape is applied to the frame and the glass-holding stop before the glass is placed in a frame. Under compression, the tape also serves as a sealant.

Glass may be held in place in the frame by spring clips inserted in holes in the metal frame or by continuous angles or stops attached to the frame with screws or snap-on spring clips. The frames of metal windows are shaped either for outside or inside glazing.

SETTING GLASS IN WOOD AND METAL SASHES

Do not glaze or reglaze exterior sash when the temperature is 40°F or lower unless absolutely necessary. Sash and door members must be thoroughly cleaned of dust with a brush or cloth dampened with turpentine or mineral spirits. Lay a continuous 1/6-inch-thick bed of putty or compound in the putty run (fig. 4-31). The glazed face of the sash can be recognized as the size on which the glass was cut. If the glass has a bowed surface, it should be set with the concave side in. Wire glass is set with the twist vertical. Press the glass firmly into place so that the bed putty will fill all irregularities.

When glazing wood sash, insert two glazier's points per side for small lights and about 8 inches apart on all sides for large lights. When glazing metal sash, use wire clips or metal glazing beads.

After the glass has been bedded, lay a continuous bead of putty against the perimeter of the glass-face putty run. Press the putty with a putty knife or glazing tool with sufficient pressure to ensure its complete adhesion to the glass and sash. Finish with full, smooth, accurately formed bevels with clean-cut miters. Trim up

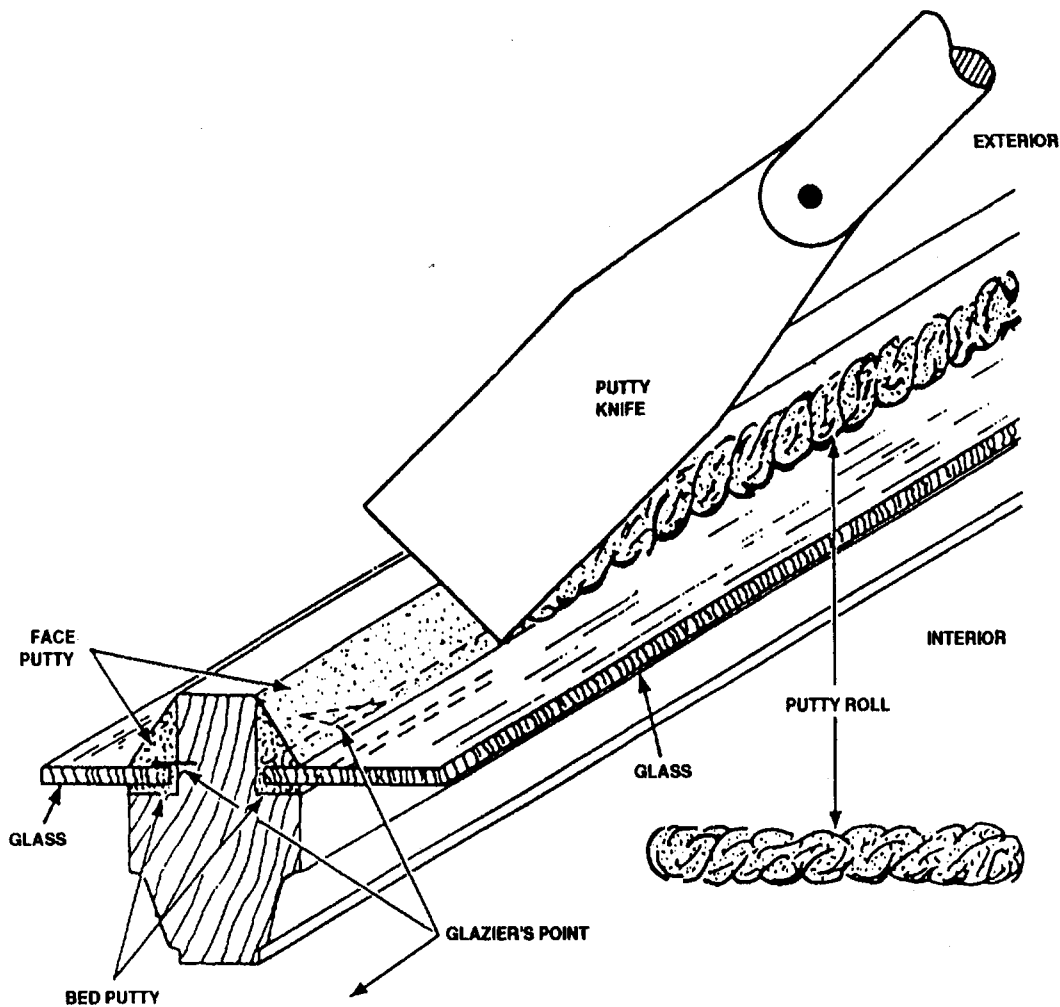


Figure 4-31.—Setting glass with glazier's points and putty.

the bed putty on the reverse side of the glass. When glazing or reglazing interior sash and transoms and interior doors, you should use wood or metal glazing beads. Exterior doors and hinged transoms should have glass secured in place with inside wood or metal glazing beads bedded in putty. In setting wired glass for security purposes, set wood or metal glazing beads, and secure with screws on the side facing the area to be protected.

Weed-sash putty should be painted as soon as it has surface-hardened. Do not wait longer than 2 months after glazing. When painting the glazing compound, overlap the glass 1/16 inch as a seal against moisture.

For metal sashes, use type 1 metal sash elastic compound. Metal-sash putty should be painted immediately after a firm skin has formed on the surface.

Depending on weather conditions, the time for skinning over may be 2 to 10 days. Type II metal-sash putty can usually be painted within 2 weeks after placing. This putty should not be painted before it has hardened because early painting may retard the set.

Clean the glass on both sides after painting. A cloth moistened with mineral spirits will remove putty stains. When scrapers are used, care should be exercised to avoid breaking the paint seal at the putty edge.

After installing large glass units in buildings under construction, it is considered good practice to place a large "X" on the glass. Use masking tape or washable paint. This will alert workers so they will not walk into the glass or damage it with tools and materials.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Basic Roof Framing, Benjamin Barnow, Tab Books, Inc., Blue Ridge Summit, Pa., 1986.

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

Exterior and Interior Trim, John E. Ball, Delmar Pub., Albany, N.Y., 1975.

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

CHAPTER 5

INTERIOR FINISH OF WALLS AND CEILINGS

Builders are responsible for finishing the interior of the buildings of a construction project. Interior finish consists mainly of the coverings of the rough walls, ceilings, and floors, and installing doors and windows with trim and hardware. In this chapter, we'll discuss wall and ceiling coverings, including the closely related topics of insulation and ventilation. In the next chapter, we'll look at floor coverings, stairway construction, and interior door and wood trim installation.

DRYWALL AND OTHER COVERINGS

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe drywall installation and finishing procedures, and identify various types of wall and ceiling coverings and the tools, fasteners, and accessories used in installation.

Though lath-and-plaster finish is still used in building construction today, drywall finish has become the most popular. Drywall finish saves time in construction, whereas plaster finish requires drying time before other interior work can be started. Drywall finish requires only short drying time since little, if any, water is required for application. However, a gypsum drywall demands a moderately low moisture content of the framing members to prevent "nail-pops." Nail-pops result when frame members dry out to moisture equilibrium, causing the nailhead to form small "humps" on the surface of the board. Stud alignment is also important for single-layer gypsum finish to prevent a wavy, uneven appearance. Thus, there are advantages to both plaster and gypsum drywall finishes and each should be considered along with the initial cost and maintenance.

DRYWALL

There are many types of drywall. One of the most widely used is gypsum board in 4- by 8-foot sheets. Gypsum board is also available in lengths up to 16 feet. These lengths are used in horizontal application. Plywood, hardboard, fiberboard, particleboard, wood

paneling, and similar types are also used. Many of these drywall finishes come prefinished.

The use of thin sheet materials, such as gypsum board or plywood, requires that studs and ceiling joists have good alignment to provide a smooth, even surface. Wood sheathing often corrects misaligned studs on exterior walls. A strongback (fig. 5-1) provides for alignment of ceiling joists of unfinished attics. It can also be used at the center of a span when ceiling joists are uneven.

Gypsum wallboard is the most commonly used wall and ceiling covering in construction today. Because gypsum is nonflammable and durable, it is appropriate for application in most building types. Sheets of drywall are nailed or screwed into place, and nail indentions or "dimples" are filled with joint compound. Joints between adjoining sheets are built up with special tape and several layers (usually three) of joint compound. Drywall is easily installed, though joint work can be tedious.

Drywall varies in composition, thickness, and edge shape. The most common sizes with tapered edges are 1/2 inch by 4 feet by 8 feet and 1/2 inch by 4 feet by 12 feet.

Regular gypsum board is commonly used on walls and ceilings and is available in various thicknesses. The most common thicknesses are 1/2 inch and 5/8 inch. Type X gypsum board has special additives that make it fire resistant.

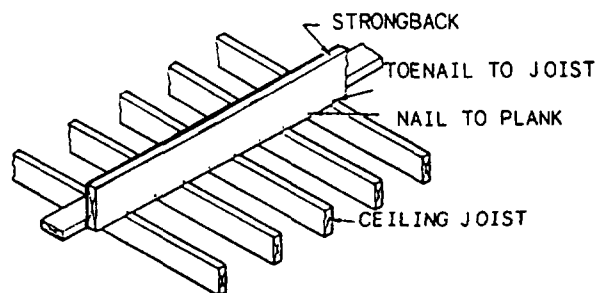


Figure 5-1.—Strongback for alignment of ceiling joists.

Types

MR (moisture resistant) or WR (water resistant) board is also called greenboard and blueboard. Being water resistant, this board is appropriate for bathrooms, laundries, and similar areas with high moisture. It also provides a suitable base for embedding tiles in mastic. MR or WR board is commonly 1/2 inch thick.

Sound-deadening board is a sublayer used with other layers of drywall (usually type X); this board is often 1/4 inch thick

Backing board has a gray paper lining on both sides. It is used as a base sheet on multilayer applications. Backing board is not suited for finishing and decorating.

Foil-backed board serves as a vapor barrier on exterior walls. This board is available in various thicknesses.

Vinyl-surfaced board is available in a variety of colors. It is attached with special drywall finish nails and is left exposed with no joint treatment.

Plasterboard or gypsum lath is used for plaster base. It is available in thickness starting at 3/8 inch, widths 16 and 24 inches, and length is usually 48 inches. Because it comes in manageable sizes, it's widely used as a plaster base instead of metal or wood lath for both new construction and renovation. This material is not compatible with portland cement plaster.

The varying lengths of drywall allow you to lay out sheets so that the number of seams is kept to a minimum. End points can be a problem, however, since the ends of the sheets aren't shaped (only the sides are). As sheet length increases, so does weight, unwieldiness, and the need for helpers. Standard lengths are 8, 9, 10, 12, and 14 feet. Sixteen-foot lengths are also available. Use the thickness that is right for the job. One-half-inch drywall is the dimension most commonly used. That thickness, which is more than adequate for studs 16 inches on center (OC), is also considered adequate where studs are 24 inches OC. Where ceiling joists are 16 inches OC, use 1/2-inch drywall, whether it runs parallel or perpendicular to joists. Where ceiling joists are 24 inches OC, though, use 1/2-inch drywall only if the sheets are perpendicular to joists.

Drywall of 1/4- and 3/8-inch thicknesses is used effectively in renovation to cover existing finish walls with minor irregularities. Neither is adequate as a single layer for walls or ceiling, however. Two 1/4-inch-thick plies are also used to wrap curving walls.

Drywall of 5/8-inch thickness is favored for quality single-layer walls, especially where studs are 24 inches OC. Use 5/8-inch drywall for ceiling joists 24 inches OC, where sheets run parallel to joists. This thickness is widely used in multiple, fire-resistant combinations.

There are several types of edging in common use. Tapered allows joint tape to be bedded and built up to a flat surface. This is the most common edge used. Tapered round is a variation on the first type. Tapered round edges allow better joints. These edges are more easily damaged, however. Square makes an acceptable exposed edge. Beveled has an edge that, when left untapped, gives a paneled look.

Tools

Commonly used tools in drywall application include a tape measure, chalk line, level, utility and drywall knives, straightedge, and a 48-inch T square (drywall square) or framing square. Other basic tools include a keyhole saw, drywall hammer (or convex head hammer), screw gun, drywall trowel, corner trowel, and a foot lift. Some of these tools are shown in figure 5-2.

The tape measure, chalk line, and level are used for layout work. The utility and drywall knives, straightedge, and squares are used for scoring and breaking drywall. The keyhole saw is used for cutting irregular shapes and openings, such as outlet box openings. A convex head or drywall hammer used for drywall nails will "dimple" the material without tearing the paper. The screw gun quickly sinks drywall screws to the adjusted depth and then automatically disengages.

Drywall knives have a variety of uses. The 6-inch knife is used to bed the tape in the first layer of joint compound and for filling nail or screw dimples. The 12-inch finishing knife "feathers out" the second layer of joint compound and is usually adequate for the third or "topping" layer. Knives 16 inches and wider are used for applying the topping coat. Clean and dry drywall knives after use. Use only the drywall knives for the purpose intended to finish drywall.

The drywall trowel resembles a concrete finishing trowel and is manufactured with a 3/16-inch concave bow. This trowel, also referred to as a "flaring," "feathering," or "bow" trowel, is used when applying the finish layer of joint compound. A corner trowel is almost indispensable for making clean interior corners.

For sanding dried joint compound smooth, use 220 grit sandpaper. Sandpaper should be wrapped around a sanding block or can be used on an orbital sander. When

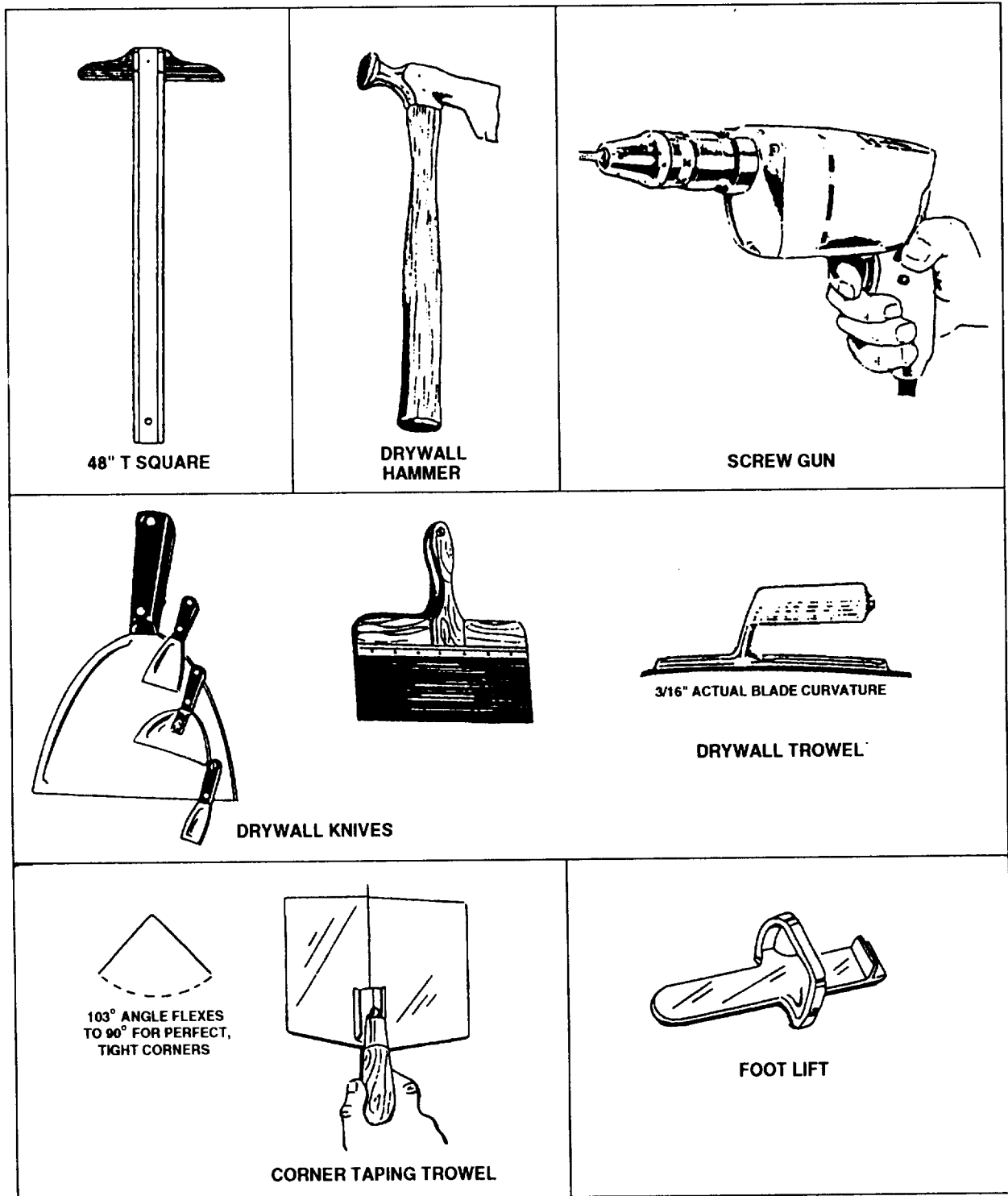


Figure 5-2.—Common tools for drywall installation.

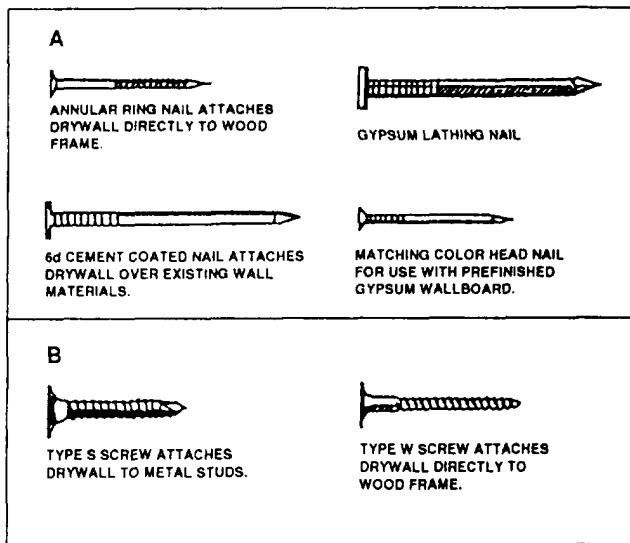


Figure 5-3.—Drywall fasteners.

sanding, ensure you're wearing the required personnel protective gear to prevent dust inhalation.

A foot lift helps you raise and lower drywall sheets while you plumb the edges. Be careful when using the foot lift—applying too much pressure to the lift can easily damage the drywall.

Fasteners

Which fasteners you use depends in part upon the material underneath. The framing is usually wood or metal studs, although gypsum is occasionally used as a base. Adhesives are normally used in tandem with screws or nails. This allows the installer to use fewer screws or nails, leaving fewer holes that require filling. For reasons noted shortly, you'll find the drywall screw the most versatile fastener for attaching drywall to framing members.

NAILS.— Drywall nails (fig. 5-3, view A) are specially designed, with oversized heads, for greater holding power. Casing or common nailheads are too small. Further, untreated nails can rust and stain a finish. The drywall nail most frequently used is the annular ring nail. This nail fastens securely into wood studs and joists. When purchasing such nails, consider the thickness of the layer or layers of drywall, and allow additional length for the nail to penetrate the underlying wood 3/4 inch. Example: 1/2-inch drywall plus 3/4-inch penetration requires a 1 1/4-inch nail. A longer nail does not fasten more securely than one properly sized, and

the longer nail is subject to the expansion and contraction of a greater depth of wood.

Smooth-shank, diamond-head nails are commonly used to attach two layers of drywall; for example, when fireproofing a wall. Again, the nail length should be selected carefully. Smooth-shank nails should penetrate the base wood 1 inch. Predecorated drywall nails, which may be left exposed, have smaller heads and are color-matched to the drywall.

SCREWS.— Drywall screws (fig. 5-3, view B) are the preferred method of fastening among professional builders, cabinetmakers, and renovators. These screws are made of high-quality steel and are superior to conventional wood screws. Use a power screw gun or an electric drill to drive in the screws. Because this method requires no impact, there is little danger of jarring loose earlier connections. There are two types of drywall screws commonly used: type S and type W.

Type S.— Type S screws (fig. 5-3, view B) are designed for attachment to metal studs. The screws are self-tapping and very sharp, since metal studs can flex away. At least 3/8 inch of the threaded part of the screw should pass through a metal stud. Although other lengths are available, 1-inch type S screws are commonly used for single-ply drywall.

Type W.— Type W screws (fig. 5-3, view B) hold drywall to wood. They should penetrate studs or joists at least 5/8 inch. If you are applying two layers of drywall, the screws holding the second sheet need to penetrate the wood beneath only 1/2 inch.

TAPE.— Joint tape varies little. The major difference between tapes is whether they are perforated or not. Perforated types are somewhat easier to bed and cover. New self-sticking fiber-mesh types (resembling window screen) are becoming popular. Having the mesh design and being self-sticking eliminates the need for the first layer of bedding joint compound.

JOINT COMPOUND.— Joint compound comes ready-mixed or in powder form. The powder form must be mixed with water to a putty consistency. Ready-mixed compound is easier to work with, though its shelf life is shorter than the powdered form. Joint compounds vary according to the additive they contain. Always read and follow the manufacturer's specifications.

ADHESIVES.— Adhesives are used to bond single-ply drywall directly to the framing members, furring strips, masonry surfaces, insulation board, or other drywall. They must be used with nails or screws.

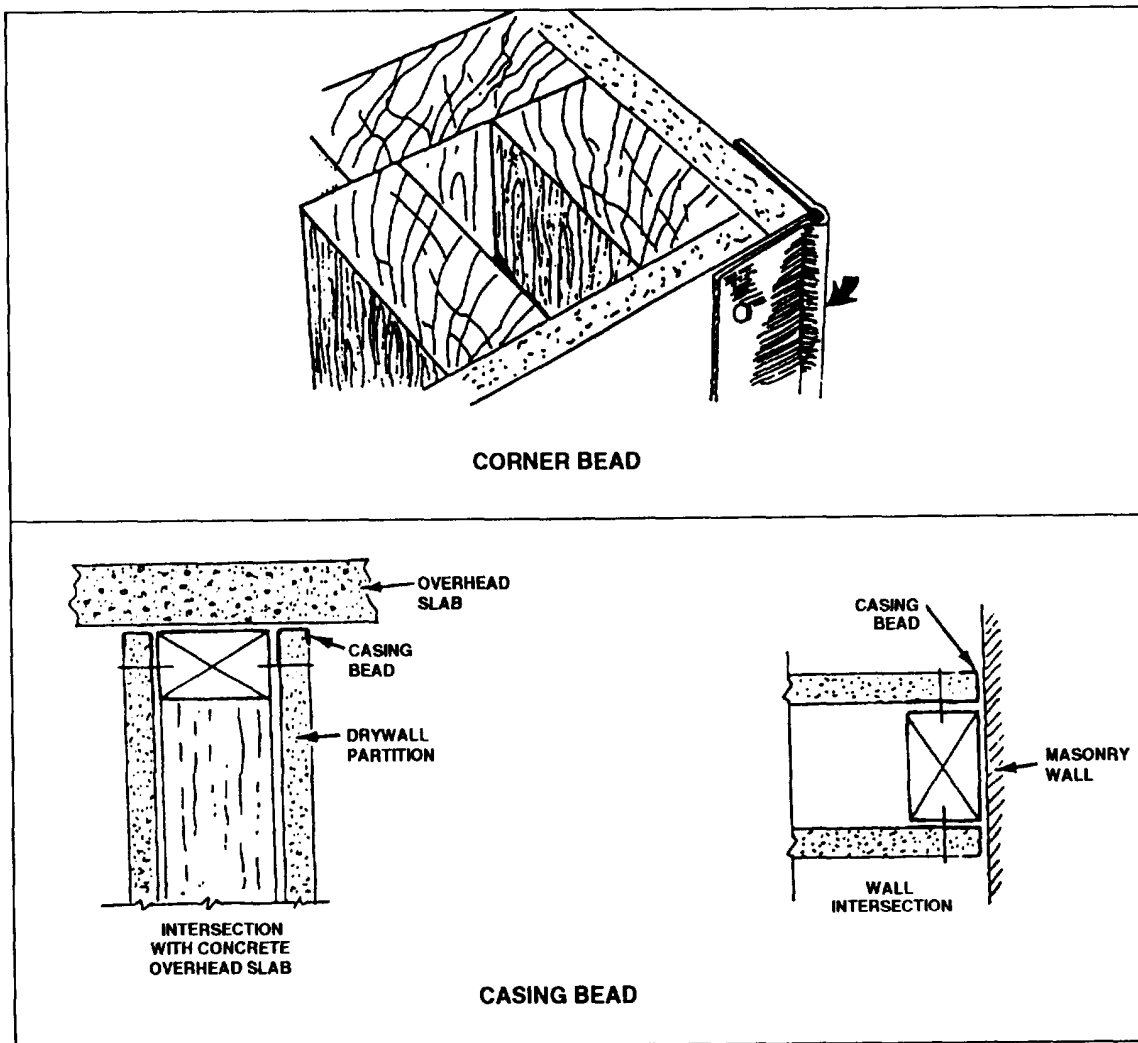


Figure 5-4.—Corner and casing beads.

Because adhesives are matched with specific materials, be sure to select the correct adhesive for the job. Read and follow the manufacturer's directions.

Accessories

A number of metal accessories have been developed to finish off or protect drywall. corner beads (fig. 5-4) are used on all exposed comers to ensure a clean finish and to protect the drywall from edge damage. corner bead is nailed or screwed every 5 inches through the drywall and into the framing members. Be sure the corner bead stays plumb as you fasten it in place. Casing beads (fig. 5-4), also called stop beads, are used where drywall sheets abut at wall intersections, wall and exposed ceiling intersections, or where otherwise

specified. Casing beads are matched to the thickness of the drywall used.

Layout

When laying out a drywall job, keep in mind that each joint will require taping and sanding. You therefore should arrange the sheets so that there will be a minimum of joint work. Choose drywall boards of the maximum practical length.

Drywall can be hung with its length either parallel or perpendicular to joists or studs. Although both arrangements work sheets running perpendicular afford better attachment. In double-ply installation, run base sheets parallel and top sheets perpendicular. For walls, the height of the ceiling is an important factor. When

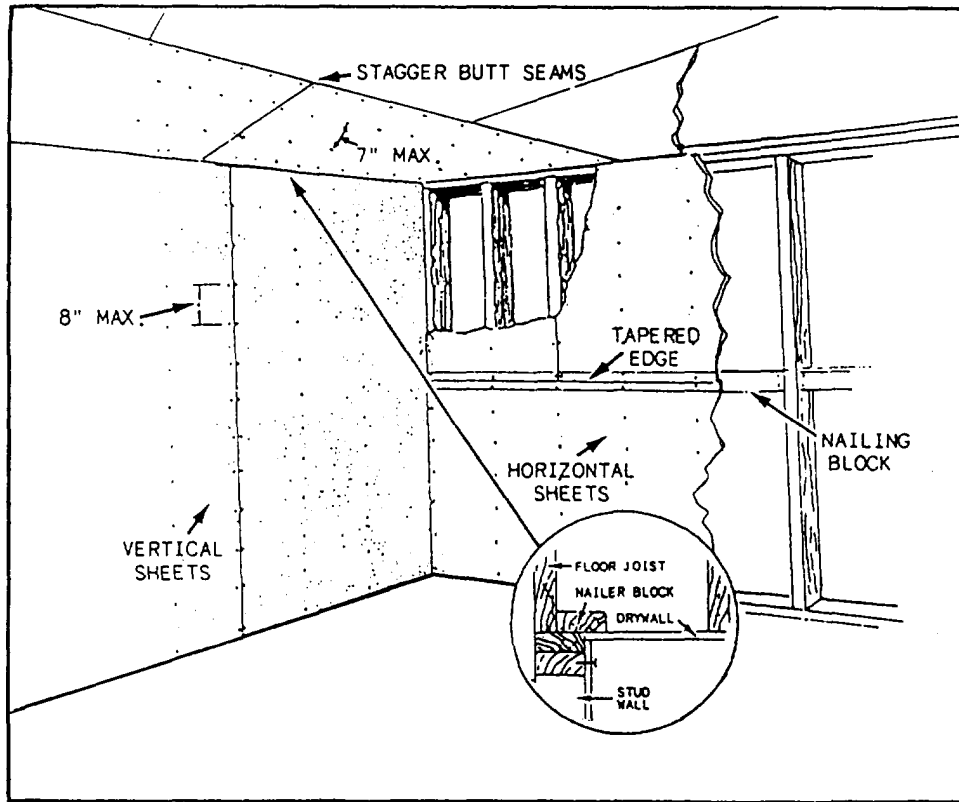


Figure 5-5.—Single-layer application of drywall.

ceilings are 8 feet 1 inch high or less, run wall sheets horizontally. Where they are higher, run wall sheets vertically, as shown in figure 5-5.

The sides of drywall taper, but the ends don't, so there are some layout constraints. End joints must be staggered where they occur. Such joints are difficult to feather out correctly. Where drywall is hung vertically, avoid side joints within 6 inches of the outside edges of doors or windows. In the case of windows, the bevel on the side of the drywall interferes with the finish trim, and the bevel may be visible. To avoid this difficulty, lay out vertical joints so they meet over a cripple (shortened) stud toward the middle of a door or window opening.

When installing drywall horizontally and an impact-resistant joint is required, you should use nailing blocks (fig. 5-5).

Handling

There are several things you can do to make working with drywall easier.

First, don't order drywall too far in advance. Drywall must be stored flat to prevent damage to the edges, and it takes up a lot of space.

Second, to cut drywall (fig. 5-6), you only need to cut through the fine-paper surface (view A). Then, grasp the smaller section and snap it sharply (view B). The gypsum core breaks along the scored line. Cut through the paper on the back (view C).

Third, when cutting a piece to length, never cut too closely. One-half-inch gaps are acceptable at the top and the bottom of a wall because molding covers these gaps. If you cut too closely, you may have difficulty getting the piece into place. Also, where walls aren't square, you may have to trim anyway.

Fourth, snap chalk lines on the drywall to indicate joists or stud centers underneath attachment is much quicker. Remember: Drywall edges must be aligned over stud, joist, or rafter centers.

Fifth, when cutting out holes for outlet boxes, fixtures, and so on, measure from the nearest fixed point(s); for example, from the floor or edge of the next piece of drywall. Take two measurements from each

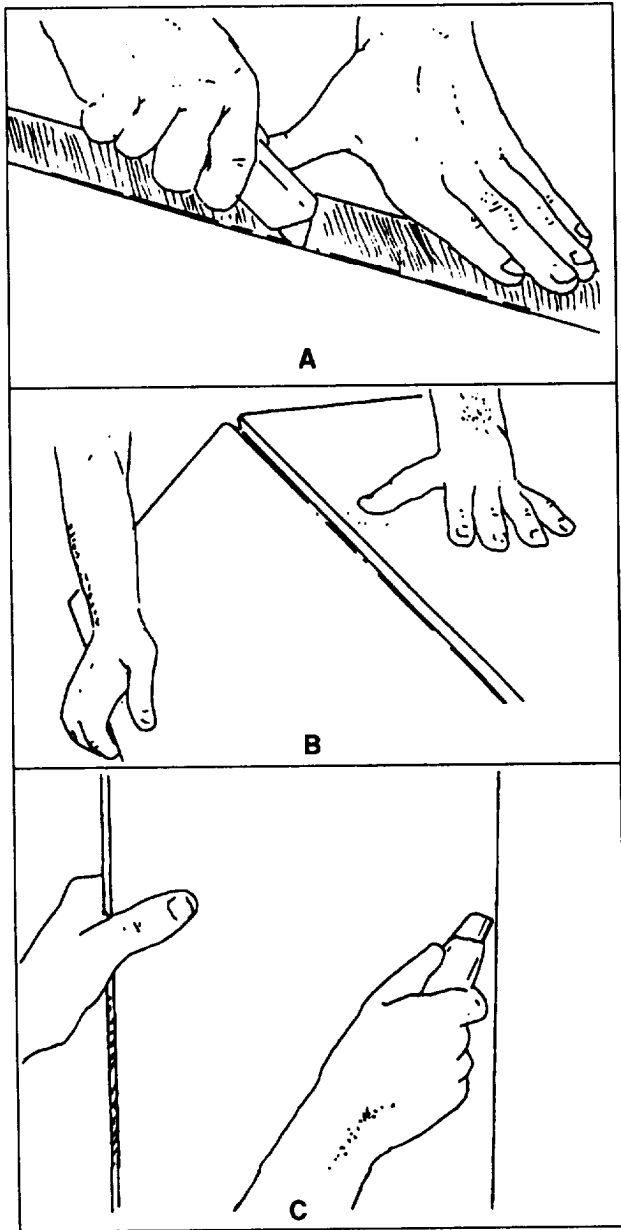


Figure 5-6.—Cutting gypsum drywall

point, so you get the true height and width of the cutout. Locate the cutout on the finish side of the drywall. To start the cut, either drill holes at the corners or start cuts by stabbing the sharp point of the keyhole saw through the drywall and then finishing the cutting with a keyhole or compass saw. It is more difficult to cut a hole with just a utility knife, but it can be done.

Installation

When attaching drywall, hold it firmly against the framing to avoid nail-pops and other weak spots. Nails

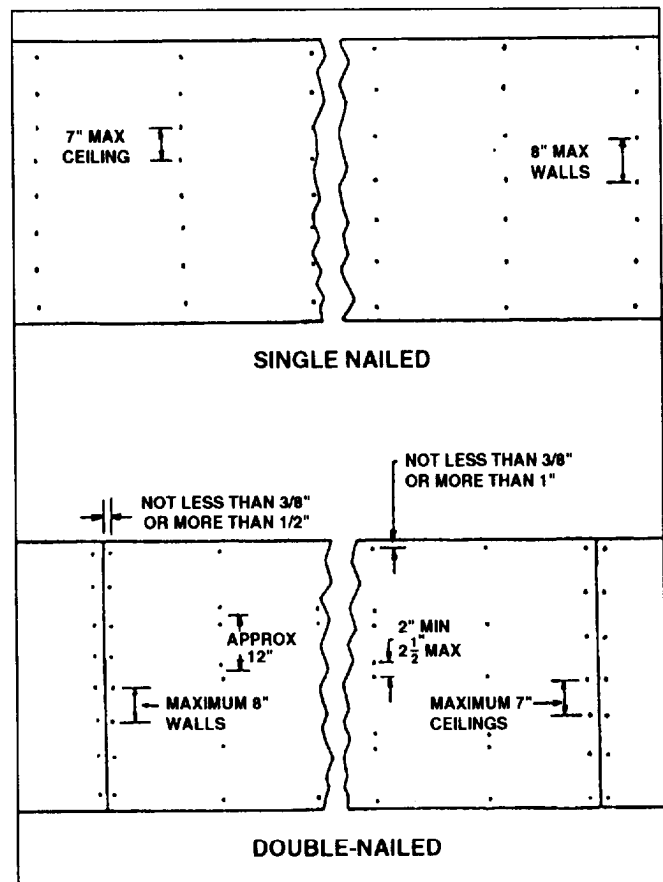


Figure 5-7.—Spacing for single and double nailing of gypsum drywall.

or screws must fasten securely in a framing member. If a nail misses the framing, pull it out, dimple the hole, and fill it in with compound; then try again. If you drive a nail in so deep that the drywall is crushed, drive in another reinforcing nail within 2 inches of the first.

When attaching drywall sheets, nail (or screw) from the center of the sheet outward. Where you double-nail sheets, single nail the entire sheet first and then add the second (double) nails, again beginning in the middle of the sheet and working outward.

SINGLE AND DOUBLE NAILING.— Sheets are single- or double-nailed. Single nails are spaced a maximum of 8 inches apart on walls and 7 inches apart on ceilings. Where sheets are double-nailed, the centers of nail pairs should be approximately 12 inches apart. Space each pair of nails 2 to 2 1/2 inches apart. Do not double-nail around the perimeter of a sheet. Instead, nail as shown in figure 5-7. As you nail, it is important that you dimple each nail; that is, drive each nail in slightly below the surface of the drywall without breaking the surface of the material. Dimpling creates a pocket that can be filled with joint compound. Although special

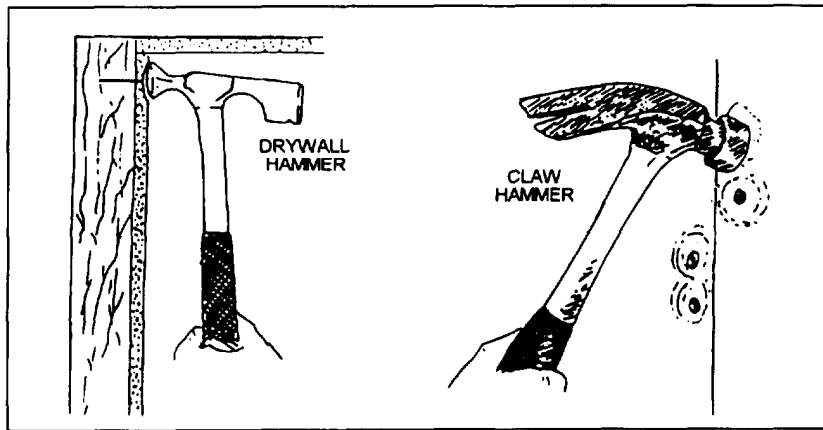


Figure 5-8.—Dimpling of gypsum drywall.

convex-headed drywall hammers are available for this operation, a conventional claw hammer also works (fig. 5-8).

SECURING WITH SCREWS.— Because screws attach more securely, fewer are needed. Screws are usually spaced 12 inches OC regardless of drywall thickness. On walls, screws maybe placed 16 inches OC for greater economy, without loss of strength. Don't double up screws except where the first screw seats poorly. Space screws around the edges the same as nails.

SECURING WITH ADHESIVES.— Adhesive applied to wood studs allows you to bridge minor irregularities along the studs and to use about half the number of nails. When using adhesives, you can space the nails 12 inches apart (without doubling up). Don't alter nail spacing along end seams, however. To attach sheets to studs, use a caulking gun and run a 3/8-inch bead down the middle of the stud. Where sheets meet over a framing member, run two parallel beads. Don't make serpentine beads, as the adhesive could ooze out onto the drywall surface. If you are laminating a second sheet of drywall over a fret, roll a liquid contact cement with a short-snap roller on the face of the sheet already in place. To keep adhesive out of your eyes, wear goggles. When the adhesive turns dark (usually within 30 minutes), it is ready to receive the second piece of drywall. Screw on the second sheet as described above.

CEILINGS.— Begin attaching sheets on the ceiling, first checking to be sure extra blocking (that will receive nails or screws) is in place above the top plates of the walls. By doing the ceiling first, you have maximum exposure of blocking to nail or screw into. If there are gaps along the intersection of the ceiling and wall, it is much easier to adjust wall pieces.

Ceilings can be covered by one person using two tees made from 2 by 4s. This practice is acceptable when dealing with sheets that are 8 foot in length. Sheets over this length will require a third tee, which is very awkward for one individual to handle. Two people should be involved with the installation of drywall on ceilings.

WALLS.— Walls are easier to hang than ceilings, and it's something one person working alone can do effectively, although the job goes faster if two people work together. As you did with the ceiling, be sure the walls have sufficient blocking in corners before you begin.

Make sure the first sheet on a wall is plumb and its leading edge is centered over a stud. Then, all you have to do is align successive sheets with the first sheet. The foot lift shown earlier in figure 5-2 is useful for raising or lowering a sheet while you level its edge. After you've sunk two or three screws or nails, the sheet will stay in place. A gap of 1/2 inch or so along the bottom of a sheet is not critical; it is easily covered by finish flooring, baseboards, and soon. If you favor a clean, modem line without trim, manufactured metal or vinyl edges (casing beads) are available for finishing the edges.

During renovation, you may find that hanging sheets horizontally makes sense. Because studs in older buildings often are not on regular centers, the joints of vertical sheets frequently do not align with the studs. Again, using the foot lift, level the top edge of the bottom sheet. Where studs are irregular, it's even more important that you note positions and chalk line stud centers onto the drywall face before hanging the sheet.

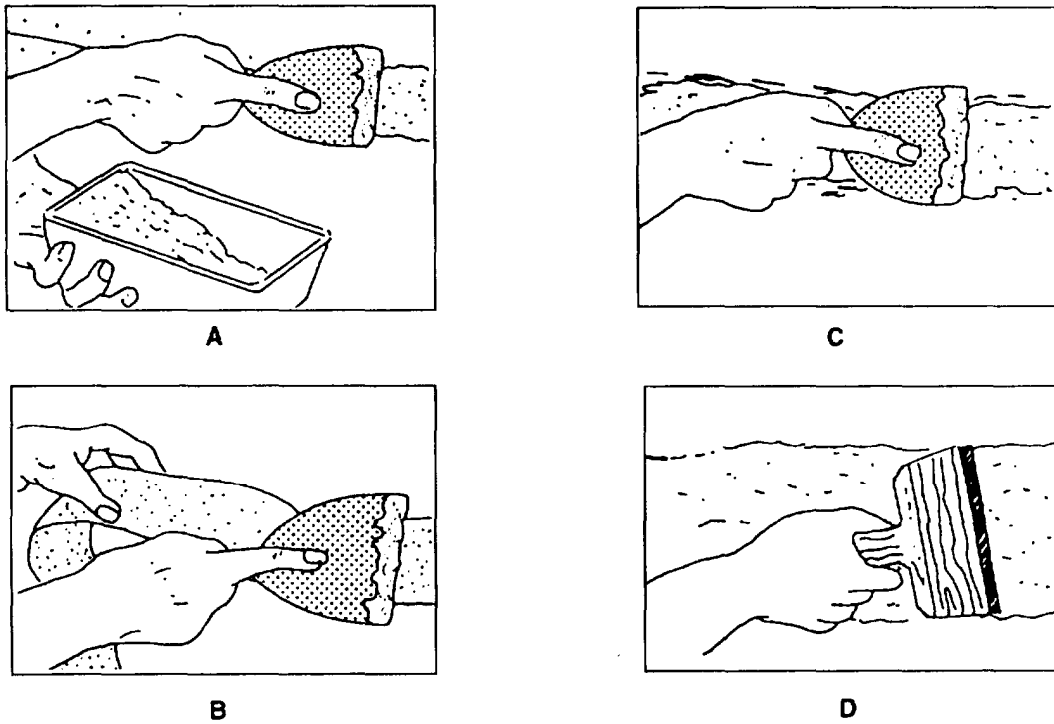


Figure 5-9.—Finishing drywall joints.

Applying drywall in older buildings yields a lot of waste because framing is not always standardized. Use the cutoffs in such out-of-the-way places as closets. Don't piece together small sections in areas where you'll notice seams. Never assume that ceilings are square with walls. Always measure from at least two points, and cut accordingly.

Drywall is quite good for creating or covering curved walls. For the best results, use two layers or 1/4-inch drywall, hung horizontally. The framing members of the curve should be placed at intervals of no more than 16 inches OC; 12 inches is better. For an 8-foot sheet applied horizontally, an arc depth of 2 to 3 feet should be no problem, but do check the manufacturer's specifications. Sharper curves may require backcutting (scoring slots into the back so that the sheet can be bent easily) or wetting (wet-sponging the front and back of the sheet to soften the gypsum). Results are not always predictable, though. When applying the second layer of 1/4-inch drywall, stagger the vertical butt joints.

Finishing

The finishing of gypsum board drywall is generally a three-coat application. Attention to drying times

between coats prevents rework that has a cost involved as well as extra time.

Where sheets of drywall join, the joints are covered with joint tape and compound (fig. 5-9). The procedure is straightforward.

1. Spread a swath of bedding compound about 4 inches wide down the center of the joint (fig. 5-9, view A). Press the tape into the center of the joint with a 6-inch finish knife (fig. 5-9, view B). Apply another coat of compound over the first to bury the tape (fig. 5-9, view C). As you apply the compound over the tape, bear down so you take up any excess. Scrape clean any excess, however, as sanding it off can be tedious.
2. When the first coat is dry, sand the edges with fine-grit sand paper while wearing personal-protective equipment. Using a 12-inch knife, apply a topping of compound 2 to 4 inches wider than the first applications (view D).
3. Sand the second coat of compound when it is dry. Apply the third and final coat, feathering it out another 2 to 3 inches on each side of the joint. You should be able to do this with a 12-inch knife. Otherwise, you should use a 16-inch "feathering trowel."

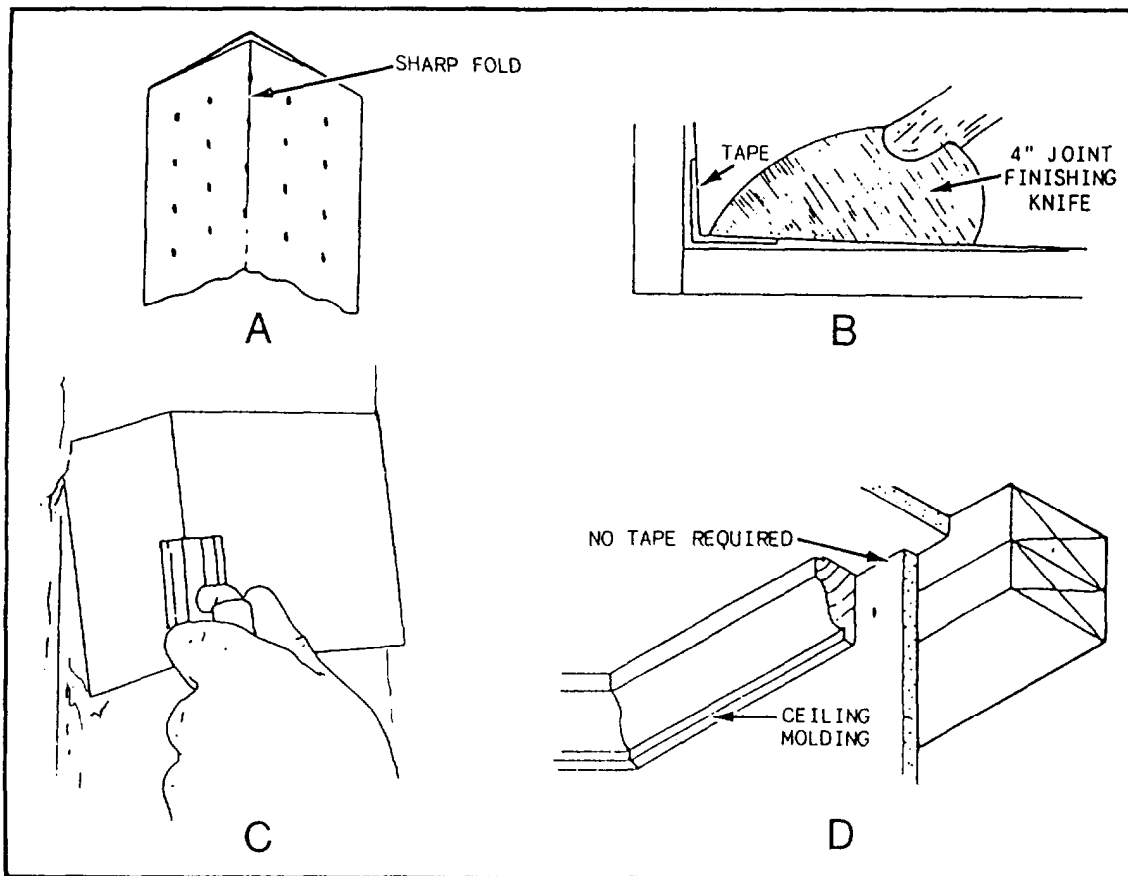


Figure 5-10.—Finishing an inside corner.

When finishing an inside corner (fig. 5-10), cut your tape the length of the corner angle you are going to finish. Apply the joint compound with a 4-inch knife evenly about 2 inches on each side of the angle. Use sufficient compound to embed the tape. Fold the tape along the center crease (view A) and firmly press it into the corner. Use enough pressure to squeeze some compound under the edges. Feather the compound 2 inches from the edge of the tape (view B). When the first coat is dry, apply a second coat. A corner trowel (view C) is almost indispensable for taping comers. Feather the edges of the compound 1 1/2 inches beyond the first coat. Apply a third coat if necessary, let it dry, and sand it to a smooth surface. Use as little compound as possible at the apex of the angle to prevent hairline cracking. When molding is installed between the wall and ceiling intersection, it is not necessary to tape the joint (view D).

When finishing an outside corner (fig. 5-11), be sure the corner bead is attached firmly. Using a 4-inch finishing knife, spread the joint compound 3 to 4 inches wide from the nose of the bead, covering the metal edges. When the compound is completely dry, sand

lightly and apply a second coat, feathering edges 2 to 3 inches beyond the first coat. A third coat maybe needed, depending on your coverage. Feather the edges of each coat 2 or 3 inches beyond each preceding coat. Corner beads are no problem if you apply compound with care and scrape the excess clean. Nail holes and screw holes usually can be covered in two passes, though shrinkage sometimes necessitates three. A tool that works well for sanding hard-to-reach places is a sanding block on an extension pole; the block has a swivel-head joint.

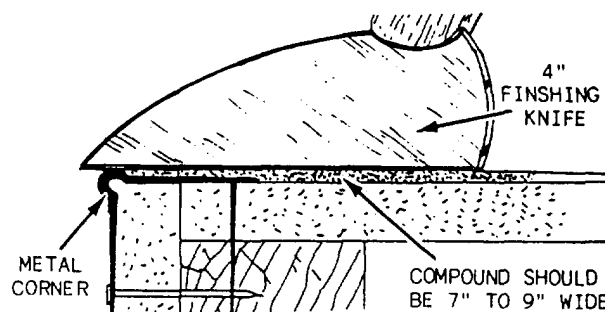


Figure 5-11.—Finishing an outside corner.

To give yourself the greatest number of decorating options in the future, paint the finished drywall surface with a coat of flat oil-base primer. Whether you intend to wallpaper or paint with latex, oil-base primer adheres best to the facing of the paper and seals it.

Renovation and Repair

For the best results, drywall should be flat against the surface to which it is being attached. How flat the nailing surface must be depends upon the desired finish effect. Smooth painted surfaces with spotlights on them require as nearly flawless a finish as you can attain. Similarly, delicate wall coverings—particularly those with close, regular patterns—accentuate pocks and lumps underneath. Textured surfaces are much more forgiving. In general, if adjacent nailing elements (studs, and so forth) vary by more than 1/4 inch, buildup low spots. Essentially, there are three ways to create a flat nailing surface:

- Frame out a new wall—a radical solution. If the studs of partition walls are buckled and warped, it's often easier to rip the walls out and replace them. Where the irregular surface is a load-bearing wall, it maybe easier to build a new wall within the old.
- Cover imperfections with a layer of 3/8-inch drywall. This thickness is flexible yet strong. Drywall of 1/4-inch thickness may suffice. Single-ply cover-up is a common renovation strategy where existing walls are ungainly but basically flat. Locate studs beforehand and use screws long enough to penetrate studs and joists at least 5/8 inch.
- Build up the surface by “furring out.” In the “furring out” procedure, furring-strips 1 by 2 inches are used. Some drywall manufacturers, however, consider that size too light for attachment, favoring instead a nominal size of 2 by 2 inches. Whatever size strips you use, make sure they (and the shims underneath) are anchored solidly to the wall behind.

By stretching strings taut between diagonal comers, you can get a quick idea of any irregularities in a wall. If studs are exposed, further assess the situation with a level held against a straight 2 by 4. Hold the straightedge plumb in front of each stud and mark low spots every 12 inches or so. Using a builder's crayon, write the depth of each low spot, relative to the straightedge, on the stud. If studs aren't exposed, locate each stud by test drilling and inserting a bent coat hanger into the hole. Chalk line

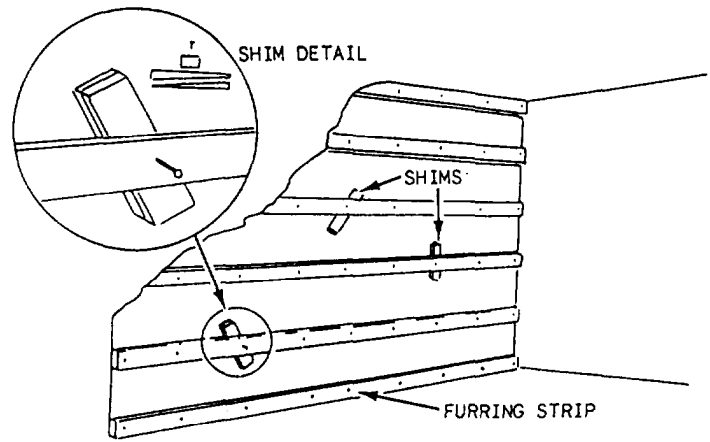


Figure 5-12.—Furring strips hacked with shims.

the center of each stud on the existing surface. Here too, mark the depth of low spots.

The objective of this process is a flat plane of furring strips over existing studs. Tack the strips in place and add shims (wood shingles are best) at each low spot marked (see fig. 5-12). To make sure a furring strip doesn't skew, use two shims, with their thin ends reversed, at each point. Tack the shims in place and plumb the furring strips again. When you are satisfied, drive the nails or screws all the way in.

When attaching the finish sheets, use screws or nails long enough to penetrate through furring strips and into the studs behind. Strips directly over studs ensure the strongest attachment. Where finish materials are not sheets—for example, single-board vertical paneling—furring should run perpendicular to the studs.

Regardless of type, finish material must be backed firmly at all nailing pints, corners, and seams. Where you cover existing finish surfaces or otherwise alter the thickness of walls, it's usually necessary to build up existing trim. Figure 5-13 shows how this might be done

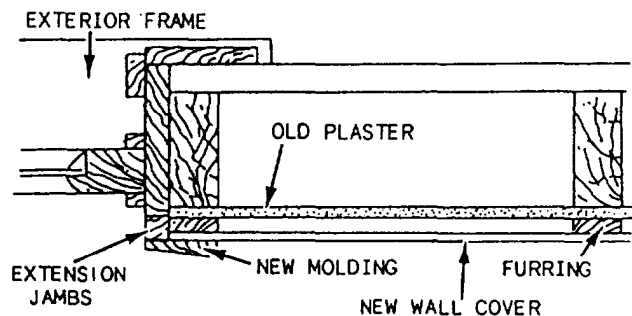


Figure 5-13.—Building up an interior window casing.

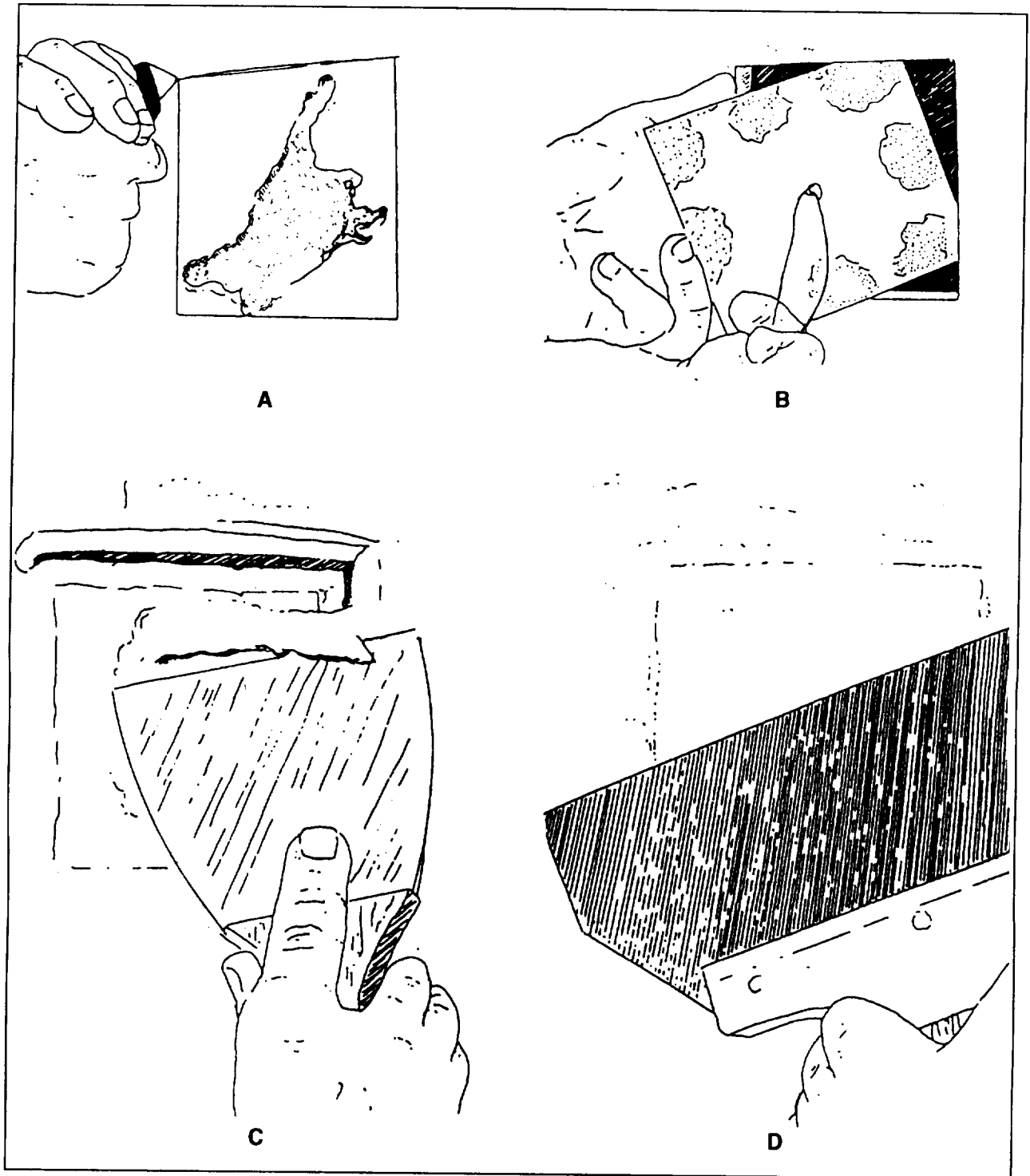


Figure 5-14.—Repairing a large hole in drywall.

for a window casing. Electrical boxes must also be extended with box extensions or plaster rings.

Masonry surfaces must be smooth, clean, and dry. Where the walls are below grade, apply a vapor barrier of polyethylene (use mastic to attach it) and install the furring strips. Use a power-actuated nail gun to attach strips to the masonry. Follow all safety procedures. If you hand nail, drive case-hardened nails into the mortar joints. Wear goggles; these nails can fragment.

Most drywall blemishes are caused by structural shifting or water damage. Correct any underlying problems before attacking the symptoms.

Popped-up nails are easily fixed by pulling them out or by dimpling them with a hammer. Test the entire wall for springiness and add roils or screws where needed. Within 2 inches of a popped-up nail, drive in another nail. Spackle both when the spots are dry, then sand and prime.

To repair cracks in drywall, cut back the edges of the crack slightly to remove any crumbly gypsum and to provide a good depression for a new filling of joint compound. Feather the edges of the compound. When dry, sand and prime them.

When a piece of drywall tape lifts, gently pull until the piece rips free from the part that's still well stuck. Sand the area affected and apply anew bed of compound for a replacement piece of tape. The self-sticking tape mentioned earlier works well here. Feather all edges.

If a sharp object has dented the drywall, merely sand around the cavity and fill it with spackling compound. A larger hole (bigger than your fist) should have a backing. One repair method is shown in figure 5-14. First, cut the edges of the hole clean with a utility knife (view A). The piece of backing should be somewhat larger than the hole itself. Drill a small hole into the middle of the backing piece and thread a piece of wire into the hole. This wire allows you to hold the piece of backing in place. Spread mastic around the edges of the backing. When the adhesive is tacky, fit the backing diagonally into the hole (view B) and, holding onto the wire, pull the piece against the back side of the hole. When the mastic is dry, push the wire back into the wall cavity. The backing stays in place. Now, fill the hole with plaster or joint compound (view C) and finish (view D). (Note: This is just one of several options available for repairing large surface damage to gypsum board.)

Compound sags in holes that are too big. If it happens, mastic a replacement piece of drywall to the backing piece. To avoid a bulge around the filled-in hole,

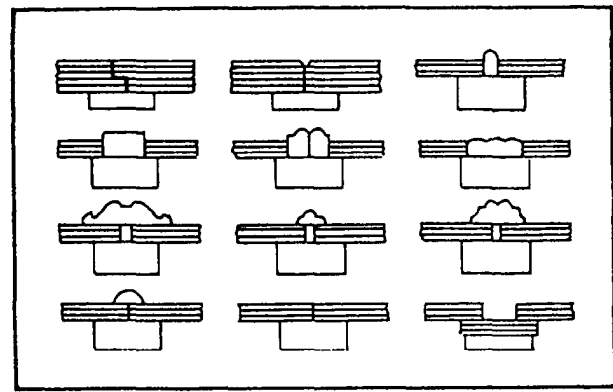


Figure 5-15.—Battens used for paneling joints.

feather the compound approximately 16 inches, or more. If the original drywall is 1/2 inch thick use 3/8-inch plasterboard as a replacement on the backing piece.

Holes larger than 8 inches should be cut back to the centers of the nearest studs. Although you should have no problem nailing a replacement piece to the studs, the top and the bottom of the new piece must be backed. The best way to install backing is to screw drywall gussets (supports) to the back of the existing drywall. Then, put the replacement piece in the hole and screw it to the gussets.

PLYWOOD

Most of the plywood used for interior walls has a factory-applied finish that is tough and durable. Manufacturers can furnish prefinished matching trim and molding that is also easy to apply. Color-coordinated putty sticks are used to conceal nail holes.

Joints between plywood sheets can be treated in a number of ways. Some panels are fabricated with machine-shaped edges that permit almost perfect joint concealment. Usually, it is easier to accentuate the joints with grooves or use battens and strips. Some of the many different styles of battens are shown in figure 5-15.

Before installation, the panels should become adjusted (conditioned) to the temperature and humidity of the room. Carefully remove prefinished plywood from cartons and stack it horizontally. Place 1-inch spacer strips between each pair of face-to-face panels. Do this at least 48 hours before application.

Plan the layout carefully to reduce the amount of cutting and the number of joints. It is important to align

panels with openings whenever possible. If finished panels are to have a grain, stand the panels around the walls and shift them until you have the most pleasing effect in color and grain patterns. To avoid mix-ups, number the panels in sequence after their position has been established.

When cutting plywood panels with a portable saw, mark the layout on the back side. Support the panel carefully and check for clearance below. Cut with the saw blade upward against the panel face. This minimizes splintering. This procedure is even more important when working with prefinished panels.

Plywood can be attached directly to the wall studs with nails or special adhesives. Use 3/8-inch plywood for this type of installation. When studs are poorly aligned or when the installation is made over an existing surface in poor condition, it is usually advisable to use furring. Nail 1- by 3- or 1- by 4-inch furring strips horizontally across the studs. Start at the floor line and continue up the wall. Spacing depends on the panel thickness. Thin panels need more support. Install vertical strips every 4 feet to support panel edges. Level uneven areas by shimmying behind the furring strips. Prefinished plywood panels can be installed with special adhesive. The adhesive is applied and the panels are simply pressed into place; no sustained pressure is required.

Begin installing panels at a corner. Scribe and trim the edges of the first panel so it is plumb. Fasten it in place before fitting the next panel. Allow approximately 1/4-inch clearance at the top and bottom. After all panels are in place, use molding to cover the space along the ceiling. Use baseboards to conceal the space at the floor line. If the molding strips, baseboards, and strips used to conceal panel joints are not prefinished, they should be spray painted or stained a color close to the tones in the paneling before installation.

On some jobs, 1/4-inch plywood is installed over a base of 1/2-inch gypsum wallboard. This backing is recommended for several reasons. It tends to bring the studs into alignment. It provides a rigid finished surface. And, it improves the fire-resistant qualities of the wall. (The plywood is bonded to the gypsum board with a compatible adhesive.)

HARDBOARD

Through special processing, hardboard (also called fiberboard) can be fabricated with a very low moisture absorption rate. This type is often scored to form a tile

pattern. Panels for wall application are usually 1/4 inch thick.

Since hardboard is made from wood fibers, the panels expand and contract slightly with changes in humidity. They should be installed when they are at their maximum size. The panels tend to buckle between the studs or attachment points if installed when moisture content is low. Manufacturers of prefinished hardboard panels recommend that they be unwrapped and placed separately around the room for at least 48 hours before application.

Procedures and attachment methods for hardboard are similar to those for plywood. Special adhesives are available as well as metal or plastic molding in matching colors. You should probably drill nail holes for the harder types.

PLASTIC LAMINATES

Plastic laminates are sheets of synthetic material that are hard, smooth, and highly resistant to scratching and wear. Although basically designed for table and countertops, they are also used for wainscoting and wall paneling in buildings.

Since plastic laminate material is thin (1/32 to 1/16 inch), it must be bonded to other supporting panels. Contact bond cement is commonly used for this purpose. Manufacturers have recently developed prefabricated panels with the plastic laminate already bonded to a base or backer material. This base consists of a 1/32-inch plastic laminate mounted on 3/8-inch particleboard. Edges are tongue and grooved so that units can be blind-nailed into place. Various matching corner and trim moldings are available.

SOLID LUMBER PANELING

Solid wood paneling makes a durable and attractive interior wall surface and may be appropriately used in nearly any type of room. Several species of hardwood and softwood are available. Sometimes, grades with numerous knots are used to obtain a special appearance. Defects, such as the deep fissures in pecky cypress, can also provide a dramatic effect.

The softwood species most commonly used include pine, spruce, hemlock and western red cedar. Boards range in widths from 4 to 12 inches (nominal size) and are dressed to 3/4 inch. Board and batten or shiplap joints are sometimes used, but tongue-and-groove (T&G) joints combined with shaped edges and surfaces are more popular.

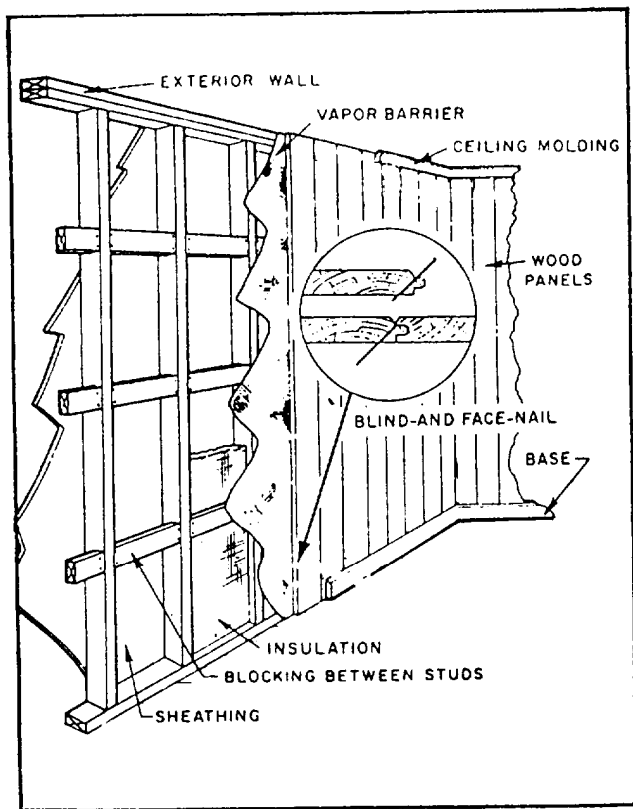


Figure 5-16.—Vertical wood paneling.

When solid wood paneling is applied horizontally, furring strips are not required—the boards are nailed directly to the studs. Inside corners are formed by butting the paneling units flush with the other walls. If random widths are used, boards on adjacent walls must match and be accurately aligned.

Vertical installations require furring strips at the top and bottom of the wall and at various intermediate spaces. Sometimes, 2- by 4-inch blocking is installed between the studs to serve as a nailing base (see fig. 5-16). Even when heavy T&G boards are used, these nailing members should not be spaced more than 24 inches apart.

Narrow widths (4 to 6 inches) of T&G paneling are blind-nailed (see insert in fig. 5-16). The nailheads do not appear on finished surfaces, and you eliminate the need for countersinking and filling nail holes. This nailing method also provides a smooth, blemish-free surface. This is especially important when clear finishes are used. Drive 6d finishing nails at a 45° angle into the base of the tongue and on into the bearing point. Carefully plumb the first piece installed and check for the plumbness at regular intervals. For lumber paneling (not tongue and grooved), use 6d casing or finishing nails. Use two roils at each nailing member for panels 6 inches or less in width and three nails for wider panels.

Exterior wall constructions, where the interior surface consists of solid wood paneling, should include a tight application of building paper located close to the backside of the boards. This prevents the infiltration of wind and dust through the joints. In cold climates, insulation and vapor barriers are important. Base, corner and ceiling trim can be used for decorative purposes or to conceal irregularities in joints.

SUSPENDED ACOUSTIC CEILING SYSTEMS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the materials used to install a suspended acoustical ceiling and explain the methods of installation.

Suspended acoustical ceiling systems can be installed to lower a ceiling, finish off exposed joints, cover damaged plaster, or make any room quieter and brighter. The majority of the systems available are primarily designed for acoustical control. However, many manufacturers offer systems that integrate the functions of lighting, air distribution, fire protection, and acoustical control. Individual characteristics of acoustical tiles, including sound-absorption coefficients, noise-reduction coefficients, light-reflection values, flame resistance, and architectural applications, are available from the manufacturer.

Tiles are available in 12- to 30-inch widths, 12- to 60-inch lengths, and 3/16- to 3/4-inch thicknesses. The larger sizes are referred to as “panels.” The most commonly used panels in suspended ceiling systems are the standard 2-by 2-foot and 2- by 4-foot acoustic panels composed of mineral or cellulose fibers.

It is beyond the scope of this training manual to acquaint you with each of the suspended acoustical ceiling systems in use today. Just as the components of these systems vary according to manufacturers, so do the procedures involved in their installation. With this in mind, the following discussion is designed to acquaint you with the principles involved in the installation of a typical suspended acoustical ceiling system.

PREPARATION FOR INSTALLATION

The success of a suspended ceiling project, as with any other construction project, is as dependent on planning as it is on construction methods and procedures. Planning, in this case, involves the selection of a grid system (either steel or aluminum), the selection and layout of a grid pattern, and the determination of

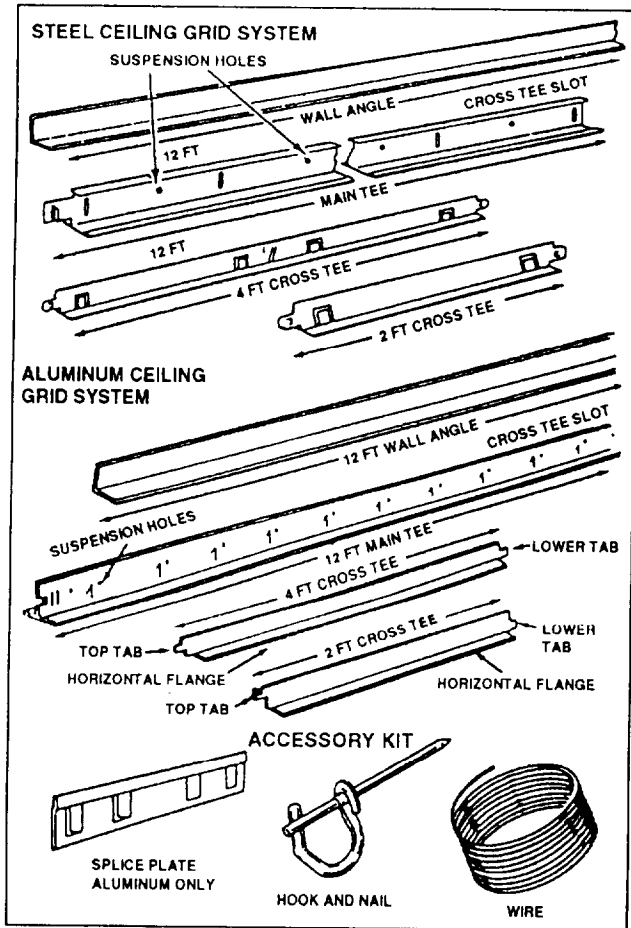


Figure 5-17.—Grid system components.

material requirements. Figure 5-17 shows the major components of a steel and aluminum ceiling grid system used for the 2- by 2-foot or 2- by 4-foot grid patterns shown in figure 5-18.

Pattern Layout

The layout of a grid pattern and the material requirements are based on the ceiling measurements and the length and width of the room at the new ceiling height. If the ceiling length or width is not divisible by 2 (that is, 2 feet), increase those dimensions to the next higher dimension divisible by 2. For example, if a ceiling measures 13 feet 7 inches by 10 feet 4 inches, the dimensions should be increased to 14 by 12 feet for material and layout purposes. Next, draw a layout on graph paper. Make sure the main tees run perpendicular to the joists. Position the main tees on your drawing so the border panels at room edges are equal and as large as possible. Try several layouts to see which looks best with the main tees. Draw in cross tees so the border panels at the room ends are equal and as large as possible. Try several combinations to determine the

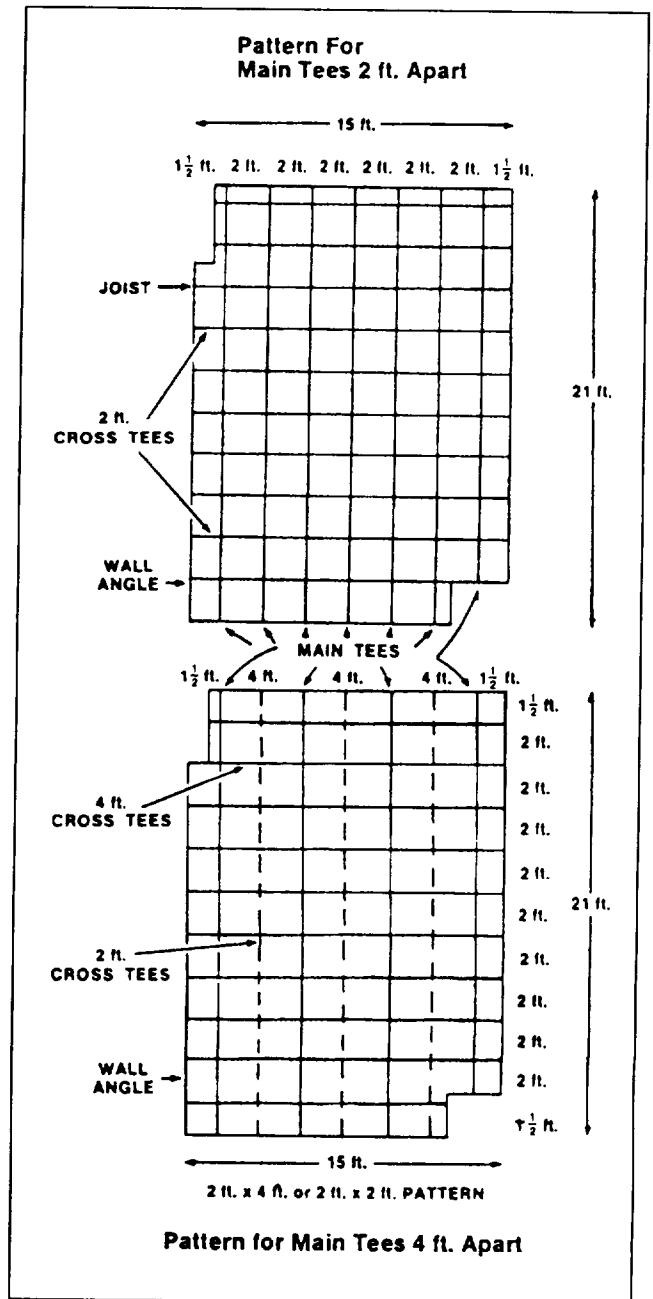


Figure 5-18.—Grid layout for main tees.

best. For 2- by 4-foot patterns, space cross tees 4 feet apart. For 2- by 2-foot patterns, space cross tees 2 feet apart. For smaller areas, the 2- by 2-foot pattern is recommended

Material Requirements

As indicated in figure 5-17, wall angles and main tees come in 12-foot pieces. Using the perimeter of a room at suspended ceiling height, you can determine the number of pieces of wall angle by dividing the perimeter by 12 and adding 1 additional piece for any fraction. Determine the number of 12-foot main tees and 2-foot or 4-foot cross tees by counting them on the grid pattern

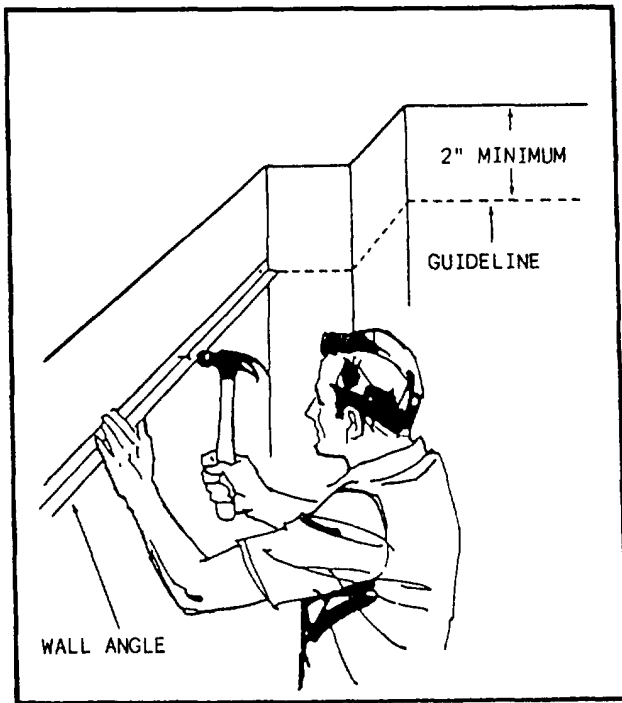


Figure 5-19.—Wall angle installation.

layout. In determining the number of 2-foot or 4-foot cross tees for border panels, you must remember that no more than 2 border tees can be cut from one cross tee.

INSTALLATION

The tools normally used to install a grid system include a hammer, chalk or pencil, pliers, tape measure, screwdriver, hacksaw, knife, and tin snips. With these, you begin by installing the wall angles, then the suspension wires, followed by the main tees, cross tees, and acoustical panels.

Wall Angles

The first step is to install the wall angles at the new ceiling height. This can be as close as 2 inches below the existing ceiling. Begin by marking a line around the entire room to indicate wall angle height and to serve as a level reference. Mark continuously to ensure that the lines at intersecting walls meet. On gypsum board, plaster, or paneled walls, install wall angles (fig. 5-19) with nails, screws, or toggle bolts. On masonry walls, use anchors or concrete nails spaced 24 inches apart. **Make sure the wall angle is level.** Overlap or miter the wall angle at corners (fig. 5-20). After the wall angles are installed the next step is to attach the suspension wires.

Suspension Wires

Suspension wires are required every 4 feet along main tees and on each side of all splices (see fig. 5-21). Attach wires to the existing ceiling with nails or screw

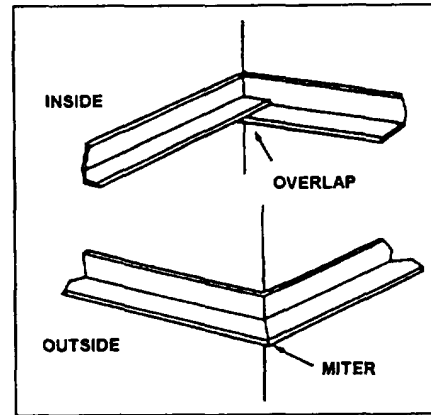


Figure 5-20.—Corner treatment.

eyelets. Before attaching the first wire, measure the distance from the wall to the first main tee. Then, stretch a guideline from an opposite wall angle to show the correct position of the first nail tee. Position suspension wires for the first tee along the guide. Wires should be cut to proper length, at least 2 inches longer than the distance between the old and new ceiling. Attach additional wires at 4-foot intervals. Pull wires to remove kinks and make 90° bends in the wires where they intersect the guideline. Move the guideline, as required, for each row. After the suspension wires are attached, the next step is to install the main tees.

Tees

In an acoustical ceiling, the panels rest on metal members called tees. The tees are suspended by wires.

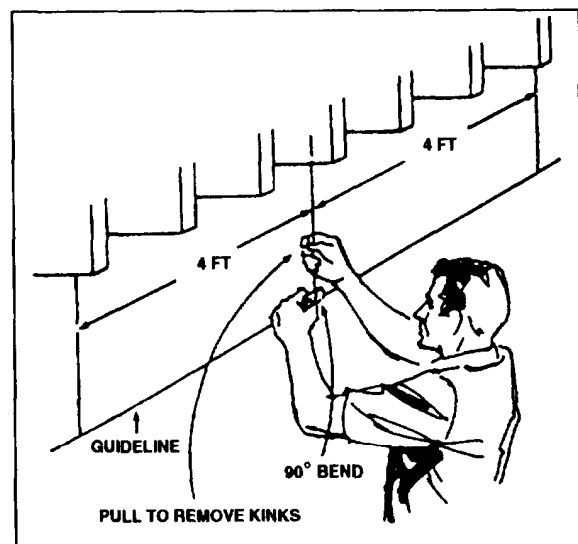


Figure 5-21.—Suspension wire installation.

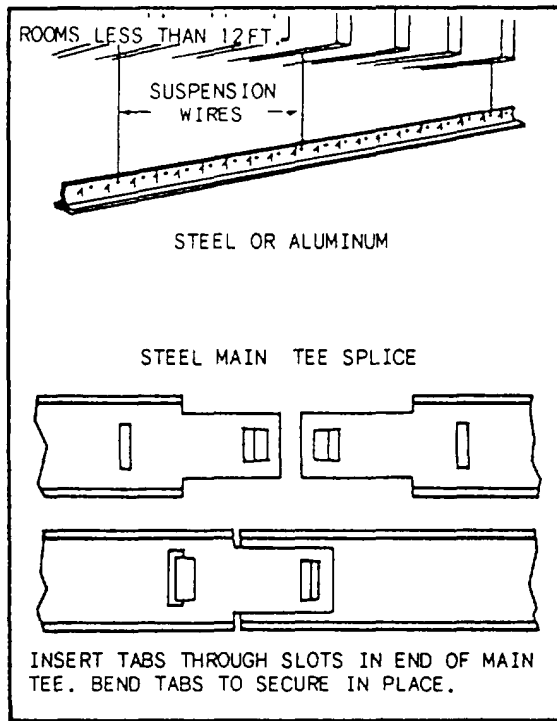


Figure 5-22.—Main tee suspension and steel splice.

MAIN TEES.— Install main tees of 12 feet or less by resting the ends on opposite wall angles and inserting the suspension wires (top view of fig. 5-22). Hang one wire near the middle of the main tee, level and adjust the wire length, then secure all wires by making the necessary turns in the wire.

For main tees over 12 feet, cut them so the cross tees do not intersect the main tee at a splice joint. Begin the installation by resting the cut end on the wall angle and attaching the suspension wire closest to the opposite end. Attach the remaining suspension wires, making sure the main tee is level before securing. The remaining tees are installed by making the necessary splices (steel splices are shown in fig. 5-22 and those for aluminum in 5-23) and resting the end on the opposite wall angle. After the main tees are installed, leveled, and secured, install the cross tees.

CROSS TEES.— Aluminum cross tees have “high” and “low” tab ends that provide easy positive installation without tools. Installation begins by cutting border tees (when necessary) to fit between the first main tee and the wall angle. Cut off the high tab end and rest this end in the main tee slot. Repeat this procedure until all border tees are installed on one side of the room. Continue across the room, installing the remaining cross tees according to your grid pattern layout. An aluminum cross tee assembly is shown in figure 5-24. At the opposite wall angle, cut off the low tab of the border tee

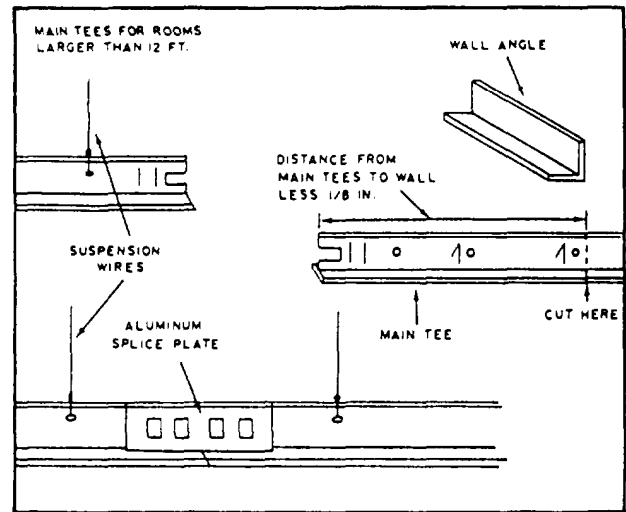


Figure 5-23.—Main tee and aluminum tee splice.

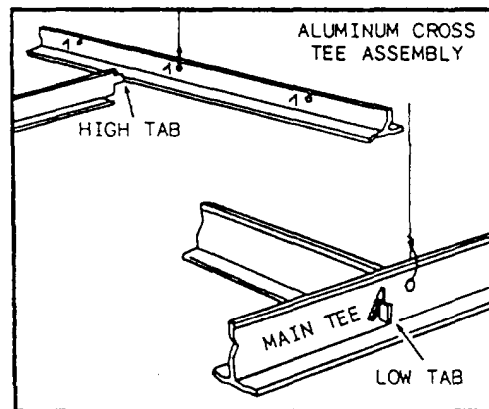


Figure 5-24.—Aluminum cross tee assembly.

and rest the cut end on the wall angle. If the border edge is less than half the length of the cross tee, use the remaining portion of the border of the previously cut tee.

Steel cross tees have the same tab on both ends and, like the aluminum tees, do not require tools for installation. The procedures used in their installation are the same as those just described for aluminum. A steel cross tee assembly is shown in figure 5-25. The final step after completion of the grid system is the installation of the acoustical panels.

Acoustical Panels

Panel installation is started by inserting all full ceiling panels. Border panels should be installed last, after they have been cut to proper size. To cut a panel, turn the finish side up, scribe with a sharp utility knife, and saw with a 12- or 14-point handsaw.

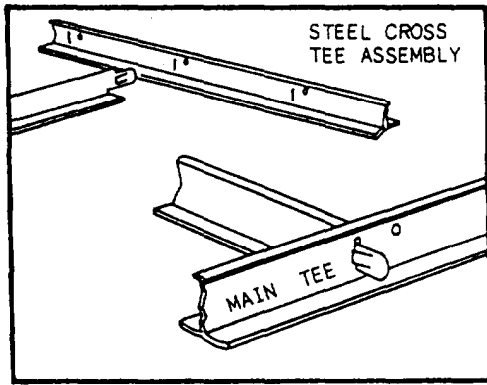


Figure 5-25.—Steel cross tee assembly.

Most ceiling panel patterns are random and do not require orientation. However, some fissured panels are designed to be installed in a specific direction and are so marked on the back with directional arrows. When installing panels on a large project, you should work from several cartons. The reason for this is that the color, pattern, or texture might vary slightly; and by working from several cartons, you avoid a noticeable change in uniformity.

Since ceiling panels are prefinished, handle them with care. Keep their surfaces clean by using talcum powder on your hands or by wearing clean canvas gloves. If panels do become soiled, use an art gum eraser to remove spots, smudges, and fingerprints. Some panels can be lightly washed with a sponge dampened with a mild detergent solution. However, before washing or performing other maintenance services, such as painting, refer to the manufacturer's instructions.

Ceiling Tile

Ceiling tile can be installed in several ways, depending on the type of ceiling or roof construction. When a flat-surfaced backing is present, such as between beams of a beamed ceiling in a low-slope roof, tiles are fastened with adhesive as recommended by the manufacturer. A small spot of a mastic type of construction adhesive at each corner of a 12-by 12-inch tile is usually sufficient. When tile is edge-matched, stapling is also satisfactory.

Perhaps the most common method of installing ceiling tile uses wood strips nailed across the ceiling joists or roof trusses (fig. 5-26, view A). These are

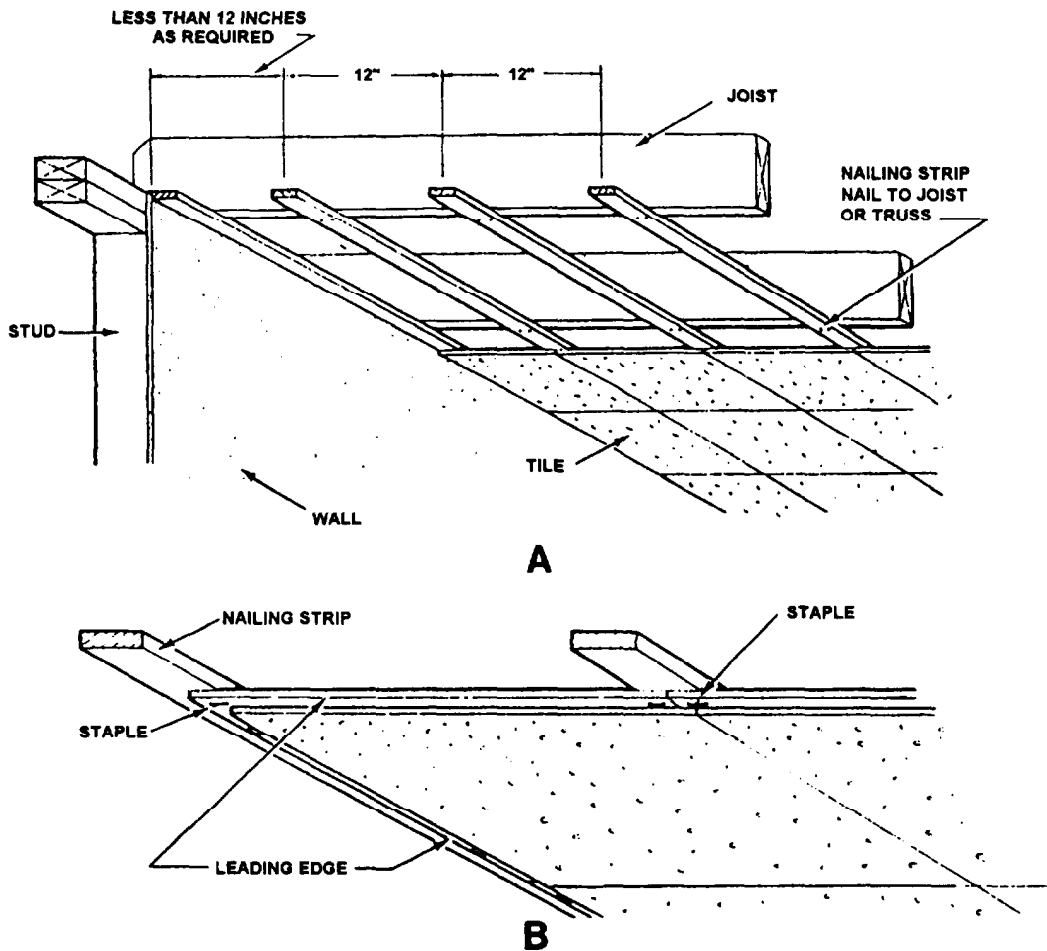


Figure 5-26.—Ceiling tile assembly.

spaced a minimum of 12 inches OC. A nominal 1- by 3-inch or 1- by 4-inch wood member can be used for roof or ceiling members spaced not more than 24 inches OC. A nominal 2- by 2-inch or 2- by 3-inch member should be satisfactory for truss or ceiling joist spacing of up to 48 inches.

In locating the strips, first measure the width of the room (the distance parallel to the direction of the ceiling joists). If, for example, this is 11 feet 6 inches, use ten 12-inch-square tiles and 9-inch-wide tile at each side edge. The second wood strips from each side are located so that they center the first row of tiles, that can now be ripped to a width of 9 inches. The last row will also be 9 inches, but do not rip these tiles until the last row is reached so that they fit tightly. The tile can be fitted and arranged the same way for the ends of the room.

Ceiling tiles normally have a tongue on two adjacent sides and a groove on the opposite adjacent sides. Start with the leading edge ahead and to the open side so that it can be stapled to the nailing strips. A small finish nail or adhesive should be used at the edge of the tiles in the first row against the wall. Stapling is done at the leading edge and the side edge of each tile (fig. 5-26, view B). Use one staple at each wood strip at the leading edge and two at the open side edge. At the opposite wall, a small finish nail or adhesive must again be used to hold the tile in place.

Most ceiling tile of this type has a factory finish; painting or finishing is not required after it is placed. Take care not to mar or soil the surface.

INSULATION

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of insulation and describe the methods of installation.

The inflow of heat through outside walls and roofs in hot weather or its outflow during cold weather is a major source of occupant discomfort. Providing heating or cooling to maintain temperatures at acceptable limits for occupancy is expensive. During hot or cold weather, insulation with high resistance to heat flow helps save energy. Also, you can use smaller capacity units to achieve the same heating or cooling result, an additional savings.

Most materials used in construction have some insulating value. Even air spaces between studs resist the passage of heat. However, when these stud spaces

are filled or partially filled with material having a high insulating value, the stud space has many times the insulating ability of the air alone.

TYPES

Commercial insulation is manufactured in a variety of forms and types, each with advantages for specific uses. Materials commonly used for insulation can be grouped in the following general classes: (1) flexible insulation (blanket and batt); (2) loose-fill insulation; (3) reflective insulation; (4) rigid insulation (structural and nonstructural); and (5) miscellaneous types.

The insulating value of a wall varies with different types of construction, kinds of materials used in construction, and types and thicknesses of insulation. As we just mentioned, air spaces add to the total resistance of a wall section to heat transmission, but an air space is not as effective as the same space filled with an insulating material.

Flexible

Flexible insulation is manufactured in two types: blanket and batt. Blanket insulation (fig. 5-27, view A) is furnished in rolls or packages in widths to fit between studs and joists spaced 16 and 24 inches OC. It comes in thicknesses of 3/4 inch to 12 inches. The body of the blanket is made of felted mats of mineral or vegetable fibers, such as rock or glass wool, wood fiber, and cotton. Organic insulations are treated to make them resistant to fire, decay, insects, and vermin. Most blanket insulation is covered with paper or other sheet material with tabs on the sides for fastening to studs or joists. One covering sheet serves as a vapor barrier to resist movement of water vapor and should always face the warm side of the wall. Aluminum foil, asphalt, or plastic laminated paper is commonly used as barrier materials.

Batt insulation (fig. 5-27, view B) is also made of fibrous material preformed to thicknesses of 3 1/2 to 12 inches for 16- and 24-inch joist spacing. It is supplied with or without a vapor barrier. One friction type of fibrous glass batt is supplied without a covering and is designed to remain in place without the normal fastening methods.

Loose Fill

Loose-fill insulation (fig. 5-27, view C) is usually composed of materials used in bulk form, supplied in bags or bales, and placed by pouring, blowing, or packing by hand. These materials include rock or glass

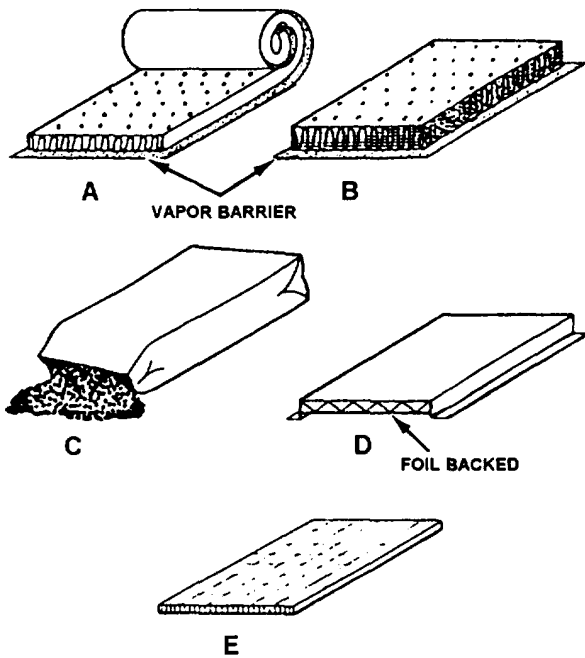


Figure 5-27.—Types of insulation.

wool, wood fibers, shredded redwood bark cork wood pulp products, vermiculite, sawdust, and shavings.

Fill insulation is suited for use between first-floor ceiling joists in unheated attics. It is also used in sidewalls of existing houses that were not insulated during construction. Where no vapor barrier was installed during construction, suitable paint coatings, as described later in this chapter, should be used for vapor barriers when blow insulation is added to an existing house.

Reflective

Most materials have the property of reflecting radiant heat, and some materials have this property to a very high degree. Materials high in reflective properties include aluminum foil, copper, and paper products coated with a reflective oxide. Such materials can be used in enclosed stud spaces, attics, and similar locations to retard heat transfer by radiation. Reflective insulation is effective only where the reflective surface faces an air space at least 3/4 inch deep. Where this surface contacts another material, the reflective properties are lost and the material has little or no insulating value. Proper installation is the key to obtaining the best results from the reflective insulation. Reflective insulation is equally effective whether the reflective surface faces the warm or cold side.

Reflective insulation used in conjunction with foil-backed gypsum drywall makes an excellent vapor barrier. The type of reflective insulation shown in figure 5-27, view D, includes a reflective surface. When properly installed, it provides an airspace between other surfaces.

Rigid

Rigid insulation (fig. 5-27, view E) is usually a fiberboard material manufactured in sheet form. It is made from processed wood, sugar cane, or other vegetable products. Structural insulating boards, in densities ranging from 15 to 31 pounds per cubic foot, are fabricated as building boards, roof decking, sheathing, and wallboard. Although these boards have moderately good insulating properties, their primary purpose is structural.

Roof insulation is nonstructural and serves mainly to provide thermal resistance to heat flow in roofs. It is called slab or block insulation and is manufactured in rigid units 1/2 inch to 3 inches thick and usually 2- by 4-foot sizes.

In building construction, perhaps the most common forms of rigid insulation are sheathing and decorative covering in sheet or in tile squares. Sheathing board is made in thicknesses of 1/2 and 25/32 inch. It is coated or impregnated with an asphalt compound to provide water resistance. Sheets are made in 2- by 8-foot sizes for horizontal application and 4- by 8-foot (or longer) sizes for vertical application.

Miscellaneous

Some insulations are not easily classified, such a insulation blankets made up of multiple layers of corrugated paper. Other types, such as lightweight vermiculite and perlite aggregates, are sometimes used in plaster as a means of reducing heat transmission. Other materials in this category are foamed-in-place insulations, including sprayed and plastic foam types. Sprayed insulation is usually inorganic fibrous material blown against a clean surface that has been primed with an adhesive coating. It is often left exposed for acoustical as well as insulating properties.

Expanded polystyrene and urethane plastic forms can be molded or foamed in place. Urethane insulation can also be applied by spraying. Polystyrene and urethane in board form can be obtained in thicknesses from 1/2 to 2 inches.

LOCATION OF INSULATION

In most climates, all walls, ceilings, roofs, and floors that separate heated spaces from unheated spaces should be insulated. This reduces heat loss from the structure during cold weather and minimizes air conditioning during hot weather. The insulation should be placed on all outside walls and in the ceiling. In structures that have unheated crawl spaces, insulation should be placed between the floor joists or around the wall perimeter.

If a blanket or batt insulation is used, it should be well supported between joists by slats and a galvanized wire mesh, or by a rigid board. The vapor barrier should be installed toward the subflooring. Press-fit or friction insulations fit tightly between joists and require only a small amount of support to hold them in place.

Reflective insulation is often used for crawl spaces, but only dead air space should be assumed in calculating heat loss when the crawl space is ventilated. A ground cover of roll roofing or plastic film, such as polyethylene, should be placed on the soil of crawl spaces to decrease the moisture content of the space as well as of the wood members.

Insulation should be placed along all walls, floors, and ceilings that are adjacent to unheated areas. These include stairways, dwarf (knee) walls, and dormers of 1 1/2 story structures. Provisions should be made for ventilating the unheated areas.

Where attic space is unheated and a stairway is included, insulation should be used around the stairway as well as in the first-floor ceiling. The door leading to the attic should be weather stripped to prevent heat loss. Walls adjoining an unheated garage or porch should also be insulated. In structures with flat or low-pitched roofs, insulation should be used in the ceiling area with sufficient space allowed above for cleared unobstructed ventilation between the joists. Insulation should be used along the perimeter of houses built on slabs. A vapor barrier should be included under the slab.

In the summer, outside surfaces exposed to the direct rays of the sun may attain temperatures of 50°F or more above shade temperatures and tend to transfer this heat into the house. Insulation in the walls and in the attic areas retards the flow of heat and improves summer comfort conditions.

Where air conditioning is used, insulation should be placed in all exposed ceilings and walls in the same manner as insulating against cold-weather heat loss. Shading of glass against direct rays of the sun and the use of insulated glass helps reduce the air-conditioning load.

Ventilation of attic and roof spaces is an important adjunct to insulation. Without ventilation, an attic space may become very hot and hold the heat for many hours. Ventilation methods suggested for protection against cold-weather condensation apply equally well to protection against excessive hot-weather roof temperatures.

The use of storm windows or insulated glass greatly reduces heat loss. Almost twice as much heat loss occurs through a single glass as through a window glazed with insulated glass or protected by a storm sash. Double glass normally prevents surface condensation and frost forming on inner glass surfaces in winter. When excessive condensation persists, paint failures and decay of the sash rail can occur.

CAUTION

Prior to the actual installation of the insulation, consult the manufacturer's specifications and guidelines for personal-protection items required. Installing insulation is not particularly hazardous; however, there are some health safeguards to be observed when working with fiberglass.

INSTALLATION

Blanket insulation and batt insulation with a vapor barrier should be placed between framing members so that the tabs of the barrier lap the edge of the studs as well as the top and bottom plates. This method is not popular with contractors because it is more difficult to apply the drywall or rock lath (plaster base). However, it assures a minimum of vapor loss compared to the loss when the tabs are stapled to the sides of the studs. To protect the top and soleplates, as well as the headers over openings, use narrow strips of vapor barrier material along the top and bottom of the wall (fig. 5-28, view A). Ordinarily, these areas are not well covered by the vapor barrier on the blanket or batt. A hand stapler is commonly used to fasten the insulation and the vapor barriers in place.

For insulation without a vapor barrier (batt), a plastic film vapor barrier, such as 4-roil polyethylene, is commonly used to envelop the entire exposed wall and ceilings (fig. 5-28, views B and C). It covers the openings as well as the window and doorheaders and edge studs. This system is one of the best from the standpoint of resistance to vapor movement. Furthermore, it does not have the installation inconveniences encountered when tabs of the insulation are stapled over

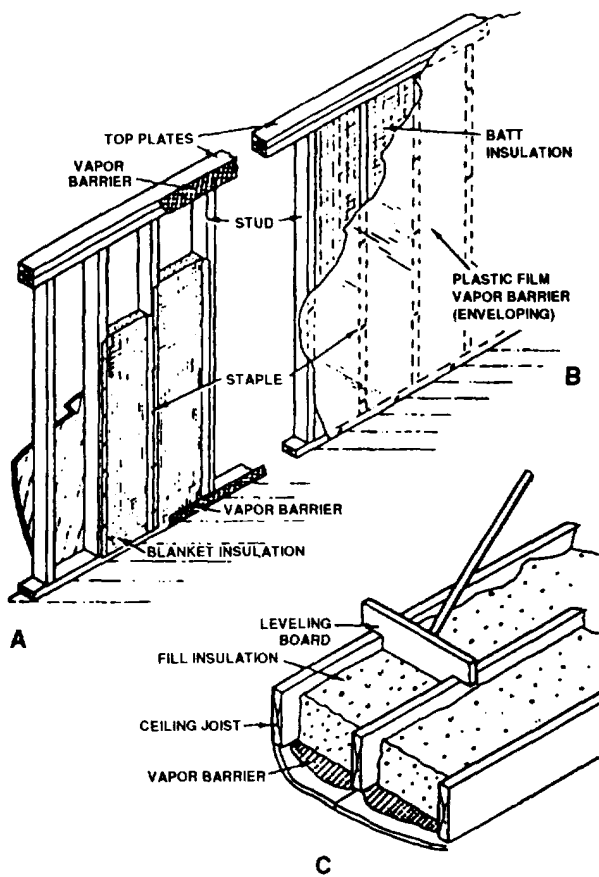


Figure 5-28.—Application of insulation.

the edges of the studs. After the drywall is installed or plastering is completed, the film is trimmed around the window and door openings.

Reflective insulation, in a single-sheet form with two reflective surfaces, should be placed to divide the space formed by the framing members into two approximately equal spaces. Some reflective insulations include air spaces and are furnished with nailing tabs. This type is fastened to the studs to provide at least a 3/4-inch space on each side of the reflective surfaces.

Fill insulation is commonly used in ceiling areas and is poured or blown into place (fig. 5-28, view C). A vapor barrier should be used on the warm side (the bottom, in case of ceiling joists) before insulation is placed. A leveling board (as shown) gives a constant insulation thickness. Thick batt insulation might also be combined to obtain the desired thickness with the vapor barrier against the back face of the ceiling finish. Ceiling insulation 6 or more inches thick greatly reduces heat loss in the winter and also provides summertime protection.

Areas around doorframes and window frames between the jambs and rough framing members also require insulation. Carefully fill the areas with

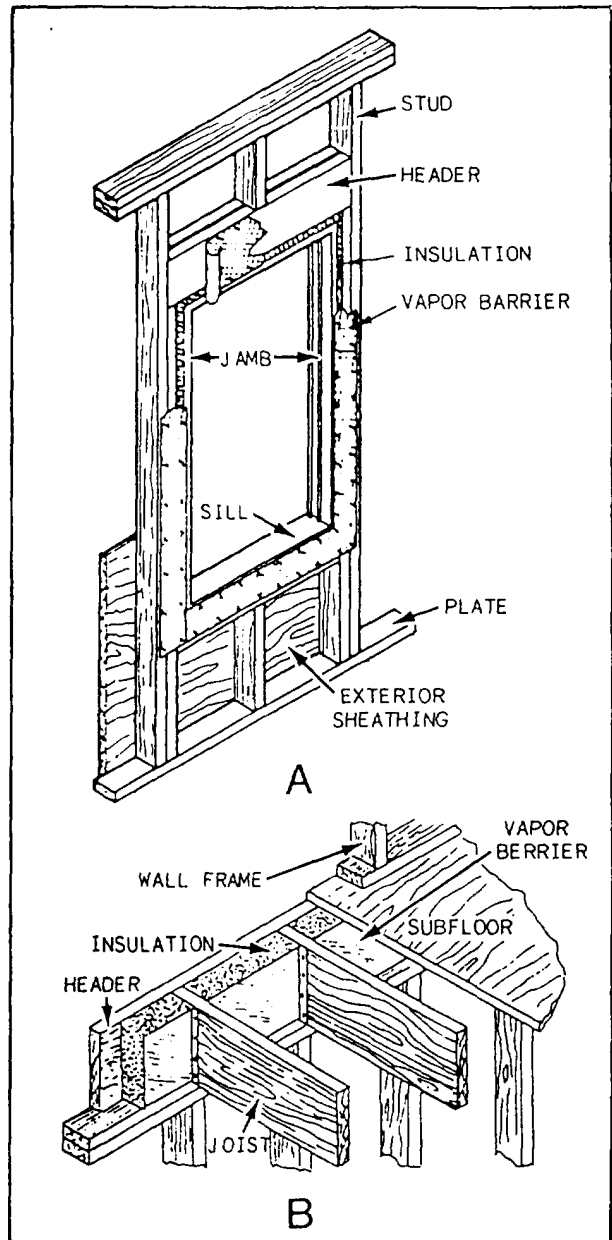


Figure 5-29.—Precautions in insulating.

insulation. Try not to compress the material, which may cause it to lose some of its insulating qualities. Because these areas are filled with small sections of insulation, a vapor barrier must be used around the openings as well as over the header above the openings (fig. 5-29, view A). Enveloping the entire wall eliminates the need for this type of vapor-barrier installation.

In 1 1/2- and 2-story structures and in basements, the area at the joist header at the outside walls should be insulated and protected with a vapor barrier (fig. 5-29, view B). Insulation should be placed behind electrical

outlet boxes and other utility connections in exposed walls to minimize condensation on cold surfaces.

VAPOR BARRIER

Most building materials are permeable to water vapor. This presents problems because considerable water vapor can be generated inside structures. In cold climates during cold weather, this vapor may pass through wall and ceiling materials and condense in the wall or attic space. In severe cases, it may damage the exterior paint and interior finish, or even result in structural member decay. For protection, a material highly resistive to vapor transmission, called a vapor barrier, should be used on the warm side of a wall and below the insulation in an attic space.

Types

Effective vapor-barrier materials include asphalt laminated papers, aluminum foil, and plastic films. Most blanket and batt insulations include a vapor barrier on one side, and some of them with paper-backed aluminum foil. Foil-backed gypsum lath or gypsum boards are also available and serve as excellent vapor barriers.

Some types of flexible blanket and batt insulations have barrier material on one side. Such flexible insulations should be attached with the tabs at their sides fastened on the inside (narrow) edges of the studs, and the blanket should be cut long enough so that the cover sheet can lap over the face of the soleplate at the bottom and over the plate at the top of the stud space. However, such a method of attachment is not the common practice of most installers.

When a positive seal is desired, wall-height rolls of plastic-film vapor barriers should be applied over studs, plates, and window and doorheaders. This system, called "enveloping," is used over insulation having no vapor barrier or to ensure excellent protection when used over any type of insulation. The barrier should be fitted tightly around outlet boxes and sealed if necessary. A ribbon of sealing compound around an outlet or switch box minimizes vapor loss at this area. Cold-air returns, located in outside walls, should be made of metal to prevent vapor loss and subsequent paint problems.

Paint Coatings

Paint coatings cannot substitute for the membrane types of vapor barriers, but they do provide some protection for structures where other types of vapor barriers were not installed during construction. Of the various types of paint, one coat of aluminum primer followed by two decorative coats of flat wall oil base

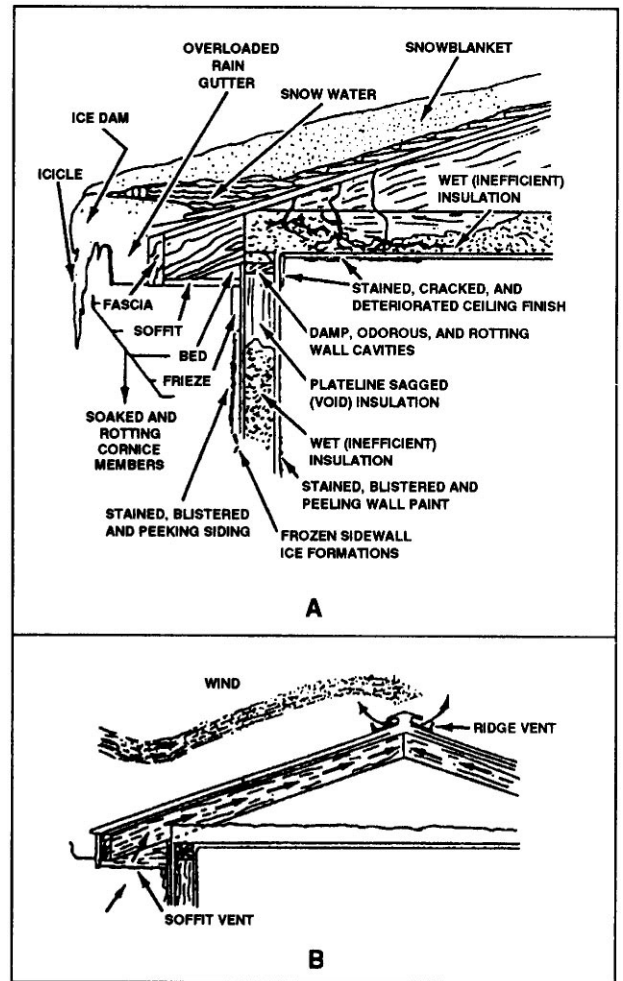


Figure 5-30.—Ice dams and protective ventilation.

paint is quite effective. For rough plasterer for buildings in very cold climates, two coats of aluminum primer may be necessary. A pigmented primer and sealer, followed by decorative finish coats or two coats of rubber-base paint, are also effective in retarding vapor transmission.

VENTILATION

Condensation of moisture vapor may occur in attic spaces and under flat roofs during cold weather. Even where vapor barriers are used, some vapor will probably work into these spaces around pipes and other inadequately protected areas and through the vapor barrier itself. Although the amount might be unimportant if equally distributed, it may be sufficiently concentrated in some cold spots to cause damage. While wood shingle and wood shake roofs do not resist vapor movement, such roofings as asphalt shingles and built-up roofs are highly resistant. The most practical method of removing the moisture is by adequate ventilation of roof spaces.

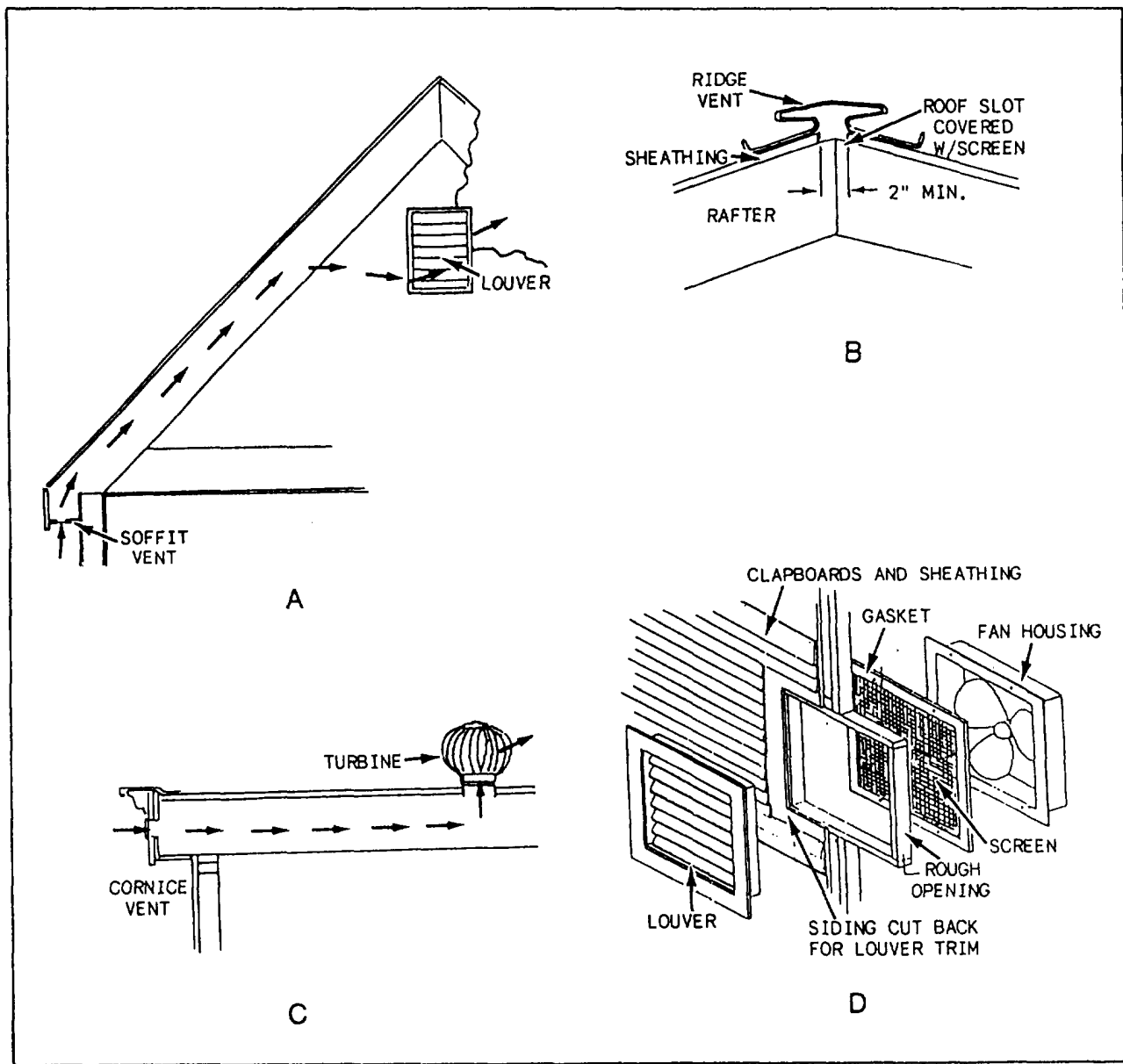


Figure 5-31.—Attic outlet vents.

A warm attic that is inadequately ventilated and insulated may cause formation of ice dams at the cornice (fig. 5-30, view A). During cold weather after a heavy snowfall, heat causes the snow next to the roof to melt. Water running down the roof freezes on the colder surface of the cornice, often forming an ice dam at the gutter that may cause water to backup at the eaves and into the wall and ceiling. Similar dams often form in roof valleys. Ventilation provides part of the solution to these problems. With a well-insulated ceiling and adequate ventilation (fig. 5-30 view B), attic temperatures are low and melting of snow over the attic space greatly reduced.

In hot weather, ventilation of attic and roof spaces offers an effective means of removing hot air and

lowering the temperature in these spaces. Insulation should be used between ceiling joists below the attic or roof space to further retard heat flow into the rooms below and materially improve comfort conditions.

It is common practice to install louvered openings in the end walls of gable roofs for ventilation. Air movement through such openings depends primarily on wind direction and velocity. No appreciable movement can be expected when there is no wind. Positive air movement can be obtained by providing additional openings (vents) in the soffit areas of the roof overhang (fig. 5-31, view A) or ridge (view B). Hip-roof structures are best ventilated by soffit vents and by outlet ventilators along the ridge. The differences in

temperature between the attic and the outside create an air movement independent of the wind, and also a more positive movement when there is wind. Turbine-type ventilators are also used to vent attic spaces (view C).

Where there is a crawl space under the house or porch, ventilation is necessary to remove the moisture vapor rising from the soil. Such vapor may otherwise condense on the wood below the floor and cause decay. As mentioned earlier, a permanent vapor barrier on the soil of the crawl space greatly reduces the amount of ventilation required.

Tight construction (including storm windows and storm doors) and the use of humidifiers have created potential moisture problems that must be resolved by adequate ventilation and the proper use of vapor barriers. Blocking of soffit vents with insulation, for example, must be avoided because this can prevent proper ventilation of attic spaces. Inadequate ventilation often leads to moisture problems, resulting in unnecessary maintenance costs.

Various styles of gable-end ventilators are available. Many are made with metal louvers and frames, whereas others may be made of wood to more closely fit the structural design. However, the most important factors are to have properly sized ventilators and to locate ventilators as close to the ridge as possible without affecting appearance.

Ridge vents require no special framing, only the disruption of the top course of roofing and the removal of strips of sheathing. Snap chalk lines running parallel to the ridge, down at least 2 inches from the peak. Using a linoleum cutter or a utility knife with a very stiff blade, cut through the roofing along the lines. Remove the roofing material and any roofing nails that remain. Set your power saw to cut through just the sheathing (not into the rafters) along the same lines. A carbide-tipped blade is best for this operation. Remove the sheathing. Nail the ridge vent over the slot you have created, using gasketed roofing nails. Remember to use compatible materials. For example, aluminum nails should be used with aluminum vent material. Because the ridge vent also covers the top of the roofing, be sure the nails are long enough to penetrate into the rafters. Caulk the underside of the vent before nailing.

The openings for louvers and in-the-wall fans (fig. 5-31, view D) are quite similar. In fact, fans are usually covered with louvers. Louver slats should have a downward pitch of 45° to minimize water blowing in. As with soffit vents, a backing of corrosion-resistant screen is needed to keep insects out. Ventilation fans may be manual or thermostatically controlled.

When installing a louver in an existing gable-end wall, disturb the siding, sheathing, or framing members

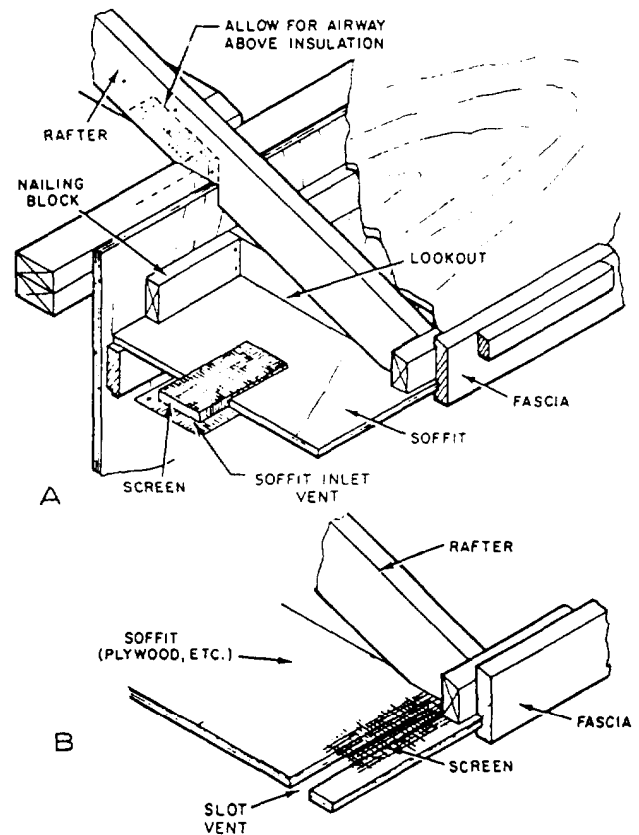


Figure 5-32.—Inlet vents.

as little as possible. Locate the opening by drilling small holes through the wall at each corner. Snap chalk lines to establish the cuts made with a reciprocating saw. Cut back the siding to the width of the trim housing the louver (or the louver-with-fan), but cut back the sheathing only to the dimensions of the fan housing. Box in the rough opening itself with 2 by 4s and nail or screw the sheathing to them. Flash and caulk a gable-end louver as you would a door or a window.

Small, well-distributed vents or continuous slots in the soffit provide good inlet ventilation. These small louvered and screened vents (see fig. 5-32, view A) are easily obtained and simple to install. Only small sections need to be cut out of the soffit to install these vents, which can be sawed out before the soffit is installed. It is better to use several small, well-distributed vents than a few large ones. Any blocking that might be required between rafters at the wall line should be installed to provide an airway into the attic area.

A continuous screened slot vent, which is often desirable, should be located near the outer edge of the soffit near the fascia (fig. 5-32, view B). This location minimizes the chance of snow entering. This type of vent is also used on the overhang of flat roofs.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure you are studying the latest revisions.

Drywall: Installation and Applications, W. Robert Harris, American Publishers, Inc., Homewood, Ill., 1979.

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

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

CHAPTER 6

INTERIOR FINISH OF FLOORS, STAIRS, DOORS, AND TRIM

This chapter continues our discussion of interior finishing. In the previous chapter, we looked at the interior finishing of walls and ceilings, and related aspects of insulation and ventilation. Now, we'll examine the common types of flooring and the construction procedures for a stairway and interior doorframing. We'll also discuss the types of wood trim and the associated installation procedures.

FLOOR COVERINGS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the common types of floor coverings and describe procedures for their placement.

Numerous flooring materials now available may be used over a variety of floor systems. Each has a property that adapts it to a particular usage. Of the practical properties, perhaps durability and ease of maintenance are the most important. However, initial cost, comfort, and appearance must also be considered. Specific service requirements may call for special properties, such as resistance to hard wear in warehouses and on loading platforms, or comfort to users in offices and shops.

There is a wide selection of wood materials used for flooring. Hardwoods and softwoods are available as strip flooring in a variety of widths and thicknesses, and as random-width planks and block flooring. Other materials include linoleum, asphalt, rubber, cork vinyl, and tile and sheet forms. Tile flooring is also available in a particleboard, which is manufactured with small wood particles combined with resin and formed under high pressure. In many areas, ceramic tile and carpeting are used in ways not thought practical a few years ago. Plastic floor coverings used over concrete or a stable wood subfloor are another variation in the types of finishes available.

WOOD-STRIP FLOORING

Softwood finish flooring costs less than most hardwood species and is often used to good advantage

in bedroom and closet areas where traffic is light. However, it is less dense than the hardwoods, less wear-resistant, and shows surface abrasions more readily. Softwoods most commonly used for flooring are southern pine, Douglas fir, redwood, and western hemlock.

Softwood flooring has tongue-and-groove edges and may be hollow-backed or grooved. Some types are also end-matched. Vertical-grain flooring generally has better wearing qualities than flat-grain flooring under hard usage.

Hardwoods most commonly used for flooring are red and white oak, beech, birch, maple, and pecan, any of which can be prefinished or unfinished.

Hardwood strip flooring is available in widths ranging from 1 1/2 to 3 1/4 inches. Standard thicknesses include 3/8, 1/2, and 3/4 inch. A useful feature of hardwood strip flooring is the undercut. There is a wide groove on the bottom of each piece that enables it to lay flat and stable, even when the subfloor surface is slightly uneven.

These strips are laid lengthwise in a room and normally at right angles to the floor joists. A subfloor of diagonal boards or plywood is normally used under the finish floor. The strips are tongue and groove and end-matched (fig. 6-1, view A). Strips are random length

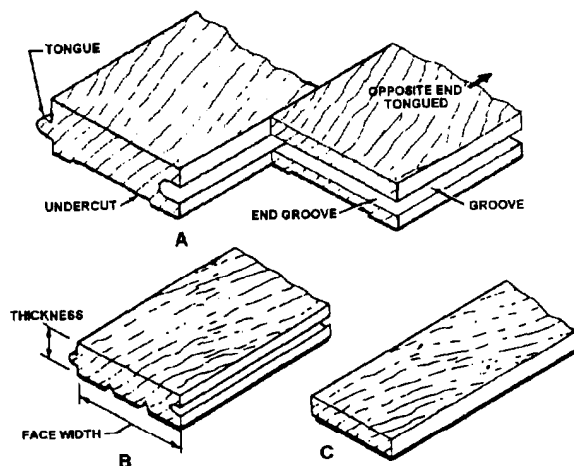


Figure 6-1.—Types of strip flooring.

and may vary from 2 to more than 16 feet. The top is slightly wider than the bottom so that tight joints result when flooring is laid. The tongue fits tightly into the groove to prevent movement and floor squeaks.

Thin strip flooring (fig. 6-1, view B) is made of 3/8-by 2-inch strips. This flooring is commonly used for remodeling work or when the subfloor is edge-blocked or thick enough to provide very little deflection under loads.

Square-edged strip flooring (fig. 6-1, view C) is also occasionally used. The strips are usually 3/8 inch by 2 inches and laid over a substantial subfloor. Face-nailing is required for this type of flooring.

Plank floors are usually laid in random widths. The pieces are bored and plugged to simulate wooden pegs originally used to fasten them in place. Today, this type of floor has tongue-and-groove edges. It is laid similar to regular strip flooring. Solid planks are usually 3/4 inch thick. Widths range from 3 to 9 inches in multiples of 1 inch.

Installation

Flooring should be laid after drywall, plastering, or other interior wall and ceiling finish is completed and dried out. Windows and exterior doors should be in place, and most of the interior trim, except base, casing, and jambs, should be installed to prevent damage by wetting or construction activity.

Board subfloors should be clean and level and covered with felt or heavy building paper. The felt or paper stops a certain amount of dust, somewhat deadens sound, and, where a crawl space is used, increases the warmth of the floor by preventing air infiltration. As a guide to provide nailing into the joists, wherever possible, mark with a chalk line the location of the joists on the paper. Plywood subflooring does not normally require building paper.

Strip flooring should normally be laid crosswise to the floor joists (fig. 6-2, view A). In conventional structures, the floor joists span the width of the building over a center-supporting beam or wall. Thus, the finish flooring of the entire floor areas of a rectangular structure will be laid in the same direction. Flooring with "L"- or "I"-shaped plans will usually have a direction change, depending on joist direction. As joists usually span the short way in a room, the flooring will be laid lengthwise to the room. This layout has a pleasing appearance and also reduces shrinkage and swelling of the flooring during seasonal changes.

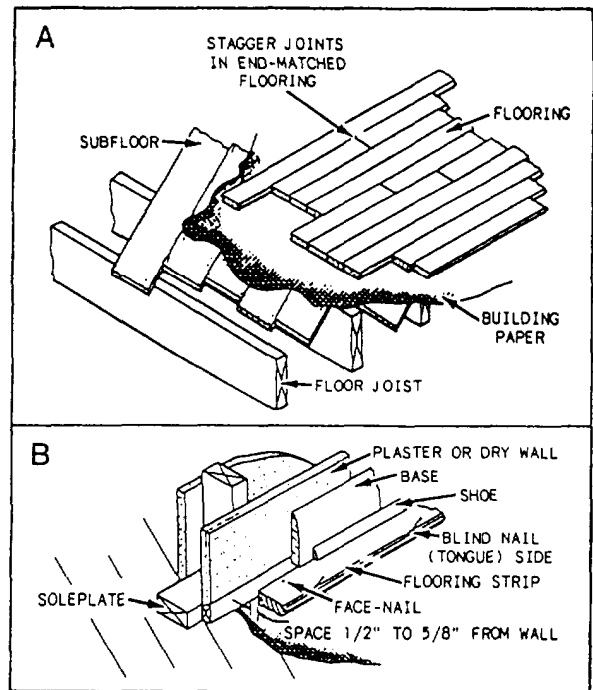


Figure 6-2.—Application of strip flooring.

Storing

When the flooring is delivered, store it in the warmest and driest place available in the building. Moisture absorbed after delivery to the building site is the most common cause of open joints between flooring strips that appear after several months of the heating season.

Floor Squeaks

Floor squeaks are usually caused by the movement of one board against another. Such movement can occur for a number of reasons: floor joists too light, causing excessive deflection; sleepers over concrete slabs not held down tightly; loose fitting tongues; or poor nailing. Adequate nailing is an important means of minimizing squeaks. Another is to apply the finish floors only after the joists have dried to 12-percent moisture content or less. A much better job results when it is possible to nail through the finish floor, through the subfloor, and into the joists than if the finish floor is nailed only to the subfloor.

Nailing

Various types of nails are used in nailing different thicknesses of flooring. Before using any type of nail, you should check with the floor manufacturer's

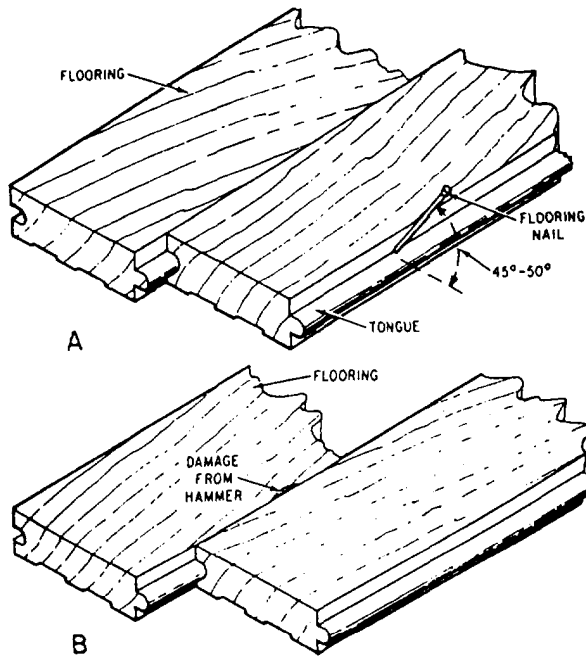


Figure 6-3.—Nailing wood flooring.

recommendations as to size and diameter for specific uses. Flooring brads are also available with blunted points to prevent splitting the tongue.

Figure 6-2, view B, shows how to nail the first strip of flooring. This strip should be placed 1/2 to 5/8 inch away from the wall. The space is to allow for expansion of the flooring when moisture content increases. The first nails should be driven straight down, through the board at the groove edge. The nails should be driven into the joist and near enough to the edge so that they will be covered by the base or shoe molding. The first strip of flooring can also be nailed through the tongue (fig. 6-3, view A). This figure shows in detail how nails should be driven into the tongue of the flooring at an angle of 45° to 50°. Don't drive the nails flush; this prevents damaging the edge by the hammerhead (fig. 6-3 view B). These nails should be set with a nail set.

To prevent splitting the flooring, predrill through the tongue, especially at the ends of the strip. For the second course of flooring from the wall, select pieces so that the butt joints are well separated from those in the first course. Under normal conditions, each board should be driven up tightly against the previous board. Cracked pieces may require wedging to force them into alignment or may be cut and used at the ends of the course or in closets. In completing the flooring, you should provide a 1/2- to 5/8-inch space between the wall and the last flooring strip. This strip should be face-nailed

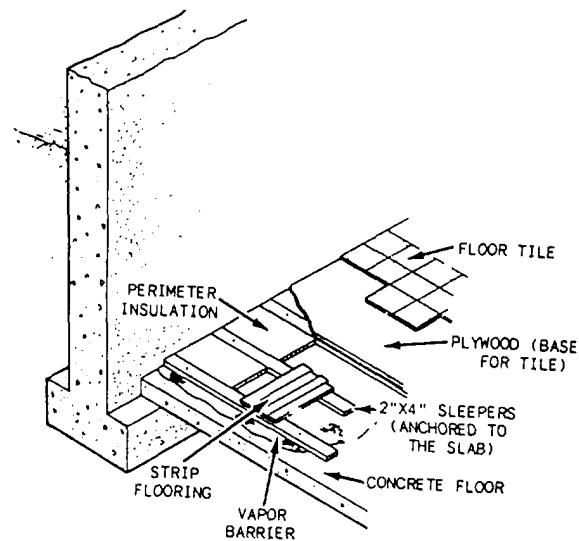


Figure 6-4.—Floor detail for existing concrete construction.

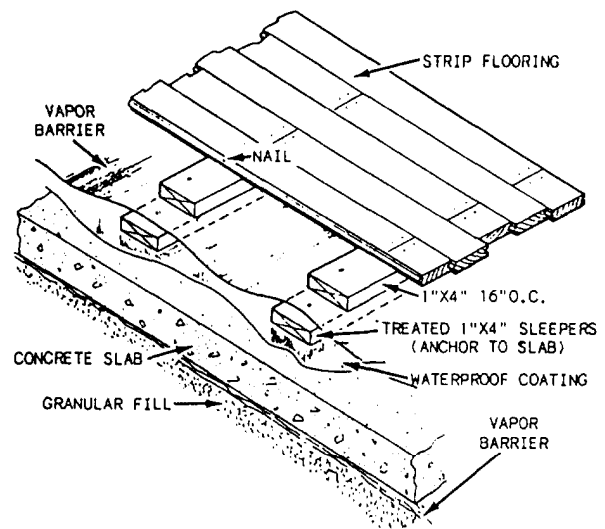


Figure 6-5.—Base for wood flooring on a slab with vapor barrier.

just like the first strip so that the base or shoe covers the set nailheads (fig. 6-2, view B).

Installation over Concrete

One of the most critical factors in applying wood flooring over concrete is the use of a good vapor barrier under the slab to resist ground moisture. The vapor barrier should be placed under the slab during construction. However, an alternate method must be used when the concrete is already in place (shown in fig. 6-4).

A system of preparing a base for wood flooring when there is a vapor barrier under the slab is shown in figure 6-5. Treated 1-by 4-inch furring strips should be

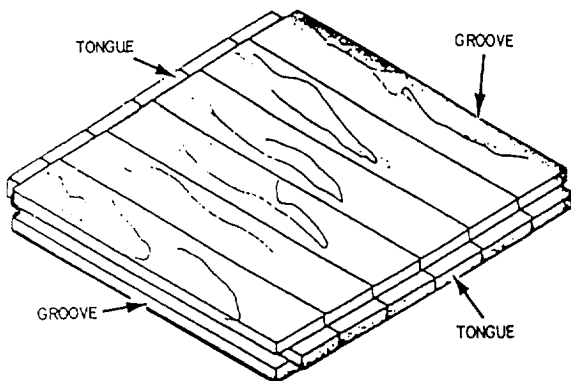
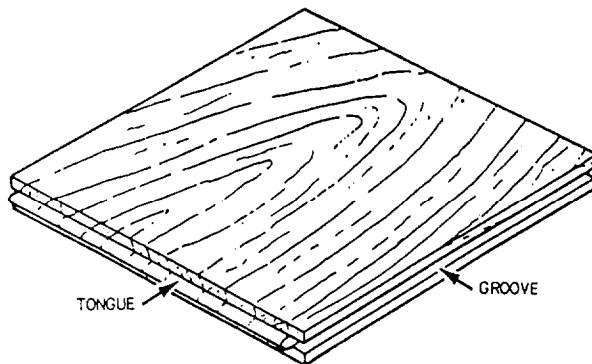


Figure 6-6.—Wood block (parquet) laminated flooring.

anchored to the existing slab. Shims can be used, when necessary, to provide a level base. Strips should be spaced no more than 16 inches on center (OC). A good waterproof or water-vapor resistant coating on the concrete before the treated strips are installed is usually recommended to aid in further reducing moisture movement. A vapor barrier, such as a 4-mil polyethylene or similar membrane, is then laid over the anchored 1- by 4-inch wood strips and a second set of 1 by 4s nailed to the first. Use 1 1/2-inch-long nails spaced 12 to 16 inches apart in a staggered pattern. The moisture content of these second members should be approximately the same as that of the strip flooring to be applied. Strip flooring can then be installed as previously described.

When other types of finish floor, such as a resilient tile, are used, plywood underpayment is placed over the 1 by 4s as a base.

WOOD BLOCK FLOORING

Wood block (parquet) flooring (fig. 6-6) is used to produce a variety of elaborate designs formed by small wood block units. A block unit consists of short lengths

of flooring, held together with glue, metal splines, or other fasteners. Square and rectangular units are produced. Generally, each block is laid with its grain at right angles to the surrounding units.

Blocks, called laminated units, are produced by gluing together several layers of wood. Unit blocks are commonly produced in 3/4-inch thicknesses. Dimensions (length and width) are in multiples of the widths of the strips from which they are made. For example, squares assembled from 2 1/4-inch strips are 6 3/4 by 6 3/4 inches, 9 by 9 inches, or 11 1/4 by 11 1/4 inches. Wood block flooring is usually tongue and groove.

UNDERLAYMENT

Flooring materials, such as asphalt, vinyl, linoleum, and rubber, usually reveal rough or irregular surfaces in the flooring structure upon which they are laid. Conventional subflooring does not provide a satisfactory surface. An underpayment of plywood or hardboard is required. On concrete floors, a special mastic material is sometimes used when the existing surface is not suitable as a base for the finish flooring.

An underpayment also prevents the finish flooring materials from checking or cracking when slight movements take place in a wood subfloor. When used for carpeting and resilient materials, the underpayment is usually installed as soon as wall and ceiling surfaces are complete.

Hardboard and Particleboard

Hardboard and particleboard both meet the requirements of an underpayment board. The standard thickness for hardboard is 1/4 inch. Particleboard thicknesses range from 1/4 to 3/4 inch.

This type of underpayment material will bridge small cups, gaps, and cracks. Larger irregularities should be repaired before the underpayment is applied. High spots should be sanded down and low areas filled. Panels should be unwrapped and placed separately around the room for at least 24 hours before they are installed. This equalizes the moisture content of the panels before they are installed.

INSTALLATION.— To install hardboard or particleboard, start at one corner and fasten each panel securely before laying the next. Some manufacturers print a nailing pattern on the face of the panel. Allow at least a 1/8- to 3/8-inch space next to a wall or any other vertical surface for panel expansion.

Stagger the joints of the underpayment panel. The direction of the continuous joints should be at right

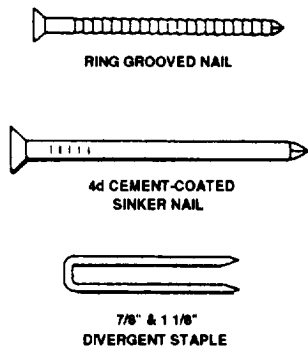


Figure 6-7.—Fasteners for underpayment.

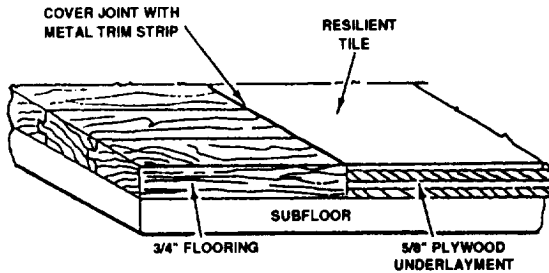


Figure 6-8.—Alignment of finish flooring materials.

angles to those in the subfloor. Be especially careful to avoid aligning any joints in the underpayment with those in the subfloor. Leave a 1/32-inch space at the joints between hardboard panels. Particleboard panels should be butted lightly.

FASTENERS.— Underayment panels should be attached to the subfloor with approved fasteners. Examples are shown in figure 6-7. For hardboard, space the fasteners 3/8 inch from the edge.

Spacing for particleboard varies for different thicknesses. Be sure to drive nailheads flush. When fastening underpayment with staples, use a type that is etched or galvanized and at least 7/8 inch long. Staples should not be spaced over 4 inches apart along panel edges.

Special adhesives can also be used to bond underpayment to subfloors. They eliminate the possibility of nail-popping under resilient floors.

Plywood

Plywood is preferred by many for underpayment. It is dimensionally stable, and spacing between joints is not critical. Since a range of thicknesses is available, alignment of the surfaces of various finish flooring materials is easy. An example of aligning resilient flooring with wood strip flooring is shown in figure 6-8.

To install plywood underpayment, follow the same general procedures described for hardboard. Turn the grain of the face-ply at right angles to the framing supports. Stagger the end joints. Nails may be spaced farther apart for plywood but should not exceed a field spacing of 10 inches (8 inches for 1/4- and 3/8-inch thicknesses) and an edge spacing of 6 inches OC. You should use ring-grooved or cement-coated nails to install plywood underpayment.

RESILIENT FLOOR TILE

After the underpayment is securely fastened, sweep and vacuum the surface carefully. Check to see that surfaces are smooth and joints level. Rough edges should be removed with sandpaper or a block plane.

The smoothness of the surface is extremely important, especially under the more pliable materials (vinyl, rubber, linoleum). Over a period of time, these materials will “telegraph” (show on the surface) even the slightest irregularities or rough surfaces. Linoleum is especially susceptible. For this reason, a base layer of felt is often applied over the underpayment when linoleum, either in tile or sheet form, is installed.

Because of the many resilient flooring materials on the market, it is essential that each application be made according to the recommendations and instructions furnished by the manufacturer of the product.

Installing Resilient Tile

Start a floor tile layout by locating the center of the end walls of the room. Disregard any breaks or irregularities in the contour. Establish a main centerline by snapping a chalk line between these two points. When snapping long lines, remember to hold the line at various intervals and snap only short sections.

Next, lay out another center line at right angles to the main center line. This line should be established by using a framing square or set up a right triangle (fig. 6-9)

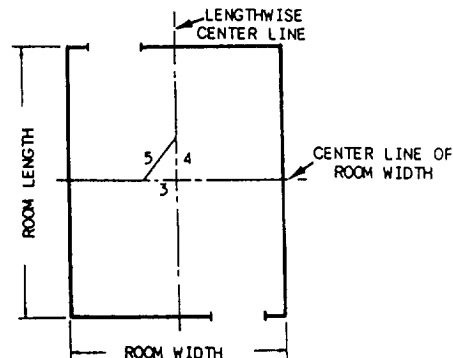


Figure 6-9.—Establishing center for laying floor tile.

with length 3 feet, height 4 feet, and hypotenuse 5 feet. In a large room, a 6:8: 10-foot triangle can be used. To establish this triangle, you can either use a chalk line or draw the line along a straightedge.

With the centerlines established, make a trial layout of tile along the center lines. Measure the distance between the wall and last tile. If the distance is less than 2 inches or more than 8 inches, move the centerline half the width of the tile (4 1/2 inches for a 9 by 9 tile) closer to the wall. This adjustment eliminates the need to install border tiles that are too narrow. (As you will learn shortly, border tiles are installed as a separate operation-after the main area has been tiled.) Check the layout along the other center line in the same way. Since the original center line is moved exactly half the tile size, the border tile will remain uniform on opposite sides of the room. After establishing the layout, you are now ready to spread the adhesive.

SPREADING ADHESIVE.— Before you spread the adhesive, reclean the floor surface. Using a notched trowel, spread the adhesive over one-quarter of the total area bringing the spread up to the chalk line but not covering it. Be sure the depth of the adhesive is the depth recommended by the manufacturer.

The spread of adhesive is very important. If it is too thin, the tile will not adhere properly. If too heavy, the adhesive will bleed between the joints.

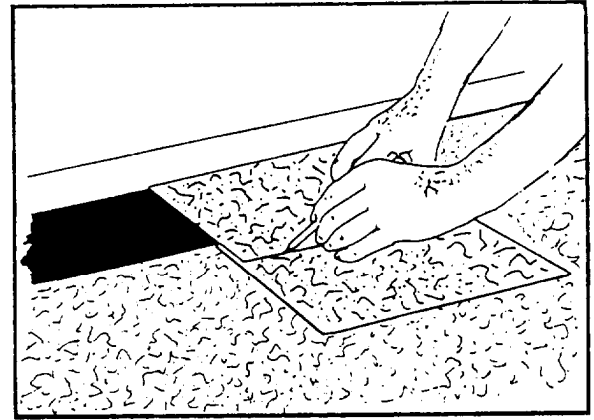


Figure 6-10.—Layout of a border tile.

Allow the adhesive to take an initial set before a single tile is laid. The time required will vary from a minimum of 15 minutes to a much longer time, depending on the type of adhesive used. Test the surface with your thumb. It should feel slightly tacky but should not stick to your thumb.

LAYING THE TILE.— Start laying the tile at the center of the room. Make sure the edges of the tile align with the chalk line. If the chalk line is partially covered with the adhesive, snap a new one or tack down a thin, straight strip of wood to act as a guide in placing the tile.

Table 6-1.—Estimating Adhesive for Floor Tile

ADHESIVE FOR FLOOR TILE	
Type and Use	Approximate Coverage in sq. ft. Per Gallon
Primer —For treating on or below grade concrete subfloors before installing asphalt tile	250 to 350
Asphalt cement —For installing asphalt tile over primed concrete subfloors in direct contact with the ground	200
Emulsion adhesive —For installing asphalt tile over lining felt	130 to 150
Lining paste —For cementing lining felt to wood subfloor	160
Floor and wall sealer —For priming chalky or dusty suspended concrete subfloors before installing resilient tile other than asphalt	200 to 300
Waterproof cement —Recommended for installing linoleum, rubber, and cork tile over any type of suspended subfloor in areas where surface moisture is a problem	130 to 150

Butt each tile squarely to the adjoining tile, with the comers in line. Carefully lay each tile in place. Do not slide the tile; this causes the adhesive to work up between the joints and prevents a tight fit. Take sufficient time to position each tile correctly. There is usually no hurry since most adhesives can be "worked" over a period of several hours.

To remove air bubbles, rubber, vinyl, and linoleum are usually rolled after a section of the floor is laid. Be sure to follow the manufacturer's recommendations. Asphalt tile does not need to be rolled.

After the main area is complete, set the border tile as a separate operation. To lay out a border tile, place a loose tile (the one that will be cut and used) over the last tile in the outside row. Now, take another tile and place it in position against the wall and mark a sharp pencil line on the first tile (fig. 6-10).

Cut the tile along the marked line, using heavy-duty shears or tin snips. Some types of tile require a special cutter or they may be scribed and broken. Asphalt tile, if heated, can be easily cut with snips.

Afler all sections of the floor have been completed, install the cove along the wall and around fixtures. A special adhesive is available for this operation. Cut the proper lengths and make a trial fit. Apply the adhesive to the cove base and press it into place.

Check the completed installation carefully. Remove any spots of adhesive. Work carefully using cleaners and procedures approved by the manufacturer.

SELF-ADHERING TILE.— Before installing self-adhering tile, you must first ensure that the floors are dry, smooth, and completely free of wax, grease, and dirt. Generally, tiles can be laid over smooth-faced resilient floors. Embossed floors, urethane floors, or cushioned floors should be removed.

Self-adhering tile is installed in basically the same way as previously mentioned types of tile. Remove the paper from the back of the tile, place the tile in position on the floor, and press it down.

Estimating Floor Tile Materials

Use table 6-1 when estimating resilient floor tile materials. This table gives you approximate square feet coverage per gallon of different types of primer and adhesives. Be sure to read and follow the manufacturer's directions. Table 6-2 provides figures for estimating the two sizes of tile most commonly used. After calculating the square feet of the area to be tiled, refer to the table

Table 6-2.—Estimating Floor Tile

SQ. FT. OF FLOOR	NUMBER OF TILES	
	9" × 9"	12" × 12"
1	2	1
2	4	2
3	6	3
4	8	4
5	9	5
6	11	6
7	13	7
8	15	8
9	16	9
10	18	10
20	36	20
30	54	30
40	72	40
50	89	50
60	107	60
70	125	70
80	143	80
90	160	90
100	178	100
200	356	200
300	534	300
400	712	400
500	890	500
Waste Tile		
1 to 50 sq. ft		14%
50 to 100 sq. ft		10%
100 to 200 sq. ft		8%
200 to 300 sq. ft		7%
300 to 1,000 sq. ft		5%
Over 1,000 sq. ft		3%

to find the number of tiles needed, then add the waste factor.

To find the number of tiles required for an area not shown in this table, such as the number of 9- by 9-inch tiles required for an area of 550 square feet, add the number of tiles needed for 50 square feet to the number of tile needed for 500 square feet. The result will be 979

tiles, to which you must add 5 percent for waste. The total number of tiles required is 1,028.

When tiling large areas, work from several different boxes of tile. This will avoid concentrating one color shade variation in one area of the floor.

SHEET VINYL FLOORING

Because of its flexibility, vinyl flooring is very easy to install. Since sheets are available in 6- to 12-foot widths, many installations can be made free of seams. Flexible vinyl flooring is fastened down only around the edges and at seams. It can be installed over concrete, plywood, or old linoleum.

To install, spread the sheet smoothly over the floor. Let excess material turn up around the edges of the room. Where there are seams, carefully match the pattern. Fasten the two sections to the floor with adhesive. Trim the edges to size by creasing the vinyl sheet material at intersections of the floor and walls and cutting it with a utility knife drawn along a straightedge. Be sure the straightedge is parallel to the wall.

After the edges are trimmed and fitted, secure them with a staple gun, or use a band of double-faced adhesive tape. Always study the manufacturer's directions carefully before starting the work.

WALL-TO-WALL CARPETING

Wall-to-wall carpeting can make a small room look larger, insulate against drafty floors, and do a certain amount of soundproofing. Carpeting is not difficult to install.

All carpets consist of a surface pile and backing. The surface pile may be nylon, polyester, polypropylene, acrylic, wool, or cotton. Each has its advantages and disadvantages. The type you select depends on your needs. Carpeting can be purchased in 9-, 12-, and 15-foot widths.

Measuring and Estimating

Measure the room in the direction in which the carpet will be laid. To broaden long, narrow rooms, lay patterned or striped carpeting across the width. For conventional rectangular rooms, measure the room lengthwise. Include the full width of doorframes so the carpet will extend slightly into the adjoining room. When measuring a room with alcoves or numerous wall projections, calculate on the basis of the widest and

longest points. This will result in some waste material, but is safer than ordering less than what you need.

Most wall-to-wall carpeting is priced by the square yard. To determine how many square yards you need, multiply the length by the width of the room in feet and divide the result by 9.

Underpayment

Except for so-called "one-piece" and cushion-backed carpeting, underpayment or padding is essential to a good carpet installation. It prolongs the life of the carpeting, increases its soundproofing qualities, and adds to underfoot comfort.

The most common types of carpet padding are latex (rubber), sponge-rubber foams, soft-and-hardback vinyl foams, and felted cushions made of animal hair or of a combination of hair and jute. Of all types, the latex and vinyl foams are generally considered the most practical. Their waffled surface tends to hold the carpet in place. Most carpet padding comes in a standard 4 1/2-foot width.

Cushion-backed carpeting is increasing in popularity, especially with do-it-yourself homeowners. The high-density latex backing is permanently fastened to the carpet, which eliminates the need for a separate underpadding. It is nonskid and heavy enough to hold the carpet in place without the use of tacks. In addition, the foam rubber backing keeps the edges of the carpet from unraveling so that it need not be bound. Foam rubber is mildewproof and unaffected by water, so the carpet can be used in basements and other below-grade installations. It can even be laid directly over unfinished concrete.

The key feature of this backing, however, is the dimensional stability it imparts to the carpet. This added characteristic means the carpet will not stretch, nor will it expand and contract from temperature or humidity changes. Because of this, these carpets can be loose-laid, with no need for adhesive or tacks to give them stability.

Preparing the Floor

To lay carpets successfully on wood floors, you must ensure that the surface is free of warps, and that all nails and tacks are either removed or hammered flush. Nail down any loose floorboards and plane down the ridges of warped boards. Fill wide cracks between floorboards with strips of wood or wood putty. Cover floors that are warped and cracked beyond reasonable repair with hardboard or plywood.

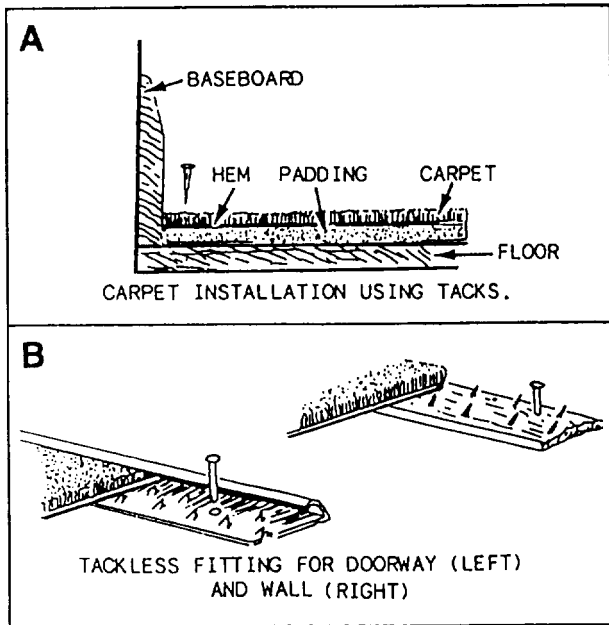


Figure 6-11.—Carpet installation.

Stone or concrete floors that have surface ridges or cracks should be treated beforehand with a floor-leveling compound to reduce carpet wear. These liquid compounds are also useful for sealing the surface of dusty or powdery floors. A thin layer of the compound, which is floated over the floor, will keep dust from working its way up through the underpadding and into the carpet pile.

The best carpeting for concrete and hard tile surfaces is the indoor-outdoor type. The backing of this carpet is made of a closed-pore type of either latex or vinyl foam, which keeps out most moisture. It is not wise to lay any of the standard paddings on top of floor tiles unless the room is well ventilated and free of condensation. Vinyl and asbestos floor tiles accumulate moisture when carpeting is laid over them. This condensation soaks through into the carpet and eventually causes a musty odor. It can also produce mildew stains.

Fastening Carpets

The standard fastening methods are with tacks or by means of tackless fittings. Carpets can also be loose-hid with only a few tacks at entrances. Carpet tack lengths are 3/4 and 1 inch. The first is long enough to go through a folded carpet hem and anchor it firmly to the floor (fig. 6-11, view A). The 1-inch tacks are used in corners where the folds of the hem make three thicknesses.

Tackless fittings (fig. 6-11, view B) are a convenient fastening method. They consist of a 4-foot wooden

batten with a number of spikes projecting at a 60° angle. The battens are nailed to the floor around the entire room, end to end and 1/4 inch from the baseboard, with the spikes facing toward the wall. The spikes grip the backing of the carpet to hold it in place. On stone or concrete floors, the battens are glued in place with special adhesives.

Though cushion-backed carpeting can stay in place without fastening, securing with double-face tape is the preferred method. Carpets can also be attached to the floor with Velcro™ tape where the frequent removability of the carpet for cleaning and maintenance is a factor.

Carpet Installation

To install a carpet, you will need a hammer, large scissors, a sharp knife, a 3-foot rule, needle and carpet thread, chalk and chalk line, latex adhesive, and carpet tape. The only specialized tool you will need is a carpet stretcher, often called a knee-kicker.

Before starting the job, remove all furniture and any doors that swing into the room. When cutting the carpet, spread it out on a suitable floor space and chalk the exact pattern of the room on the pile surface; then cut along the chalk line with the scissors or sharp knife.

Join unseamed carpet by placing the two pieces so the pile surfaces meet edge to edge. Match patterned carpets carefully. With plain carpets, lay each piece so the piles run the same way. Join the pieces with carpet thread, taking stitches at 18-inch intervals along the seam. Pull the carpet tight after each stitch to take up slack. Sew along the seam between stitches. Tuck any protruding fibers back into the pile. Carpet can also be seamed by cementing carpet tape to the backing threads with latex adhesive.

Open the carpet to room length and position it before starting to putdown the padding. The pile should fall away from windows to avoid uneven shading in daylight. Fold one end of the carpet back halfway and put the padding down on the exposed part of the floor. Do the same at the other end. This avoids wrinkles caused by movement of the padding.

To tack start at the corner of the room that is formed by the two walls with the fewest obstructions. Butt the carpet up against the wall, leaving about 1 1/2 inches up the baseboard for hemming. Attach the carpet temporarily with tacks about 6 inches from the baseboard along these two walls. Use the knee-kicker to stretch the carpet, first along the length, then the width. Start from the middle of the wall, stretching alternately toward opposite comers. When it is smooth, tack down the stretched area temporarily.

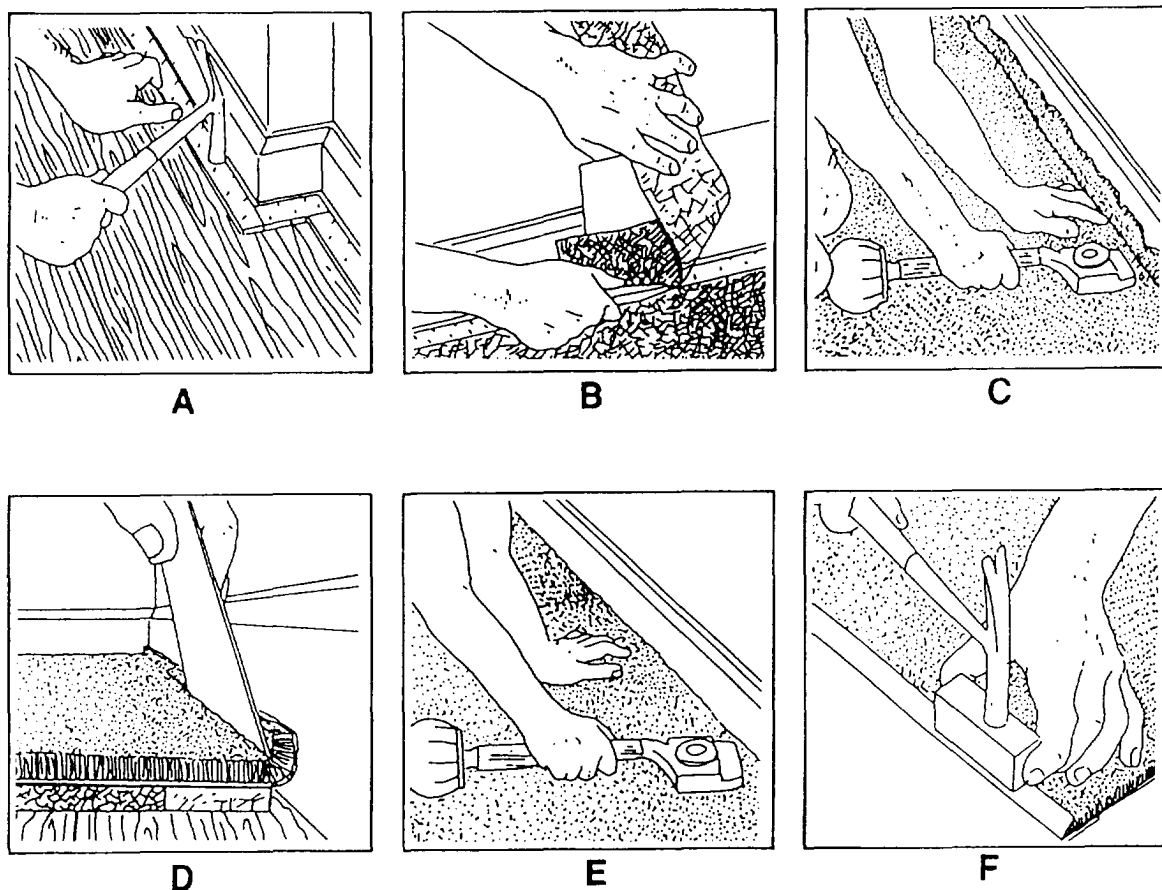


Figure 6-12.—Carpet installation using tackless fastenings.

Cut slots for pipes, fireplace protrusions, and radiators. Trim back the padding to about 2 inches from the wall to leave a channel for the carpet hem. Fold the hem under and tack the carpet in place with a tack every 5 inches. Be sure the tacks go through the fold

When installing carpet, use tackless fastening strips, as shown in figure 6-12, view A. Position and trim the padding (view B) so that it meets the strip at the wall, but does not overlap the strip. Tack it down so it does not move. Lay out the carpeting and, using a knee-kicker, stretch the carpet over the nails projecting out of the tackless strip (view C). Trim the carpet, leaving a 3/8-inch overlap, which is tucked into place between the wall and the tackless strip (view D). (If you trim too much carpeting, lift the carpeting off the spikes of the tackless strip and use the knee-kicker to restretch the carpet [view E]). Protect the exposed edge of the carpet at doorways with a special metal binder strip or bar (view F). The strip is nailed to the floor at the doorway and the carpet slipped under a metal lip, which is then hammered down to grip the carpet edge.

Tacks can be used as an alternative to a binder strip. Before tacking, tape the exposed edge of woven carpet

to prevent fraying if the salvage has been trimmed off. Cement carpet tape to the backing threads with latex adhesive. Nonwoven or latex-backed carpet will not fray, but tape is still advisable to protect exposed edges. Any door that drags should be removed and trimmed.

When installing cushion-backed carpeting, you can eliminate several steps. For instance, you don't need to use tack strips or a separate padding. Although these instructions apply to most such carpeting, read the manufacturer's instructions for any deviation in technique or use of material.

To install a cushioned carpet, apply 2-inch-wide double-face tape flush with the wall around the entire room (fig. 6-13, view A). Roll out and place the carpet. Fold back the carpet and remove the protective paper from the tape. Press the carpet down firmly over the tape and trim away excess (view B). A metal binder strip or an aluminum saddle is generally installed in doorways (view C). If your room is wider than the carpet, you will have to seam two pieces together. Follow the manufacturer's recommendations.

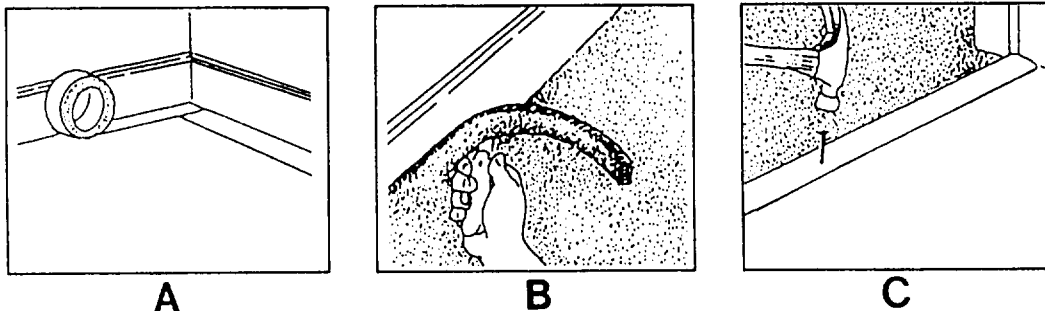


Figure 6-13.—Installing cushion-backed carpeting.

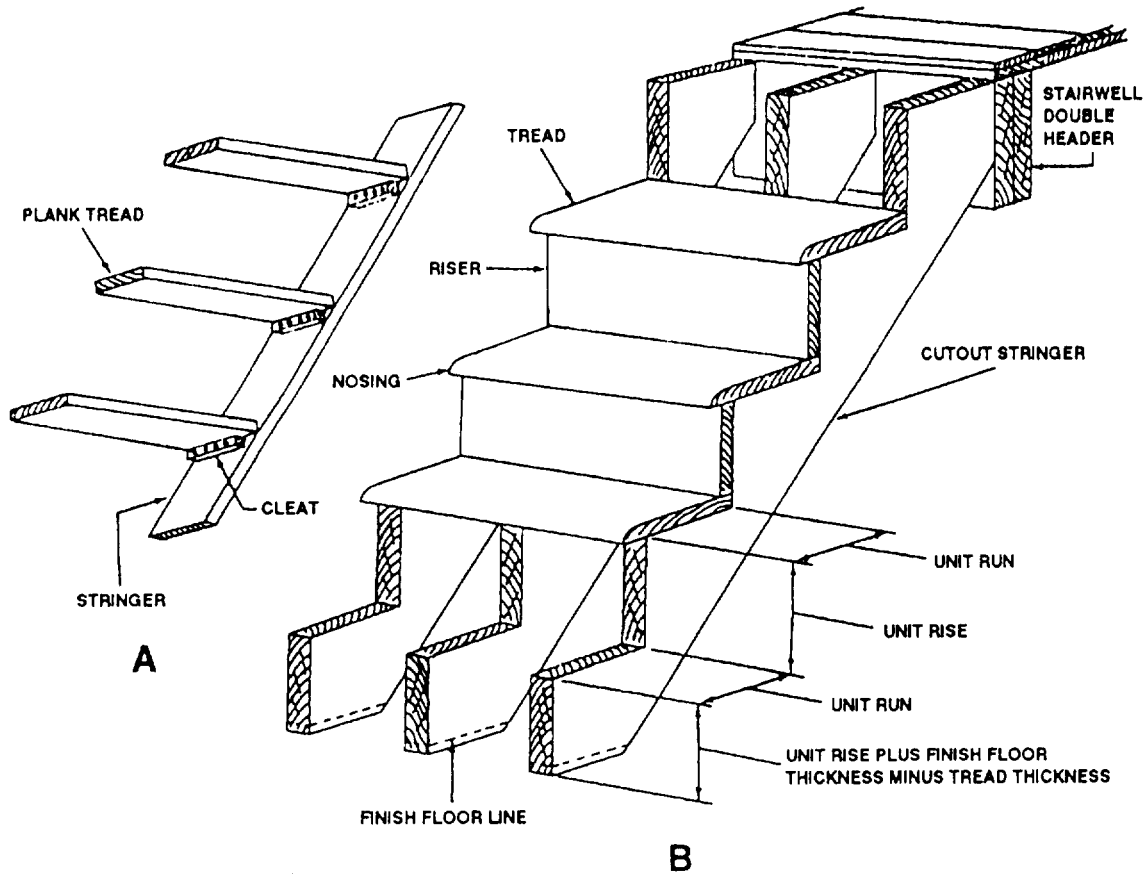


Figure 6-14.—Stairways.

STAIRS

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe a stairway layout and how to frame stairs according to drawings and specifications.

There are many different kinds of stairs (interior and exterior), each serving the same purpose—the movement of personnel and products from one floor to

another. All stairs have two main parts, called treads and stringers. The underside of a simple stairway, consisting only of stringers and treads, is shown in figure 6-14, view A. Treads of the type shown are called plank treads. This simple type of stairway is called a cleat stairway because of the cleats attached to the stringers to support the treads.

A more finished type of stairway has the treads mounted on two or more sawtooth-edged stringers, and includes risers (fig. 6-14, view B). The stringers shown

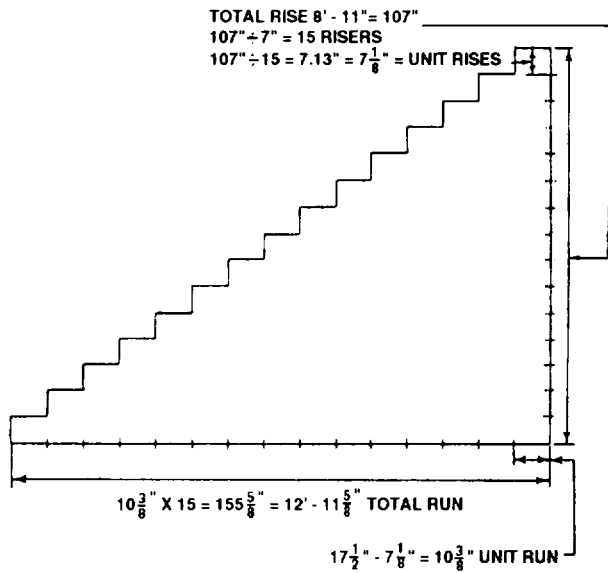


Figure 6-15.—Unit rise and run.

are cut from solid pieces of dimensional lumber (usually 2 by 12s) and are called cutout, or sawed, stringers.

STAIRWAY LAYOUT

The first step in stairway layout is to determine the unit rise and unit run (fig. 6-14, view B). The unit rise is calculated on the basis of the total rise of the stairway, and the fact that the customary unit rise for stairs is 7 inches.

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

At the time stairs are laid out, only the subflooring is installed. If both the lower and the upper floors are to be covered with finish flooring of the same thickness, the measured vertical distance from the lower subfloor

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

Let's assume that the total rise measures 8 feet 11 inches, as shown in figure 6-15. Knowing this, you can determine the unit rise as follows. First, reduce the total rise to inches—in this case it comes to 107 inches. Next, divide the total rise in inches by the average unit rise, which is 7 inches. The result, disregarding any fraction, is the number of risers the stairway will have—in this case, $107/7$ or 15. Now, divide the total rise in inches by the number of risers—in this case, $107/15$, or nearly $7\frac{1}{8}$ inches. This is the unit rise, as shown in figure 6-15.

The unit run is calculated on the basis of the unit rise and a general architect's rule that the sum of the unit run and unit rise should be $17\frac{1}{2}$ inches. Then, by this rule, the unit run is $17\frac{1}{2}$ inches minus $7\frac{1}{8}$ inches or $10\frac{3}{8}$ inches.

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

In figure 6-16, three methods of anchoring the upper end of a stairway are shown. In view A, there is a complete tread at the top of the stairway. This means the number of complete treads is the same as the number of

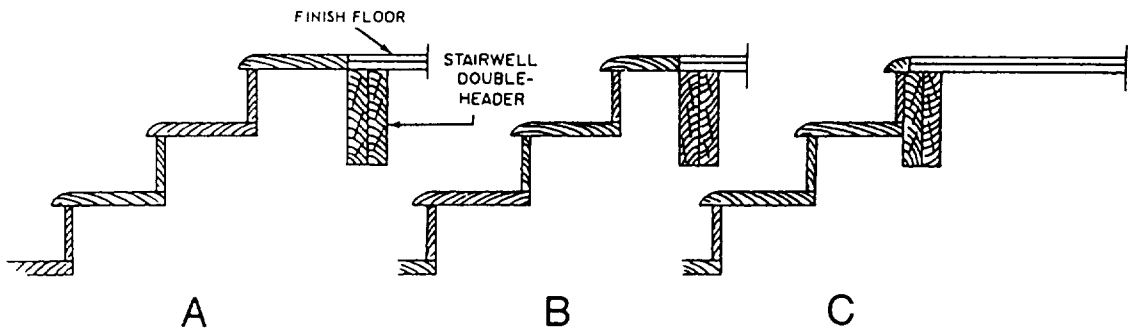


Figure 6-16.—Method for anchoring upper end of a stairway.

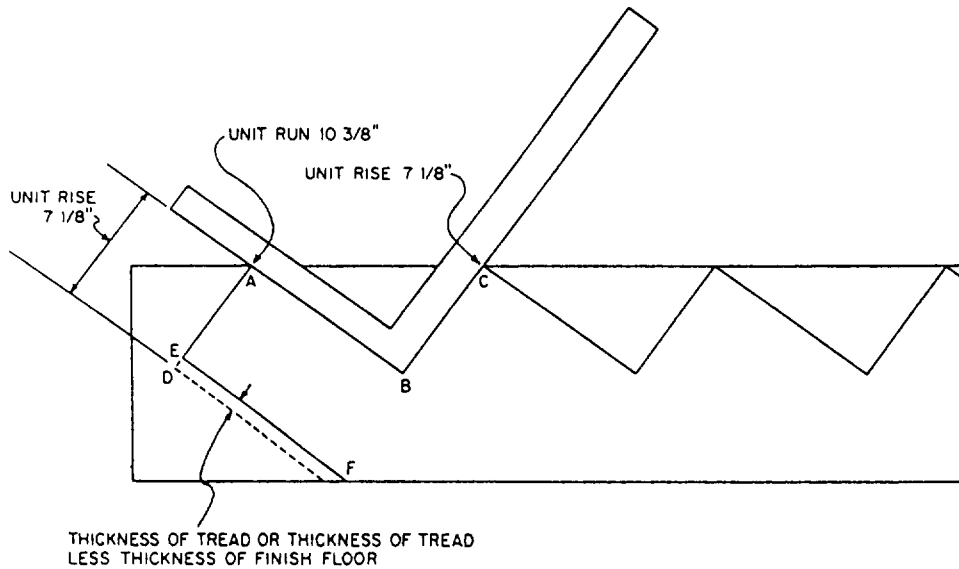


Figure 6-17.—Layout of lower end of cutout stringer.

risers. For the stairway shown in figure 6-15, there are 15 risers and 15 complete treads. Therefore, the total run of the stairway is equal to the unit run times 15, or 12 feet 11 5/8 inches.

In view B, only part of a tread is at the top of the stairway. If this method were used for the stairway shown in figure 6-15, the number of complete treads would be one less than the number of risers, or 14. The total run of the stairway would be the product of 14 multiplied by 10 3/8, plus the run of the partial tread at the top. Where this run is 7 inches, for example, the total run equals 152 1/4 inches, or 12 feet 8 1/4 inches.

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

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

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

Assume that you are to use the method of upper-end anchorage shown in view A of figure 6-16 to lay out a stringer for the stairway shown in figure 6-15. This

stairway has a total rise of 8 feet 11 inches and a total run of 12 feet 11 5/8 inches. The stringer must be long enough to form the hypotenuse of a triangle with sides of those two lengths. For an approximate length estimate, call the sides 9 and 13 feet long. Then, the length of the hypotenuse will equal the square root of 9^2 plus 13^2 . This is the square root of 250, about 15.8 feet or 15 feet 9 1/2 inches.

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

Figure 6-17 shows the layout at the lower end of the stringer. Set the framing square to the unit run on the tongue and the unit rise on the blade, and draw the line AB. This line represents the bottom tread. Then, draw AD perpendicular to AB. Its length should be equal to the unit rise. This line represents the bottom riser in the stairway. You may have noticed that the thickness of a tread in the stairway has been ignored. This thickness is now about to be accounted for by making an allowance in the height of this first riser. This process is called "dropping the stringer."

As you can see in figure 6-14, view B, the unit rise is measured from the top of one tread to the top of the next for all risers except the bottom one. For the bottom riser, unit rise is measured from the finished floor surface to the surface of the first tread. If AD were cut to the unit rise, the actual rise of the first step would be the sum of the unit rise plus the thickness of a tread. Therefore, the length of AD is shortened by the thickness of a tread, as shown in figure 6-17, by the

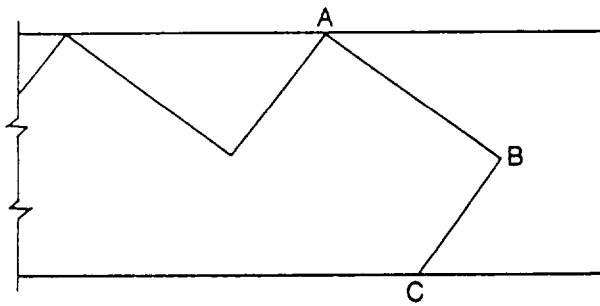


Figure 6-18.—Layout of upper end of cutout stringer.

thickness of a tread less the thickness of the finish flooring. The first is done if the stringer rests on a finish floor, such as a concrete basement floor. The second is done where the stringer rests on subflooring.

When you have shortened AD to AE, draw EF parallel to AB. This line represents the bottom horizontal anchor edge of the stringer. Then, proceed to lay off the remaining risers and treads to the unit rise and unit run until you have laid off 15 risers and 15 treads. Figure 6-18 shows the layout at the upper end of the stringer. The line AB represents the top, the 15th tread. BC, drawn perpendicular to AB, represents the upper vertical anchor edge of the stringer. This edge butts against the stairwell header.

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

STAIRWAY CONSTRUCTION

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

The stairs in a structure are broadly divided into principal stairs and service stairs. Service stairs are porch, basement, and attic stairs. Some of these may be simple cleat stairways; others may be open-riser stairways. An open-riser stairway has treads anchored

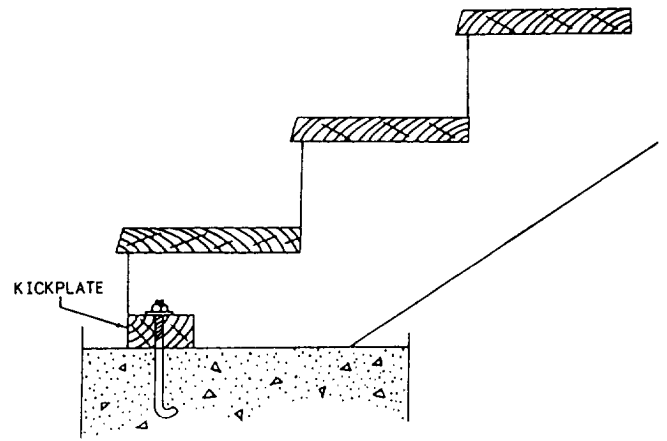


Figure 6-19.—Kickplate for anchoring stairs to concrete.

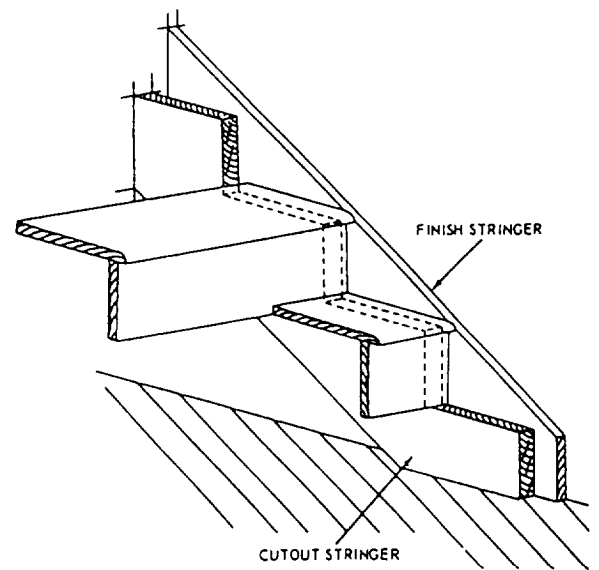


Figure 6-20.—Finish stringer.

on cutout stringers or stair-block stringers, but no risers. The lower ends of the stringers on porch, basement, and other stairs anchored on concrete are fastened with a kickplate (shown in fig. 6-19).

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

A principal stairway usually has a finished appearance. Rough cutout stringers are concealed by

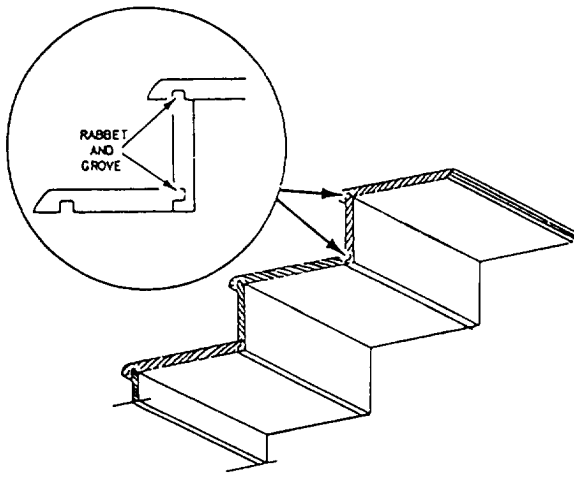


Figure 6-21.—Rabbet-and-groove-jointed treads and risers.

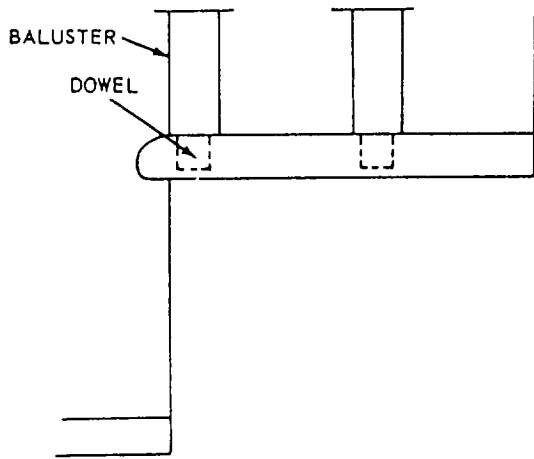


Figure 6-22.—Joining a baluster to the tread.

finish stringers (see fig. 6-20). Treads and risers are often rabbet-jointed as in figure 6-21.

Vertical members that support a stairway handrail are called balusters. Figure 6-22 shows a method of joining balusters to treads. Here, dowels, shaped on the lower ends of the balusters, are glued into holes bored in the treads.

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

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

INTERIOR DOORFRAMING

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe the procedures for laying out and installing interior doorframes, doors, and the hardware used.

Rough openings for interior doors are usually framed to be 3 inches higher than the door height and 2 1/2 inches wider than the door width. This provides for the frame and its plumbing and leveling in the opening. Interior doorframes are made up of two side jambs, a head jamb, and the stop moldings upon which the door closes. The most common of these jambs is the one-piece type (shown in fig. 6-23, view A). Jambs can be obtained in standard 5 1/4 inch widths for plaster walls and 4 5/8 inch widths for walls with 1/2-inch drywall finish. The two- and three-piece adjustable jambs (views B and C) are also standard types. Their principal advantage is in being adaptable to a variety of wall thicknesses.

Some manufacturers produce interior doorframes with the doors fitted and prehung, ready for installing. Installation of the casing completes the job. When used with two- or three-piece jambs, casings can even be installed at the factory.

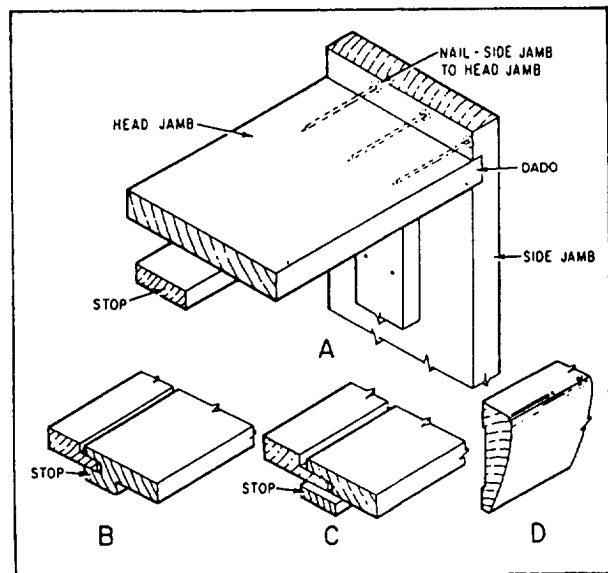
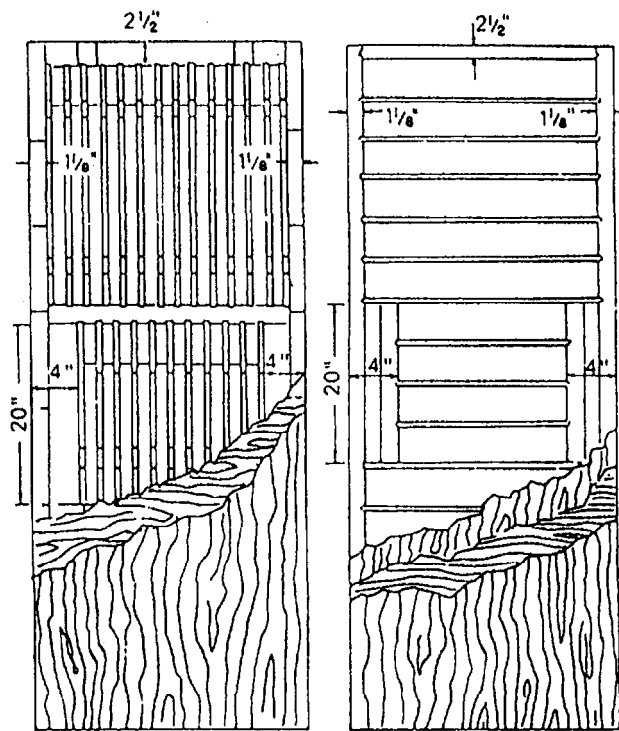


Figure 6-23.—Interior door framing parts.



FIVE-PLY HOT PRESS
HOLLOW CORE

SEVEN-PLY HOLLOW CORE

Figure 6-24.—Hollow-core construction of flushed doors.

Common minimum widths for single interior doors are as follows: bedrooms and other habitable rooms, 2 feet 6 inches; bathrooms, 2 feet 4 inches; and small closets and linen closets, 2 feet. These sizes vary a great deal, and sliding doors, folding door units, and similar types are often used for wardrobes and may be 6 feet or more in width. However, in most cases, the jamb stop and casing parts are used in some manner to frame and finish the opening.

CASING

Casing is the edge trim around interior door openings and is also used to finish the room side of windows and exterior doorframes. Casing usually varies in widths from 2 1/4 to 3 1/2 inches, depending on the style. Casing is available in thicknesses from 1/2 to 3/4 inch, although 11/16 inch is standard in many of the narrow-line patterns. A common casing pattern is shown in figure 6-23, view D.

The two general types of interior doors are the flush and the panel. Flush interior doors usually have a hollow core of light framework and are faced with thin plywood or hardboard (shown in fig. 6-24). Plywood-faced flush

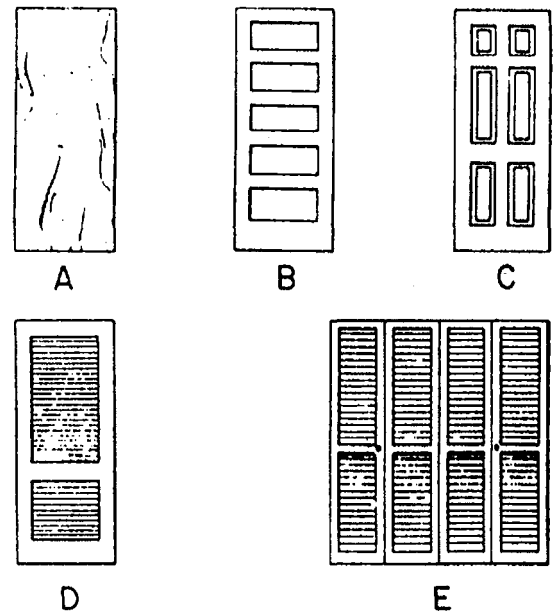


Figure 6-25.—Interior door types.

doors (fig. 6-25, view A) maybe obtained in gum, birch, oak mahogany, and several other wood species, most of which are suitable for natural finish. Nonselected grades are usually painted as hardboard-faced doors.

The panel door consists of solid stiles (vertical side members), rails (cross pieces), and panels of various types. The five-cross panel and the colonial-type panel doors are perhaps the most common of this style (fig. 6-25, views B and C). The louvered door (view D) is also popular and is commonly used for closets because it provides some ventilation. Large openings for wardrobes are finished with sliding or folding doors, or with flush or louvered doors (view E). Such doors are usually 1 1/8 inches thick.

Hinged doors should open or swing in the direction of natural entry, against a blank wall whenever possible. They should not be obstructed by other swinging doors. Doors should never be hinged to swing into a hallway.

FRAME AND TRIM INSTALLATION

When the frame and doors are not assembled and prefitted, the side jambs should be fabricated by nailing through the dado into the head jamb with three 7d or 8d coated nails (fig. 6-23 view A). The assembled frames are then fastened in the rough openings by shingle wedges used between the side jamb and the stud (fig. 6-26, view A). One jamb is plumbed and leveled using four or five sets of shingle wedges for the height of the frame. Two 8d finishing nails should be used at each

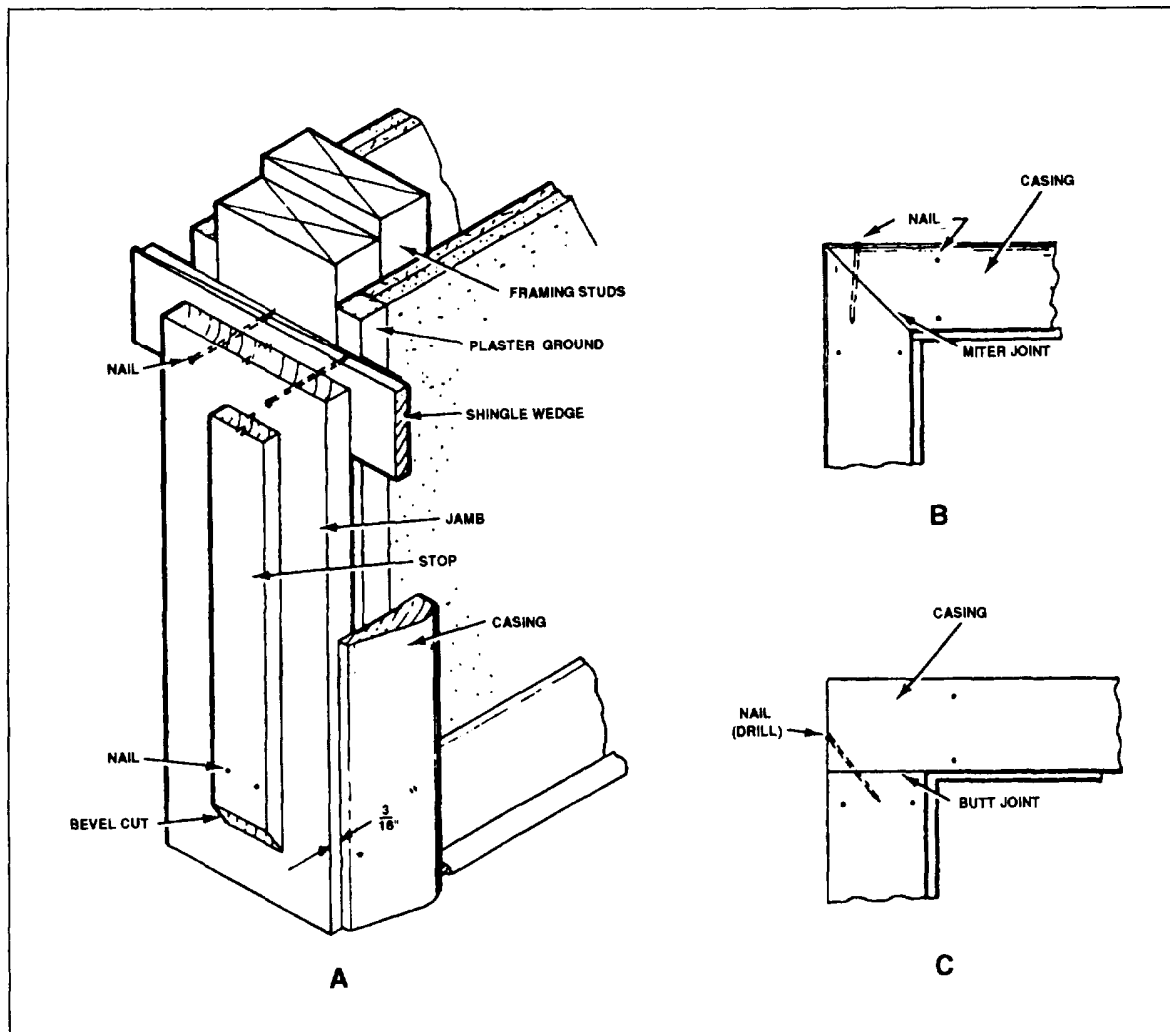


Figure 6-26.—Doorframe and trim.

wedged area one driven so that the doorstop covers it. The opposite side jamb is then fastened in place with shingle wedges and finishing nails, using the first jamb as a guide in keeping a uniform width.

Casings should be nailed to both the jamb and the framing members. You should allow about a 3/16-inch edge distance from the face of the jamb. Use 6d or 7d finish or casing nails, depending on the thickness of the casing. To nail into the stud, use 4d or 5d finish nails or 1 1/2-inch brads to fasten the timer edge of the casing to the jamb. For hardwood casing, it is advisable to predrill to prevent splitting. Nails in the casing should be located in pairs and spaced about 16 inches apart along the full height of the opening at the head jamb.

Casing with any form of molded shape must have a mitered joint at the corners (fig. 6-26, view B). When

casing is square-edged, a butt joint maybe made at the junction of the side and head casing (fig. 6-26, view C). If the moisture content of the casing material is high, a mitered joint may open slightly at the outer edge as the material dries. This can be minimized by using a small glued spline at the corner of the mitered joint. Actually, use of a spline joint under any moisture condition is considered good practice, and some prefitted jamb, door, and casing units are provided with splined joints. Nailing into the joint after drilling helps retain a close fit.

The door opening is now complete except for fitting and securing the hardware and nailing the stops in proper position. Interior doors are normally hung with two 3 1/2-by 3 1/2-inch loose-pin butt hinges. The door is fitted into the opening with the clearances shown in

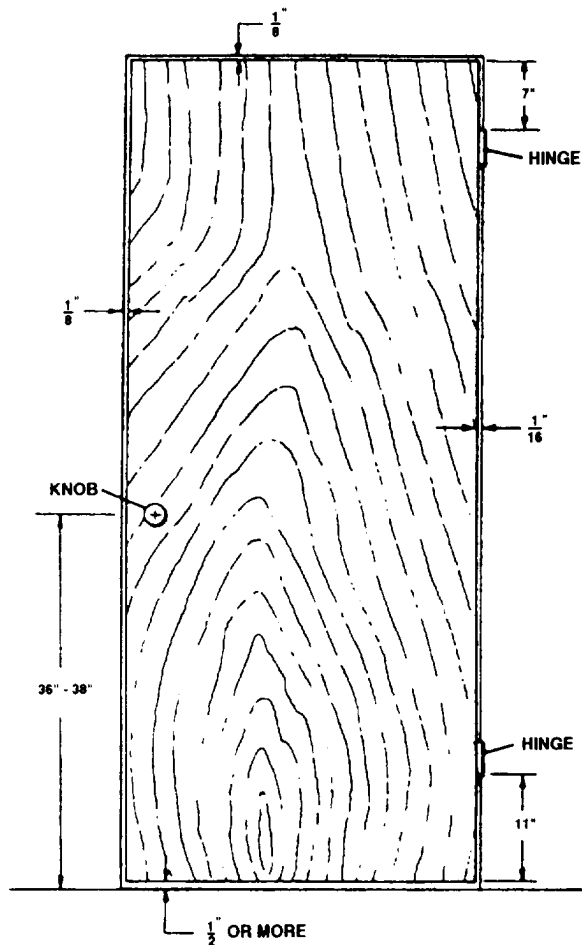


Figure 6-27.—Door clearances.

figure 6-27. The clearance and location of hinges, lockset, and doorknob may vary somewhat, but they are generally accepted by craftsmen and conform to most millwork standards. The edge of the lock stile should be beveled slightly to permit the door to clear the jamb when swung open. If the door is to swing across heavy carpeting, the bottom clearance may need to be slightly more.

When fitting doors, you should temporarily nail the stop in place; this stop will be nailed in permanently when the door has been hung. Stops for doors in single-piece jambs are generally $7/16$ inch thick and may be $3/4$ inch to $2\ 1/4$ inches wide. They are installed with a mitered joint at the junction of the side and head jambs. A 45° bevel cut at the bottom of the stop, about 1 to $1\ 1/2$ inches above the finish floor, eliminates a dirt pocket and makes cleaning or refinishing of the floor easier (fig. 6-26, view A).

Some manufacturers supply prefitted doorjambs and doors with the hinge slots routed and ready for installation. A similar door buck (jamb) of sheet metal with formed stops and casing is also available.

DOOR HARDWARE INSTALLATION

Hardware for doors is available in a number of finishes, with brass, bronze, and nickel being the most common. Door sets are usually classified as entry lock for interior doors; bathroom set (inside lock control with safety slot for opening from the outside); bedroom lock (keyed lock); and passage set (without lock).

As mentioned earlier, doors should be hinged so that they open in the direction of natural entry. They should also swing against a blank wall whenever possible and never into a hallway. The door swing directions and sizes are usually shown on the working drawings. The "hand of the door" (fig. 6-28) is the expression used to describe the direction in which a door is to swing (normal or reverse) and the side from which it is to hang (left or right).

When ordering hardware for a door, be sure to specify whether it is a left-hand door, a right-hand door, a left-hand reverse door, or a right-hand reverse door.

Hinges

You should use three hinges for hanging $1\ 3/4$ -inch exterior doors and two hinges for the lighter interior doors. The difference in exposure on the opposite sides of exterior doors causes a tendency to warp during the winter. Three hinges reduce this tendency. Three hinges are also useful on doors that lead to unheated attics and for wider and heavier doors that may be used within the structure. If a third hinge is required center it between the top and bottom hinges.

Loose-pin butt hinges should be used and must be of the proper size for the door they support. For $1\ 3/4$ -inch-thick doors, use 4- by 4-inch butts; for $1\ 3/8$ -inch doors, you should use $3\ 1/2$ - by $3\ 1/2$ -inch butts. After the door is fitted to the tied opening with the proper clearances, hinge halves are fitted to the door. They are routed into the door edge with about a $3/16$ -inch back distance (fig. 6-29, view A). One hinge half should be set flush with the surface and must be fastened square with the edge of the door. Screws are included with each pair of hinges.

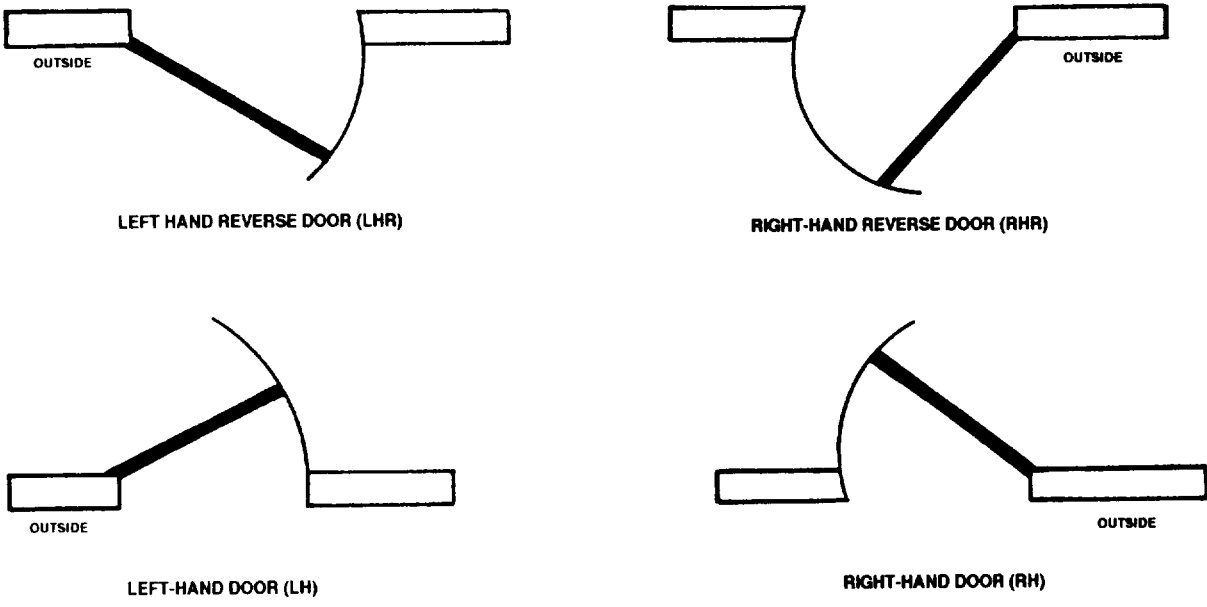


Figure 6-28.—“Hands” of doors.

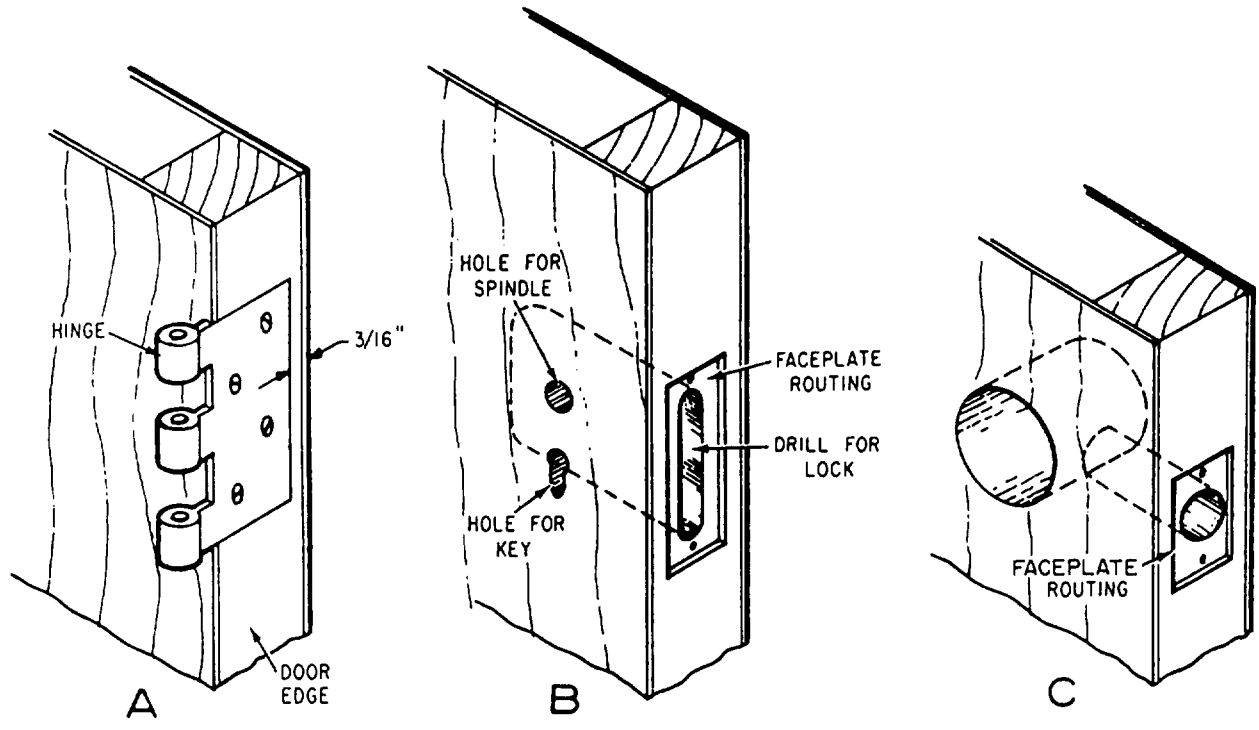


Figure 6-29.—Installation of door hardware.

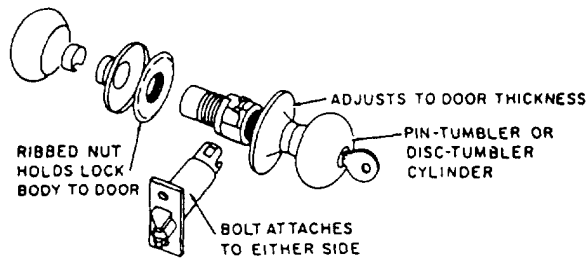


Figure 6-30.—Parts of a cylinder lock.

The door should now be placed in the opening and blocked up at the bottom for proper clearance. The jamb should be marked at the hinge locations, and the remaining hinge half routed and fastened in place. The door should then be positioned in the opening and the pins slipped in place. If you have installed the hinges correctly and the jambs are plumb, the door should swing freely.

Locks

The types of door locks differ with regard to installation, cost, and the amount of labor required to set them. Some types, such as mortise locks, combination dead bolts, and latch locksets, require drilling of the edge and face of the door and then routing of the edge to accommodate the lockset and faceplate (fig. 6-29,

view B). A bored lockset (view C) is easy to install since it requires only one hole drilled in the edge and one in the face of the door. Boring jigs and faceplate markers are available to ensure accurate installation.

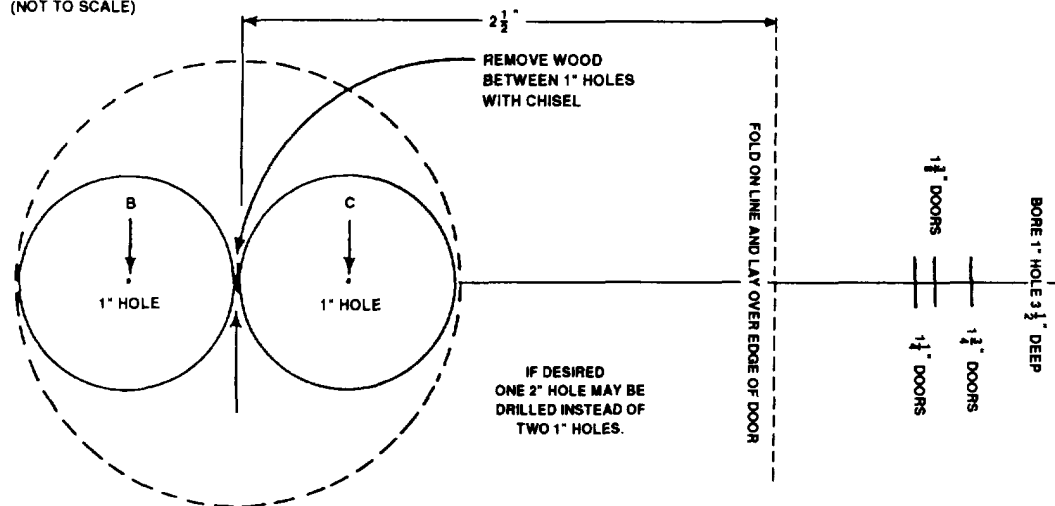
The lock should be installed so that the doorknob is 36 to 38 inches above the floor line. Most sets come with paper templates, marking the location of the lock and size of the holes to be drilled. Be sure to read the manufacturer's installation instructions carefully. Recheck your layout measurements before you drill any holes.

The parts of an ordinary cylinder lock for a door are shown in figure 6-30. The procedure for installing a lock of this type is as follows:

1. Open the door to a convenient working position and check it in place with wedges under the bottom near the outer edge.
2. Measure up 36 inches from the floor (the usual knob height), and square a line across the face and edge of the lock stile.
3. Place the template, which is usually supplied with a cylinder lock, on the face of the door at the proper height and alignment with layout lines and mark the centers of the holes to be drilled. (A typical template is shown in fig. 6-31.)

DRILL TEMPLATE

(NOT TO SCALE)



CAUTION!

LOCATE ALL HOLES CORRECTLY. DRILL ALL HOLES STRAIGHT. HALFWAY FROM EACH SIDE OF DOOR.

Figure 6-31.—Drill template for locksets.

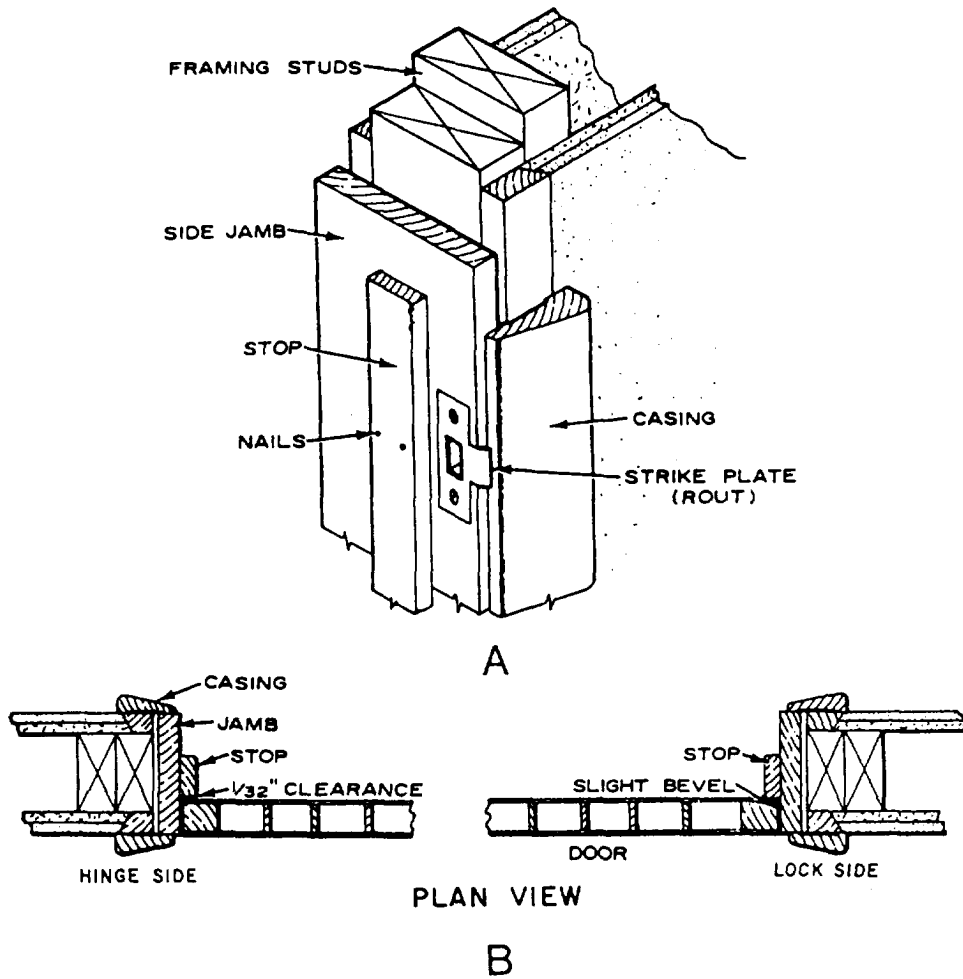


Figure 6-32.—Door details.

4. Drill the holes through the face of the door and then the hole through the edge to receive the latch bolt. It should be slightly deeper than the length of the bolt.
5. Cut again for the latch-bolt mounting plate, and install the latch unit.
6. Install the interior and exterior knobs.
7. Find the position of the strike plate and install it in the jamb.

Strike Plates

The strike plate, which is routed into the doorjamb, holds the door in place by contact with the latch. To install, mark the location of the latch on the doorjamb and locate the position of the strike plate by outlining it. Rout out the marked outline with a chisel and also rout for the latch (fig. 6-32, view A). The strike plate should

be flush with or slightly below the face of the doorjamb. When the door is latched, its face should be flush with the edge of the jamb.

Doorstops

The stops that have been temporarily set during the fitting of the door and the hardware may now be nailed in permanently. You should use finish nails or brads, 1 1/2 inches long. The stop at the lock side (fig. 6-32, view B) should be nailed first, setting it tight against the door face when the door is latched. Space the nails in pairs 16 inches apart.

The stop behind the hinge side should be nailed next, and a 1/32-inch clearance from the door face should be allowed to prevent scraping as the door is opened. The head-jamb stop should then be nailed in place. Remember that when the door and trim are painted, some of the clearance will be taken up.

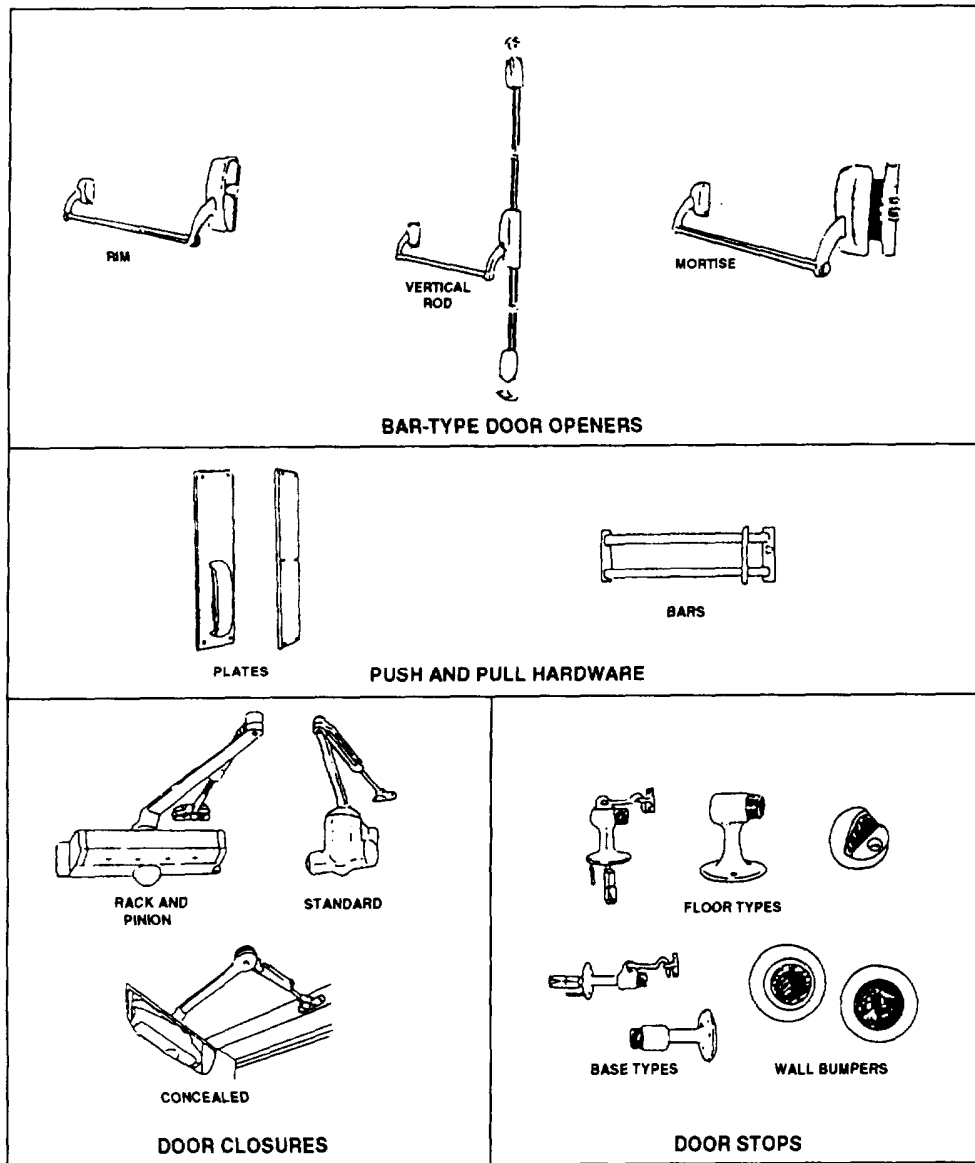


Figure 6-33.—Commercial hardware.

COMMERCIAL/INDUSTRIAL HARDWARE

The items of commercial/industrial door hardware shown in figure 6-33 are usually installed in commercial or industrial buildings, not residential housing. These items are used where applicable, in new construction or in alterations or repairs of existing facilities. Most of these items are made for use in or on metal doors, but some items are made for wood doors. Follow the manufacturer's installation instructions. Recommended door hardware locations for standard steel doors are shown in figure 6-34. Standard 7-foot doors are usually used in commercial construction.

INTERIOR WOOD TRIM

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of interior wood trim and the associated installation procedures.

The casing around the window frames on the interior of a structure should be the same pattern as that used around the interior doorframes. Other trim used for a double-hung window frame includes the sash, stops, stool, and apron (fig. 6-35, view A). Another method of using trim around windows has the entire opening

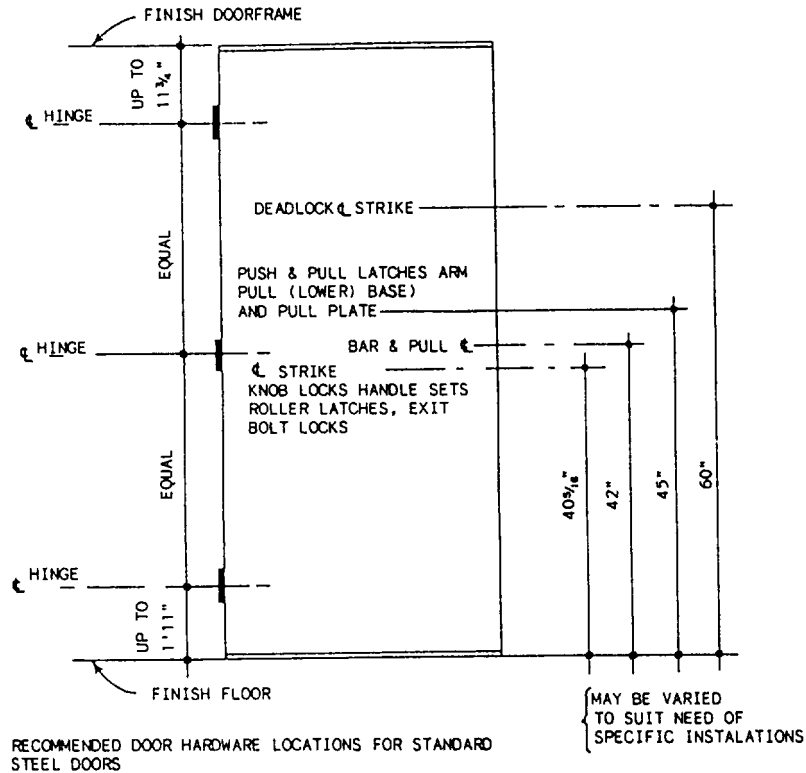


Figure 6-34.-Location of hardware for steel doors.

enclosed with casing (fig. 6-35, view B). The stool serves as a filler trim member between the bottom sash rail and the bottom casing.

The stool is the horizontal trim member that laps the windowsill and extends beyond the casing at the sides, with each end notched against the plastered wall. The apron serves as a finish member below the stool. The window stool is the first piece of window trim to be installed and is notched and fitted against the edge of the jamb and plaster line, with the outside edge being flush against the bottom rail of the window sash. The stool is blind-nailed at the ends so that the casing and the stop cover the nailheads. Prechilling is usually necessary to prevent splitting. The stool should also be nailed at the midpoint of the sill and to the apron with finishing nails. Face-nailing to the sill is sometimes substituted or supplemented with toenailing of the outer edge to the sill.

The window casing should be installed and nailed as described for doorframes (fig. 6-26, view A) except for the inner edge. This edge should be flush with the inner face of the jambs so that the stop covers the joint between the jamb and casing. The window stops are then nailed to the jambs so that the window sash slides smoothly. Channel-type weather stripping often

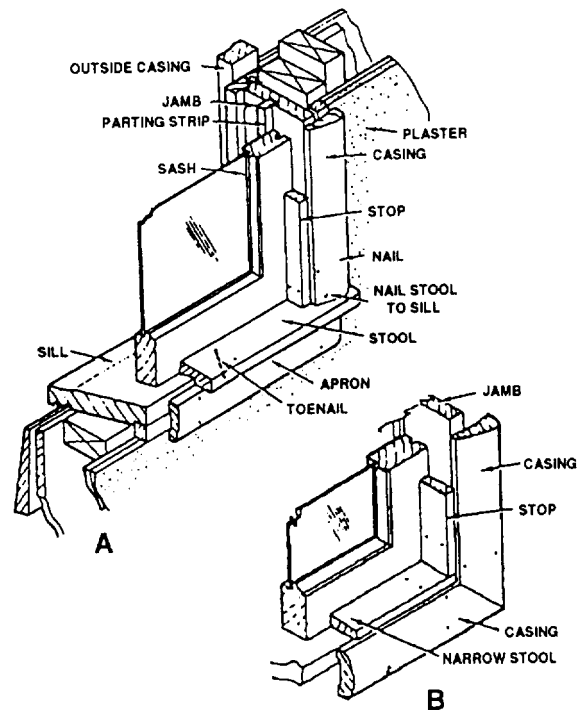


Figure 6-35.—Installation of window trim.

includes full-width metal subjamb into which the upper and lower sash slide, replacing the parting strip. Stops are located against these instead of the sash to provide a small amount of pressure. The apron is cut to a length equal to the outer width of the casing line (fig. 6-35, view A). It should be nailed to the windowsill and to the 2-by 4-inch framing sill below.

When casing is used to finish the bottom of the window frame, as well as the sides and top, the narrow stool butts against the side window jamb. Casing should then be mitered at the bottom corners (fig. 6-35, view B) and nailed as previously described.

BASE MOLDING

Base molding serves as a finish between the finished wall and floor. It is available in several widths and forms. Two-piece base consists of a baseboard topped with a small base cap (fig. 6-36, view A). When plaster is not straight and true, the small base molding will conform more closely to the variations than will the wider base alone. A common size for this type of baseboard is 5/8 inch by 3 1/4 inches or wider. One-piece base varies in size from 7/16 inch by 2 1/4 inches to 1/2 inch by 3 1/4 inches and wider (fig. 6-36, views B and C). Although a baseboard is desirable at the junction of the wall and carpeting to serve as a protective bumper, wood trim is sometimes eliminated entirely.

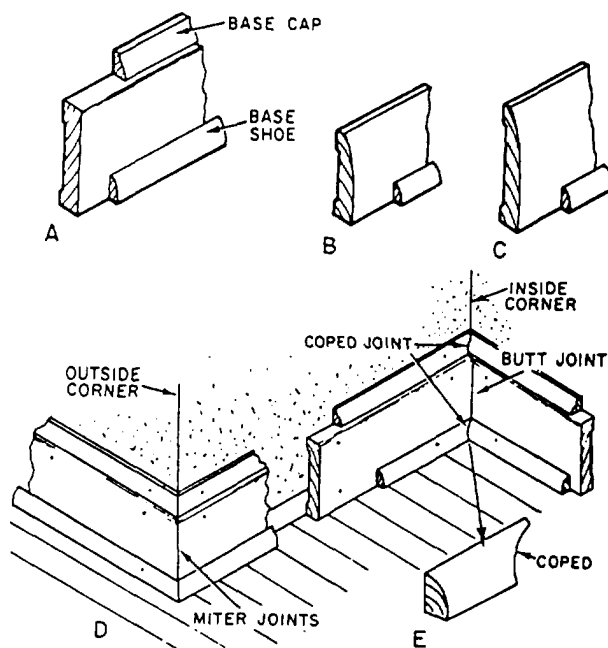


Figure 6-36.-Base moldings.

Most baseboards are finished with a 1/2-by 3/4-inch base shoe (fig. 6-36, view A). A single base molding without the shoe is sometimes placed at the wall-floor junction, especially where carpeting might be used.

Square-edged baseboard should be installed with a butt joint at the inside comers and a mitered joint at the outside comers (fig. 6-36, view D). It should be nailed to each stud with two 8d finishing nails. Molded single-piece base, base moldings, and base shoe should have a coped joint at the inside corners and a mitered joint at the outside corners. In a coped joint, the first piece is square-cut against the plaster or base and the second piece of molding coped. This is done by sawing a 45° miter cut and using a coping saw to trim the molding along the inner line of the miter (fig. 6-36, view E). The base shoe should be nailed into the baseboard itself. Then, if there is a small amount of shrinkage of the joists, no opening will occur under the shoe.

To butt-join a piece of baseboard to another piece already in place at an inside corner, set the piece to be joined in position on the floor, bring the end against or near the face of the other piece, and take off the line of the face with a scribe (fig. 6-37). Use the same procedure when butting ends of the baseboard against the side casings of the doors.

For miter-joining at an outside corner, proceed as shown in figure 6-38. First, set a marker piece of baseboard across the wall corner, as shown view A, and mark the floor along the edge of the piece. Then set the piece to be mitered in place. Mark the point where the wall corner intersects the top edge and the point where

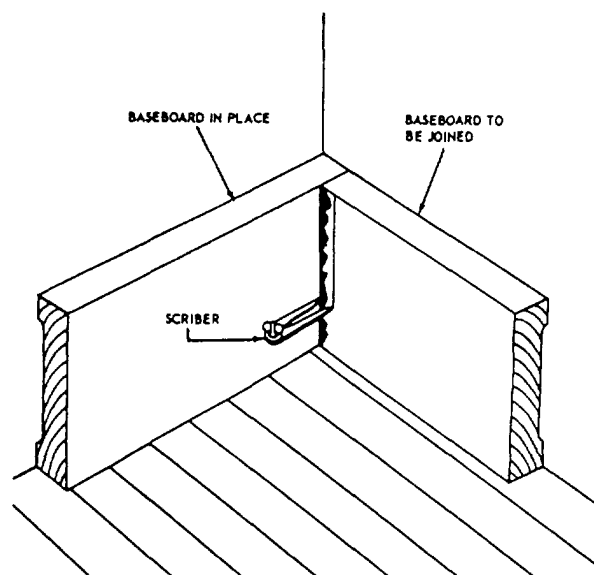


Figure 6-37.-Butt-joining baseboard at inside corners.

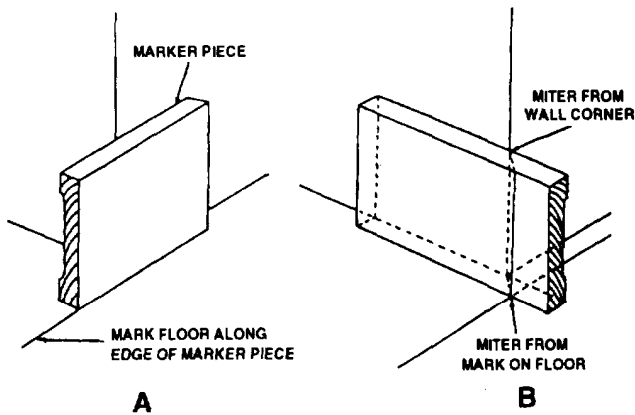


Figure 6-38.-Miter-joining at inside corners.

the mark on the floor intersects the bottom edge. Lay 45° lines across the edge from these points to make a 90° corner. Connect these lines with a line across the face (view B), and miter to the lines as indicated.

The most economical, and sometimes the quickest, method of installing baseboard is to use vinyl. In addition to its flexibility, it comes with premolded inside and outside corners. When installing vinyl base, follow the manufacturer's recommended installation procedures for both the base and adhesive.

CEILING MOLDING

Ceiling moldings (fig. 6-39) are sometimes used at the junction of the wall and ceiling for an architectural effect or to terminate drywall paneling of gypsum board or wood. As with base moldings, inside corners should be cope-jointed (fig. 6-39, view A). This ensures a tight joint and retains a good fit if there are minor moisture changes.

A cutback edge at the outside of the molding (view B) partially conceals any unevenness of the plaster and makes painting easier where there are color changes. For gypsum drywall construction, a small, simple molding (view C) might be desirable. Finish nails should be driven into the upper wall plates and also into the ceiling joists for large molding when possible.

DECORATIVE TREATMENT

The decorative treatment for interior doors, trim, and other millwork may be painted or given a natural finish with stain, varnish, or other nonpigmented material. The paint or natural finish desired for the woodwork in various rooms often determines the species of wood to be used.

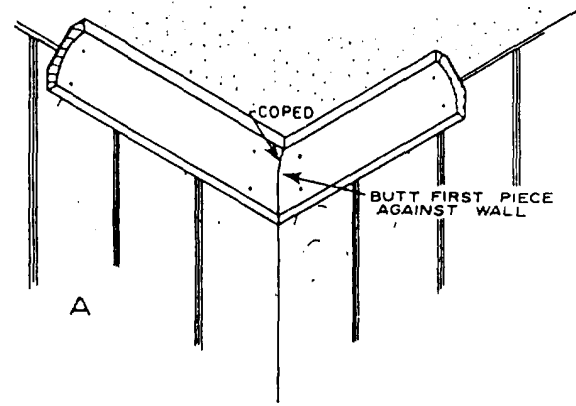


Figure 6-39.-Ceiling moldings.

Interior finish to be painted should be smooth, close-grained, and free from pitch streaks. Species meeting these requirements include ponderosa pine, northern white pine, redwood, and spruce. Birch, gum, and yellow poplar are recommended for their hardness and resistance to hard usage. Ash, birch, cherry, maple, oak, and walnut provide a beautiful natural finish decorative treatment. Some require staining to improve appearance.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this **TRAMAN** was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Carpentry, Leonard Keel, American Technical Publishers, Inc., Alsip, Ill., 1985.

Exterior and Interior Trim, John E. Ball, Delmar Publishers, Inc., Albany, N.Y., 1975.

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

CHAPTER 7

PLASTERING, STUCCOING, AND CERAMIC TILE

Plaster and stucco are like concrete in that they are construction materials applied in a plastic condition that harden in place. They are also basically the same material. The fundamental difference between the two is location. If used internally, the material is called plaster; if used externally, it is called stucco. Ceramic tile is generally used to partially or entirely cover interior walls, such as those in bathrooms, showers, galleys, and corridors. The tile is made of clay, pressed into shape, and baked in an oven.

This chapter provides information on the procedures, methods, and techniques used in plastering, stuccoing, and tile setting. Also described are various tools, equipment, and materials the Builder uses when working with these materials.

PLASTER

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify plaster ingredients, state the principles of mix design, and describe common types and uses of gypsum plaster.

A plaster mix, like a concrete mix, is made plastic by the addition of water to dry ingredients (binders and aggregates). Also, like concrete, a chemical reaction of the binder and the water, called hydration, causes the mix to harden.

The binders most commonly used in plaster are gypsum, lime, and portland cement. Because gypsum plaster should not be exposed to water or severe moisture conditions, it is usually restricted to interior use. Lime and portland cement plaster may be used both internally and externally. The most commonly used aggregates are sand, vermiculite, and perlite.

GYPSUM PLASTER

Gypsum is a naturally occurring sedimentary gray, white, or pink rock. The natural rock is crushed, then heated to a high temperature. This process (known as calcining) drives off about three-quarters of the water of crystallization, which forms about 20 percent of the weight of the rock in its natural state. The calcined

material is then ground to a fine powder. Additives are used to control set, stabilization, and other physical or chemical characteristics.

For a type of gypsum plaster called Keene's cement, the crushed gypsum rock is heated until nearly all the crystallization water is removed. The resulting material, called Keene's cement, produces a very hard, fine-textured finish coat.

The removal of crystallization water from natural gypsum is a dehydration process. In the course of setting, mixing water (water of hydration) added to the mix dehydrates with the gypsum, causing recrystallization. Recrystallization results in hardening of the plaster.

Base Coats

There are four common types of gypsum base coat plasters. Gypsum neat plaster is gypsum plaster without aggregate, intended for mixing with aggregate and water on the job. Gypsum ready-mixed plaster consists of gypsum and ordinary mineral aggregate. On the job, you just add water. Gypsum wood-fibered plaster consists of calcined gypsum combined with at least 0.75 percent by weight of nonstaining wood fibers. It may be used as is or mixed with one part sand to produce base coats of superior strength and hardness. Gypsum bond plaster is designed to bond to properly prepared monolithic concrete. This type of plaster is basically calcined gypsum mixed with from 2- to 5-percent lime by weight.

Finish Coats

There are five common types of gypsum-finish coat plasters.

Ready-mix gypsum-finish plasters are designed for use over gypsum-plaster base coats. They consist of finely ground calcined gypsum, some with aggregate and others without. On the job, just add water.

Gypsum acoustical plasters are designed to reduce sound reverberation. Gypsum gauging plasters contain lime putty. The putty provides desirable setting properties, increases dimensional stability during drying, and provides initial surface hardness.

Gauging plasters are obtainable in slow-set, quick-set, and special high-strength mixtures.

Gypsum molding plaster is used primarily in casting and ornamental plasterwork. It is available neat (that is, without admixtures) or with lime. As with Portland cement mortar, the addition of lime to a plaster mix makes the mix more “buttery.”

Keene’s cement is a fine, high-density plaster capable of a highly polished surface. It is customarily used with fine sand, which provides crack resistance.

LIME PLASTER

Lime is obtained principally from the calcining of limestone, a very common mineral. Chemical changes occur that transform the limestone into quicklime, a very caustic material. When it comes in contact with water, a violent reaction, hot enough to boil the water, occurs.

Today, the lime manufacturers slake the lime as part of the process of producing lime for mortar. Slaking is done in large tanks where water is added to convert the quicklime to hydrated lime without saturating it with water. The hydrated lime is a dry powder with just enough water added to supply the chemical reaction. Hydration is usually a continuous process and is done in equipment similar to that used in calcining. After the hydrating process, the lime is pulverized and bagged. When received by the plasterer, hydrated lime still requires soaking with water.

In mixing medium-slaking and slow-slaking limes, you should add the water to the lime. Slow-slaking lime must be mixed under ideal conditions. It is necessary to heat the water in cold weather. Magnesium lime is easily drowned, so be careful you don’t add too much water to quick-slaking calcium lime. When too little water is added to calcium and magnesium limes, they can be burned. Whenever lime is burned or drowned, a part of it is spoiled. It will not harden and the paste will not be as viscous and plastic as it should be. To produce plastic lime putty, soak the quicklime for an extended period, as much as 21 days.

Because of the delays involved in the slaking process of quicklime, most building lime is the hydrated type. Normal hydrated lime is converted into lime putty by soaking it for at least 16 hours. Special hydrated lime develops immediate plasticity when mixed with water and may be used right after mixing. Like calcined gypsum, lime plaster tends to return to its original rock-like state after application.

For interior base coat work, lime plaster has been largely replaced by gypsum plaster. Lime plaster is now used mainly for interior finish coats. Because lime putty is the most plastic and workable of the cementitious materials used in plaster, it is often added to other less workable plaster materials to improve plasticity. For lime plaster, lime (in the form of either dry hydrate or lime putty) is mixed with sand, water, and a gauging material. The gauging material is intended to produce early strength and to counteract shrinkage tendencies. It can be either gypsum gauging plaster or Keene’s cement for interior work or portland cement for exterior work. When using gauging plaster or Keene’s cement, mix only the amount you can apply within the initial set time of the material.

PORTLAND CEMENT PLASTER

Portland cement plaster is similar to the Portland cement mortar used in masonry. Although it may contain only cement, sand, and water, lime or some other plastering material is usually added for “butteriness.”

Portland cement plaster can be applied directly to exterior and interior masonry walls and over metal lath. Never apply portland cement plaster over gypsum plasterboard or over gypsum tile. Portland cement plaster is recommended for use in plastering walls and ceilings of large walk-in refrigerators and cold-storage spaces, basements, toilets, showers, and similar areas where an extra hard or highly water-resistant surface is required.

AGGREGATES

As we mentioned earlier, there are three main aggregates used in plaster: sand, vermiculite, and perlite. Less frequently used aggregates are wood fiber and pumice.

Sand

Sand for plaster, like sand for concrete, must contain no more than specified amounts of organic impurities and harmful chemicals. Tests for these impurities and chemicals are conducted by Engineering Aids.

Proper aggregate gradation influences plaster strength and workability. It also has an effect on the tendency of the material to shrink or expand while setting. Plaster strength is reduced if excessive fine aggregate material is present in a mix. The greater quantity of mixing water required raises the water-cement ratio, thereby reducing the dry-set

density. The cementitious material becomes over-extended since it must coat a relatively larger overall aggregate surface. An excess of coarse aggregate adversely affects workability-the mix becomes harsh working and difficult to apply.

Plaster shrinkage during drying can be caused by an excess of either fine or coarse aggregate. You can minimize this problem by properly proportioning the raw material, and using good, sharp, properly size-graded sand.

Generally, any sand retained on a No. 4 sieve is too coarse to use in plaster. Only a small percentage of the material (about 5 percent) should pass the No. 200 sieve.

Vermiculite

Vermiculite is a micaceous mineral (that is, each particle is laminated or made up of adjoining layers). When vermiculite particles are exposed to intense heat, steam forms between the layers, forcing them apart. Each particle increases from 6 to 20 times in volume. The expanded material is soft and pliable with a color varying between silver and gold.

For ordinary plasterwork vermiculite is used only with gypsum plaster; therefore, its use is generally restricted to interior applications. For acoustical plaster, vermiculite is combined with a special acoustical binder.

The approximate dry weight of a cubic foot of 1:2 gypsum-vermiculite plaster is 50 to 55 pounds. The dry weight of a cubic foot of comparable sand plaster is 104 to 120 pounds.

Perlite

Raw perlite is a volcanic glass that, when flash-roasted, expands to form irregularly shaped frothy particles containing innumerable minute air cells. The mass is 4 to 20 times the volume of the raw particles. The color of expanded perlite ranges from pearly white to grayish white.

Perlite is used with calcined gypsum or portland cement for interior plastering. It is also used with special binders for acoustical plaster. The approximate dry weight of a cubic foot of 1:2 gypsum-perlite plaster is 50 to 55 pounds, or about half the weight of a cubic foot of sand plaster.

Wood Fiber and Pumice

Although sand, vermiculite, and perlite makeup the great majority of plaster aggregate, other materials, such

as wood fiber and pumice, are also used. Wood fiber may be added to neat gypsum plaster, at the time of manufacture, to improve its working qualities. Pumice is a naturally formed volcanic glass similar to perlite, but heavier (28 to 32 pounds per cubic foot versus 7.5 to 15 pounds for perlite). The weight differential gives perlite an economic advantage and limits the use of pumice to localities near where it is produced.

WATER

In plaster, mixing water performs two functions. First, it transforms the dry ingredients into a plastic, workable mass. Second, it combines with the binder to induce hardening. As with concrete, there is a maximum quantity of water per unit of binder required for complete hydration; an excess over this amount reduces the plaster strength.

In all plaster mixing, though, more water is added than is necessary for complete hydration of the binder. The excess is necessary to bring the mix to workable consistency. The amount to be added for workability depends on several factors: the characteristics and age of the binder, application method, drying conditions, and the tendency of the base to absorb water. A porous masonry base, for example, draws a good deal of water out of a plaster mix. If this reduces the water content of the mix below the maximum required for hydration, incomplete curing will result.

As a general rule, only the amount of water required to attain workability is added to a mix. The water should be potable and contain no dissolved chemicals that might accelerate or retard the set. **Never use water previously used to wash plastering tools for mixing plaster.** It may contain particles of set plaster that may accelerate setting. Also avoid stagnant water; it may contain organic material that can retard setting and possibly cause staining.

PLASTER BASE INSTALLATION

LEARNING OBJECTIVE: Upon completing this section, you should be able to associate the names and purposes of each type of lath used as a plaster base. You should also be able to describe the procedures used in plastering, including estimating materials and the procedures for mixing and applying plaster bases.

For plastering, there must be a continuous surface to which the plaster can be applied and to which it will

cling—the plaster base. A continuous concrete or masonry surface may serve as a base without further treatment.

BASES

For plaster bases, such as those defined by the inner edges of the studs or the lower edges of the joists, a base material, called lath, must be installed to form a continuous surface spanning the spaces between the structural members.

Wood Lath

Wood lath is made of white pine, spruce, fir, redwood, and other soft, straight-grained woods. The standard size of wood lath is 5/16 inch by 1 1/2 inches by 4 feet. Each lath is nailed to the studs or joists with 3-penny (3d) blued lathing nails.

Laths are nailed six in a row, one above the other. The next six rows of lath are set over two stud places. The joints of the lath are staggered in this way so cracks will not occur at the joinings. Lath ends should be spaced 1/4 inch apart to allow movement and prevent buckling. Figure 7-1 shows the proper layout of wood lath. To obtain a good key (space for mortar), space the laths not less than 3/8 inch apart. Figure 7-2 shows good spacing with strong keys.

Wood laths come 50 to 100 to the bundle and are sold by the thousand. The wood should be straight-grained, and free of knots and excessive pitch. Don't use old lath; dry or dirty lath offers a poor bonding surface. Lath must be damp when the mortar is applied. Dry lath pulls the moisture out of the mortar, preventing proper setting. The best method to prevent dry lath is to wet it thoroughly the day before plastering. This lets the wood swell and reach a stable condition ideal for plaster application.

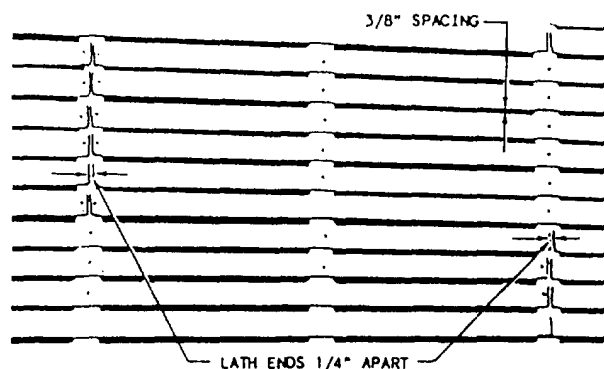


Figure 7-1.—Wood lath with joints staggered every sixth course.

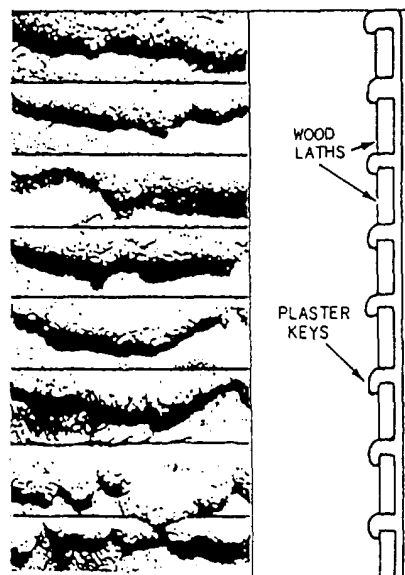


Figure 7-2.—Wood lath, showing proper keys.

Board Lath

Of the many kinds of lathing materials available, board lath is the most widely used today. Board lath is manufactured from mineral and vegetable products. It is produced in board form, and in sizes generally standardized for each application to studs, joists, and various types of wood and metal timing.

Board lath has a number of advantages. It is rigid, strong, stable, and reduces the possibility of dirt filtering through the mortar to stain the surface. It is insulating and strengthens the framework structure. Gypsum board lath is fire resistant. Board lath also requires the least amount of mortar to cover the surface.

Board laths are divided into two main groups: gypsum board and insulation board. Gypsum lath is made in a number of sizes, thicknesses, and types. Each type is used for a specific purpose or condition. Note: Only gypsum mortar can be used over gypsum lath. Never apply lime mortar, portland cement, or any other binding agent to gypsum lath.

The most commonly used size gypsum board lath is the 3/8 inch by 16 inches by 48 inches, either solid or perforated. This lath will not burn or transmit temperatures much in excess of 212°F until the gypsum is completely calcined. The strength of the bond of plaster to gypsum lath is great. It requires a pull of 864 pounds per square foot to separate gypsum plaster from gypsum lath (based on a 2:1 mix of sand and plaster mortar).

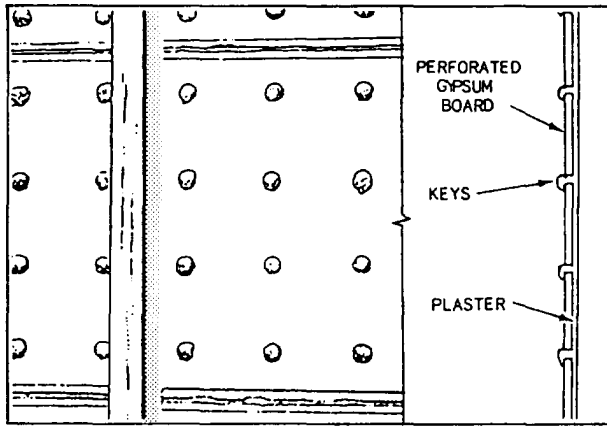


Figure 7-3.—Keys formed with perforated gypsum board.

There is also a special fire-retardant gypsum lath, called type X. It has a specially formulated core, containing minerals giving it additional fire protection.

Use only one manufacturer's materials for a specified job or area. This ensures compatibility. Always strictly follow the manufacturer's specifications for materials and conditions of application.

Plain gypsum lath plaster base is used in several situations: for applying nails and staples to wood and nailable steel framing; for attaching clips to wood framing, steel studs, and suspended metal grillage; and for attaching screws to metal studs and furring channels. Common sizes include 16 by 48 inches, 3/8 or 1/2 inch thick, and 16 by 96 inches, 3/8 inch thick.

Perforated gypsum lath plaster base is the same as plain gypsum lath except that 3/4-inch round holes are punched through the lath 4 inches on center (OC) in each direction. This gives one 3/4-inch hole for each 16 square inches of lath area. This provides mechanical keys in addition to the natural plaster bond and obtains higher fire ratings. Figure 7-3 shows back and side views of a completed application.

Insulating gypsum lath plaster base is the same as plain gypsum lath, but with bright aluminum foil laminated to the back. This creates an effective vapor barrier at no additional labor cost. In addition, it provides positive insulation when installed with the foil facing a 3/4-inch minimum air space. When insulating gypsum lath plaster is used as a ceiling, and under winter heating conditions, its heat-resistance value is approximately the same as that for 1/2-inch insulation board.

Long lengths of gypsum lath are primarily used for furring the interior side of exterior masonry walls. It is available in sizes 24 inches wide, 3/8 inch thick, and up to 12 feet in length.

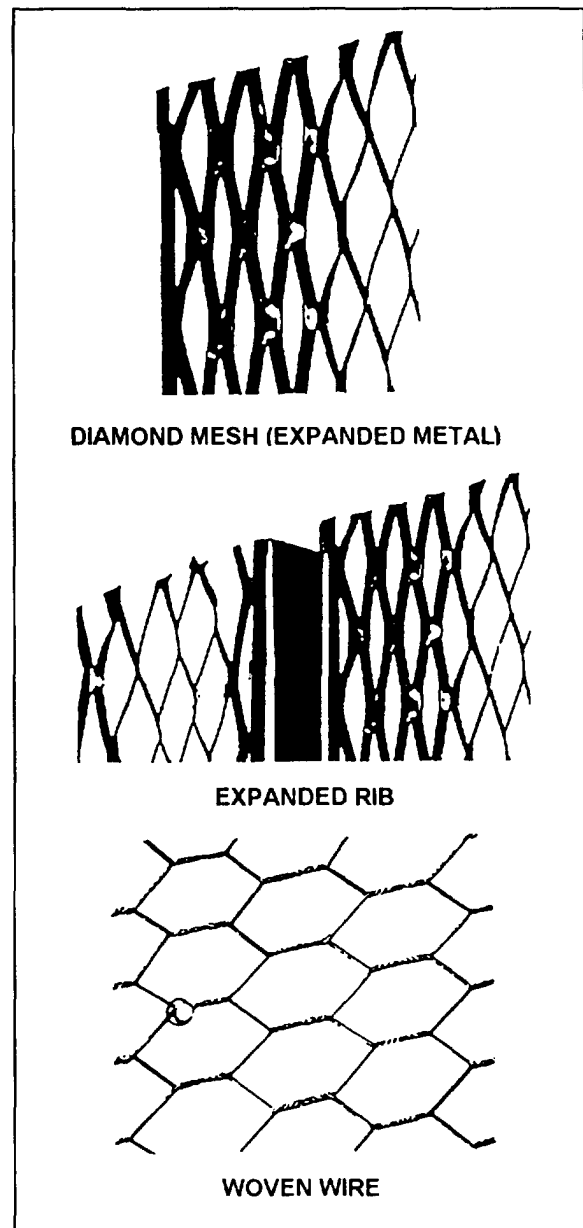


Figure 7-4.—Types of metal lath.

Gypsum lath is easily cut by scoring one or both sides with a utility knife. Break the lath along the scored line. Be sure to make neatly fitted cutouts for utility openings, such as plumbing pipes and electrical outlets.

Metal Lath

Metal lath is perhaps the most versatile of all plaster bases. Essentially a metal screen, the bond is created by keys formed by plaster forced through the openings. As the plaster hardens, it becomes rigidly interlocked with the metal lath.

Three types of metal lath are commonly used: diamond mesh (expanded metal), expanded rib, and wire mesh (woven wire). These are shown in figure 7-4.

DIAMOND MESH.— The terms “diamond mesh” and “expanded metal” refer to the same type of lath (fig. 7-4). It is manufactured by first cutting staggered slits in a sheet and then expanding or stretching the sheet to form the screen openings. The standard diamond mesh lath has a mesh size of 5/16 by 9/16 inch. Lath is made in sheets of 27 by 96 inches and is packed 10 sheets to a bundle (20 square yards).

Diamond mesh lath is also made in a large mesh. This is used for stucco work, concrete reinforcement, and support for rock wool and similar insulating materials. Sheet sizes are the same as for the small mesh. The small diamond mesh lath is also made into a self-furring lath by forming dimples into the surface that hold the lath approximately 1/4 inch away from the wall surface. This lath may be nailed to smooth concrete or masonry surfaces. It is widely used when replastering old walls and ceilings when the removal of the old plaster is not desired. Another lath form is paper-backed where the lath has a waterproof or kraft paper glued to the back of the sheet. The paper acts as a moisture barrier and plaster saver.

EXPANDED RIB.— Expanded rib lath (fig. 7-4) is like diamond mesh lath except that various size ribs are formed in the lath to stiffen it. Ribs run lengthwise of the lath and are made for plastering use in 1/8-, 3/8-, and 3/4-inch rib height. The sheet sizes are 27 to 96 inches in width, and 5-, 10-, and 12-foot lengths for the 3/4-inch rib lath.

WIRE MESH.— Woven wire lath (fig. 7-4) is made of galvanized wire of various gauges woven or twisted together to form either squares or hexagons. It is commonly used as a stucco mesh where it is placed over tar paper on open-stud construction or over various sheathing.

INSTALLATION

Let's now look at the basic installation procedures for plaster bases and accessories.

Gypsum Lath

Gypsum lath is applied horizontally with staggered end joints, as shown in figure 7-5. Vertical end joints should be made over the center of studs or joists. Lath joints over openings should not occur at the jamb line. Do not force the boards tightly together; let them butt loosely so the board is not under compression before the plaster is applied. Use small pieces only where necessary. The most common method of attaching the boards has been the lath nail. More recently, though,

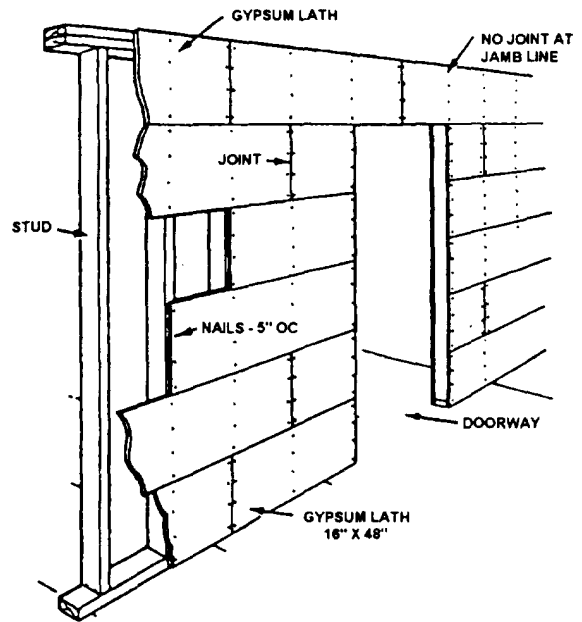


Figure 7-5.-Lath joints.

staples have gained wider use (due mainly to the ready availability of power guns).

The nails used are 1 1/8 inches by 13 gauge, flat headed, blued gypsum lath nails for 3/8-inch-thick boards and 1 1/4 inches for 1/2-inch boards. There are also resin-coated nails, barbed-shaft nails, and screw-type nails in use. Staples should be No. 16 U.S. gauge flattened galvanized wire formed with a 7/16-inch-wide crown and 7/8-inch legs with divergent points for 3/8-inch lath. For 1/2-inch lath, use 1-inch-long staples.

Four nails or staples are used on each support for 16-inch-wide lath and five for 2-foot-wide lath. Some special fire ratings, however, require five nails or staples per 16-inch board. Five nails or staples are also recommended when the framing members are spaced 24 inches apart.

Start nailing or stapling 1/2 inch from the edges of the board. Nail on the framing members falling on the center of the board first, then work to either end. This should prevent buckling.

Insulating lath should be installed much the same as gypsum lath except that slightly longer blued nails are used. A special waterproof facing is provided on one type of gypsum board for use as a ceramic tile base when the tile is applied with an adhesive.

Metal Lath

All metal lath is installed with the sides and ends lapped over each other. The laps between supports should be securely tied, using 18-gauge tie wire. In general, metal lath is applied with the long length at right angles to the supports. Rib lath is placed with the ribs against the supports and the ribs nested where the lath overlaps. Generally, metal lath and wire lath are lapped at least 1 inch at the ends and 1/2 inch at the sides. Some wire lath manufacturers specify up to 4 1/2-inch end lapping and 2-inch side laps. This is done to mesh the wires and the paper backing.

Lath is either nailed, stapled, or hog-tied (heavy wire ring installed with a special gun) to the supports at 6-inch intervals. Use 1 1/2-inch barbed roofing nails with 7/16-inch heads or 1 inch 4-gauge staples for the flat lath on wood supports. For ribbed lath, heavy wire lath, and sheet lath, nails or staples must penetrate the wood 1 3/8 inches for horizontal application and at least 3/4 inch for vertical application. When common nails are used, they must be bent across at least three lath strands.

On channel iron supports, the lath is tied with No. 18-gauge tie wire at 4-inch intervals using lathers' nippers. For wire lath, the hog tie gun can be used. Lath must be stretched tight as it is applied so that no sags or buckles occur. Start tying or nailing at the center of the sheet and work toward the ends. Rib lath should have ties looped around each rib at all supports, as the main supporting power for rib lath is the rib.

When you install metal laths at both inside and outside corners, bend the lath to form a corner and carry it at least 4 inches in or around the corner. This provides the proper reinforcement for the angle or corner.

Lath Accessories

A wide variety of metal accessories is produced for use with gypsum and metal lathing. Lathing accessories are usually installed before plastering to form true corners, act as screeds for the plasterer, reinforce possible weak points, provide control joints, and provide structural support.

Lathing accessories consist of structural components and miscellaneous accessories. The principal use of structural components is in the construction of hollow partitions. A hollow partition is one containing no building framing members, such as studs and plates. Structural components are lathing accessories that take the place of the missing framing members supporting

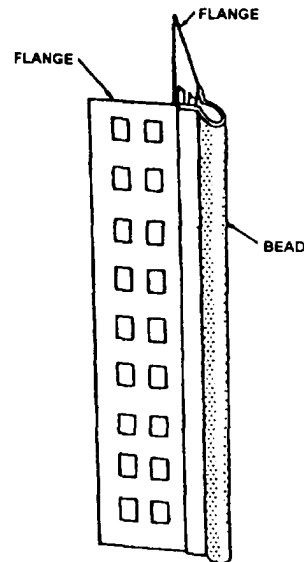


Figure 7-6.—Perforated flanged corner bead.

the lath. These include prefabricated metal studs and floor and ceiling runner tracks. The runner tracks take the place of missing stud top and bottom plates. They usually consist of metal channels. Channels are also used for furring and bracing.

Miscellaneous accessories consist of components attached to the lath at various locations. They serve to define and reinforce corners, provide dividing strips between plaster and the edges of baseboard or other trim, and define plaster edges at unframed openings.

Corner beads fit over gypsum lath outside corners to provide a true, reinforced corner. They are available in either small-nose or bullnose types, with flanges of either solid or perforated (fig. 7-6) metal. They are available with expanded metal flanges.

Casing beads are similar to corner beads and are used both as finish casings around openings in plaster walls and as screeds to obtain true surfaces around doors and windows. They are also used as stops between a plaster surface and another material, such as masonry or wood paneling. Casing beads are available as square sections, modified-square sections, and quarter-rounds.

Base or parting screeds are used to separate plaster from other flush surfaces, such as concrete. Ventilating expansion screed is used on the underside of closed soffits and in protected vertical surfaces for ventilation of enclosed attic spaces. Drip screeds act as terminators of exterior portland cement plaster at concrete foundation walls. They are also used on external horizontal corners of plaster soffits to prevent drip stains

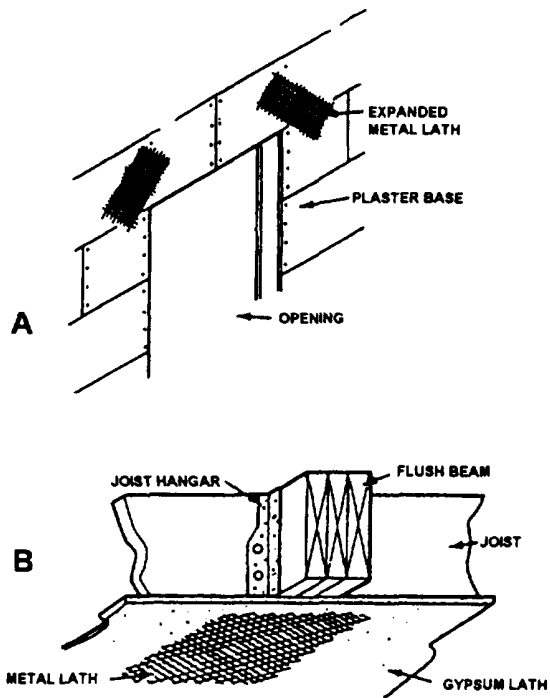


Figure 7-7.-Metal lath used to minimize cracking.

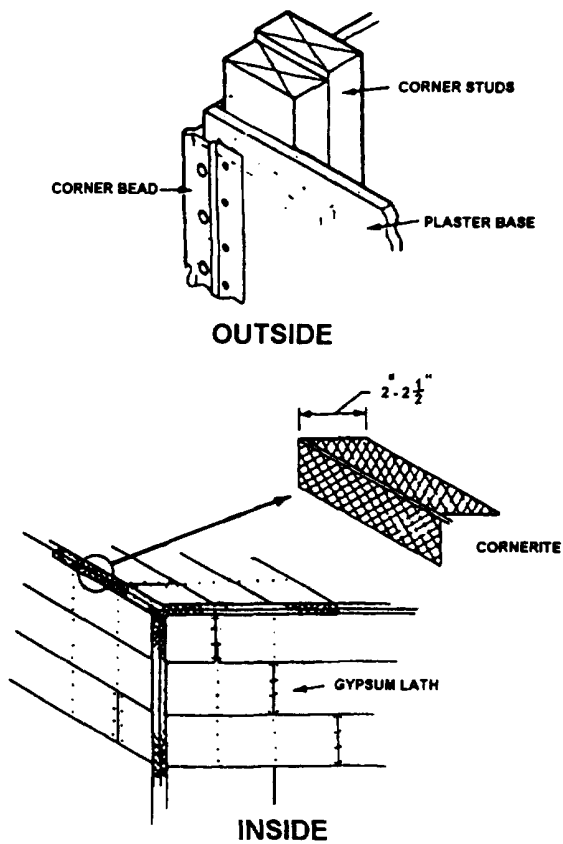


Figure 7-8.-Plaster reinforcing at corners.

on the underside of the soffit. A metal base acts as a flush base at the bottom of a plaster wall. It also serves as a plaster screed.

Joint Reinforcing

Because some drying usually takes place in the wood framing members after a structure is completed, some shrinkage is expected. This, in turn, may cause plaster cracks to develop around openings and in the comers. To minimize, if not eliminate, these cracks, use expanded metal lath in key positions over the plaster-base material as reinforcements. Strip reinforcement (strips of expanded metal lath) can be used over door and window openings (fig. 7-7, view A). A 10- to 20-inch strip is placed diagonally across each upper corner of the opening and tacked in place.

Strip reinforcement should also be used under flush ceiling beams (fig. 7-7, view B) to prevent plaster cracks. On wood drop beams extending below the ceiling line, the metal lath is applied with furring nails to provide space for keying the plaster.

Corner beads of expanded metal lath or of perforated metal (fig. 7-8) should be installed on all outside comers. They should be applied plumb and level. Each bead acts as a leveling edge when walls are plastered and reinforces the corner against mechanical damage. To minimize plaster cracks, reinforce the inside comers at the juncture of walls and ceilings. Metal lath, or wire fabric, is tacked lightly in place in these corners.

Control joints (an example of which is shown in fig. 7-9) are formed metal strips used to relieve stresses and strains in large plaster areas or at junctures of dissimilar materials on walls and ceilings. Cracks can develop in plaster or stucco from a single cause or a combination of causes, such as foundation settlement, material shrinkage, building movement, and so forth. The control joint minimizes plaster cracking and assures proper plaster thickness. The use of control joints is extremely important when Portland cement plaster is used.

Plastering Grounds

Plastering grounds are strips of wood used as plastering guides or strike-off edges and are located around window and door openings and at the base of the walls. Grounds around interior door openings (such as fig. 7-10, view A) are full-width pieces nailed to the sides over the studs and to the underside of the header. They are 5 1/4 inches wide, which coincides with the standard jamb width for interior walls with a plaster

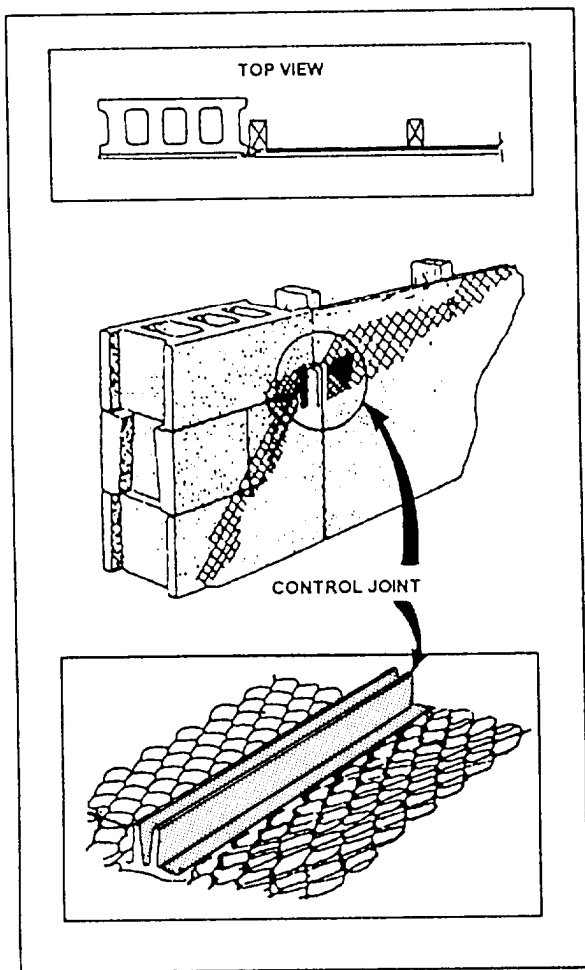


Figure 7-9.-Control joint.

finish. They are removed after the plaster has dried. Narrow strip grounds (fig. 7-10, view B) can also be used around interior openings.

In window and exterior door openings, the frames are normally in place before the plaster is applied. Thus, the inside edges of the side and head jamb can, and often do, serve as grounds. The edge of the window might also be used as a ground, or you can use a narrow 7/8-inch-thick ground strip nailed to the edge of the 2-by 4-inch sill (fig. 7-10, view C). These are normally left in place and covered by the casing.

A similar narrow ground or screed is used at the bottom of the wall to control the thickness of the gypsum plaster and to provide an even surface for the baseboard and molding. This screed is also left in place after the plaster has been applied.

Mixing

Some plaster comes ready-mixed, requiring only the addition of enough water to attain minimum required

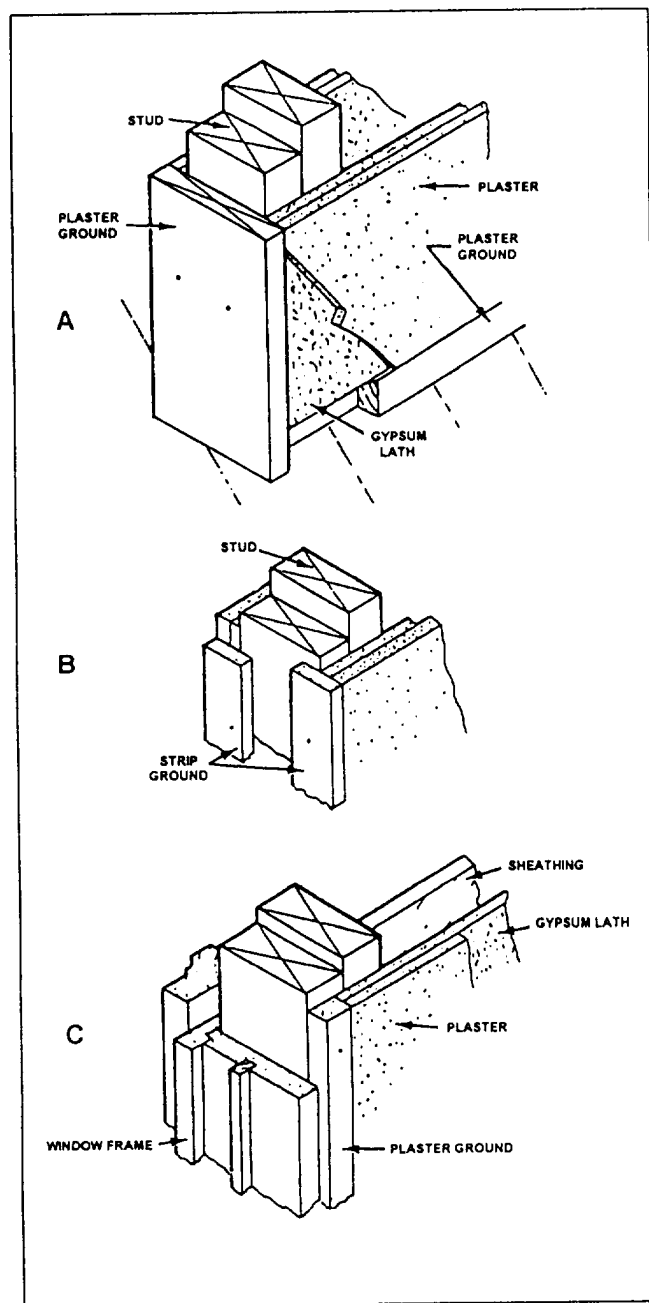


Figure 7-10.—Plaster grounds.

workability. For job mixing, tables are available giving recommended ingredient proportions for gypsum, lime, lime-portland cement, and portland cement plaster for base coats on lath or on various types of concrete or masonry surfaces, and for finish coats of various types. In this chapter, we'll cover recommended proportions for only the more common types of plastering situations.

In the following discussion, one part of cementitious material means 100 pounds (one sack) of gypsum, 100 pounds (two sacks) of hydrated lime, 1 cubic foot

Table 7-1.—Base Coat Proportions for Different Types of Work

INGREDIENT	PROPORTION
Two-Coat Masonry Work¹	
Gypsum plaster	1:3
Lime plaster using hydrated lime	1:7.5
Lime plaster using lime putty	1:3.5
Three-Coat Work on a Masonry Base²	
Gypsum plaster	Both coats 1:3
Portland cement plaster	Both coats 1:3 to 1:5
Work on a Metal Lath	
Gypsum plaster	Same as for three-coat work on gypsum lath
Lime plaster using hydrated lime	Scratch 1:6.75, brown 1:9
Lime plaster using lime putty	Scratch 1:3, brown 1:4
Portland cement plaster	Both coats 1:3 to 1:5
¹ Portland cement plaster is not used for two-coat work, and two-coat work is not usually done on metal lath	
² Lime plaster is not usually used for three-coat work on a masonry base	

of lime putty, or 94 pounds (one sack) of portland cement. One part of aggregate means 100 pounds of sand or 1 cubic foot of vermiculite or perlite. Note: Vermiculite and perlite are not used with lime plaster. While aggregate parts given for gypsum or portland cement plaster may be presumed to refer to either sand or vermiculite/perlite, the aggregate part given for lime plaster means sand only.

BASE COAT PROPORTIONS.— Two-coat plasterwork consists of a single base coat and a finish coat. Three-coat plasterwork consists of two base coats (the scratch coat and the brown coat) and a finish coat.

Portland cement plaster cannot be applied to a gypsum base. Lime plaster can, but, in practice, only gypsum plaster is applied to gypsum lath as a base coat. For two-coat work on gypsum lath, the recommended base coat proportions for gypsum plaster are 1:2.5. For two-coat work on a masonry (either monolithic concrete or masonry) base, the recommended base coat proportions are shown in table 7-1. Also shown in table 7-1 are proportions for three-coat work on a masonry base and proportions for work on metal lath.

For three-coat work on gypsum lath, the recommended base coat proportions for gypsum plaster are shown in table 7-2.

FINISH COAT PROPORTIONS.— A lime finish can be applied over a lime, gypsum, or portland cement base coat. Other finishes should be applied only to base coats containing the same cementitious material. A gypsum-vermiculite finish should be applied only to a gypsum-vermiculite base coat.

Finish coat proportions vary according to whether the surface is to be finished with a trowel or with a float. (These tools are described later.) The trowel attains a smooth finish; the float produces a textured finish.

For a trowel-finish coat using gypsum plaster, the recommended proportions are 200 pounds of hydrated lime or 5 cubic feet of lime putty to 100 pounds of gypsum gauging plaster.

Table 7-2.—Recommended Base Coat Proportions for Gypsum Plaster

COAT	PROPORTION
Scratch coat	1:2
Brown coat	1:3
Both coats	1:2.5

For a trowel-finish coat using lime-Keene's cement plaster, the recommended proportions are, for a medium-hard finish, 50 pounds of hydrated lime or 100 pounds of lime putty to 100 pounds of Keene's cement. For a hard finish, the recommended proportions are 25 pounds of hydrated lime or 50 pounds of lime putty to 100 pounds of Keene's cement.

For a trowel-finish coat using lime-portland cement plaster, the recommended proportions are 200 pounds of hydrated lime or 5 cubic feet of lime putty to 94 pounds of Portland cement.

For a finish coat using portland cement-sand plaster, the recommended proportions are 300 pounds of sand to 94 pounds of Portland cement. This plaster may be either troweled or floated. Hydrated lime up to 10 percent by weight of the portland cement, or lime putty up to 24 percent of the volume of the portland cement, may be added as a plasticizer.

For a trowel-finish coat using gypsum gauging or gypsum neat plaster and vermiculite aggregate, the recommended proportions are 1 cubic foot of vermiculite to 100 pounds of plaster.

Estimates

The total volume of plaster required for a job is the product of the thickness of the plaster times the net area to be covered. Plaster specifications state a minimum thickness, which you must not go under. Also, you should exceed the specs as little as possible due to the increased tendency of plaster to crack with increased thickness.

Mixing Plaster

The two basic operations in mixing plaster are determining the correct proportions and the actual mixing methods used.

PROPORTIONS.—The proper proportions of the raw ingredients required for any plastering job are found in the job specifications. The specs also list the types of materials to use and the type of finish required for each area. Hardness and durability of the plaster surface depend upon how accurately you follow the correct proportions. Too much water gives you a fluid plaster that is hard to apply. It also causes small holes to develop in the finish mortar coat. Too much aggregate in the mix, without sufficient binder to unite the mixture, causes aggregate particles to crumble off. **Without exception, consult the specifications prior to the commencement of any plaster job.**

MIXING METHODS.—As a Builder, you will be mixing plaster either by hand or using a machine.

Hand Mixing.—To hand-mix plaster, you will need a flat, shallow mixing box and a hoe. The hoe usually has one or more holes in the blade. Mixed plaster is transferred from the mixing box to a mortar board, similar to that used in bricklaying. Personnel applying the plaster pick it up from the mortarboard.

In hand mixing, first place the dry ingredients in a mixing box and thoroughly mix until a uniform color is obtained. After thoroughly blending the dry ingredients, you then cone the pile and add water to the mix. Begin mixing by pulling the dry material into the water with short strokes. Mixing is continued until the materials have been thoroughly blended and proper consistency has been attained. With experience, a person acquires a feel for proper consistency. Mixing should not be continued for more than 10 to 15 minutes after the materials have been thoroughly blended. Excessive agitation may hasten the rate of solution of the cementitious material and reduce initial set time.

Finish-coat lime plaster is usually hand-mixed on a 5- by 5-foot mortar board called a finishing board. Hydrated lime is first converted to lime putty by soaking in an equal amount of water for 16 hours. In mixing the plaster, you first form the lime putty into a ring on the finishing board. Next, pour water into the ring and sift the gypsum or Keene's cement into the water to avoid lumping. Last, allow the mix to stand for 1 minute, then thoroughly blend the materials. Sand, if used, is then added and mixed in.

Machine Mixing.—For a quicker, more thorough mix, use a plaster mixing machine. A typical plaster mixing machine (shown in fig. 7-11) consists primarily of a metal drum containing mixing blades, mounted on

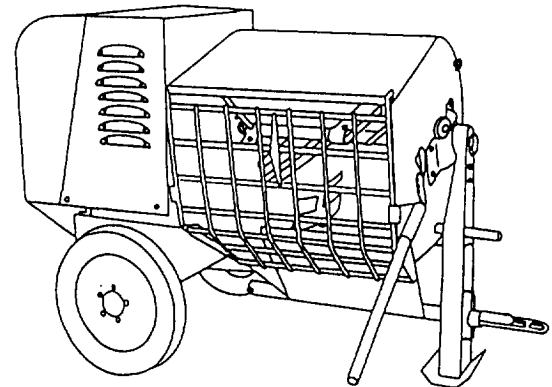


Figure 7-11.—Plaster mixing machine.

a chassis equipped with wheels for road towing. Sizes range from 3 1/2 to 10 cubic feet and can be powered by an electric or a gasoline motor. Mixing takes place either by rotation of the drum or by rotation of the blades inside the drum. Tilt the drum to discharge plaster into a wheelbarrow or other receptacle.

When using a plaster mixer, add the water first, then add about half the sand. Next, add the cement and any admixture desired. Last, add the rest of the sand. Mix until the batch is uniform and has the proper consistency—3 to 4 minutes is usually sufficient. Note that excessive agitation of mortar speeds up the setting time. Most mixers operate at top capacity when the mortar is about 2 inches, at most, above the blades. When the mixer is charged higher than this, proper mixing fails to take place. Instead of blending the materials, the mixer simply folds the material over and over, resulting in excessively dry mix on top and too wet mix underneath—a bad mix. Eliminate this situation by not overloading the machine.

Handling Materials

Personnel handling cement or lime bags should wear recommended personnel protective gear. Always practice personal cleanliness. Never wear clothing that is hard and stiff with cement. Such clothing irritates the skin and may cause serious infection. Any susceptibility of skin to cement and lime burns should be immediately reported to your supervisor.

Don't pile bags of cement or lime more than 10 bags high on a pallet except when stored in bins or enclosures built for such purposes. Place the bags around the outside of the pallet with the tops of the bags facing the center. To prevent piled bags from falling outward, crosspile the first five tiers of bags, each way from any corner, and make a setback starting with the sixth tier. If you have to pile above the 10th tier, make another setback. The back tier, when not resting against a wall of sufficient strength to withstand the pressure, should be set back one bag every five tiers, the same as the end tiers.

During unpling, the entire top of the pile should be kept level and the setbacks maintained for every five tiers.

Lime and cement must be stored in a dry place to help prevent the lime from crumbling and the cement from hydrating before it is used.

PLASTER APPLICATION TOOLS AND TECHNIQUES

LEARNING OBJECTIVE: Upon completing this section, you should be able to state the uses of plastering tools, and describe the techniques of plastering.

A plaster layer must have uniform thickness to attain complete structural integrity. Also, a plane plaster surface must be flat enough to appear flat to the eye and receive surface-applied materials, such as casings and other trim, without the appearance of noticeable spaces. Specified flatness tolerance is usually 1/8 inch in 10 feet.

TOOLS

Plastering requires the use of a number of tools, some specialized, including trowels, hawk, float, straight and feather edges, darby, scarifier, and plastering machines.

Trowels

Steel trowels are used to apply, spread, and smooth plaster. The shape and size of the trowel blade are determined by the purpose for which the tool is used and the manner of using it.

The four common types of plastering trowels are shown in figure 7-12. The rectangular trowel, with a blade approximately 4 1/2 inches wide by 11 inches long, serves as the principle conveyor and manipulator

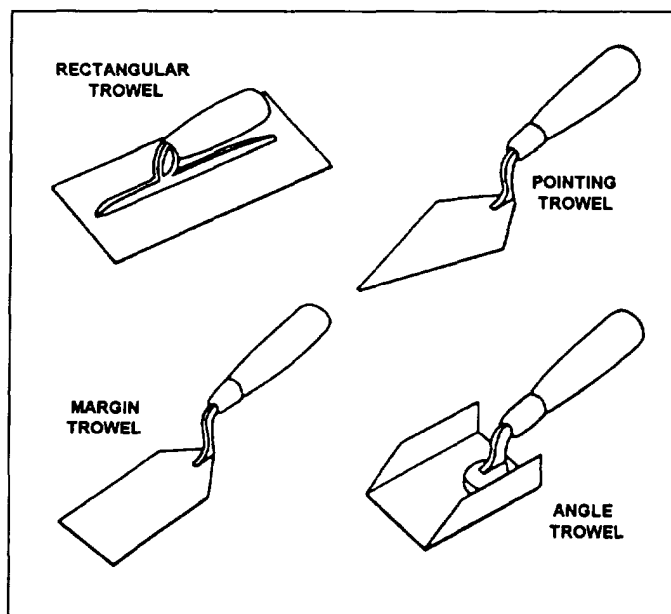


Figure 7-12.—Plastering trowels.

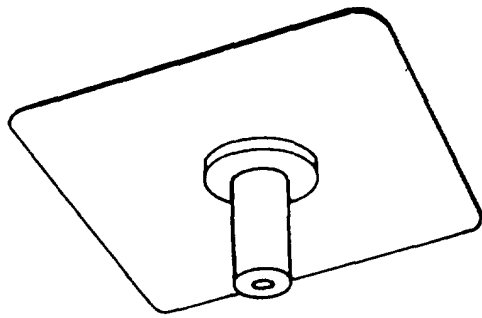


Figure 7-13.—Plastering hawk.

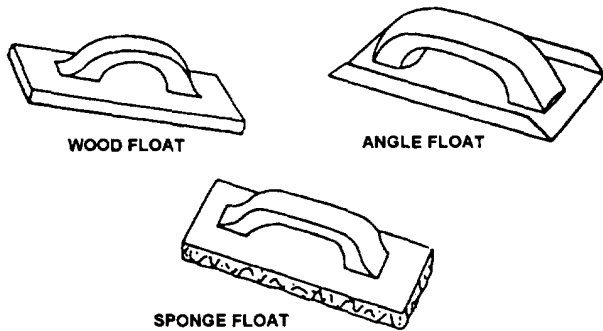


Figure 7-14.—Plastering floats.

of plaster. The pointing trowel, 2 inches wide and about 10 inches long, is used in places where the rectangular trowel doesn't fit. The margin trowel is a smaller trowel, similar to the pointing trowel, but with a square, rather than a pointed, end. The angle trowel is used for finishing corner angles formed by adjoining right-angle plaster surfaces.

Hawk

The hawk (fig. 7-13) is a square, lightweight sheet-metal platform with a vertical central handle, used for carrying mortar from the mortar board to the place where it is to be applied. The plaster is then removed from the hawk with the trowel. The size of a hawk varies from a 10- to a 14-inch square. A hawk can be made in the field from many different available materials.

Float

A float is glided over the surface of the plaster to fill voids and hollows, to level bumps left by previous operations, and to impart a texture to the surface. The most common types of float are shown in figure 7-14. The wood float has a wood blade 4 to 5 inches wide and about 10 inches long. The angle float has a stainless steel

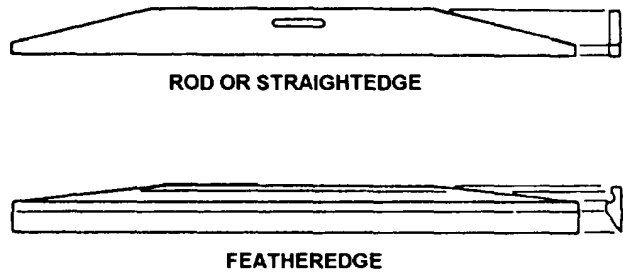


Figure 7-15.—Straightedge and featheredge.

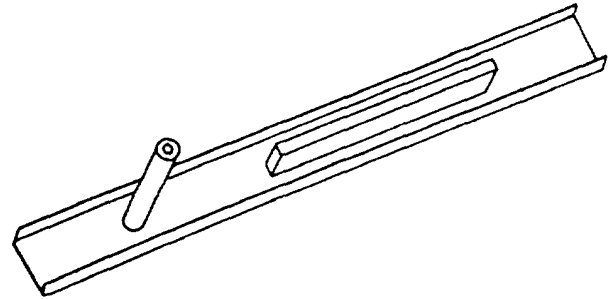


Figure 7-16.—Darby.

or aluminum blade. The sponge float is faced with foam rubber or plastic, intended to attain a certain surface texture.

In addition to the floats just mentioned, other floats are also used in plasterwork. A carpet float is similar to a sponge float, but faced with a layer of carpet material. A cork float is faced with cork.

Straight and Feather Edges

The rod or straightedge consists of a wood or lightweight metal blade 6 inches wide and 4 to 8 feet long (see fig. 7-15). This is the first tool used in leveling and straightening applied plaster between the grounds. A wood rod has a slot for a handle cut near the center of the blade. A metal rod usually has a shaped handle running the length of the blade.

The featheredge (fig. 7-15) is similar to the rod except that the blade tapers to a sharp edge. It is used to cut in inside corners and to shape sharp, straight lines at outside corners where walls intersect.

Darby

The darby (fig. 7-16) is, in effect, a float with an extra long (3 1/2 to 4 foot) blade, equipped with handles for two-handed manipulation. It is used for further straightening of the base coat, after rodding is

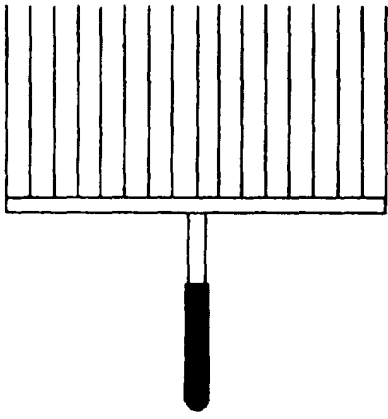


Figure 7-17.-Scarifier.

completed, to level plaster screeds and to level finish coats. The blade of the darby is held nearly flat against the plaster surface, and in such a way that the line of the edge makes an angle 45° with the line of direction of the stroke.

When a plaster surface is being leveled, the leveling tool must move over the plaster smoothly. If the surface is too dry, lubrication must be provided by moistening. In base coat operations, dash or brush on water with a water-carrying brush called a browning brush. This is a fine-bristled brush about 4 to 5 inches wide and 2 inches thick, with bristles about 6 inches long. For finish coat operations, a finishing brush with softer, more pliable bristles is used.

Scarifier

The scarifier (fig. 7-17) is a raking tool that leaves furrows approximately $1/8$ inch deep, $1/8$ inch wide, and $1/2$ inch to $3/4$ inch apart. The furrows are intended to improve the bond between the scratch coat and the brown coat.

Plastering Machines

There are two types of plastering machines: wet mix and dry mix. The wet-mix pump type carries mixed plaster from the mixing machine to a hose nozzle. The dry-mix machine carries dry ingredients to a mixing nozzle where water under pressure combines with the mix and provides spraying force. Most plastering machines are of the wet-mix pump variety.

A wet-mix pump may be of the worm-drive, piston-pump, or hand-hopper type. In a worm-drive machine, mixed plaster is fed into a hopper and forced through the hose to the nozzle by the screw action of a

rotor and stator assembly in the neck of the machine. A machine of this type has a hopper capacity of from 3 to 5 cubic feet and can deliver from 0.5 to 2 cubic feet of plaster per minute. On a piston-pump machine, a hydraulic, air-operated, or mechanically operated piston supplies the force for moving the wet plaster. On a hand-hopper machine, the dry ingredients are placed in a hand-held hopper just above the nozzle. Hopper capacity is usually around $1/10$ cubic foot. These machines are mainly used for applying finish plaster.

Machine application reduces the use of the hawk and trowel in initial plaster application. However, the use of straightening and finishing hand tools remains about the same for machine-applied plaster.

CREWS

A typical plastering crew for hand application consists of a crew leader, two to four plasterers, and two to four tenders. The plasterers, under the crew leader's supervision, set all levels and lines and apply and finish the plaster. The tenders mix the plaster, deliver it to the plasterers, construct scaffolds, handle materials, and do cleanup tasks.

For a machine application, a typical crew consists of a nozzle operator who applies the material, two or three plasterers leveling and finishing, and two to three tenders.

BASE COAT APPLICATION

Lack of uniformity in the thickness of a plaster coat detracts from the structural performance of the plaster, and the thinner the coat, the smaller the permissible variation from uniformity. Specifications usually require that plaster be finished "true and even, within $1/8$ -inch tolerance in 10 feet, without waves, cracks, or imperfections." The standard of $1/8$ inch appears to be the closest practical tolerance to which a plasterer can work by the methods commonly in use.

The importance of adhering to the recommended minimum thickness for the plaster cannot be overstressed. A plaster wall becomes more rigid as thickness over the minimum recommended increases. As a result, the tendency to crack increases as thickness increases. However, tests have shown that a reduction of thickness from a recommended minimum of $1/2$ inch to $3/8$ inch, with certain plasters, decreases resistance by as much as 60 percent, while reduction to $1/4$ inch decreases it as much as 82 percent.

Gypsum

The sequence of operations in three-coat gypsum plastering is as follows:

1. Install the plaster base.
2. Attach the grounds.
3. Apply the scratch coat approximately 3/16 inch thick.
4. Before the scratch coat sets, rake and cross rake.
5. Allow the scratch coat to set firm and hard.
6. Apply plaster screeds (if required).
7. Apply the brown coat to a depth of the screeds.
8. Using the screeds as guides, straighten the surface with a rod.
9. Fill in any hollows and rod again.
10. Level and compact the surface with a darby; then rake and cross rake to receive the finish coat.
11. Define angles sharply with an angle float and a featheredge. Trim back the plaster around the grounds so the finish coat can be applied flush with the grounds.

Lime

The steps for lime base coat work are similar to those for gypsum work except that, for lime, an additional floating is required the day after the brown coat is applied. This extra floating is required to increase the density of the slab and to fill in any cracks that may have developed because of shrinkage of the plaster. A wood float with one or two nails protruding 1/8 inch from the sole (called a devil's float) is used for this purpose.

Portland Cement

Portland cement plaster is actually cement mortar. It is usually applied in three coats, the steps being the same as those described for gypsum plaster. Minimum recommended thicknesses are usually 3/8 inch for the scratch coat and brown coat, and 1/8 inch for the finish coat.

Portland cement plaster should be moist-cured, similar to concrete. The best procedure is fog-spray curing. The scratch coat and the brown coat should both

be fog-sprayed cured for 48 hours. The finish coat should not be applied for at least 7 days after the brown coat. It too should be spray-cured for 48 hours.

FINISH COAT APPLICATION

Interior plaster can be finished by troweling, floating, or spraying. Troweling makes a smooth finish; floating or spraying makes a finish of a desired surface texture.

Smooth Finish

Finish plaster made of gypsum gauging plaster and lime putty (called white coat or putty coat) is the most widely used material for smooth finish coats. A putty coat is usually applied by a team of two or more persons. The steps are as follows:

1. One person applies plaster at the angles.
2. Another person follows immediately, straightening the angles with a rod or featheredge.
3. The remaining surface is covered with a skim coat of plaster. Pressure on the trowel must be sufficient to force the material into the rough surface of the base coat to ensure a good bond.
4. The surface is immediately doubled back to bring the finish coat to final thickness.
5. All angles are floated, with additional plaster added if required to fill hollows.
6. The remaining surface is floated, and all hollows filled. This operation is called drawing up. The hollows being filled are called cat faces.
7. The surface is allowed to draw for a few minutes. As the plaster begins to set, the surface-water glaze disappears and the surface becomes dull. At this point, troweling should begin. The plasterer holds the water brush in one hand and the trowel in the other, so troweling can be done immediately after water is brushed on.
8. Water is brushed on lightly, and the entire surface is rapidly troweled with enough pressure to compact the finish coat fully. The troweling operation is repeated until the plaster has set.

The sequence of steps for trowel finishes for other types of finish plasters is about the same. Gypsum-finish plaster requires less troweling than white-coat plaster. Regular Keene's cement requires longer troweling, but quick-setting Keene's cement requires less. Preliminary finishing of portland cement-sand is done with a wood

float, after which the steel trowel is used. To avoid excessive drawing of fines to the surface, delay troweling of the portland cement-sand as long as possible. For the same reason, the surface must not be troweled too long.

The steps in float finishing are about the same as those described for trowel finishing except, of course, that the final finish is obtained with the float. A surface is usually floated twice: a rough floating with a wooden float first, then a final floating with a rubber or carpet float. With one hand the plasterer applies with the brush, while moving the float in the other hand in a circular motion immediately behind the brush.

Special Textures

Some special interior-finish textures are obtained by methods other than or in addition to floating. A few of these are listed below.

STIPPLED.— After the finish coat has been applied, additional plaster is daubed over the surface with a stippling brush or roller.

SPONGE.— By pressing a sponge against the surface of the finish coat, you get a very soft, irregular texture.

DASH.— The dash texture is obtained by throwing plaster onto the surface from a brush. It produces a fairly coarse finish that can be modified by brushing the plaster with water before it sets.

TRAVERTINE.— The plaster is jabbed at random with a whisk broom, wire brush, or other tool that will form a dimpled surface. As the plaster begins to set, it is troweled intermittently to form a pattern of rough and smooth areas.

PEGGLE.— A rough finish, called peggle, is obtained by throwing small pebbles or crushed stone against a newly plastered surface. If necessary, a trowel is used to press the stones lightly into the plaster.

STUCCO

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the composition of stucco, and state the procedures for mixing, applying, and curing.

“Stucco” is the term applied to plaster whenever it is applied to the exterior of a building or structure. Stucco can be applied over wood frames or masonry structures. A stucco finish lends warmth and interest to projects.

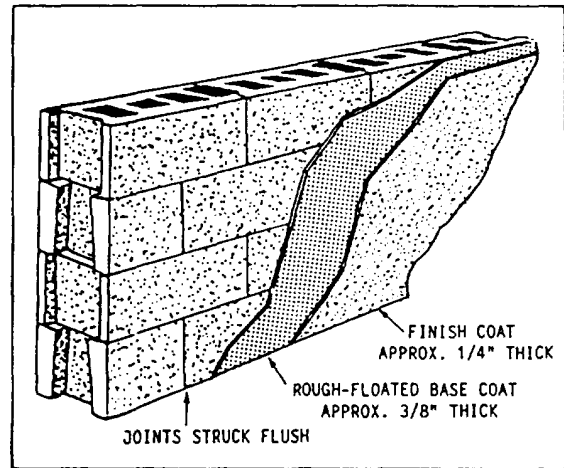


Figure 7-18.—Masonry (two-coat work directly applied).

COMPOSITION

Stucco is a combination of cement or masonry cement, sand and water, and frequently a plasticizing material. Color pigments are often used in the finish coat, which is usually a factory-prepared mix. The end product has all the desirable properties of concrete. Stucco is hard strong, fire resistant, weather resistant, does not deteriorate after repeated wetting and drying, resists rot and fungus, and retains colors.

The material used in a stucco mix should be free of contaminants and unsound particles. Type I normal Portland cement is generally used for stucco, although type II, type III, and air-entraining may be used. The plasticizing material added to the mix is hydrated lime. Mixing water must be potable. The aggregate used in cement stucco can greatly affect the quality and performance of the finished product. It should be well graded, clean, and free from loam, clay, or vegetable matter, which can prevent the cement paste from properly binding the aggregate particles together. Follow the project specifications as to the type of cement, lime, and aggregate to be used.

APPLICATION

Metal reinforcement should be used whenever stucco is applied on wood frame, steel frame, flashing, masonry, or any surface not providing a good bond. Stucco may be applied directly on masonry.

The rough-floated base coat is approximately 3/8 inch thick. The finish coat is approximately 1/4 inch thick. Both are shown in figure 7-18 applied to a masonry surface. On open-frame construction

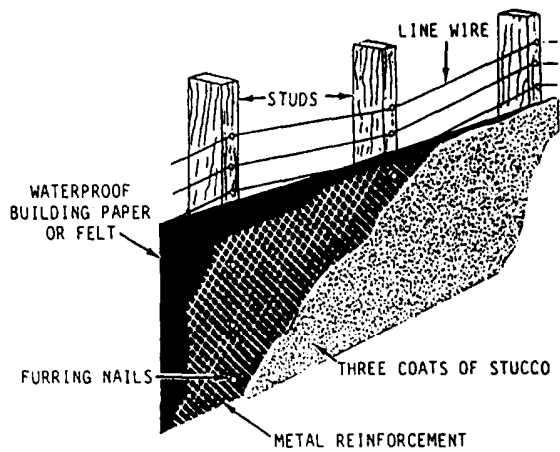


Figure 7-19.-Open-frame construction.

(fig. 7-19), nails are driven one-half their length into the wood. Spacing should be 5 to 6 inches OC from the bottom. Nails should be placed at all corners and openings throughout the entire structure on the exterior.

The next step is to place wire on the nails. This is called installing the line wire. Next, a layer of waterproof paper is applied over the line wire. Laps should be 3 to 4 inches and nailed with roofing nails. Install wire mesh (stucco netting), which is used as the reinforcement for the stucco.

Furring nails (fig. 7-20) are used to hold the wire away from the paper to a thickness of three-eighths of an inch. Stucco or sheathed frame construction is the same as open frame except no line wire is required. The

open and sheathed frame construction requires three coats of 3/8-inch scratch coat horizontally scored or scratched, a 3/8-inch brown coat, and a 1/8-inch finish coat.

Stucco is usually applied in three coats. The first coat is the scratch coat; the second the brown coat; and the final coat the finish coat. On masonry where no reinforcement is used, two coats maybe sufficient. Start at the top and work down the wall. This prevents mortar from falling on the completed work. The first, or scratch, coat should be pushed through the mesh to ensure the metal reinforcement is completely embedded for mechanical bond. The second, or brown, coat should be applied as soon as the scratch coat has setup enough to carry the weight of both coats (usually 4 or 5 hours). The brown coat should be moist-cured for about 48 hours and then allowed to dry for about 5 days. Just before the application of the finish coat, the brown coat should be uniformly dampened. The third, or finish, coat is frequently pigmented to obtain decorative colors. Although the colors may be job-mixed, a factory-prepared mix is recommended. The finish coat maybe applied by hand or machine. Stucco finishes are available in a variety of textures, patterns, and colors.

Surface Preparation

Before the various coats of stucco can be applied, the surfaces have to be prepared. Roughen the surfaces of masonry units enough to provide good mechanical key, and clean off paint, oil, dust, soot, or any other material that may prevent a tight bond. Joints may be

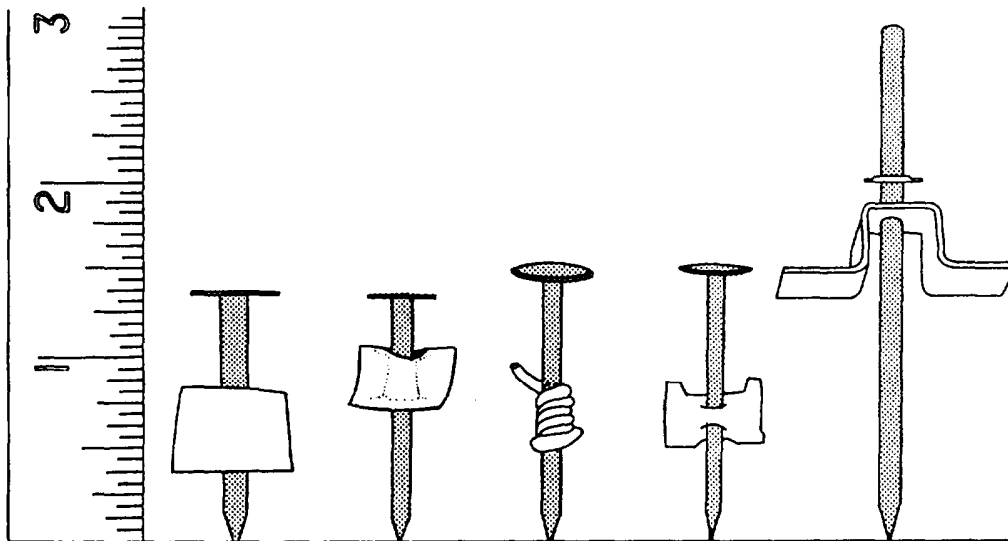


Figure 7-20.-Several types of furring nails.

struck off flush or slightly raked. Old walls softened and disintegrated by weather action, surfaces that cannot be cleaned thoroughly, such as painted brickwork, and all masonry chimneys should be covered with galvanized metal reinforcement before applying the stucco. When masonry surfaces are not rough enough to provide good mechanical key, one or more of the following actions may be taken:

- Old cast-in-place concrete or other masonry may be roughened with bush hammers or other suitable hand tools. Roughen at least 70 percent of the surface with the hammer marks uniformly distributed. Wash the roughened surface free of chips and dust. Let the wall dry thoroughly.
- Concrete surfaces may be roughened with an acid wash. Use a solution of 1 part muriatic acid to 6 parts water. Note: Add muriatic acid to the water; never add water to the acid. First, wet the wall so the acid will act on the surface only. More than one application may be necessary. After the acid treatment, wash the wall thoroughly to remove all acid. Allow the washed wall to dry thoroughly.

CAUTION

When your crew members are using muriatic acid, make sure they wear goggles, rubber gloves, and other protective clothing and equipment.

- You can quickly rough masonry surfaces using a power-driven roughing machine (such as that shown in figure 7-21) equipped with a cylindrical cage fitted with a series of hardened steel cutters. The cutters should be mounted to provide a flailing action that results in a scored pattern. After roughing, wash the wall clean of all chips and dust and let it dry.

Suction is absolutely necessary to attain a proper bond of stucco on concrete and masonry surfaces. It is also necessary in first and second coats so the following coats bond properly. Uniform suction also helps obtain a uniform color. If one part of the wall draws more moisture from the stucco than another, the finish coat may be spotty. Obtain uniform suction by dampening the wall evenly, but not soaking, before applying the stucco. The same applies to the scratch and brown coats. If the surface becomes dry in spots, dampen those areas again to restore suction. Use a fog spray for dampening.

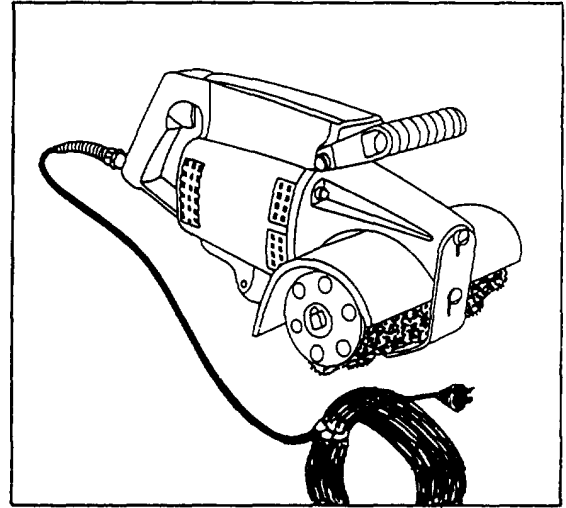


Figure 7-21.—Power-driven roughing machine.

When the masonry surface is not rough enough to ensure an adequate bond for a trowel-applied scratch coat, use the dash method. Acid-treated surfaces usually require a dashed scratch coat. Dashing on the scratch coat aids in getting a good bond by excluding air that might get trapped behind a trowel-applied coat. Apply the dash coat with a fiber brush or whisk broom, using a strong whipping motion at right angles to the wall. A cement gun or other machine that can apply the dash coat with considerable force also produces a suitable bond. Keep the dash coat damp for at least 2 days immediately following its application and then allow it to dry.

Protect the finish coat against exposure to sun and wind for at least 6 days after application. During this time, keep the stucco moist by frequent fog-spraying.

Mixing

Mixing procedures for stucco are similar to those for plaster. Three things you need to consider before mixing begins are the type of material you are going to use, the backing to which the material will be applied, and the method used to mix the material (hand or machine). As with plaster, addition of too much of one raw ingredient or the deletion of a raw material gives you a bad mix. Prevent this by allowing only the required amount of ingredients in the specified mix.

Applying

Stucco can be applied by hand or machine. Machine application allows application of material over a large area without joinings (joinings are a problem for

hand-applied finishes). To apply stucco, begin at the top of the wall and work down. Make sure the crew has sufficient personnel to finish the total wall surface without joinings (laps or interruptions).

Curing

The curing of stucco depends on the surface to which it is applied, the thickness of the material, and the weather. Admixtures can be used to increase workability, prevent freezing, and to waterproof the mortar. Using high-early cement reduces the curing time required for the cement to reach its initial strength (3 days instead of 7). Air-entraining cement is used to resist freezing action.

COMMON FAULTS

There are times when the finish you get is not what you expected. Some of the most common reasons for discoloration and stains are listed below:

- Failure to have uniform suction in either of the base coats;
- Improper mixing of the finish coat materials;
- Changes in materials or proportions during the work;
- Variations in the amount of mixing water;
- Use of additional water to retemper mortar; and
- Corrosion and rust from flashing or other metal attachments and failure to provide drips and washes on sills and projecting trim.

CERAMIC TILE

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the different types of ceramic tile and associated mortars, adhesives, and grouts, and state the procedures for setting tiles.

Ceramic tile is used extensively where sanitation, stain resistance, ease in cleaning, and low maintenance are desired. Ceramic tiles are commonly used for walls and floors in bathrooms, laundry rooms, showers, kitchens, laboratories, swimming pools, and locker rooms. The tremendous range of colors, patterns, and designs available in ceramic tile even includes three-dimensional sculptured tiles. Extensive use has

been made of ceramic tile for decorative effects throughout buildings, both inside and outside.

CLASSIFICATIONS

Tile is usually classified by exposure (interior or exterior) and location (walls or floors), although many tiles may be used in all locations. Since exterior tile must be frostproof, the tiles are kiln fired to a point where they have a very low absorption. Tiles vary considerably in quality among manufacturers. This may affect their use in various exposures and locations.

SIZES

Tile is generally available in the following square sizes: 4 1/4 by 4 1/4, 6 by 6, 3 by 3, and 1 3/8 by 1 3/8 inches. Rectangular sizes available include 8 1/2 by 4 1/4, 6 by 4 1/4, and 1 3/8 by 4 1/4 inches. Tile often comes mounted into sheets (usually between 1 and 2 square feet) with some type of backing on the sheet or between the tiles to hold them together.

Tiles with less than 6 square inches of face area and about 1/4 inch thick are called ceramic mosaics. Ceramic mosaic tile sizes range from 3/8 by 3/8 inch to about 2 by 2 inches, and they are available from the manufacturers in both sheet and roll form. Often, large tile is scored by the manufacturer to resemble small tiles.

FINISHES

Tile finishes include glazed, unglazed, textured (matte) glazed porcelain, and abrasive. Glazed and matte glazed finishes may be used for light-duty floors but should not be used in areas of heavy traffic where the glazed surface may be worn away. Glazed ceramic wall tiles usually have a natural clay body (nonvitreous, 7-to 9-percent absorption), and a vitreous glaze is fused to the face of the tile. This type of tile is not recommended for exterior use. Glazed tile should never be cleaned with acid, which mars the finish. Use only soap and water. Unglazed ceramic mosaics have dense, nonvitreous bodies uniformly distributed through the tile. Certain glazed mosaics are recommended for interior use only, others for wall use only. Porcelain tiles have a smoother surface than mosaics and are denser, with an impervious body of less than one-half of 1-percent absorption. This type of tile may be used throughout the interior and exterior of a building. An abrasive finish is available as an aggregate embedded in the surface or an irregular surface texture.

Tiles are available with self-spacing lugs, square edges, and cushioned edges (slightly rounded) (see

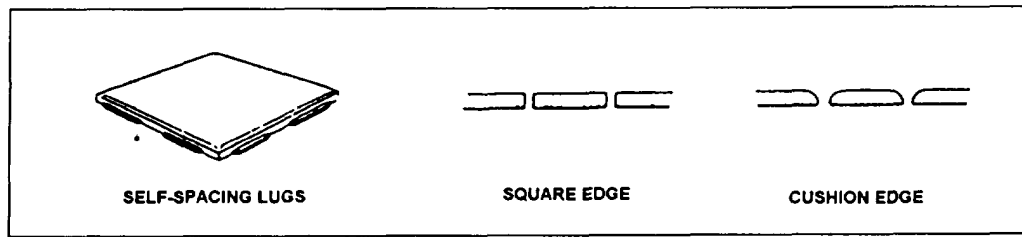


Figure 7-22.—Tile edges.

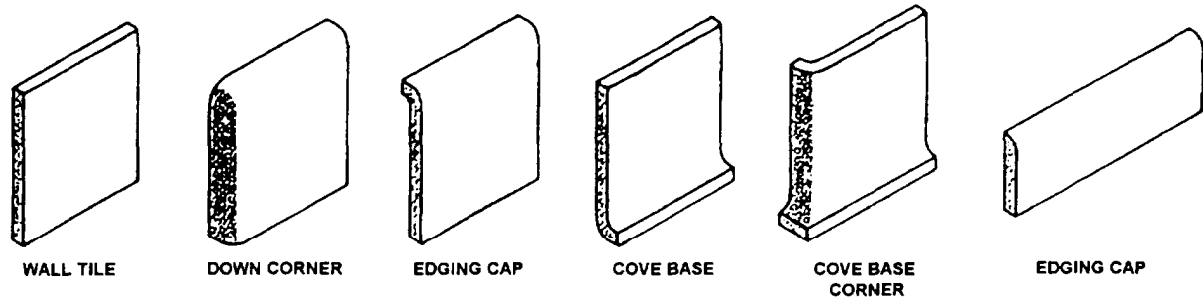


Figure 7-23.—Trimmer shapes.

fig. 7-22). The lugs assure easy setting and uniform joints. The edges available vary with the size of the tile and the manufacturer.

Margins, comers, and base lines are finished with trimmers of various shapes (fig. 7-23). A complete line of shaped ceramic trim is available from manufacturers. Other accessories include towel bars, shelf supports, paper holders, grab rails, soap holders, tumbler holders, and combination toothbrush and tumbler holders, to list a few of the more popular units.

MORTARS AND ADHESIVES

The resistance of ceramic tile to traffic depends primarily on base and bonding material rigidity, grout strength, hardness, and the accurate leveling and smoothness of the individual tiles in the installation. The four basic installation methods are cement mortar (the only thick bed method), dry-set mortar, epoxy mortar, and organic adhesives (mastic).

Cement Mortar

Cement mortar for setting ceramic tiles is composed of a mixture of portland cement and sand. The mix proportions for floors may vary from 1:3 to 1:6 by volume. For walls, a portland cement, sand, and hydrated lime mix may vary from 1:3:1 to 1:5 1/2:1. These proportion ratios are dictated by the project specifications. The mortar is placed on the surface 3/4 to 1 inch thick on walls and 3/4 inch to 1 1/4 inches thick on floors. A neat cement bond coat is applied over it

while the cement mortar is fresh and plastic. After soaking in water for at least 30 minutes, the tiles are installed over the neat cement bond coat. This type of installation, with its thick mortar bed, permits wall and floor surfaces to be sloped. This installation provides a bond strength of 100 to 200 pounds per square inch. A waterproof backing is sometimes required, and the mortar must be damp-cured.

Dry-Set Mortar

Dry-set mortar is a thin-bed mortar of premixed portland cement, sand, and admixtures that control the setting (hardening) time of the mortar. It may be used over concrete, block, brick, cellular foamed glass, gypsum wallboard, and unpainted dry cement plaster, as well as other surfaces. A sealer coat is often required when the base is gypsum plaster. It is not recommended for use over wood or wood products. Dry-set mortar can be applied in one layer 3/32 inch thick, and it provides a bond strength of 500 pounds per square inch. This method has excellent water and impact resistance and may be used on exteriors. The tiles do not have to be presoaked, but the mortar must be damp-cured.

Epoxy Mortar

Epoxy mortar can be applied in a bed as thin as 1/8 inch. When the epoxy resin and hardener are mixed on the job, the resulting mixture hardens into an extremely strong, dense setting bed. Pot life, once the parts are mixed, is about 1 hour if the temperature is 82°F or higher. This mortar has excellent resistance to the

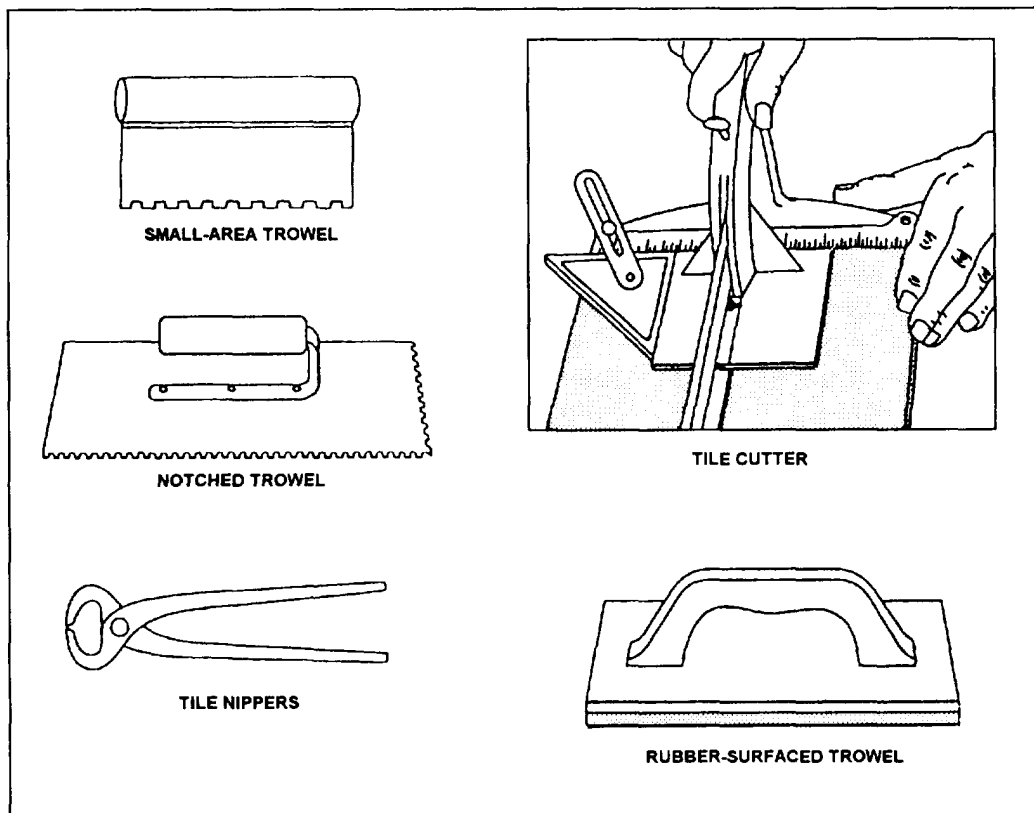


Figure 7-24. Special tile-setting tools.

corrosive conditions often encountered in industrial and commercial installations. It may be applied over bases of wood, plywood, concrete, or masonry. This type of mortar is nonshrinking and nonporous. A bond strength of over 1,000 pounds per square inch is obtained with this installation method.

Organic Adhesives

Organic adhesives (mastics) are applied in a thin layer with a notched trowel. They are solvent-base, rubber material. Porous materials should be primed before mastic is applied to prevent some of the plasticizers and oils from soaking into the backing. Suitable surfaces include wood, concrete, masonry, gypsum wallboard, and plaster. The bond strength available varies considerably among manufacturers, but the average is about 100 pounds per square inch.

GROUTS

The joints between the tiles must be filled with a grout selected to meet the tile requirements and exposure. Tile grouts may be portland cement base, epoxy base, furans, or latex.

Cement grout consists of portland cement and admixtures. This is better in terms of waterproofing, uniform color, whiteness, shrink resistance, and fine

texture than a plain cement. It may be colored and used in all areas subject to ordinary use. When the grout is placed, the tiles should be wet. Moisture is required for proper curing.

Drywall grout has the same characteristics as dry-set mortar and is suitable for areas of ordinary use. Tiles to be set in drywall grout do not require wetting except during very dry conditions.

Epoxy grout consists of an epoxy resin and hardener. It produces a joint that is stainproof, resistant to chemicals, hard, smooth, impermeable, and easy to clean. It is used extensively in counters that must be kept sanitary for foods and chemicals. It has the same basic characteristics as epoxy mortars.

Furan resin grout is used in industrial areas requiring high resistance to acids and weak alkalis. Special installation techniques are required with this type of grouting.

Latex grout is used for a more flexible and less permeable finish than cement grout. It is made by introducing a latex additive into the Portland cement grout mix.

TOOLS

A selection of special tools, shown in figure 7-24, should be available when doing tile installation work.

A primary tool is a notched trowel with the notches of the depth recommended by the adhesive manufacturers. A trowel with notches on one side and smooth on the other is preferred. Different sized trowels are available.

A tile cutter is the most efficient tool for cutting ceramic tile. The scribe on the cutter has a tungsten carbide tip. A glass cutter can be used but quickly dulls.

Use tile nippers when trimming irregular shapes. Nip off very small pieces of the tile you are cutting. Attempting to take big chunks at one time can crack the tile.

A rubber-surfaced trowel is used to force grout into the joints of the tile.

APPLICATION TECHNIQUES

There are three primary steps in tile installation: applying a mortar bed, applying adhesive, and setting tiles in place.

Mortar

Before applying a mortar bed to a wall having wooden studs, you first tack a layer of waterproof paper to the studs. You then nail metal lath over the paper. The first coat of mortar applied to a wall for setting tiles is a scratch coat; the second is a float, leveling, or brown coat.

A scratch coat for application as a foundation coat must be at least 1/4 inch thick and composed of 1 part cement to 3 parts sand, with the addition of 10-percent hydrated lime by volume of the cement used. While still plastic, the scratch coat is deeply scored or scratched and cross scratched. Keep the scratch coat protected and reasonably moist during the hydration period. All mortar for scratch and float coats should be used within 1 hour after mixing. Do not retemper partially hardened mortar. Apply the scratch coat not more than 48 hours, nor less than 24 hours, before setting the tile.

The float coat should be composed of 1 part cement, 1 part of hydrated lime, and 3 1/2 parts sand. It should be brought flush with screeds or temporary guide strips, placed to give a true and even surface at the proper distance from the finished face of the tile.

Wall tiles should be thoroughly soaked for a minimum of 30 minutes in clean water before being set. Set tiles by troweling a skim coat of neat Portland cement mortar on the float coat, or applying a skim coat to the back of each tile unit and immediately floating the tiles into place. Joints must be straight, level, perpendicular, of even width, and not exceeding 1/16 inch. Wainscots are built of full courses. These may

extend to a greater or lesser height, but in no case more than 1 1/2-inch from the specified or figured height. Vertical joints must be maintained plumb for the entire height of the tile work.

All joints in wall tile should be grouted full with a plastic mix of neat white cement or commercial tile grout immediately after a suitable area of the tile has been set. Tool the joints slightly concave; cut off and wipe excess mortar from the face of tiles. Any spaces, crevices, cracks, or depressions in the mortar joints after the grout has been cleaned from the surface should be roughened at once and filled to the line of the cushioned edge (if applicable) before the mortar begins to harden. Tile bases or coves should be solidly backed with mortar. Make all joints between wall tiles and plumbing or other built-up fixtures with a light-colored caulking compound. Immediately after the grout has set, apply a protective coat of noncorrosive soap or other approved protection to the tile wall surfaces.

The installation of wall tile over existing and patched or new plaster surfaces in an existing building is completed as previously described, except that an adhesive is used as the bonding agent. Where wall tile is to be installed in areas subject to intermittent or continual wetting, prime the wall areas with adhesive following the manufacturer's recommendations.

Adhesive

Wall tiles may be installed either by floating or buttering the adhesive. In floating, apply the adhesive uniformly over the prepared wall surface using quantities recommended by the manufacturer. Use a notched trowel held at the proper angle to spread adhesive to the required uniform thickness. Touch up thin or bare spots with an additional coating of adhesive. The area coated at one time should not be any larger than that recommended by the manufacturer. In the buttering method, daub the adhesive on the back of each tile. Use enough so that, when compressed, the adhesive forms a coating not less than 1/16 inch thick over 60 percent of the back of each tile.

Laying Tile

The key to a professional-looking ceramic tile job is to start working with a squared-off area. Most rooms do not have perfectly square comers. As a result, the first step is to mark off a square area in such a way that fractional tiles at the comers (edges) are approximately the same size. Begin by finding the lowest point of the wall you are tiling. From this corner draw a horizontal line one full tile height above the low point and extend

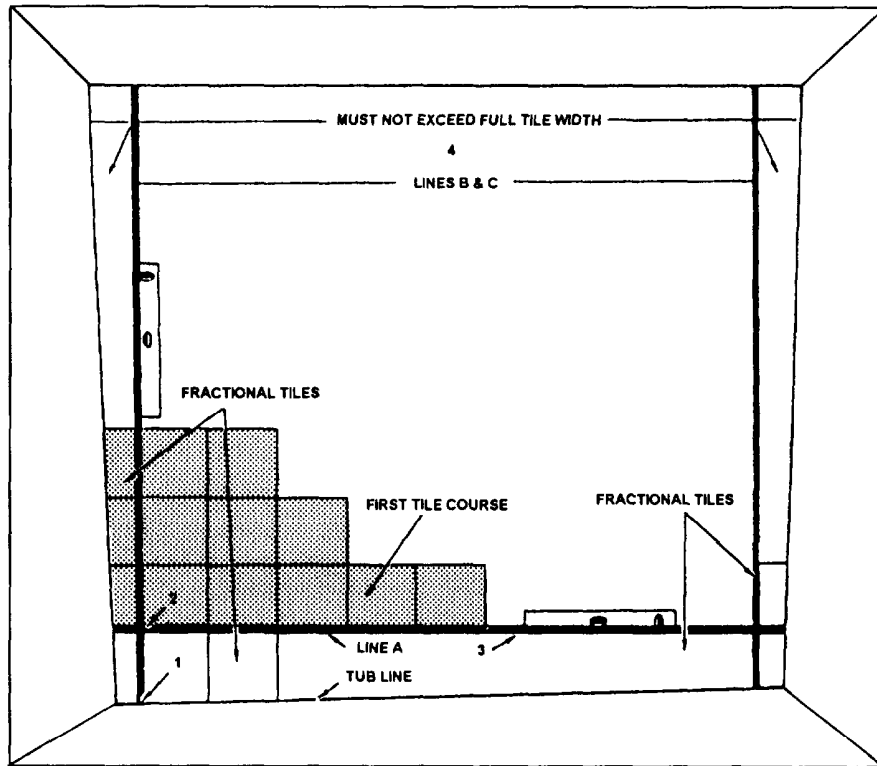


Figure 7-25.-Steps used for squaring a wall.

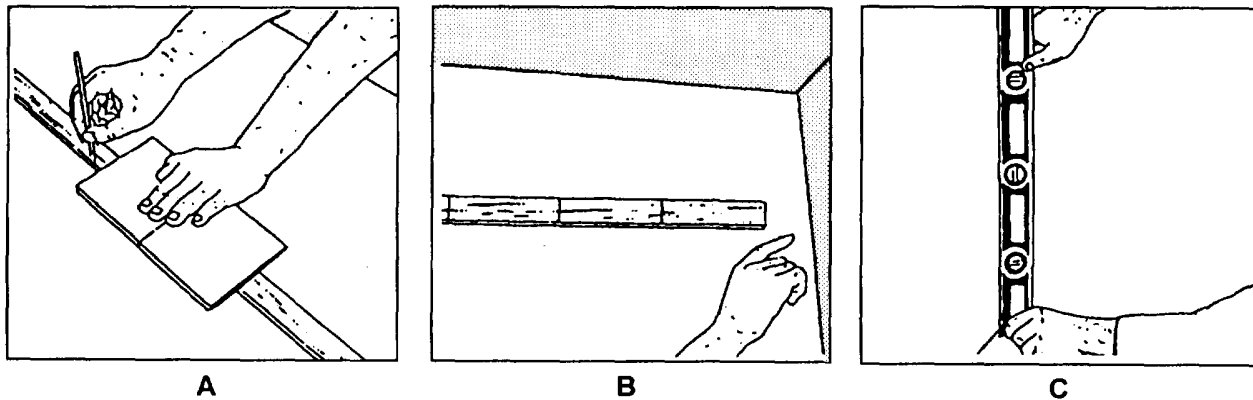


Figure 7-26.-Layout for installing ceramic wall tile.

this line level across the entire width of the room. Refer to the bathroom wall example in figure 7-25 as you study the following steps:

1. Find the low point of the tub.
2. Measure up the height of one full tile at the low point. Draw a horizontal line A. It must be level.
3. Use a tile-measuring stick (fig. 7-26) to determine the position of full-width tiles in such a way that fractional tiles at each corner or edge are equal.

4. Draw vertical lines B and C perpendicular to line A (fig. 7-25). Apply tiles to the squared-off area first. Then cut and apply fractional tiles.

Another method for figuring fractional tiles (edges) is to employ the "half-tile rule." (The stick method is good for short walls, but the half-tile rule is needed for long walls.) Take the number of full-size tiles required for one course, multiply this by the tile size, subtract this answer from the wall length in inches, add one full tile size and divide by 2. The result is the size of end tiles.

After determining fractional tiles, use a piece of scrap wood from 36 inches to 48 inches in length to mark up a tile-measuring stick (fig. 7-26, view A). Mark off a series of lines equal to the width of a tile. Lay this stick on the wall and shift it back and forth to determine the starting point for laying the tiles. Make sure the fractional tiles at the end of each row are of equal widths (fig. 7-26, view B).

Use a level to establish a line perpendicular to the horizontal starting line (fig. 7-26, view C). At both ends of the horizontal line, draw vertical lines to form the squared-off area. To make the tile application easier, you can fasten battens to the wall on the outside of the drawn lines.

Use a trowel to spread the mastic over approximately a 3- by 3-foot area of the wall. Use the notched side to form ridges in the mastic, pressing hard against the surface so that the ridges are the same height as the notches on the tool. Allow the mastic to set for 24 hours before applying grout. Follow the manufacturer's mixing instructions closely and use a rubber-surfaced trowel to spread the grout over the tile surface. Work the trowel in an arc, holding it at a slight angle so that grout is forced into the spaces between the tiles.

Start tiling at either of the vertical lines and tile half the wall at a time, working in horizontal rows. Press each tile into the mastic, but do not slide them—the mastic may be forced up the edges onto the tile surface. After each course of tile is applied, check with the level before spreading more mastic. If a line is crooked, remove all tiles in that line and apply fresh ones. Do not use the removed tiles until the mastic has been cleaned off. Finish tiling the main area before fitting edge tiles.

When the grout begins to dry, wipe the excess from the tiles with a damp rag. After the grout is thoroughly dry, rinse the wall and wipe it with a clean towel.

Nonstaining caulking compound should be used at all joints between built-in fixtures and tile work and at the top of ceramic tile bases to ensure complete waterproofing. Inside corners should be caulked before a corner bead is applied.

Promptly replace cracked and broken tiles. This protects the edges of adjacent tiles and helps maintain waterproofing and appearance. Timely pointing of displaced joint material and spalled areas in joints is necessary to keep tiles in place.

A new tile surface should be cleaned according to the tile manufacturer's recommendations to avoid damage to the glazed surfaces.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Gypsum Construction Handbook, United States Gypsum Company, Chicago, Ill., 1987.

Materials and Methods of Architectural Construction, John Wiley & Sons, New York, 1958.

Plastering Skills, American Technical Publishers, Inc., Alsip, Ill., 1984.

CHAPTER 8

STRUCTURAL COATINGS AND PRESERVATIVES

The final stage of most construction projects is the application of protective coatings, or “painting.” As with all projects, you should follow the plans and specifications for surface preparation and application of the finish coat. The specifications give all the information you need to complete the tasks. But, to have a better understanding of structural coatings, you need to know their purposes, methods of surface preparation, and application techniques.

PURPOSES OF STRUCTURAL COATINGS

LEARNING OBJECTIVE: Upon completing this section, you should be able to state the purposes of the different types of structural coatings and how each is employed.

The protection of surfaces is the most important consideration in determining the maintenance cost of structures. Structural coatings serve as protective shields between the base construction materials and elements that attack and deteriorate them. Regularly programmed structural coatings offer long-range protection, extending the useful life of a structure.

PREVENTIVE MAINTENANCE

The primary purpose of a structural coating is protection. This is provided initially with new construction and maintained by a sound and progressive preventive maintenance program. Programmed painting enforces inspection and scheduling. A viable preventive maintenance program will help ensure that minor problems are detected at an early stage—before they become major failures later. An added advantage derived from preventive maintenance is the detection of faulty structural conditions or problems caused by leakage or moisture.

Resistance to moisture from rain, snow, ice, and condensation constitutes perhaps the greatest single protective characteristic of paint, the most common type of structural coating. Moisture causes metal to corrode and wood to swell, warp, or rot. Interior wall finishes of buildings can be ruined by moisture

entering through neglected exterior surfaces. Porous masonry is attacked and destroyed by moisture. Therefore, paint films must be as impervious to moisture as possible to provide a protective, water-proof film over the surface to which they are applied. Paint also acts as a protective film against acids, alkalies, material organisms, and other damaging elements.

SANITATION AND CLEANLINESS

Painting is an essential part of general maintenance programs for hospitals, kitchens, mess halls, offices, warehouses, and living quarters. Paint coatings provide smooth, nonabsorptive surfaces that are easily washed and kept free of dirt and foodstuffs. Adhering foodstuffs harbor germs and cause disease. Coating rough or porous areas seals out dust and grease that would otherwise be difficult to remove.

Odorless paints are used in these areas because conventional paint solvent odors are obnoxious to personnel. In food preparation areas, the odors maybe picked up by nearby food.

FIRE RETARDANCE

Certain types of structural coatings delay the spread of fire and assist in confining a fire to its area of origin. Fire-retardant coatings should not be considered substitutes for conventional paints. The use of fire-retardant coatings is restricted to areas of highly combustible surfaces, and must be justified and governed by the specific agency's criteria. Fire-retardant coatings are not used in buildings containing automatic sprinkler systems.

CAMOUFLAGE

Camouflage paints have special properties, making them different from conventional paints. Their uses are limited to special applications. Do not use camouflage paints as substitutes for conventional paints. Use this paint only on exterior surfaces to render buildings and structures inconspicuous by blending them in with the surrounding environment.

ILLUMINATION AND VISIBILITY

White and light-tinted coatings applied to ceilings and walls reflect both natural and artificial light and help brighten rooms and increase visibility. On the other hand, darker colors reduce the amount of reflected light. Flat coatings diffuse, soften, and evenly distribute illumination, whereas gloss finishes reflect more like mirrors and may create glare. Color contrasts improve visibility of the painted surface, especially when paint is applied in distinctive patterns. For example, white on black, white on orange, or yellow on black can be seen at greater distances than single colors or other combinations of colors.

IDENTIFICATION AND SAFETY

Certain colors are used as standard means of identifying objects and promoting safety. For example, fire protection equipment is painted red. Containers for kerosene, gasoline, solvents, and other flammable liquids should be painted a brilliant yellow and marked with large black letters to identify their contents. The colors of signal lights and painted signs help control traffic safely by providing directions and other travel information.

TYPES OF COATINGS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of structural coatings and finishes, and the general characteristics of each.

As a Builder, you must consider many factors when selecting a coating for a particular job. One important factor is the type of coating, which depends on the composition and properties of the ingredients. Paint is composed of various ingredients, such as pigment, nonvolatile vehicle, or binder, and solvent, or thinner. Other coatings may contain only a single ingredient.

PAINT

In this section, we'll cover the basic components of paint—pigment, vehicles, and solvents—and explain the characteristics of different types of paint.

Composition

Paint is composed of two basic ingredients: pigment and a vehicle. A thinner may be added to change the application characteristics of the liquid.

PIGMENT.— Pigments are insoluble solids, ground finely enough to remain suspended in the vehicle for a considerable time after thorough stirring or shaking. Opaque pigments give the paint its hiding, or covering, capacity and contribute other properties (white lead, zinc oxide, and titanium dioxide are examples). Color pigments give the paint its color. These may be inorganic, such as chrome green, chrome yellow, and iron oxide, or organic, such as toluidine red and phthalocyanine blue. Transparent or extender pigments contribute bulk and also control the application properties, durability, and resistance to abrasion of the coating. There are other special-purpose pigments, such as those enabling paint to resist heat, control corrosion, or reflect light.

VEHICLES, OR BINDERS.— The vehicle, or binder, of paint is the material holding the pigment together and causing paint to adhere to a surface. In general, paint durability is determined by the resistance of the binder to the exposure conditions. Linseed oil, once the most common binder, has been replaced, mainly by the synthetic alkyd resins. These result from the reaction of glycerol phthalate and an oil and may be made with almost any property desired. Other synthetic resins, used either by themselves or mixed with oil, include phenolic resin, vinyl, epoxy, urethane, polyester, and chlorinated rubber. Each has its own advantages and disadvantages. When using these materials, it is particularly important that you exactly follow the manufacturers' instructions.

SOLVENTS, OR THINNERS.— The only purpose of a solvent, or thinner, is to adjust the consistency of the material so that it can be applied readily to the surface. The solvent then evaporates, contributing nothing further to the film. For this reason, the cheapest suitable solvent should be used. This solvent is likely to be naphtha or mineral spirits. Although turpentine is sometimes used, it contributes little that other solvents do not and costs much more.

NOTE

Synthetic resins usually require a special solvent. It is important the correct one be used; otherwise, the paint may be spoiled entirely.

Types

Paints, by far, comprise the largest family of structural coatings you will be using to finish products, both interior and exterior. In the following

section, we'll cover some of the most commonly encountered types.

OIL-BASED PAINTS.— Oil-based paints consist mainly of a drying oil (usually linseed) mixed with one or more pigments. The pigments and quantities of oil in oil paints are usually selected on the basis of cost and their ability to impart to the paint the desired properties, such as durability, economy, and color. An oil-based paint is characterized by easy application and slow drying. It normally chalks in such a manner as to permit recoating without costly surface preparation. Adding small amounts of varnish tends to decrease the time it takes an oil-based paint to dry and to increase the paint's resistance to water. Oil-based paints are not recommended for surfaces submerged in water.

ENAMEL.— Enamels are generally harder, tougher, and more resistant to abrasion and moisture penetration than oil-based paints. Enamels are obtainable in flat, semigloss, and gloss. The extent of pigmentation in the paint or enamel determines its gloss. Generally, gloss is reduced by adding lower cost pigments called extenders. Typical extenders are calcium carbonate (whiting), magnesium silicate (talc), aluminum silicate (clay), and silica. The level of gloss depends on the ratio of pigment to binder.

EPOXY.— Epoxy paints are a combined resin and a polyamide hardener that are mixed before use. When mixed, the two ingredients react to form the end product. Epoxy paints have a limited working, or pot, life, usually 1 working day. They are outstanding in hardness, adhesion, and flexibility-plus, they resist corrosion, abrasion, alkali, and solvents. The major uses of epoxy paints are as tile-like glaze coatings for concrete or masonry, and for structural steel in corrosive environments. Epoxy paints tend to chalk on exterior exposure; low-gloss levels and fading can be anticipated. Otherwise, their durability is excellent.

LATEX.— Latex paints contain a synthetic chemical, called latex, dispersed in water. The kinds of latex usually found in paints are styrene-butadiene (so-called synthetic rubber), polyvinyl acetate (PVA or vinyl), and acrylic. Latex paints differ from other paints in that the vehicle is an emulsion of binder and water. Being water-based, latex paints have the advantage of being easy to apply. They dry through evaporation of the water. Many latex paints have excellent durability. This makes them particularly useful for coating plaster and masonry surfaces. Careful surface preparation is required for their use.

RUBBER-BASED.— Rubber-based paints are solvent thinned and should not be confused with latex binders (often called rubber-based emulsions). Rubber-based paints are lacquer-type products and dry rapidly to form finishes highly resistant to water and mild chemicals. They are used for coating exterior masonry and areas that are wet, humid, or subject to frequent washing, such as laundry rooms, showers, washrooms, and kitchens.

PORTLAND CEMENT.— Portland cement mixed with several ingredients acts as a paint binder when it reacts with water. The paints are supplied as a powder to which the water is added before being used. Cement paints are used on rough surfaces, such as concrete, masonry, and stucco. They dry to form hard, flat, porous films that permit water vapor to pass through readily. When properly cured, cement paints of good quality are quite durable. When improperly cured, they chalk excessively on exposure and may present problems in repainting.

ALUMINUM.— Aluminum paints are available in two forms: ready mixed and ready to mix. Ready-mixed aluminum paints are supplied in one package and are ready for use after normal mixing. They are made with vehicles that will retain metallic brilliance after moderate periods of storage. They are more convenient to use and allow for less error in mixing than the ready-to-mix form.

Ready-to-mix aluminum paints are supplied in two packages: one containing clear varnish and the other, the required amount of aluminum paste (usually two-thirds aluminum flake and one-third solvent). You mix just before using by slowly adding the varnish to the aluminum paste and stirring. Ready-to-mix aluminum paints allow a wider choice of vehicles and present less of a problem with storage stability. A potential problem with aluminum paints is moisture in the closed container. When present, **moisture may react with the aluminum flake to form hydrogen gas that pressurizes the container.** Pressure can cause the container to bulge or even pop the cover off the container. Check the containers of ready-mixed paints for bulging. If they do, puncture the covers carefully before opening to relieve the pressure. Be sure to use dry containers when mixing aluminum paints.

VARNISHES

In contrast to paints, varnishes contain little or no pigment and do not obscure the surface to which applied. Usually a liquid, varnish dries to a hard,

transparent coating when spread in a thin film over a surface, affording protection and decoration.

Of the common types of varnishes, the most important are the oils, including spar, flat, rubbing, and color types. These are extensively used to finish and refinish interior and exterior wood surfaces, such as floors, furniture, and cabinets. Spar varnish is intended for exterior use in normal or marine environments, although its durability is limited. To increase durability, exterior varnishes are especially formulated to resist weathering.

Varnishes produce a durable, elastic, and tough surface that normally dries to a high-gloss finish and does not easily mar. Often, a lower gloss may be obtained by rubbing the surface with a very fine steel wool. However, it is simpler to use a flat varnish with the gloss reduced by adding transparent-flattening pigments, such as certain synthetic silicas. These pigments are dispersed in the varnish to produce a clear finish that dries to a low gloss, but still does not obscure the surface underneath (that is, you can still see the grain of the wood).

SHELLAC

Shellac is purified lac formed into thin flakes and widely used as a binder in varnishes, paints, and stains. (Lac is a resinous substance secreted by certain insects.) The vehicle is wood alcohol. The natural color of shellac is orange, although it can be obtained in white. Shellac is used extensively as a finishing material and a sealant. Applied over knots in wood, it prevents bleeding.

LACQUERS

Lacquers may be clear or pigmented and can be lusterless, semigloss, or glossy. Lacquers dry or harden quickly, producing a firm oil- and water-resistant film. But many coats are required to achieve adequate dry-film thickness. It generally costs more to use lacquers than most paints.

STAINS

Stains are obtainable in four different kinds: oil, water, spirit, and chemical. Oil stains have an oil vehicle; mineral spirits can be added to increase penetration. Water stains are solutions of aniline dyes and water. Spirit stains contain alcohol. Chemical stains work by means of a chemical reaction when dissolved by water. The type of stain to use depends

largely on the purpose, the location, and the type of wood being covered.

SURFACE PREPARATION

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe the procedures used in preparing surfaces for painting.

The most essential part of any painting job is proper surface preparation and repair. Each type of surface requires specific cleaning procedures. Paint will not adhere well, provide the protection necessary, or have the desired appearance unless the surface is in proper condition for painting. Exterior surface preparation is especially important because hostile environments can accelerate deterioration.

METALS

As a Builder, you are most likely to paint three types of metals: ferrous, nonferrous, and galvanized. Improper protection of metals is likely to cause fatigue in the metal itself and may result in costly repairs or even replacement. Correct surface preparation, prior to painting, is essential.

Ferrous

Cleaning ferrous metals, such as iron and steel, involves the removal of oil, grease, previous coatings, and dirt. Keep in mind that once you prepare a metal surface for painting, it will start to rust immediately unless you use a primer or pretreatment to protect the surface.

Nonferrous

The nonferrous metals are brass, bronze, copper, tin, zinc, aluminum, nickel, and others not derived from iron ore. Nonferrous metals are generally cleaned with a solvent type of cleaner. After cleaning, you should apply a primer coat or a pretreatment.

Galvanized

Galvanized iron is one of the most difficult metals to prime properly. The galvanizing process forms a hard, dense surface that paint cannot penetrate. Too often, galvanized surfaces are not prepared properly, resulting in paint failure. Three steps must be taken to develop a sound paint system.

1. Wash the galvanized surface with a solvent to remove grease, waxes, or silicones. Manufacturers sometimes apply these to resist "white rust" that may form on galvanized sheets stored

under humid conditions. Mineral spirits or acid washes should definitely not be used at this stage.

2. Etch the surface with a mild phosphoric acid wash. Etching increases paint adhesion and helps overcome the stress forces generated by expansion and contraction of the galvanized coating. After acid washing the surface, rinse it with clean water and allow to dry. When using acid, remember the situation can represent actual or potential danger to yourself and other employees in the area. Continuous and automatic precautionary measures minimize safety problems and improve both efficiency and morale of the crew.
3. Apply a specially formulated primer. Two basic types of primer are in common use: zinc-bound and cementitious-resin. The zinc-bound type is used for normal exposure. Most types of finish can be used over this type of primer. Latex emulsion paints provide a satisfactory finish. Oil-based products should not be used over cementitious-resin primers. A minimum of two coats of finish is recommended over each type of primer.

CONCRETE AND MASONRY

In Navy construction, concrete and masonry are normally not painted unless painting is required for damp-proofing. Cleaning concrete and masonry involves the removal of dirt, mildew, and efflorescence (a white, powdery crystalline deposit that often forms on concrete and masonry surfaces).

Dirt and Fungus

Dirt and fungus are removed by washing with a solution of trisodium phosphate. The strength of the solution may vary from 2 to 8 ounces per gallon of water, depending upon the amount of dirt or mildew on the surface. Immediately after washing, rinse off all the trisodium phosphate with clear water. If using oil paint, allow the surface to dry thoroughly before painting.

Efflorescence

For efflorescence, first remove as much of the deposit as possible by dry brushing with a wire brush or a stiff fiber brush. Next, wet the surface thoroughly with clear water; then, scrub with a stiff brush dipped in a 5-percent solution (by weight) of muriatic acid. Allow the acid solution to remain on the surface about 3 minutes before scrubbing, but rinse thoroughly with

clear water immediately after scrubbing. Work on small areas not larger than 4 square feet. Wear rubber gloves, a rubber apron, and goggles when mixing and applying the acid solution. In mixing the acid, always add acid to water. **Do not add water to acid; this can cause the mixture to explode.** For a very heavy deposit, the acid solution may be increased to 10 percent and allowed to remain on the surface for 5 minutes before it is scrubbed.

Repairing Defects

All defects in a concrete or masonry surface must be repaired before painting. To repair a large crack, cut the crack out to an inverted-V shape and plug it with grout (a mixture of two or three parts of mortar sand, one part of portland cement, and enough water to make it putty-like in consistency). After the grout sets, damp cure it by keeping it wet for 48 hours. If oil paint is to be used, allow at least 90 days for weathering before painting over a grout-filled crack.

PLASTER AND WALLBOARD

Whenever possible, allow new plaster to age at least 30 days before painting if oil-based paint is being applied. Latex paint can be applied after 48 hours, although a 30-day wait is generally recommended. Before painting, fill all holes and cracks with spackling compound or patching plaster. Cut out the material along the crack or hole in an inverted-V shape. To avoid excessive absorption of water from the patching material, wet the edges and bottom of the crack or hole before applying the material. Fill the opening to within 1/4 inch of the surface and allow the material to set partially before bringing the level up flush with the surface. After the material has thoroughly set (depending on the type of filler used), use fine sandpaper to smooth out the rough spots. Plaster and wallboard should have a sealer or a prime coat applied before painting. When working with old work, remove all loose or scaling paint, sand lightly, and wash off all dirt, oil, and stains. Allow the surface to dry thoroughly before applying the new finish coat.

WOOD

Before being painted, a wood surface should be closely inspected for loose boards, defective lumber, protruding nail heads, and other defects or irregularities. Loose boards should be nailed tight, defective lumber should be replaced, and all nail heads should be counter-sunk.

A dirty wood surface is cleaned for painting by sweeping, dusting, and washing with solvent or soap and water. In washing wood, take care to avoid

excessive wetting, which tends to raise the grain. Wash a small area at a time, then rinse and dry it immediately.

Wood that is to receive a natural finish (meaning not concealed by an opaque coating) may require bleaching to a uniform or light color. To bleach, apply a solution of 1 pound of oxalic acid to 1 gallon of hot water. More than one application may be required. After the solution has dried, smooth the surface with fine sandpaper.

Rough wood surfaces must be sanded smooth for painting. Mechanical sanders are used for large areas, hand sanding for small areas. For hand sanding, you should wrap sandpaper around a rubber, wood, or metal sanding block. For a very rough surface, start with a coarse paper, about No. 2 or 2 1/2. Follow this with a No. 1/2, No. 1, or No. 1 1/2. You should finish with

about a No. 2/0 grit. For fine work, such as furniture sanding, you should finish with a freer grit.

Sap or resin in wood can stain through a coat, or even several coats, of paint. Remove sap or resin by scraping or sanding. Knots in resinous wood should be treated with knot sealer.

Green lumber contains a considerable amount of water, most of which must be removed before use. This not only prevents shrinkage after installation, but prevents blistering, cracking, and loss of adhesion after applied paint. Be sure all lumber used has been properly dried and kept dry before painting.

CONDITIONERS

Conditioners are often applied on masonry to seal a chalky surface to improve adhesion of water-based

Table 8-1.—Treatments of Various Substrates

MECHANICAL	WOOD	METAL		CONCRETE AND MASONRY	PLASTER AND WALLBOARD
		Steel	Other		
Hand Cleaning	S	S	S	S	S
Power Tool Cleaning	S*	S	S	S	
Flame Cleaning		S			
Blast Cleaning			S		
Brush-Off		S		S	
All Other		S			
Chemical and Solvent			S		
Solvent Cleaning	S	S			
Alkali Cleaning		S		S	
Steam Cleaning		S		S	
Acid Cleaning		S		S	
Pickling		S			
Pretreatments					
Hot Phosphate		S			
Cold Phosphate		S	S		
Wash Primers		S			
Conditioners, Sealers, and Fillers					
Conditioners				S	
Sealers	S				
Fillers	S			S	

S—Satisfactory for use as indicated
 *—Sanding only

topcoats. Sealers are used on wood to prevent resin running or bleeding. Fillers are used to produce a smooth finish on open-grained wood and rough masonry. Table 8-1 presents the satisfactory treatments of the various surfaces.

Since water-thinned latex paints do not adhere well to chalky masonry surfaces, an oil-based conditioner is applied to the chalky substrate before latex paint is applied. The entire surface should be vigorously wire brushed by hand or power tools, then dusted to remove all loose particles and chalk residue. The conditioner is then brushed on freely to assure effective penetration and allowed to dry. Conditioner is not intended for use as a finish coat.

SEALERS

Sealers are applied to bare wood like coats of paint. Freshly exuded resin, while still soft, may be scraped off with a putty knife and the area cleaned with alcohol.

Remove hardened resin by scraping or sanding. Since sealer is not intended as a prime coat, it should be used only when necessary and applied only over the affected area. When previous paint becomes discolored over knots on pine lumber, the sealer should be applied over the old paint before the new paint is applied.

FILLERS

Fillers are used on porous wood, concrete, and masonry to provide a smoother finish coat.

Wood

Wood fillers are used on open-grained hardwoods. In general, hardwoods with pores larger than those found in birch should be filled. Table 8-2 lists the characteristics of various woods and which ones require fillers. The table also contains notes on finishing. Filling is done after staining. Stain should be allowed to dry for 24 hours before the filler is

Table 8-2.Characteristics of Wood

NAME OF WOOD	TYPE OF GRAIN			NOTES ON FINISHING
	SOFT	HARD		
	Closed	Open	Closed	
Ash		X		Requires filler
Alder	X			Stains well
Aspen			X	Paints well
Basswood			X	Paints well
Beech			X	Paints poorly; varnishes well
Birch			X	Paints and varnishes well
Cedar	X			Paints and varnishes well
Cherry			X	Varnishes well
Chestnut		X		Requires filler; paints poorly
Cottonwood			X	Paints well
Cypress			X	Paints and varnishes well
Elm		X		Requires filler; paints poorly
Fir	X			Paints poorly
Gum			X	Varnishes well
Hemlock	X			Paints fairly well
Hickory		X		Requires filler
Mahogany		X		Requires filler
Maple			X	Varnishes well
Oak		X		Requires filler
Pine	X			Variable depending on grain
Teak		X		Requires filler
Walnut		X		Requires filler
Redwood	X			Paints well

Note: Any type of finish may be applied unless otherwise specified

applied. If staining is not warranted, natural (uncolored) filler is applied directly to the bare wood. The filler may be colored with some of the stain to accentuate the grain pattern of the wood.

To apply, you first thin the filler with mineral spirits to a creamy consistency, then liberally brush it across the grain, followed by a light brushing along the grain. Allow it to stand 5 to 10 minutes until most of the thinner has evaporated. At this time, the finish will have lost its glossy appearance. Before it has a chance to set and harden, wipe the filler off across the grain using burlap or other coarse cloth, rubbing the filler into the pores of the wood while removing the excess. Finish by stroking along the grain with clean rags. All excess filler must be removed.

Knowing when to start wiping is important. Wiping too soon pulls the filler out of the pores. Allowing the filler to set too long makes it hard to wipe off. A simple test for dryness consists of rubbing a finger across the surface. If a ball is formed, it's time to wipe. If the filler slips under the pressure of the finger, it is still too wet for wiping. Allow the filler to dry for 24 hours before applying finish coats.

Masonry

Masonry fillers are applied by brush to bare and previously prepared (all loose, powdery, flaking

material removed) rough concrete, concrete block, stucco, or other masonry surfaces. The purpose is to fill the open pores in the surface, producing a fairly smooth finish. If the voids on the surface are large, you should apply two coats of filler, rather than one heavy coat. This avoids mud cracking. Allow 1 to 2 hours drying time between coats. Allow the final coat to dry 24 hours before painting.

PAINT MIXING AND CONDITIONING

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe the techniques used in mixing and applying paint.

Most paints used in the Navy are ready-mixed, meaning the ingredients are already combined in the proper proportions. When oil paint is left in storage for long periods of time, the pigments settle to the bottom. These must be remixed into the vehicle before the paint is used. The paint is then strained, if necessary. All paint should be placed in the paint shop at least 24 hours before use. This is to bring the paint to a temperature between 65°F and 85°F.

There are three main reasons to condition and mix paint. First, you need to redisperse, or reblend, settled pigment with the vehicle. Second, lumps, skins, or other impediments to proper application need to be

Table 8-3.—Mixing Procedures

COATING	EQUIPMENT	REMARKS
Enamel, semigloss, or flat paints (oil type)	Manual, propeller, or shaker	Mix until homogeneous
Water-based paints (latex type)	Manual or propeller	Use extreme care to avoid air entrapment
Clear finishes	Manual, propeller, or shaker	Generally require little or no mixing
Extremely viscous finishes; for example, coal tar paints	Drum-type mixer	Use extreme care to avoid air entrapment
Two-package metallic paints; for example, aluminum paints	Propeller	Add small amount of liquid to paste; mix well. Slowly add remainder of vehicle, while stirring, until coating is homogeneous. With metallic powder, first make into a paste with solvent, and then proceed as above
Two-Component Systems	Propeller, shaker, or drum-type mixer	Mix until homogeneous. Check label for special instructions

eliminated. And, third, the paint must be brought to its proper application temperature.

MIXING

Paints should be mixed, or blended, in the paint shop just before they are issued. Mixing procedures vary among different types of paints. Regardless of the procedure used, try not to overmix; this introduces too much air into the mixture. Table 8-3 outlines the types of equipment and remarks for various coatings. Mixing is done by either a manual or mechanical method. The latter is definitely preferred to ensure maximum uniformity. Manual mixing is less efficient than mechanical in terms of time, effort, and results. It should be done only when absolutely necessary and be limited to containers no larger than 1 gallon. Nevertheless, it is possible to mix 1-gallon and 5-gallon containers by hand. To do so, first pour half of the paint vehicle into a clean, empty container. Stir the paint pigment that has settled to the bottom of the container into the remaining paint vehicle. Continue to stir the paint as you return the other half slowly to its original container. Stir and pour the paint from can to can. This process of mixing is called boxing paint. The mixed paint must have a completely blended

appearance with no evidence of varicolored swirls at the top. Neither should there be lumps of undispersed solids or foreign matter. Figure 8-1 illustrates the basic steps for boxing paint.

There are only three primary true-pigmented colors: red, blue, and yellow. Shades, tints, and hues are derived by mixing these colors in various proportions. Figure 8-2 shows a color triangle with one primary color at each of its points. The lettering

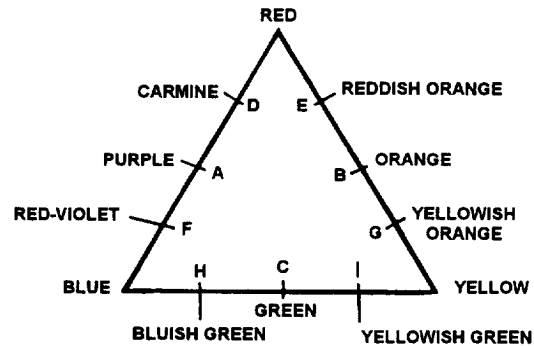


Figure 8-2.—A color triangle.

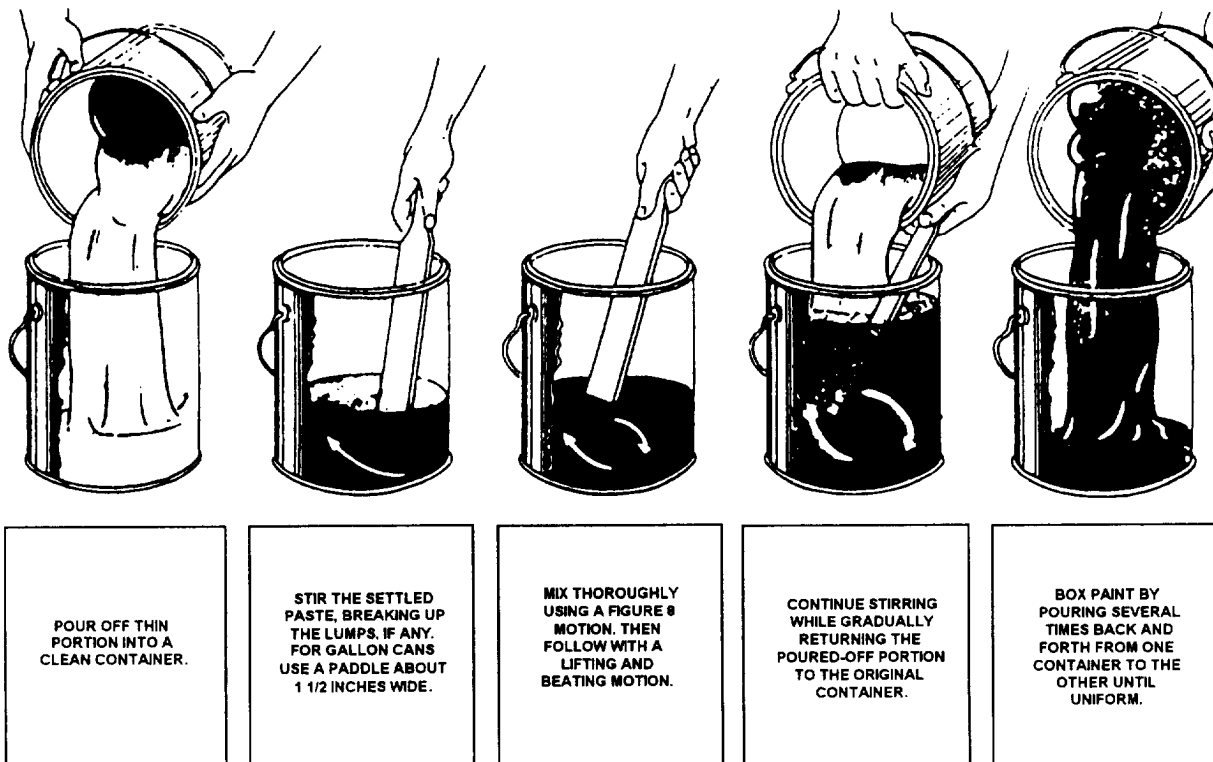


Figure 8-1.—Manual mixing and boxing.

in the triangle indicates the hues that result when colors are mixed.

- A**— Equal proportions of red and blue produce purple.
- B**— Equal proportions of red and yellow produce orange.
- C**— Equal proportions of blue and yellow produce green.
- D**— Three parts of red to one part of blue produce carmine.
- E**— Three parts of red to one part of yellow produce reddish orange.
- F**— Three parts of blue to one part of red produce red-violet.
- G**— Three parts of yellow to one part of red produce yellowish orange.
- H**— Three parts of blue to one part of yellow produce bluish green.
- I**— Three parts of yellow to one part of blue produce yellowish green.

Hues are known as chromatic colors, whereas black, white, and gray are achromatic (neutral colors). Gray can be produced by mixing black and white in different proportions.

Thinning

When received, paints should be ready for application by brush or roller. Thinner can be added for either method of application, but the supervisor or inspector must give prior approval. Thinning is often required for spray application. Unnecessary or excessive thinning causes an inadequate thickness of the applied coating and adversely affects coating longevity and protective qualities. When necessary, thinning is done by competent personnel using only the thinning agents named by the specifications or label instructions. Thinning is not done to make it easier to brush or roll cold paint materials. They should be preconditioned (warmed) to bring them up to 65°F to 85°F.

Straining

Normally, paint in freshly opened containers does not require straining. But in cases where lumps, color flecks, or foreign matter are evident, paints should be strained after mixing. When paint is to be sprayed, it must be strained to avoid clogging the spray gun.

Skins should be removed from the paint before mixing. If necessary, the next step is thinning. Finally, the paint is strained through a fine sieve or commercial paint strainer.

Tinting

Try not to tint paint. This will reduce waste and eliminate the problem of matching special colors at a later date. Tinting also affects the properties of the paint, often reducing performances to some extent. One exception is the tinting of an intermediate coat to differentiate between that coat and a topcoat; this helps assure you don't miss any areas. In this case, use only colorants of known compatibility. Try not to add more than 4 ounces of tint per gallon of paint. If more is added, the paint may not dry well or otherwise perform poorly.

When necessary, tinting should be done in the paint shop by experienced personnel. The paint must be at application viscosity before tinting. Colorants must be compatible, fresh, and fluid to mix readily. Mechanical agitation helps distribute the colorants uniformly throughout the paint.

APPLICATION

The common methods of applying paint are brushing, rolling, and spraying. The choice of method is based on several factors, such as speed of application, environment, type and amount of surface, type of coating to be applied, desired appearance of finish, and training and experience of painters. Brushing is the slowest method, rolling is much faster, and spraying is usually the fastest by far. Brushing is ideal for small surfaces and odd shapes or for cutting in corners and edges. Rolling and spraying are efficient on large, flat surfaces. Spraying can also be used for round or irregular shapes.

Local surroundings may prohibit the spraying of paint because of fire hazards or potential damage from over-spraying (accidentally getting paint on adjacent surfaces). When necessary, adjacent areas not to be coated must be covered when spraying is performed. This results in loss of time and, if extensive, may offset the speed advantage of spraying.

Brushing may leave brush marks after the paint is dry. Rolling leaves a stippled effect. Spraying yields the smoothest finish, if done properly. Lacquer products, such as vinyls, dry rapidly and should be sprayed. Applying them by brush or roller may be difficult, especially in warm weather or outdoors on

breezy days. The painting method requiring the most training is spraying. Rolling requires the least training.

PAINT FAILURES

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the common types of coating failures and recognize the reasons for each.

A coating that prematurely reaches the end of its useful life is said to have failed. Even protective coatings properly selected and applied on well-prepared surfaces gradually deteriorate and eventually fail. The speed of deterioration under such conditions is less than when improper painting procedures are earned out. Inspectors and personnel responsible for maintenance painting must recognize signs of deterioration to establish an effective and efficient system of inspection and programmed painting. Repainting at the proper time avoids the problems resulting from painting either too soon or too late. Applying coatings ahead of schedule is costly and eventually results in a heavy buildup that tends to quicken deterioration of the coating. Applying a coating after it is scheduled results in costly surface preparation and may be responsible for damage to the structure, which may then require expensive repairs.

In the following sections, we'll look at some of the more common types of paint failures, the reasons for such failures, methods of prevention, and cures.

SURFACE PREPARATION FAULTS

Paint failures can result from many causes. Here, we'll look at some of the most common caused by faults in surface preparation.

Alligatoring

Alligatoring (fig. 8-3) refers to a coating pattern that looks like the hide of an alligator. It is caused by uneven expansion and contraction of the undercoat. Alligatoring can have several causes: applying an enamel over an oil primer; painting over bituminous paint, asphalt, pitch, or shellac; and painting over grease or wax.

Peeling

Peeling (fig. 8-4) results from inadequate bonding of the topcoat with the undercoat or the underlying surface. It is nearly always caused by inadequate surface preparation. A topcoat peels when applied to a wet, dirty, oily or waxy, or glossy surface. All glossy surfaces must

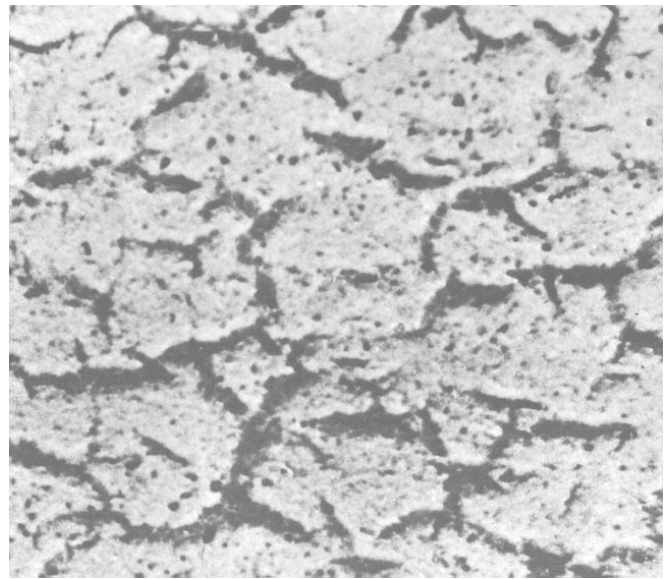


Figure 8-3.—Alligatoring.

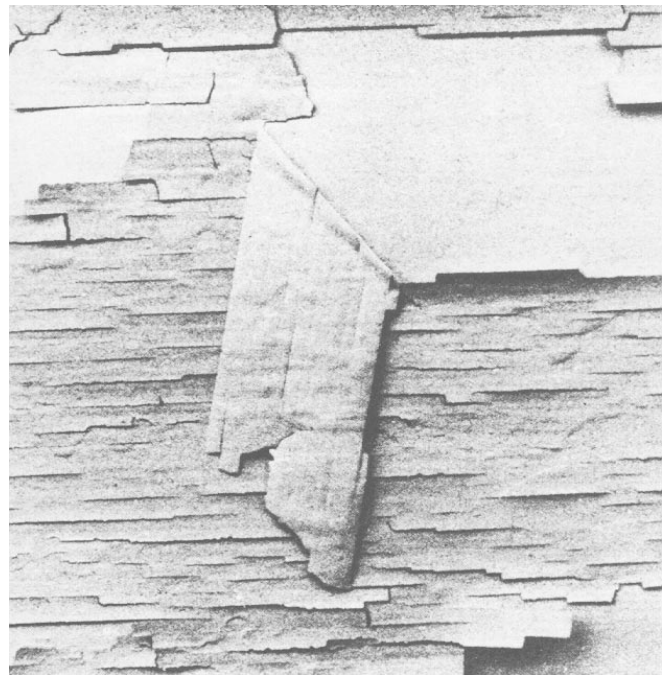


Figure 8-4.—Peeling.

be sanded before painting. Also, the use of incompatible paints can cause the loss of adhesion. The stresses in the hardening film can then cause the two coatings to separate and the topcoat to flake and peel.

Blistering

Blistering is caused by the development of gas or liquid pressure under the paint. Examples are shown

in figure 8-5. The root cause of most blistering, other than that caused by excessive heat, is inadequate ventilation plus some structural defect allowing moisture to accumulate under the paint. A prime source of this problem, therefore, is the use of essentially porous major construction materials that allow moisture to pass through. Insufficient drying time between coats is another prime reason for blistering. All blisters should be scraped off, the paint edges feathered with sandpaper, and the bare places primed before the blistered area is repainted.

Prolonged Tackiness

A coat of paint is dry when it ceases to be “tacky” to the touch. Prolonged tackiness indicates excessively slow drying. This may be caused by insufficient drier in the paint, a low-quality vehicle in the paint, applying the paint too thickly, painting over an undercoat that is not thoroughly dry, painting over a waxy, oily, or greasy surface, or painting in damp weather.

Inadequate Gloss

Sometimes a glossy paint fails to attain the normal amount of gloss. This may be caused by inadequate surface preparation, application over an undercoat that is not thoroughly dry, or application in cold or damp weather.

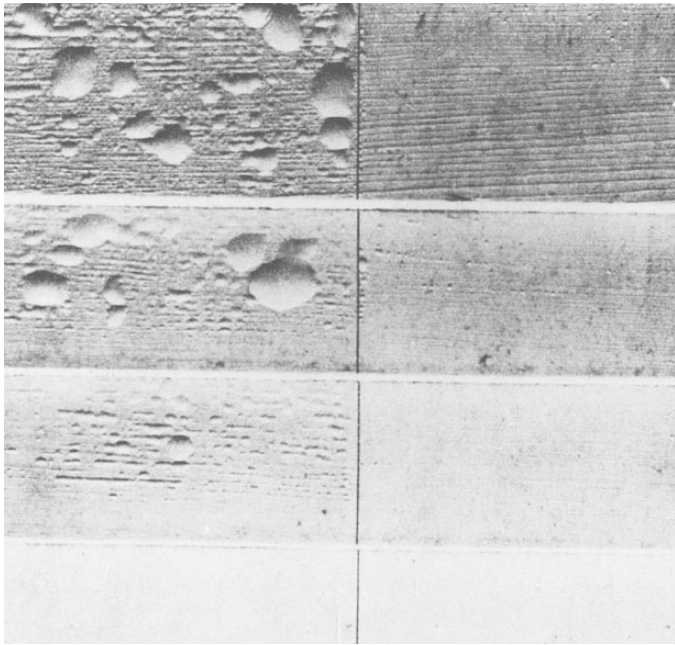


Figure 8-5.—Blistering.

IMPROPER APPLICATION

One particular area you, as a Builder, have direct control over is application. It takes a lot of practice, but you should be able to eliminate the two most common types of application defects: crawling and wrinkling.

Crawling

Crawling (fig. 8-6) is the failure of a new coat of paint to wet and form a continuous film over the preceding coat. This often happens when latex paint is applied over high-gloss enamel or when paints are applied on concrete or masonry treated with a silicone water repellent.

Wrinkling

When coatings are applied too thickly, especially in cold weather, the surface of the coat dries to a skin over a layer of undried paint underneath. This usually causes wrinkling (fig. 8-7). Wrinkling can be avoided in brush painting or roller painting by brushing or rolling each coat of paint as thinly as possible. In spray painting, you can avoid wrinkling by keeping the gun in constant motion over the surface whenever the trigger is down.

PAINT DEFECTS

Not all painting defects are caused by the individual doing the job. It sometimes happens that the coating itself is at fault. Chalking, checking, and cracking are the most common types of product defects you will notice in your work as a Builder.

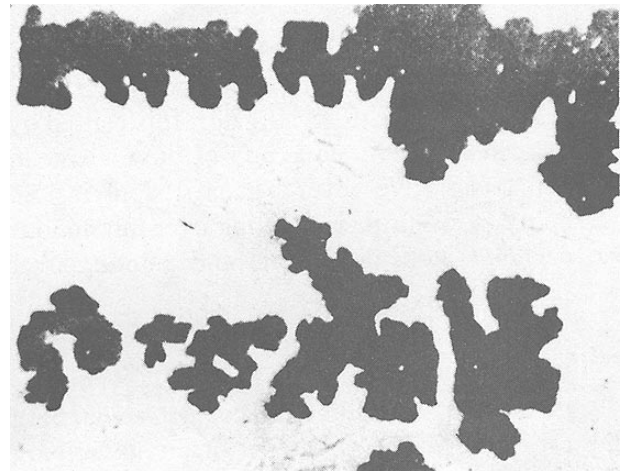


Figure 8-6.-Crawling.

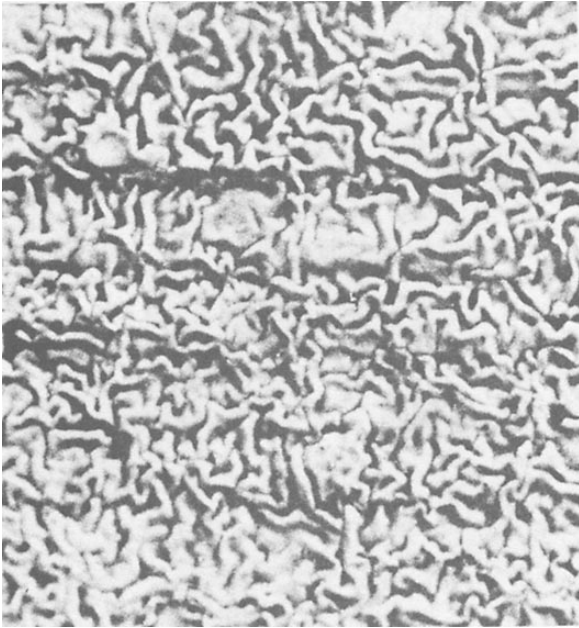


Figure 8-7.—Wrinkling.

Chalking

Chalking (fig. 8-8) is the result of paint weathering at the surface of the coating. The vehicle is broken down by sunlight and other destructive forces, leaving behind loose, powdery pigment that can easily be rubbed off with the finger. Chalking takes place rapidly with soft paints, such as those based on linseed oil. Chalking is most rapid in areas exposed to sunshine. In the Northern Hemisphere, for example, chalking is most rapid on the south side of a building. On the other hand, little chalking takes place in areas protected from sunshine and rain, such as under eaves or overhangs. Controlled chalking can be an asset, especially in white paints where it acts as a self-cleaning process and helps to keep the surface clean and white. The gradual wearing away reduces the thickness of the coating, thus

allowing continuous repainting without making the coating too thick for satisfactory service.

Do not use a chalking or self-cleaning paint above natural brick or other porous masonry surfaces. The chalking will wash down and stain or discolor these areas.

Chalked paints are generally easier to repaint since the underlying paint is in good condition and requires little surface preparation. But, this is not the case with water-thinned paints; they adhere poorly to chalky surfaces.

Checking and Cracking

Checking and cracking are breaks in a coating formed as the paint becomes hard and brittle. Temperature changes cause the substrate and overlying paint to expand and contract. As the paint becomes hard, it gradually loses its ability to expand without breaking. Checking (fig. 8-9) consists of tiny breaks in only the upper coat or coats of the paint film

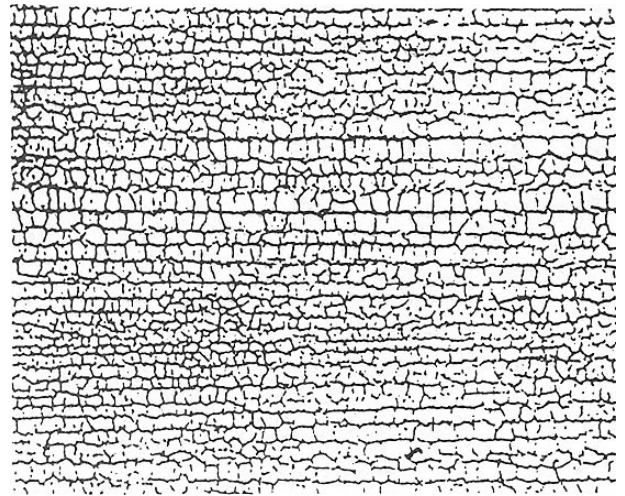


Figure 8-9.—Severe checking.

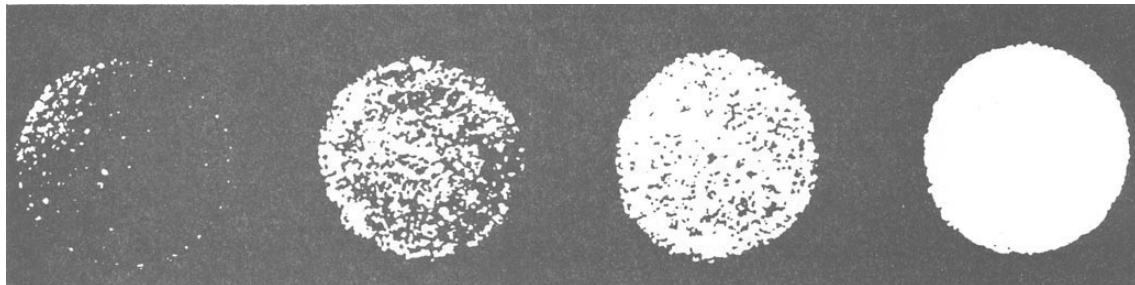


Figure 8-8.—Degrees of chalk.

without penetrating to the substrate. The pattern is usually similar to that of a crow's foot. Cracking is larger with longer breaks extending through to the substrate (fig. 8-10). Both result from stresses exceeding the strength of the coating. But, whereas checking arises from stress within the paint film, cracking is caused by stresses between the film and the substrate.

Cracking generally takes place to a greater extent on wood, due to its grain, than on other substrates. The stress in the coating is greatest across the grain, causing cracks to form parallel to the grain of the wood. Checking and cracking are aggravated by excessively thick coatings that have reduced elasticity. Temperature variations, humidity, and rainfall are also concerns for checking or cracking.

WOOD PRESERVATIVES

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe how to treat wood for protection against dry rot, termites, and decay.

There are three destructive forces against which most wood protective measures are directed: biological deterioration (wood is attacked by a number of organisms), fire, and physical damage. In this section, we'll deal with protecting wood products against biological deterioration.

Damage to wood buildings and other structures by termites, wood bores, and fungi is a needless waste. The ability of wood to resist such damage can be greatly

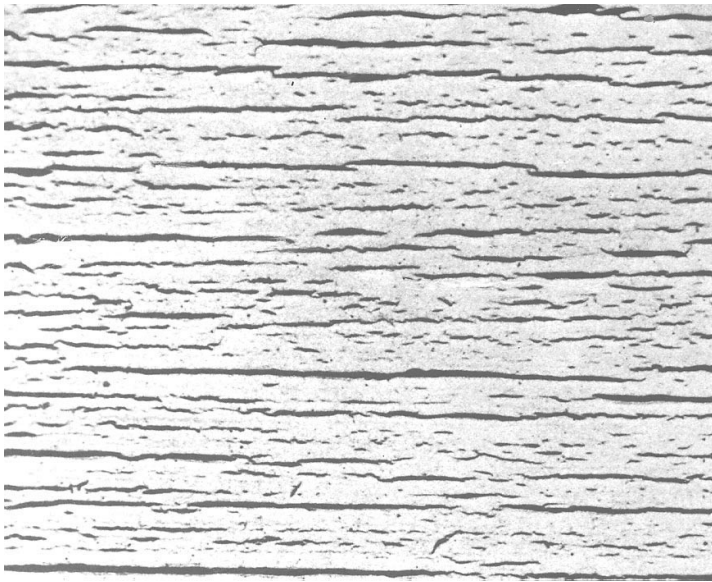


Figure 8-10.-Severe cracking.

increased by proper treatment and continued maintenance. Wood defects are also caused by improper care after preservation treatment. All surfaces of treated wood that are cut or drilled to expose the untreated interior must be treated with a wood preservative.

APPLICATION METHODS

There are two basic methods for treating wood: pressure and nonpressure. Pressure treatment is superior to nonpressure, but costly and time consuming. Building specifications dictate which method to use.

Pressure

The capacity of any wood to resist dry rot, termites, and decay can be greatly increased by impregnating the wood with a general-purpose wood preservative or fungicide. It's important to remember that good **pressure** treatment adds to the service life of wood in contact with damp ground. It does not, however, **guarantee** the wood will remain serviceable throughout the life of the building it supports.

Woods of different timber species do not treat with equal ease. Different woods have different capacities for absorbing preservatives or other liquids. In any given wood, sapwood is more absorbent than heartwood. Hardwoods are, in general, less absorbent than softwoods. Naturally, the extent to which a preservative protects increases directly with the depth it penetrates below the surface of the wood. As we just mentioned, the best penetration is obtained by a pressure method. Table 8-4 shows the ease of preservative penetration into various woods. In the table, use E for easy, M for moderate, and D for difficult.

Nonpressure

Nonpressure methods of applying preservatives to a surface include dipping, brushing, and spraying. Figure 8-11 shows how you can improvise long tanks for the dipping method. Absorption is rapid at first, then much slower. A rule of thumb holds that in 3 minutes wood absorbs half the total amount of preservative it will absorb in 2 hours. However, the extent of the penetration depends upon the type of wood, its moisture content, and the length of time it remains immersed.

Surface application by brush or spray is the least satisfactory method of treating wood from the

Table 8-4.—Preservative Penetration

SPECIES	RELATIVE EASE OF GETTING PENETRATION INTO	
	Sapwood	Heartwood
Pines (most species)	E	M to D
Ponderosa pine	E	M
White fir	E	M
Most other true firs	E to M	D
Eastern hemlock	M	D
Western hemlock	E	E to M
Redwood	M to D	M to D
Douglas fir (Coast)	E to M	M to D
Douglas fir (Rocky Mountain)	D	D
Western larch	E	D
Sitka spruce	M	M
Most other spruces	D	D
Western red cedar	D	D
White oak	E	D
Selected red oaks	E	E

Notes: E—Easy; M—Moderate; D—Difficult

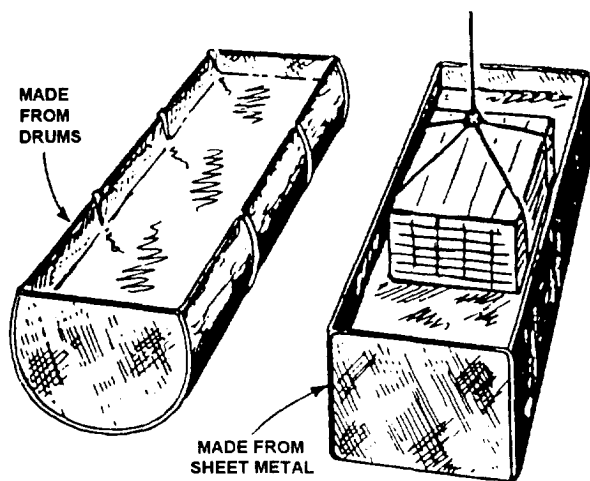


Figure 8-11.—Improvised tanks for dip treating lumber.

standpoint of maximum penetration. However, it is more or less unavoidable in the case of already installed wood, as well as treated wood that has been cut or drilled to expose the untreated interior.

FIELD-MIXED PRESERVATIVES

Pentachlorophenol and creosote coal tar are likely to be the only field-mixed preservatives used by the

Builder. The type of treatment or preservative depends on the severity of exposure and the desired life of the end product.

Preservatives can be harmful to personnel if improperly handled. When applying preservatives, you should take the following precautions:

- Avoid undue skin contact;
- Avoid touching the face or rubbing the eyes when handling pretreated material;
- Avoid inhalation of toxic (poisonous) material;
- Work only in a properly ventilated space and use approved respirators; and
- Wash with soap and water after contact.

PAINTING SAFETY

LEARNING OBJECTIVE: Upon completing this section, you should be able to state the principal fire and health hazards associated with painting operations.

Every painting assignment exposes Builders to conditions and situations representing actual or potential danger. Toxic and flammable materials,

pressurized equipment, ladders, scaffolding, and rigging always make painting a hazardous job. Hazards may also be inherent in the very nature of the environment or result from ignorance or carelessness by the painter.

The main causes of painting accidents are unsafe working conditions or equipment, and careless personnel. The proper setting up and dismantling of equipment, the required safety checks, and the proper care of equipment may require more time than is spent using it. Nevertheless, safety measures must be taken.

FIRE HAZARDS

Certain general rules regarding fire and explosion hazards apply to all situations. All paint materials should have complete label instructions stipulating the potential fire hazards and precautions to be taken. Painters must be advised and reminded of the fire hazards that exist under the particular conditions of each job. They need to be aware of the dangers involved and the need to work safely. Proper fire-fighting equipment must always be readily available in the paint shop, spray room, and other work areas where potential fire hazards exist. Electric wiring and equipment installed or used in the paint shop, including the storage room and spray room, must conform to the applicable requirements of the National Electrical Code (NEC) for hazardous areas.

HEALTH HAZARDS

Many poisons, classified as toxic and skin-irritating, are used in the manufacture of paint. Although your body can withstand small quantities of poisons for short periods, overexposure can have

harmful effects. Continued exposure to even small amounts may cause the body to become sensitized; subsequent contact, even in small amounts, may cause an aggravated reaction. The poisons in paint are definite threats to normally healthy individuals and serious dangers to persons having chronic illnesses or disorders. Nevertheless, health hazards can be avoided by a common-sense approach of avoiding unnecessary contact with toxic or skin-imitating materials.

As with all tasks the Builder undertakes, safety must be a primary concern from the earliest planning stages to the final cleanup. Shortcuts, from personnel protection to equipment-related safety devices, should not be permitted. Follow the project safety plan, and consult all applicable safety manuals when involved with any paint operation. Remember, work safe, stay safe.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Paints and Protective Coatings, NAVFAC MO-110, Departments of the Army, Navy, and Air Force, Washington, D.C., 1991.

Wood Preservation, NAVFAC MO-312, Department of the Navy, Naval Facilities Engineering Command, Washington, D.C., 1968.

CHAPTER 9

ADVANCED BASE FIELD STRUCTURES AND EMBARKATION

The primary responsibility of the Seabees is the construction of advanced bases during the early phases of crises and other emergency situations. As Builders, it is our job to move swiftly to hostility areas and build temporary facilities and structures to support U.S. military operations. We are expected to react expediently.

The most widely used structure for expediency and as a temporary facility is the preengineered building. This chapter covers the process involved with the erection of such buildings, as well as wood-frame tents, latrines, and the process of embarkation.

PREENGINEERED BUILDINGS

LEARNING OBJECTIVE: Upon completing this section, you should be able to explain the principles and procedures involved in the preparation and erection of preengineered metal buildings.

The preengineered building (PEB) discussed here is a commercially designed structure, fabricated by civilian industry to conform to armed forces specifications. A preengineered structure offers an advantage in that it is designed for erection in the shortest possible time. Each PEB is shipped as a complete building kit. All necessary materials and instructions for erection are included. Preengineered structures are available from various manufacturers.

The typical PEB is a 40- by 100-foot structure. The 20- by 48-foot PEB is a smaller version of the 40- by 100-foot PEB using the same erection principles. Layout and erection of either size PEB is normally assigned to Builders.

PREPLANNING

A preplan of the erection procedures should be made based on a study of the working drawings or manufacturers' instructions. Preplanning should include the establishment of the most logical and expeditious construction sequence. Consideration should be given to the manpower, equipment, rigging, and tools required. Everything necessary for erection should then be procured. The advantages of constructing and using

jigs and templates for assembling parts of similar trusses, frames, and so on, should also be evaluated.

Although Builders must be familiar with the layout and erection procedures for both the 40- by 100-foot and the 20- by 48-foot PEBs, we will use the 20- by 48-foot rigid-frame, straight-walled PEB as the model for our discussion. This building is prefabricated and shipped in compact crates ready for erection. Each structure is shipped as a complete kit, including all materials and an instruction manual. It is extremely important to follow the manual; you can easily install a part incorrectly.

The 20- by 48-foot rigid-frame building is designed for erection with basic hand tools and a minimum number of people. The instruction manual may suggest the PEB can be erected by seven persons. For military construction, though, two teams or work crews supervised by an E-6 are recommended. The building is designed for erection on a floor system of piers, concrete blocks, or a concrete slab.

When completed, a single rigid-frame building is easy to expand for additional space. Buildings can be erected end to end, as in figure 9-1, or side by side "in multiple." As this type of building uses only bolted connections, it can be disassembled easily, moved to a new location, and re-erected without waste or damage.

Component Parts

The component parts of a prefabricated structure are shipped knocked down (KD). A manufacturer's instruction manual accompanies each shipment. The manual contains working drawings and detailed instructions on how the parts should be assembled. Directions vary with different types of structures, but there are certain basic erection procedures that should be followed in all cases.

Working Drawings

The working drawings show which items are **not** prefabricated or included in the shipment. These must be constructed in the field. Make plans in advance for the procurement of necessary materials for these items. Foundations, for example, are often designated "to be constructed in the field."

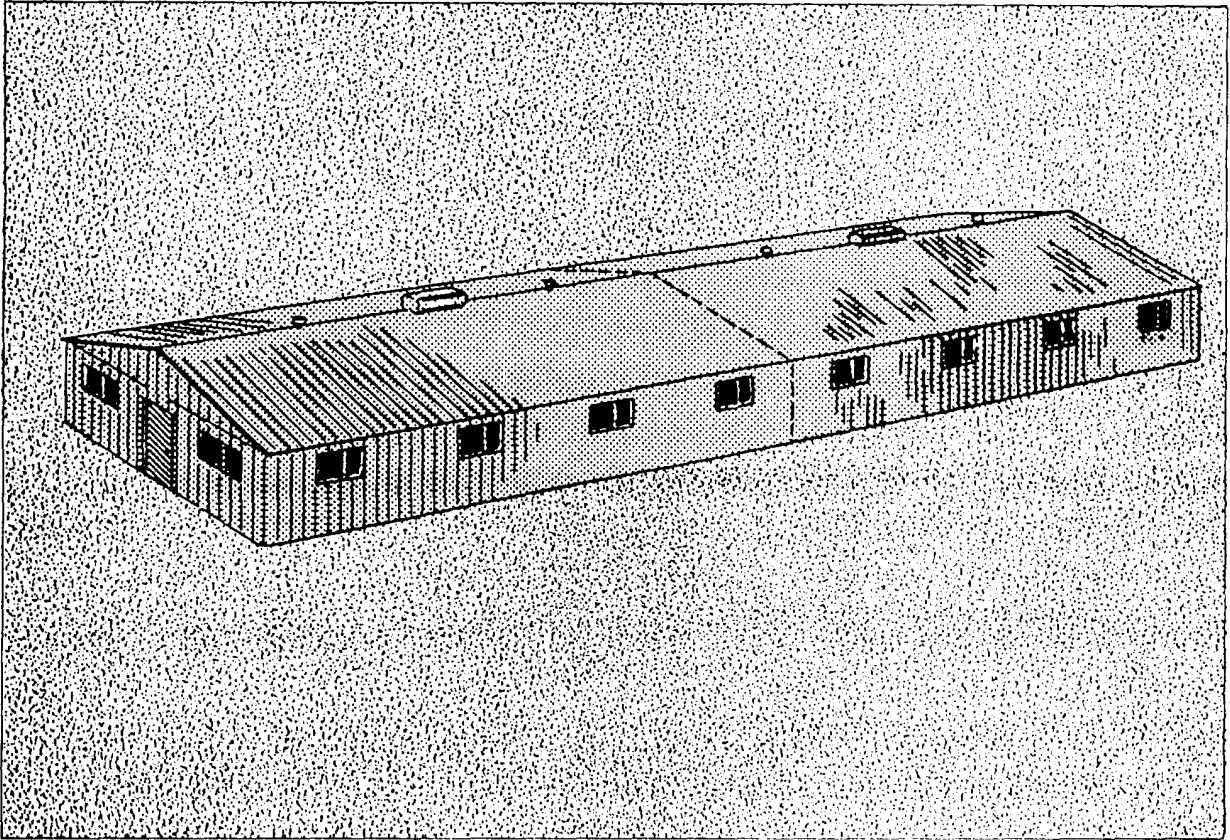


Figure 9-1.—Two 20- by 48-foot rigid-frame, preengineered buildings erected end to end.

FOUNDATIONS

In addition to the usual reasons for stressing the importance of a square and level foundation, there is another reason peculiar to the erection of a pre-fabricated structure. Prefabricated parts are designed to fit together without forcing. If the foundation is even slightly out of square or not perfectly level, many of the parts will not fit together as designed. Continuously check the alignment of the anchor bolts prior to, during, and after concrete is poured.

PREELECTION WORK

A lot of preliminary work is necessary before the erection of a PEB can begin. After the building site is selected, prepare to pour the foundation and slab.

Before concrete for the foundation piers can be poured, templates for the anchor bolts are placed on the forms, and anchor bolts are inserted in the holes. The threads of the bolts are greased and nuts are placed on them to protect the threads from the concrete. After a last-minute check to ensure all forms are level and the anchor bolts are properly aligned, concrete is placed in

the forms and carefully worked around the bolts so they remain vertical and true.

While the foundation is being prepared, other crewmembers are assigned various kinds of preliminary work. This work includes uncrating material and inventory, bolting up rigid-frame assemblies, assembling door leaves, and glazing windows. When all preliminary work is properly completed, assembly and erection of the entire building are quicker and you have fewer problems.

All materials, except paneling, should be uncrated and laid out in an orderly manner so parts can be easily found. Don't uncrate paneling until it is ready to install. When the crates are opened, don't damage the lumber; you can use it for scaffolding, props, and sawhorses.

After the building foundation has been prepared, and where practical, building materials should be placed on the building site near the place where they will be used. Girts, purlins, cave struts, and brace rods should be equally divided along each side of the foundation. Panels and miscellaneous parts that will not be used immediately should be placed on boards on each side of the foundation and covered with tarpaulins or

similar covering until needed. Parts making up the rigid-frame assemblies should be laid out ready for assembly and in position for raising.

Always exercise care when unloading materials.

Remember: Damaged parts can delay getting the job done in the shortest possible time. To avoid damage, lower the materials to the ground—don't drop them.

ERECTION

Figure 9-2, view A, will help you identify the various structural members of a PEB and their locations. View B shows the placement of liner panels. Each part serves a specific purpose and must be installed in the proper location to ensure a sound

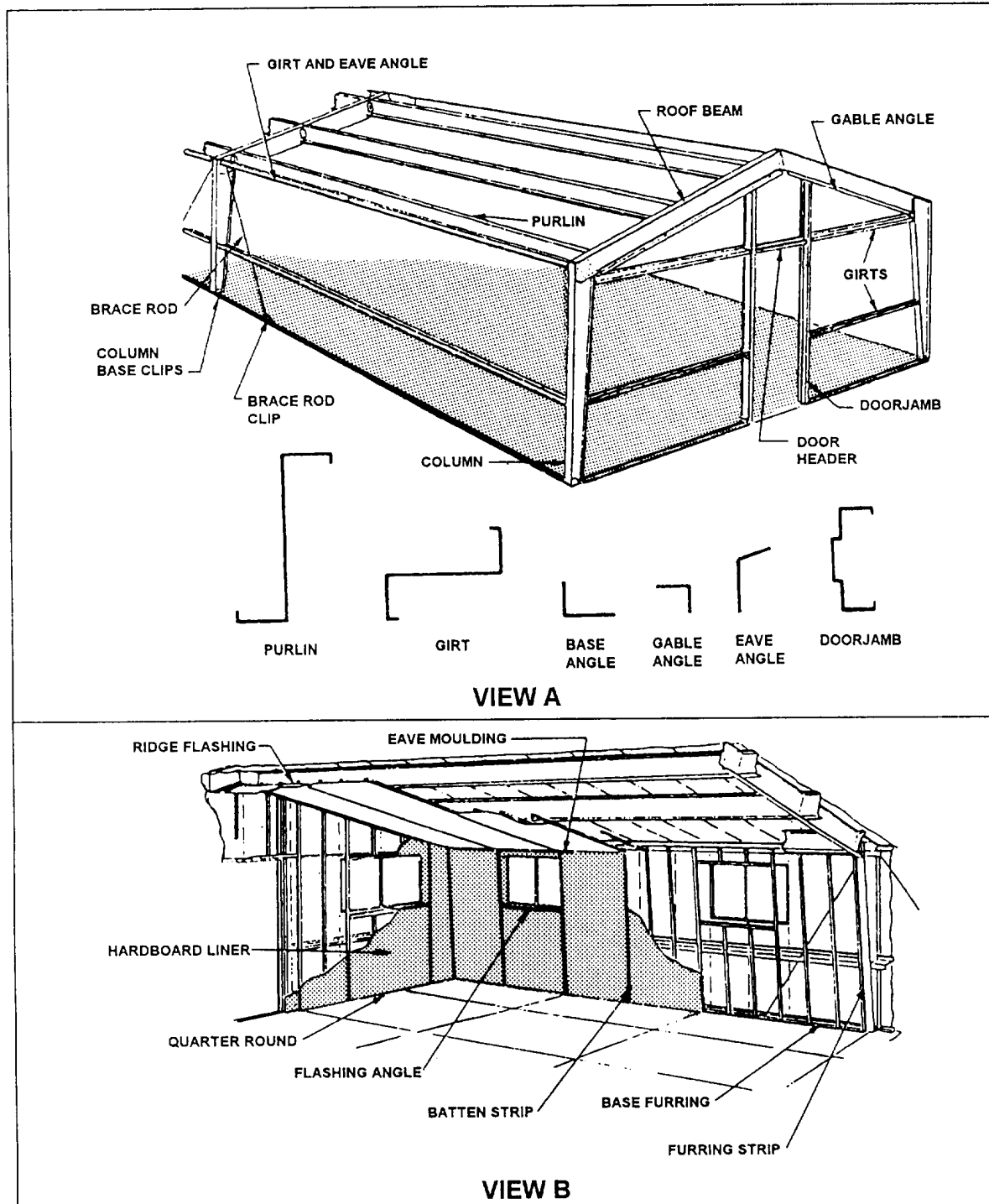


Figure 9-2.—Identification of the structural members (view A) and the liner panels (view B).

structure. Never omit any part called for on the detailed erection drawings. Each of the members, parts, and accessories is labeled by stencil; it is not necessary to guess which part goes where. Refer to the erection plans and find the particular members you need as you work.

High-strength steel bolts are used at rigid-frame connections: roof-beam splice and roof beam to column. These high-strength bolts are identified by a Y stamped into the head, as shown in figure 9-3. All high-strength steel bolts and nuts should be tightened to give at least the required minimum bolt tension values. The bolts may be tightened with a torque wrench, an impact wrench, or an open-end wrench.

When a PEB is not erected on a concrete slab, a floor system by the same manufacturer should be used. Read and follow the manufacturer's instructions when you are installing the floor system.

Layout

After the floor system or concrete slab has been prepared, the next step is to uncrate and lay out the structural parts. Lay the parts out in the following manner:

- Parts making up the frame assembly should be laid out, ready for assembly and in position for raising.
- Girts, purlins, and base angles should be divided (equally) along each side of the foundation.
- End-wall parts should be divided equally between the two ends.

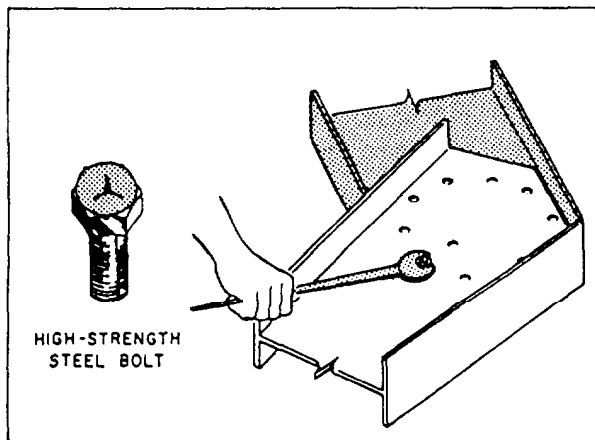


Figure 9-3.—High-strength steel bolt.

- All miscellaneous parts should be centrally located.
- Panels and other parts not used immediately should be placed on boards and protected from the environment and jobsite debris.
- Lay out the column and roof beams for assembly, using crate lumber to block up the frames. Erect the center frame first. Use the minimum number of high-strength bolts to bring the frame members together. Install the remaining bolts to get the proper tightness.

Exterior Assembly

Use galvanized machine bolts to assemble the girt and purlin clips to the frame. Keep in mind that the end frames have girt and purlin clips on one side only. The center frame has girt and purlin clips on each side of the frame.

The eave girts should be attached to the eave angles with 5/16-inch left-hand nuts and shoulder bolts. An example is shown in figure 9-4. You will need two eave angles for each eave girt. In fastening these together, remember the short section of the eave angle is always fastened to the left side of the eave girt. The long section of the eave angle is fastened to the right side of the eave girt.

Use 3/8- by 1-inch galvanized machine bolts to attach the gable angle and doorjamb top clips to the bottom flange of the end frame roof beams.

A-FRAME.— To erect the frame, place A-frame props in position—one 8-foot frame at each side of the building and a 10-foot frame in the center of the

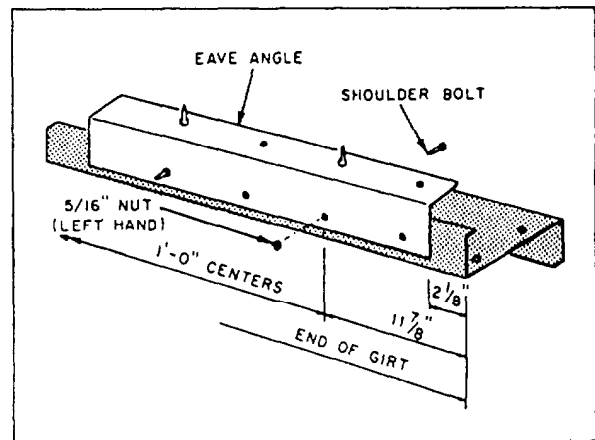


Figure 9-4.—Attaching eave angle to girt.

building (see fig. 9-5). Prop the frame on two sawhorses and attach tag lines to assist in raising the ridge. Raise the frame and brace it up with the A-frames. The end frames are erected in a similar manner, except that they are held in position by installing purlins and girts.

BRACE RODS.— After all sidewall girts, cave girts, and base angles have been installed, install the brace rods. Look at figure 9-6. First, attach brace rod clips to the floor. Then, insert the end of the brace rod down through the hole in the sidewall girt. Connect the top end through the cave girt and the cave girt clip. Finally, connect the bottom end through the clip on the floor.

As soon as the four brace rods are in position, use them to plumb the building. To plumb the rigid frame, tighten or loosen the rod nuts at the brace rod clips to adjust the column to plumb condition. Don't forget: When you tighten one side, the other side must be loosened.

To make sure you are installing the end-wall members correctly, snap a chalk line across the building, using one edge of the columns for positioning the line. Mark the center of the building on this line. Then, drop a plumb bob from the center of the joint of the roof beams at the ridge, with the line over the same side of the roof beam as the chalk line. Adjust the frame so

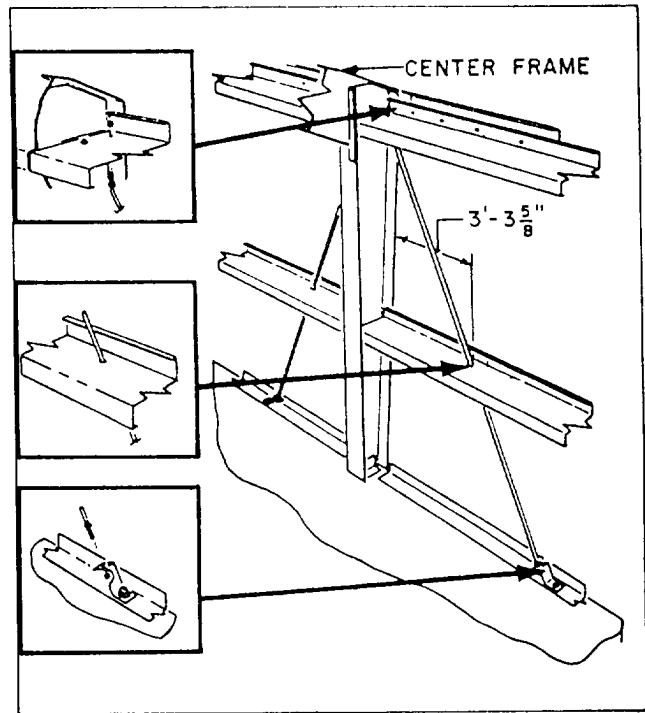


Figure 9-6. Installing brace rods.

the plumb bob is directly over the center mark. Brace the roof beam in this position until the roof panels are in place.

EXTERIOR WALLS.— Uncrate exterior panels and distribute them near where they will be used. First, separate and place panels for each end wall. Place full-length wall panels for each corner. Centrally locate lower and upper sidewall panels and above and below window panels, along each side of the building. Place roof and ridge panels in stacks of eight each on the floor. Make sure you fashion all joints properly. Next, tighten all fasteners using metal-backed neoprene washers with all roof fasteners and with all shoulder bolts in the sidewalls. Then, properly apply black mastic or sealant to all roof panel side laps and end laps.

Start paneling the end wall at one corner and work across to the other corner. Install the corner panel, locating the bottom of the panel over the first two shoulder bolts in the base angle. Use a level to plumb this panel with the other shoulder bolts located at the center of the corrugations. Locate the "below window panel" over the base angle shoulder bolts, and impale over the shoulder bolts. Remove the panel and reinstall it so that it underlaps the first panel by pulling out on the corrugated edge of the first panel.

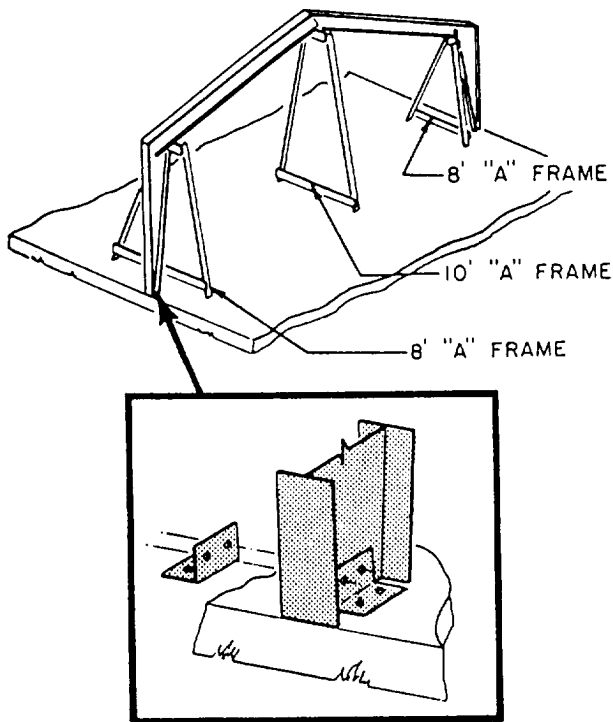


Figure 9-5. Frame erection with A-frame props.

For installing paneling and windows, follow the same general instructions as those given for the end wall. However, be sure that the girts are in a straight line before impaling panels onto shoulder bolts. It is important to block the girts in a straight line with crating lumber cut to the correct length. The drawings should be checked for proper location of shoulder bolts. The first shoulder bolt should be 12 inches from the center of the column, then 12 inches on center (OC).

Recheck the plumb of the center frame. Adjust the brace rods to plumb if necessary. Check the drawings for the location of base angles.

The upper wall panels must overlap the lower wall panels for weathertightness. Remember to use metal-backed neoprene washers and No. 10 hex nuts on shoulder bolts. Use machine screws (1/4 by 3/4 inch) for panel-to-panel connections at side laps.

ROOF ASSEMBLIES.— Since the roof panels are factory-punched for panel-to-purlin connection, the purlins must be accurately aligned. Spacer boards constructed from crating lumber can be used to align purlins, as shown in figure 9-7. Move the spacer boards ahead to the next bay as the paneling progresses. Before you actually start paneling the roof, place the spacer board over the shoulder bolts and insert nails in the 5/16-inch holes in the ridge purlins.

Start roof paneling at one end of the building. Place the panels so the holes in the corrugation lineup with the shoulder bolts in the roof beam, cave angles, and ridge purlins. Install one eave panel to each side of the building. The eave panels should be installed

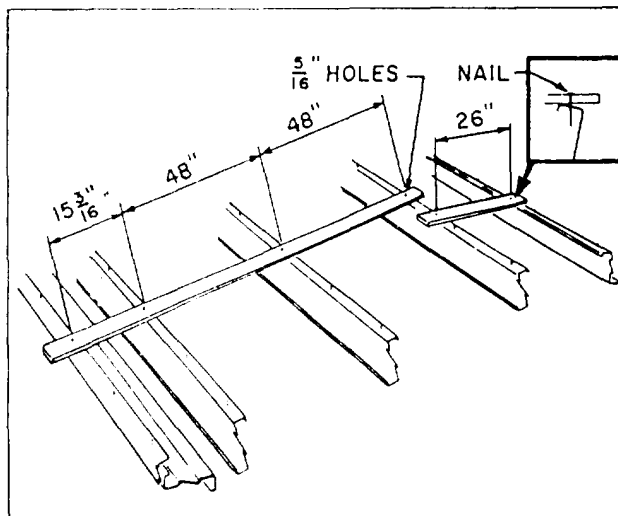


Figure 9-7.-Aligning purlins with spacer board.

one row ahead of the ridge panels (see fig. 9-8). Before proceeding with the work, make sure you are applying enough black mastic or sealant. Roof paneling should continue in this order to ensure a weathertight joint at the corner laps. However, you should check the drawings for the location and installation of the smoke stacks and ridge ventilation.

DOORS AND WINDOWS.— Doorjambs can be hung anytime after the end-wall structural parts are completed. But, they must be hung before installing the interior lining. A helpful hint is to hang the doors before installing the exterior end-wall paneling. This makes adjustments on the door frame easier.

Hinges are factory-welded to the doorjamb, and the entrance doors are supposed to swing to the inside of the building. Remove the hinge leaf from the doorjamb and attach it to the door with 1-inch No. 10 flathead wood screws. Hang the door and make adjustments to get the proper clearances at the top and sides of the door. Install the lockset in the door and attach the faceplate to the door with 3/4-inch No. 8 flathead wood screws. Attach the strike plate to the doorjamb with 1/2-inch No. 8 flathead machine screws.

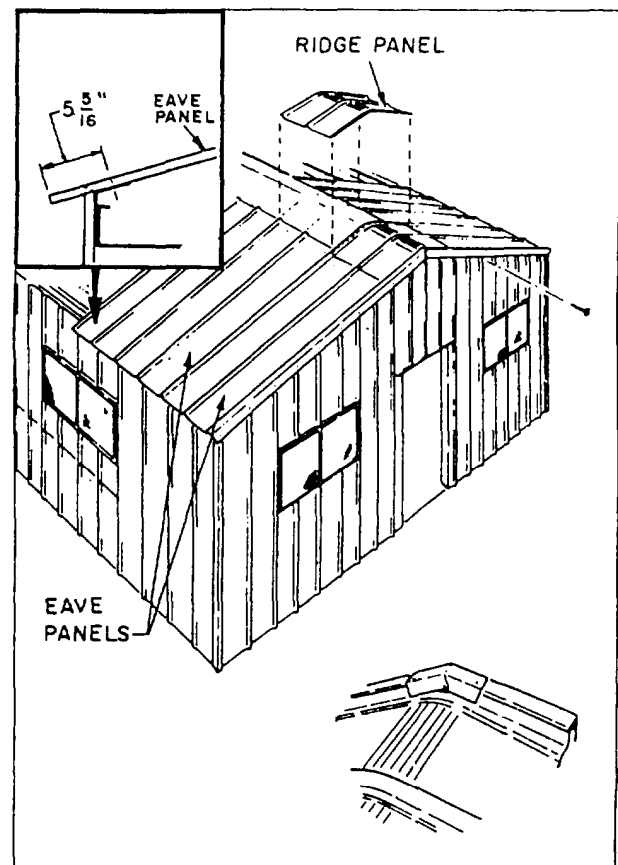


Figure 9-8.-Installing ridge and eave panels.

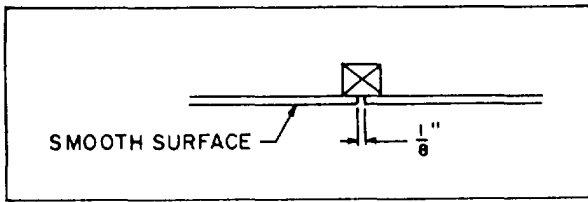


Figure 9-9.-Installing hardboard.

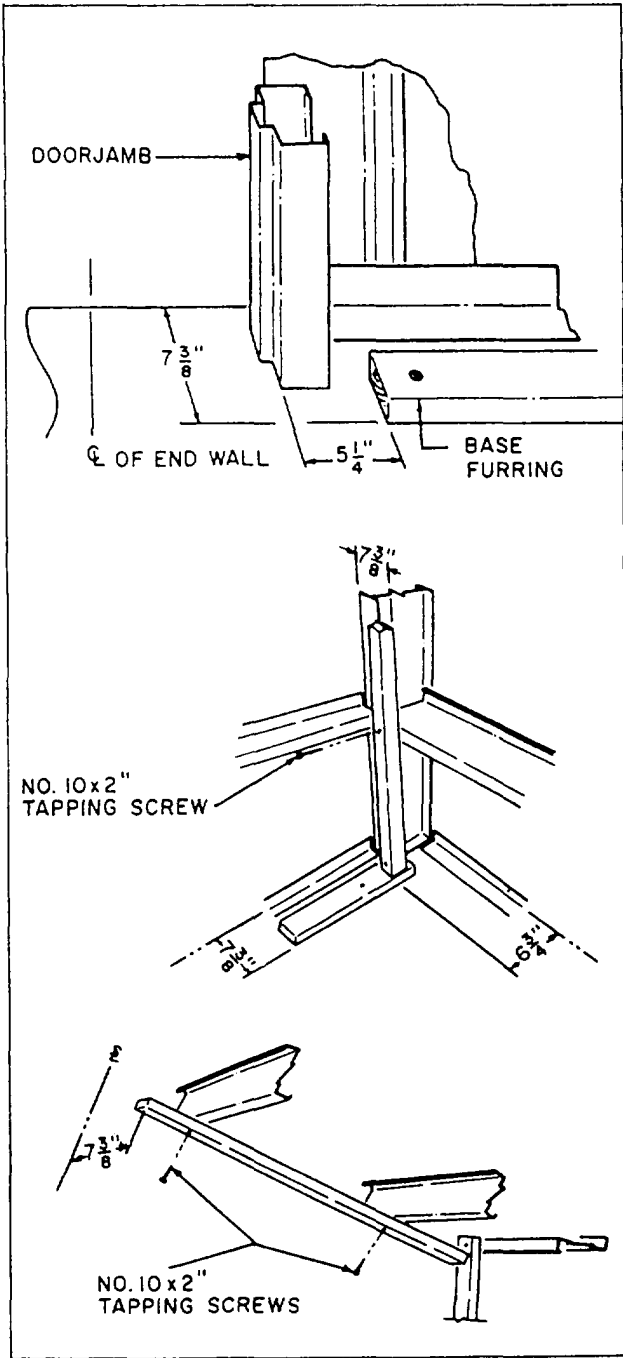


Figure 9-10.-Installing furring for the end-wall liners.

Hinges are also factory-welded to screen doors, which swing to the outside of the building. The method used in hanging screen doors is similar to hanging entrance doors. A spring, however, is needed to hold the screen door closed.

Interior Assembly

After the exterior members have been erected, work can begin on installing the interior assemblies. These include the liner panels, furring, hardboard flashing, and the trim.

LINER PANELS.— Installation of the liner panels consists of installing furring strips, hardboard liner panels, and trim and battens. Various liner panel parts were shown earlier in view B of figure 9-2.

To install end walls properly, precut the liner panels according to the cutting diagrams. The hardboard must be installed with the smooth surface exposed and with a 1/8-inch gap between panels to allow for expansion (fig. 9-9). A scrap piece of hardboard or batten can be used as a shim or spacer to maintain the proper gap.

BASE FURRING.— Nail the base furring to the floor 3 inches from each end and 2 feet 8 inches OC, with the inside edge 7 3/8 inches from the building structural line. You can get a better of this by referring to figure 9-10. When base furring is to be used on a wood floor, use 8d box nails. Use 1 1/4-inch No. 9 concrete nails for a concrete floor. Drill the 2 by 2s and girts with a 5/32-inch bit so furring can be attached to the sidewall and cave girt with 2-inch panhead No. 10 sheet-metal screws. Attach the hardboard to the furring strips with 1 1/4-inch aluminum shingle nails on 4-inch centers at the sides and ends (see fig. 9-11). Use 8-inch centers at the intermediate furring.

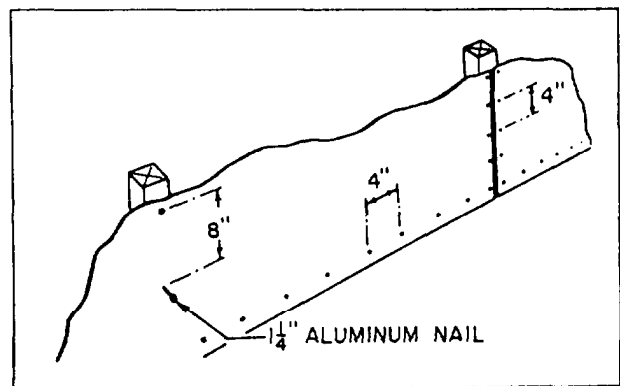


Figure 9-11.-Nailing pattern for attaching hardboard to furring.

VERTICAL FURRING.— The vertical furring (fig. 9- 12) should be installed immediately after the base, corner, and gable furrings are in place. The center line of the furring on each side of the window should be in line with the center line of the end-wall panel corrugations (shown in the inserts). After the end-wall hardboard has been installed, attach side and top flashing to the door. Attach flashing to the furring with 4d aluminum nails and to the door frames with 1/2-inch No. 10 sheet-metal screws, as shown in figure 9-13.

SIDEWALL AND CEILING FURRING.— After installing the end-wall liner, install furring for the sidewall and ceiling. Cut the base so the end just clears the inside flange of the center-frame column. Nail the furring in the same manner as the end walls.

HARDBOARD FLASHING.— With the furring in place, you can now install the hardboard liner. Install

the top and bottom hardboard flashing, as shown in figure 9-14. Insert the outside edge into the retaining grooves in the window. Nail metal flashing angle and hardboard to the horizontal furring with 4d aluminum nails 1 foot 8 inches OC. Install side hard-board flashing and metal flashing angles using the same procedures discussed above.

The installed ceiling furring should intersect side-wall furring. When all the ceiling furring has been installed, the hardboard liner can be installed. Remember the 1/8-inch gap between panels. The smoke stack assembly should be attached to the block- ing and furring with 4d aluminum nails. Hand trim the hard-board flashing for the ends of the ventilator opening and attach the metal ventilator flashing (see fig. 9- 15).

TRIM.— Install the cave molding with the beveled edge against the ceiling panels. Attach each sidewall furring strip with 4d aluminum nails. Use

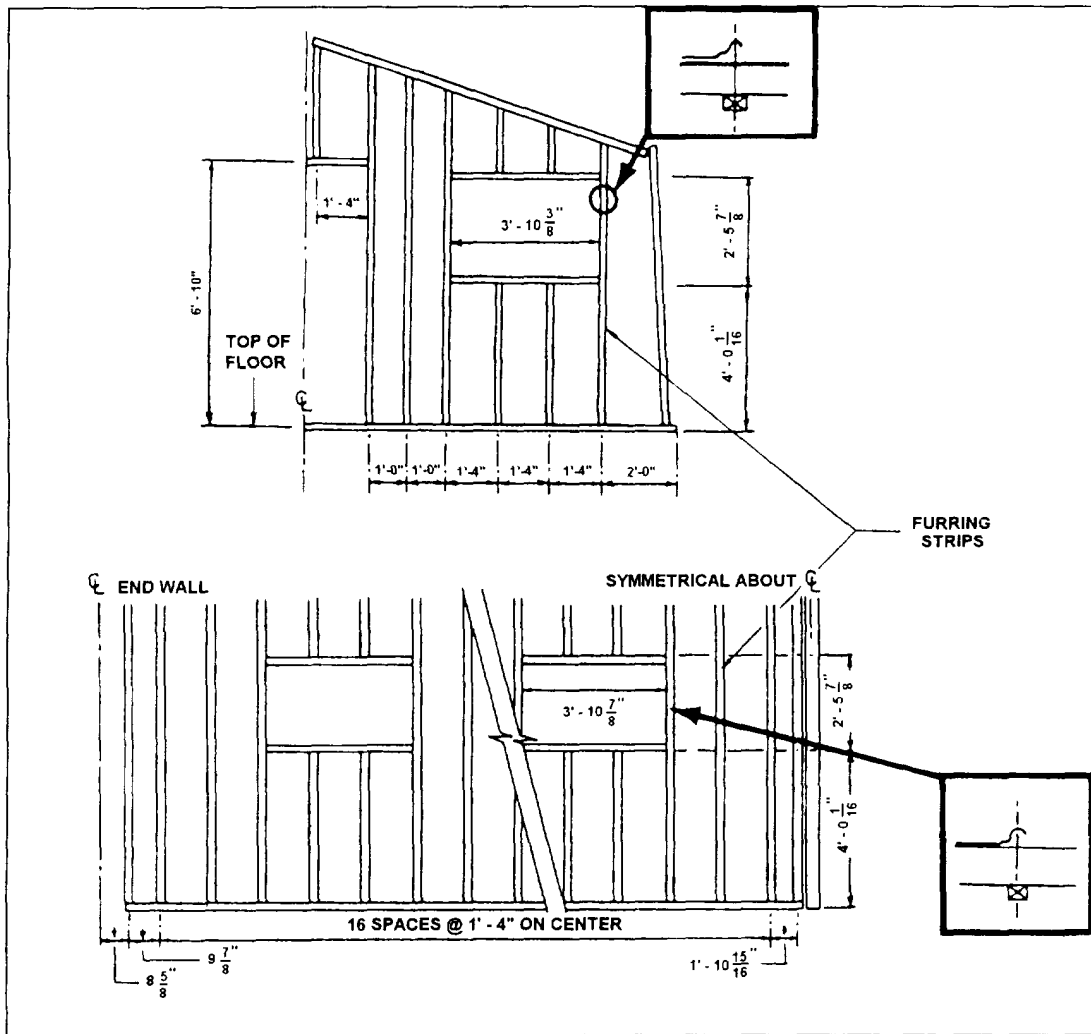


Figure 9-12.-Placing furring for liners.

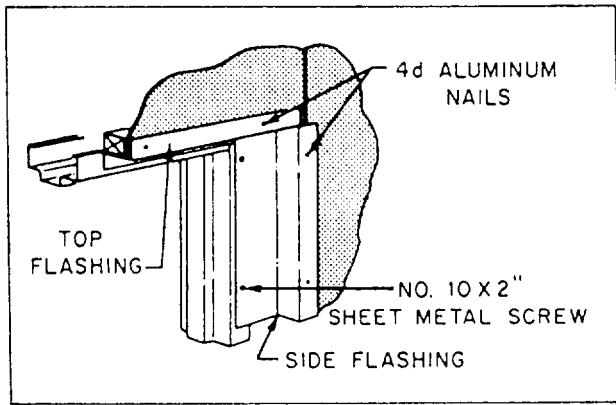


Figure 9-13.-Side and top flashing for the doors.

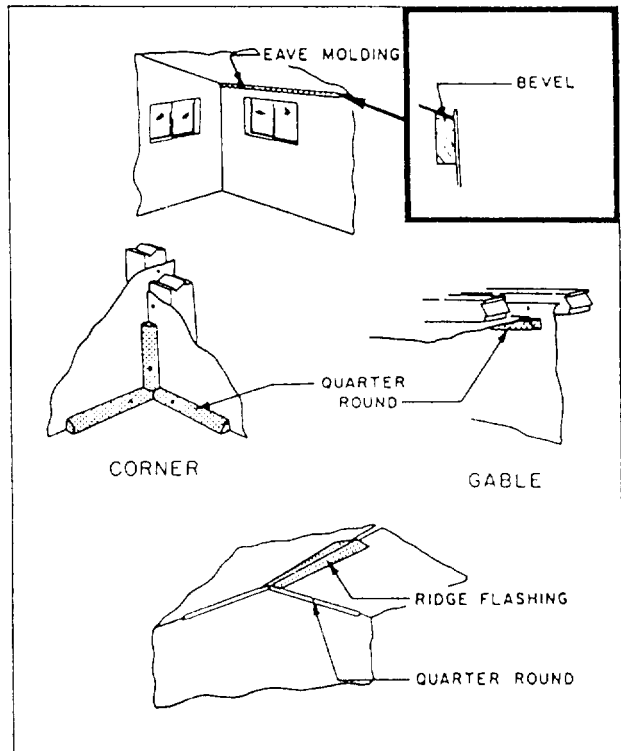


Figure 9-16.-Interior trim.

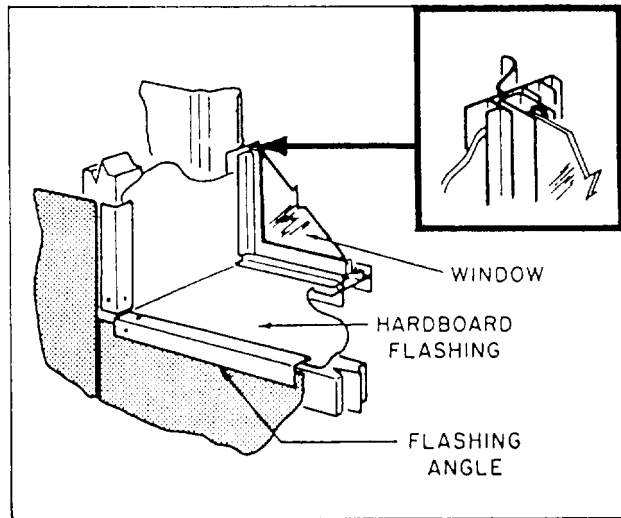


Figure 9-14.-Top and bottom hardboard flashing.

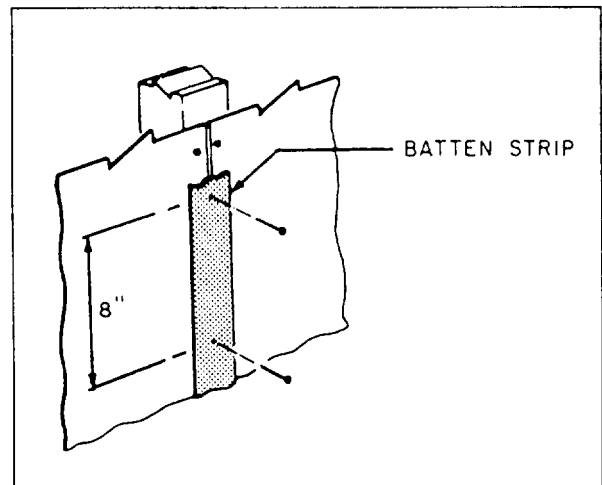


Figure 9-17.-Batten strip.

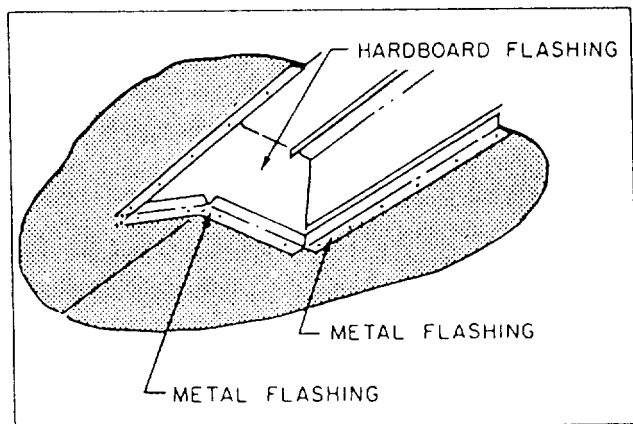


Figure 9-15.-Metal ventilator flashing.

quarter-round molding to trim the ceiling to the end wall, end wall to sidewall, and walls to floor. Use metal ridge flashing, as shown in figure 9-16, to trim the ridge of the ceiling liner. It can be attached to the ceiling furrings with 4d aluminum nails. Check the drawings to make sure you are installing it correctly. Next, cut battens to the required length and attach them to the furring with 4d aluminum nails, 8 inches OC. An example of this is shown in figure 9-17.

General Comments

Don't be careless with bolts, nuts, and miscellaneous fasteners just because they are furnished in quantities greater than actual requirements. Be careful when using these fasteners to prevent scattering them on the ground. Each evening, empty your pockets of fasteners and other small parts before leaving the erection site.

An extra amount of mastic or sealant is also furnished with each PEB. Here too, reasonable care in applying mastic to roof panels and roof accessories ensures an adequate supply.

Crating lumber can be used to construct an entrance platform and stairs at each end of a PEB. Figure 9-18 shows one way this might be done.

DISASSEMBLY PROCEDURES

Disassembly of a preengineered building should not be difficult once you are familiar with the erection procedures. Basically, it involves accurately marking the parts and following some basic steps.

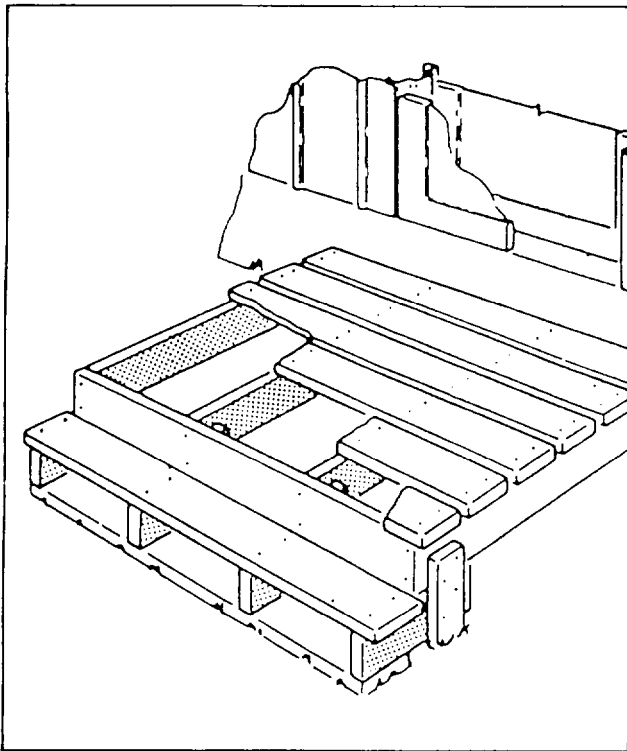


Figure 9-18. Crate platform.

Marking

It's obvious but worth repeating: In disassembling a building, be sure to clearly mark or number all parts. You will then know where the parts go when reassembling the building.

Steps

There are five main steps in disassembling a PEB:

1. Remove hardboard liner panels.
2. Remove windows, door leaves, and end wall.
3. Remove diagonal brace angles and sag rods.
4. Remove braces, girts, and purlins.
5. Let down frames.

Handling of the building components during disassembly is very important. You may have to reuse these same components again at another location. As you complete disassembly, protect those components from damage. Any damaged components will have to be replaced, and time might not be on your side.

WOOD-FRAME CONSTRUCTION

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the characteristics of wood-frame tents, SEA huts, and field-type latrines.

There are three basic types of wood-frame construction of concern to Builders: tents with wood frames for support; SEA huts (developed in Southeast Asia during the Vietnam war); and field latrines.

WOOD-FRAME TENTS

Figure 9-19 shows working drawings for framing and flooring of a 16- by 32-foot wood-frame tent. Tents of this type are used for temporary housing, storage, showers, washrooms, latrines, and utility spaces at an advanced base.

Tent floors consist of floor joists (16-foot lengths of 2 by 4s) and sheathing (4- by 8-foot sheets of 1/2-inch plywood). The supports for the floor framing are doubled 2 by 4 posts anchored on 2 by 12 by 12 mudsills. The wall-framing members are 2 by 4 studs, spaced 4-feet OC. The roof-framing members are 2 by 4 rafters, spaced 4-feet OC. The plates (2 by 4s) and the bracing members (1 by 6s) are fabricated in the field. A representative floor-framing plan for a

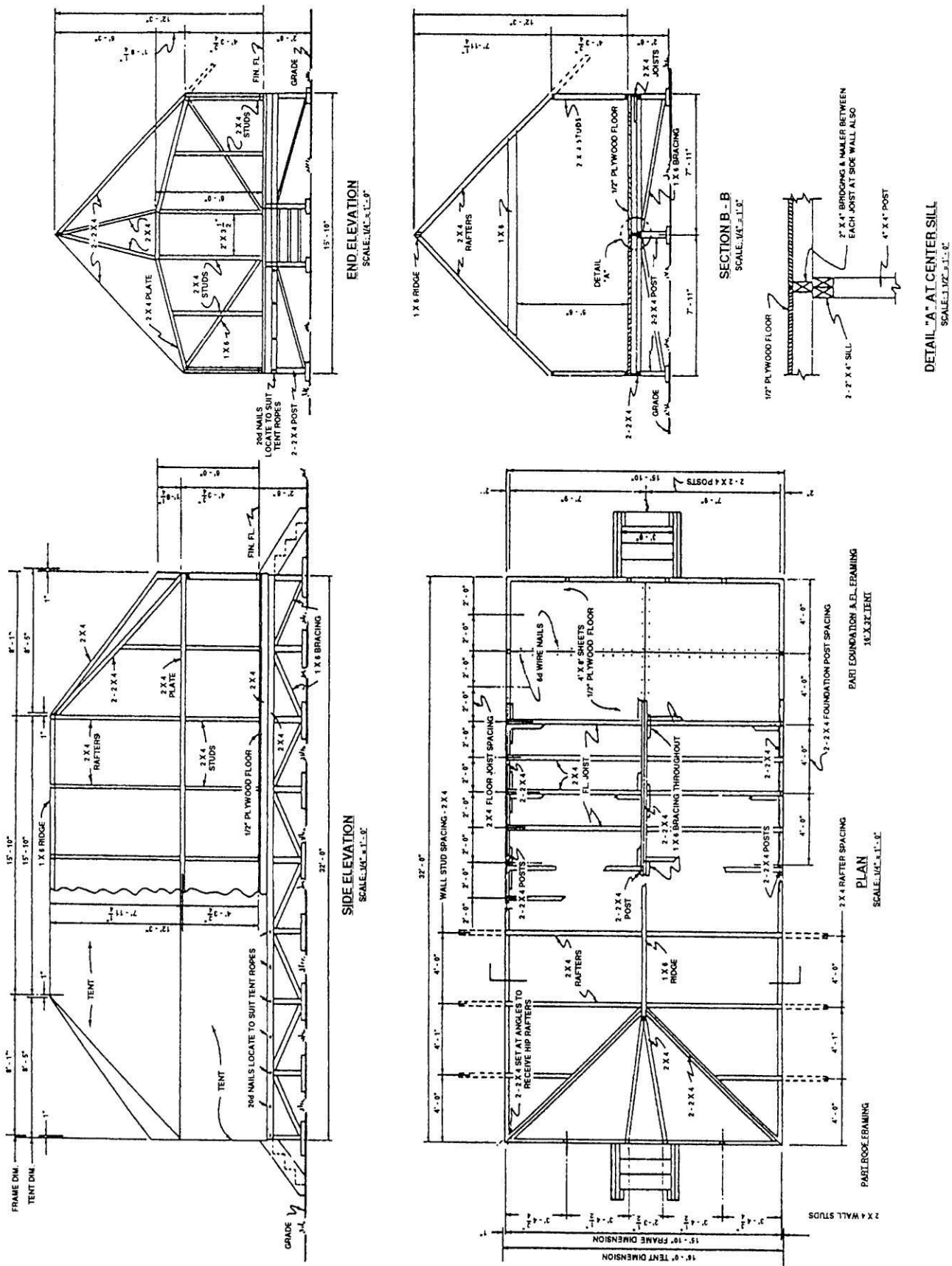


Figure 9-19.—Framing and flooring plans for a 16- by 32-foot wood-frame tent.

field-type shower and a washroom is shown in figure 9-20.

Basically, all field structures are derived from the 16- by 32-foot wood-frame tent. However, if more tent space is needed, a 40- by 100-foot model is available. This tent is not difficult to assemble because it is put together without a floor. It can be erected without a strongback frame since it comes complete with ridge pieces, poles, stakes, and line, and does not require framing. But no matter how easy erection may seem, **always read and follow the instructions.**

SEA HUT

When the 16- by 32-foot wood-frame tent is modified with a metal roof, extended rafters, and screened-in areas, it is called a Southeast Asia (SEA) hut. An example of the completed product is shown in figure 9-21. The SEA hut was originally developed in Vietnam for use in tropical areas by U.S. troops for berthing; but, it can readily be adapted for any use in any situation. It is also known as a strongback because of the roof and sidewall materials.

The SEA hut is usually a standard prefabricated unit, but the design can be easily changed to fit local

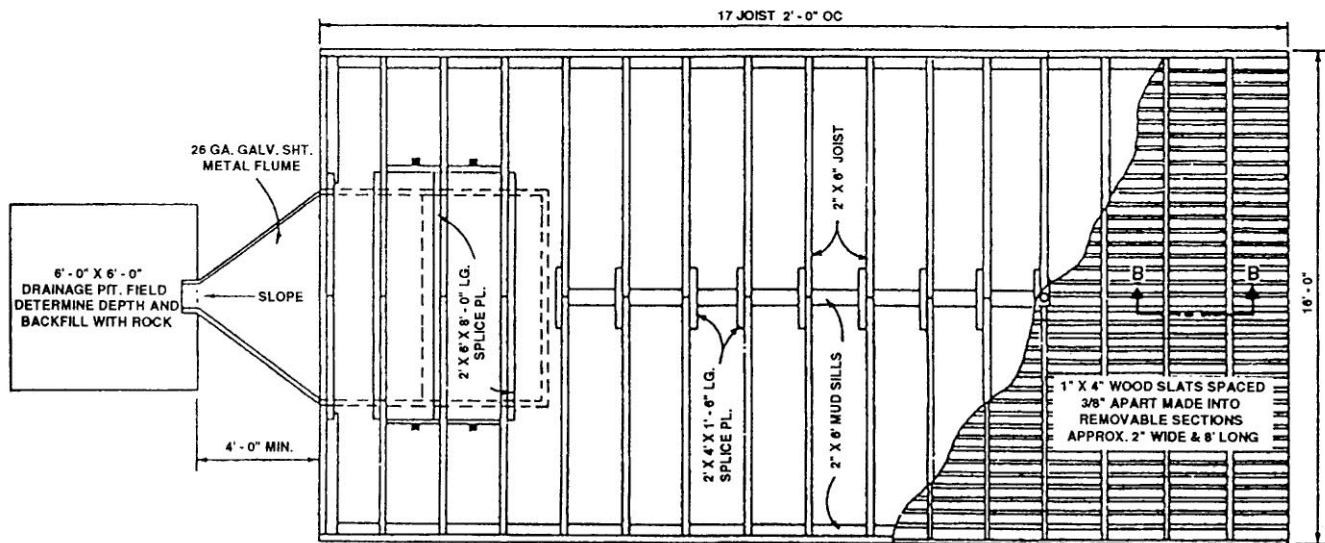


Figure 9-20.-Floor-framing plan.

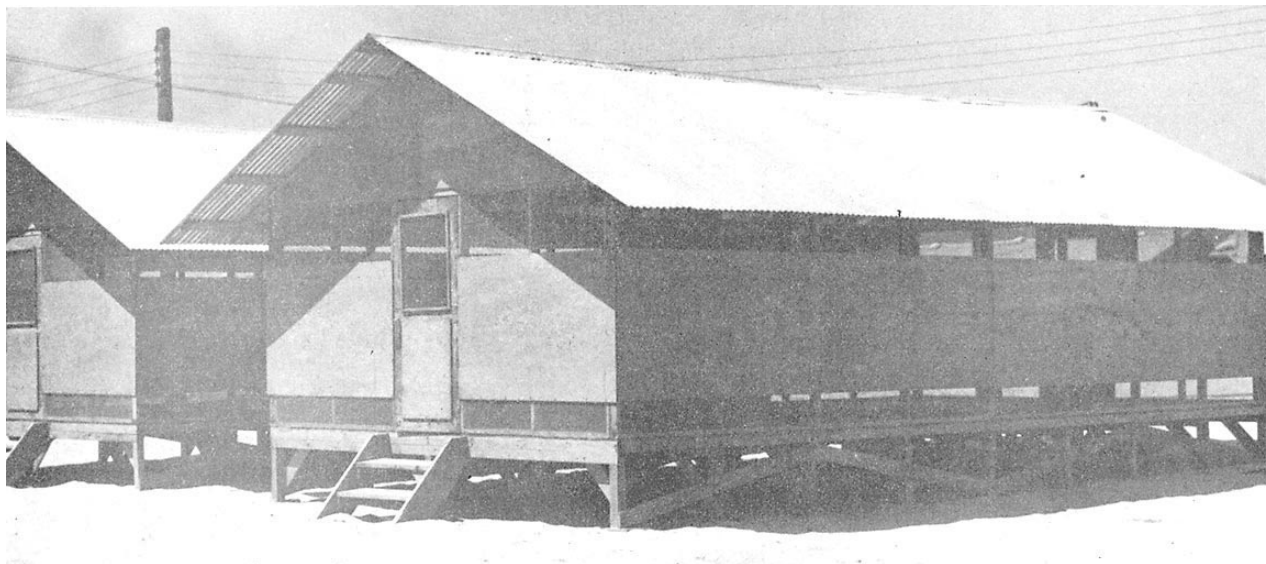


Figure 9-21.—Completed SEA huts.

requirements, such as lengthening the floor or making the roof higher. The standard prefabrication of a SEA hut permits disassembly for movement to other locations when structures are needed rapidly. As with all disassembly of buildings, ensure it is not damaged in the process.

FIELD-TYPE LATRINES

Temporary facilities for disposal of human waste are one of the first things to be constructed at an advance base. A number of field-type latrines are designed for this purpose; a 16-by 32-foot wood-frame tent maybe used to shelter the latrine.

Four Seat

A prefabricated four-seat latrine box is shown in figure 9-22. It can be collapsed for shipment, as shown in figure 9-23.

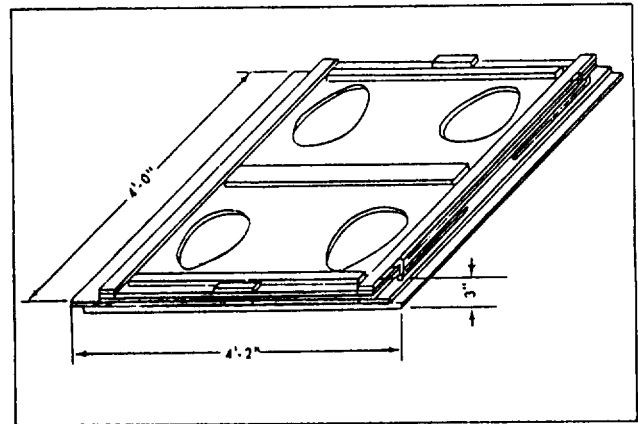


Figure 9-23.-Latrine box collapsed for shipment.

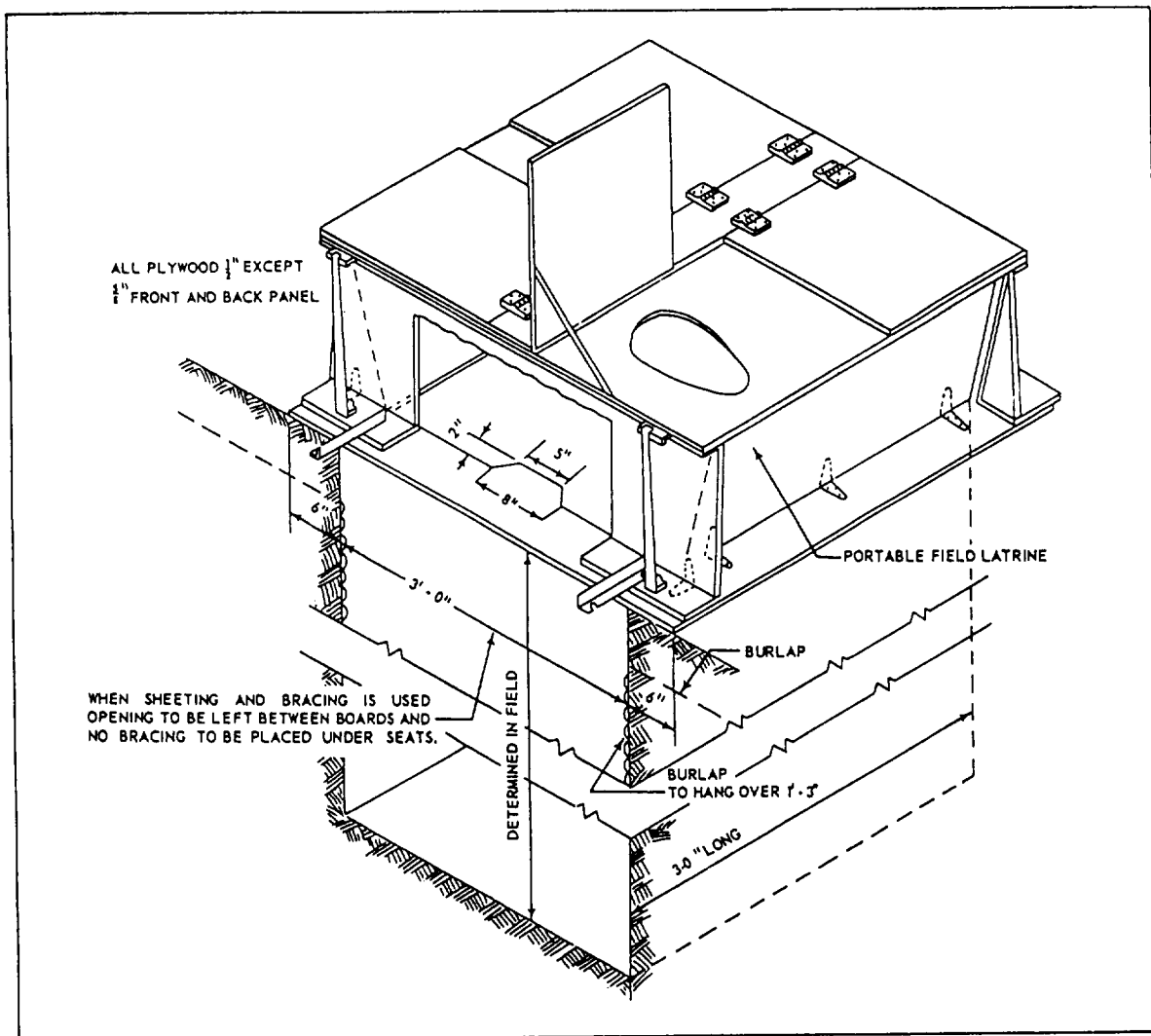


Figure 9-22.-Prefabricated four-seat latrine box.

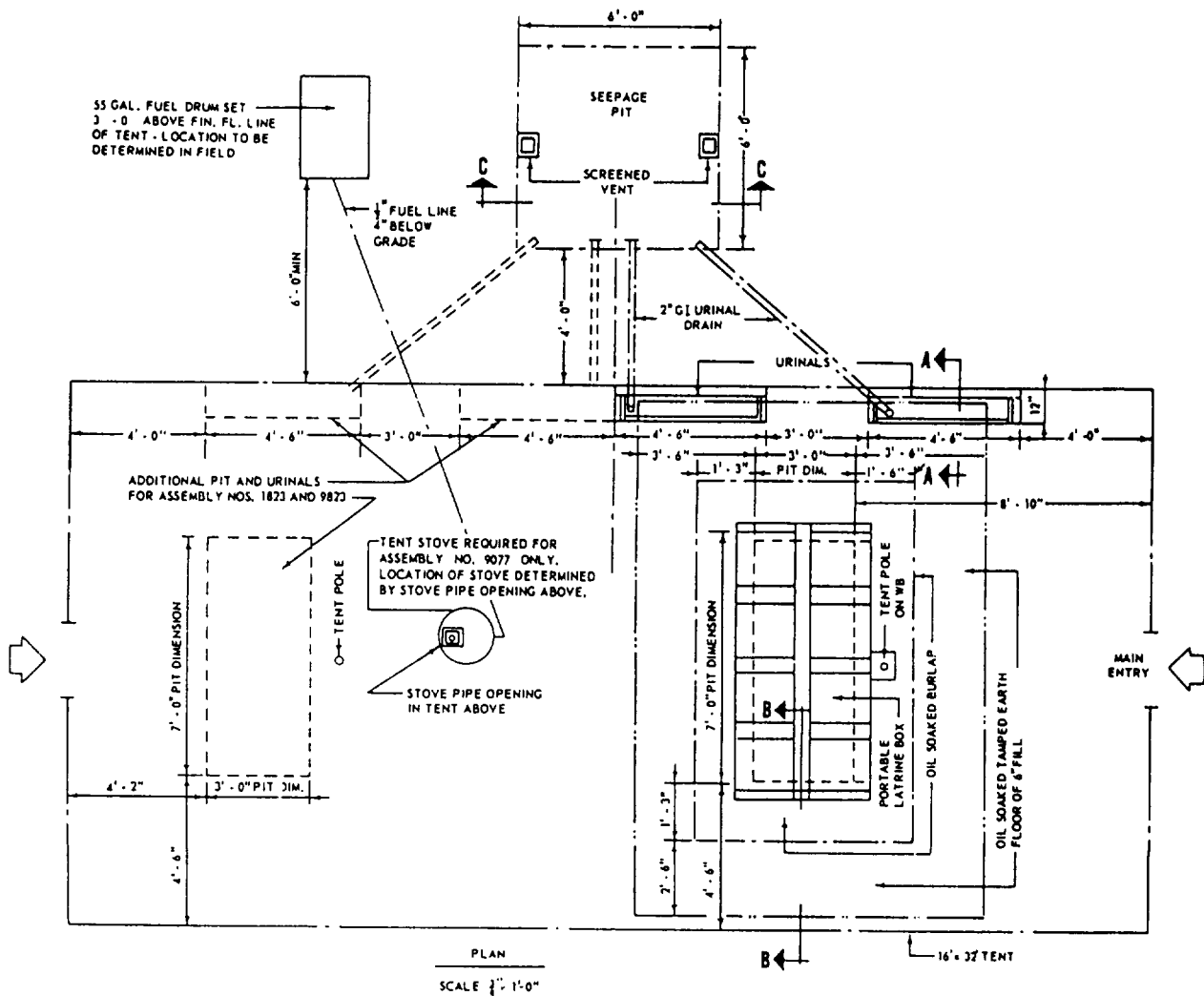


Figure 9-24.-Plan view of eight-seat field-type latrine.

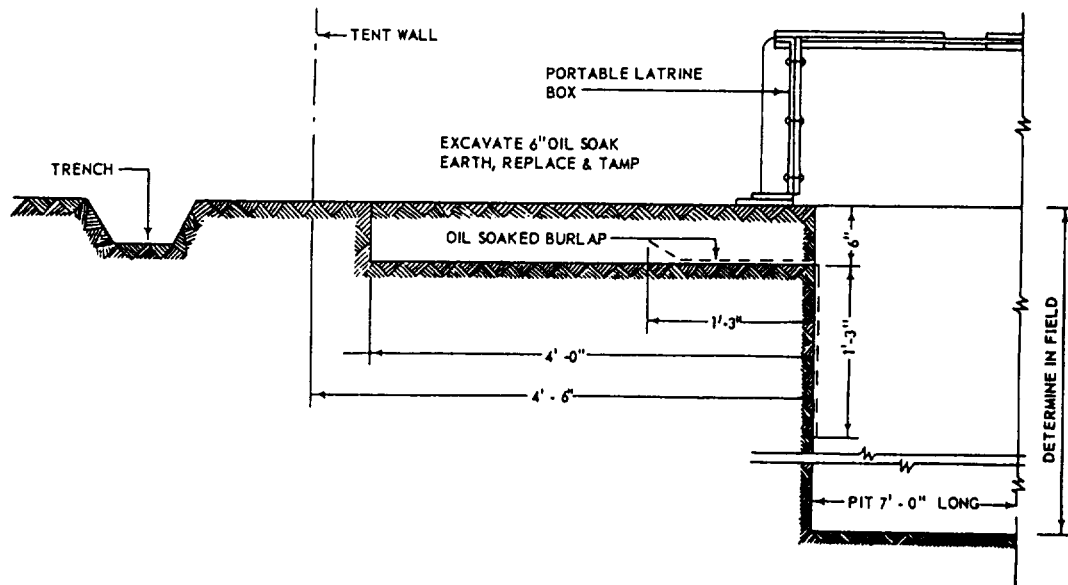


Figure 9-25.-Margin of oil-soaked earth around latrine boxes.

Eight Seat

A plan view of an eight-seat field-type latrine is shown in figure 9-24. Two four-seat boxes straddle a 3-by 7-foot pit. After the pit is dug, but before the boxes are placed, a 4-foot-wide margin around the pit is excavated to a depth of 6 inches, as shown in figure 9-25. A layer of oil-soaked burlap is laid in this-excavation. Then, the excavated earth is soaked with oil, replaced, and tamped down to keep surface water out.

Two 4-foot 6-inch trough-type urinals are furnished with the eight-seat latrine. Each is mounted in a frame constructed as shown in figure 9-26. A 2-inch urinal drainpipe leads from the downpipe on each urinal to a 6- by 6-foot urinal seepage pit. The seepage pit is constructed as shown in figure 9-27.

As indicated in figure 9-24, the eight-seat field-type latrine can be expanded to a 16-seat field-type latrine.

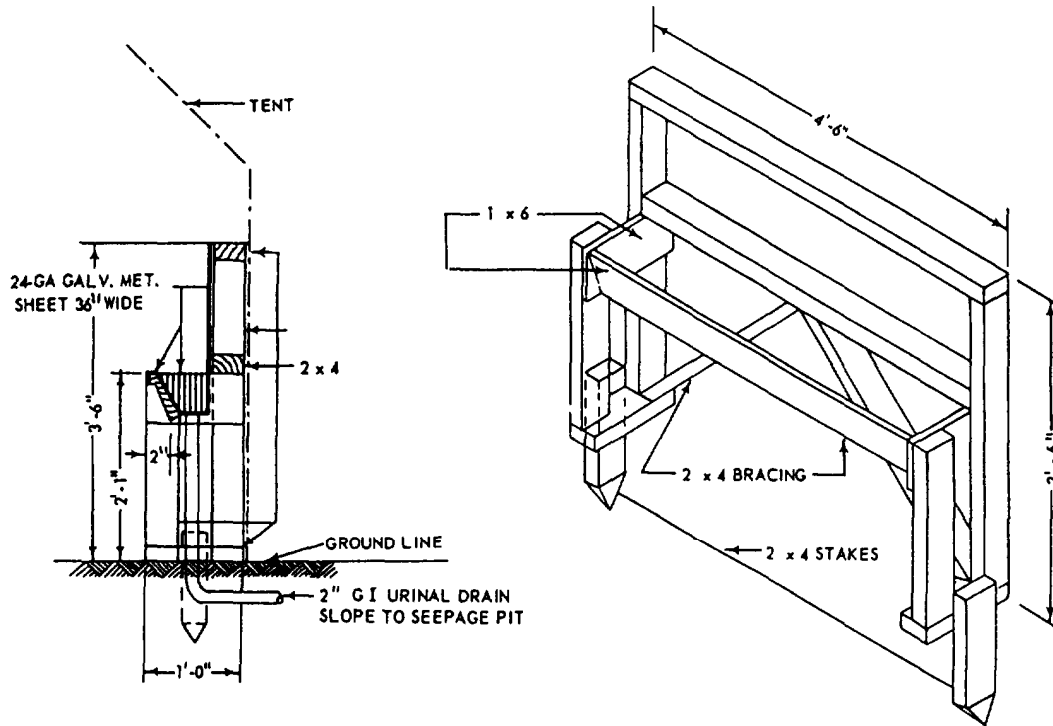


Figure 9-26. Frame for urinal trough.

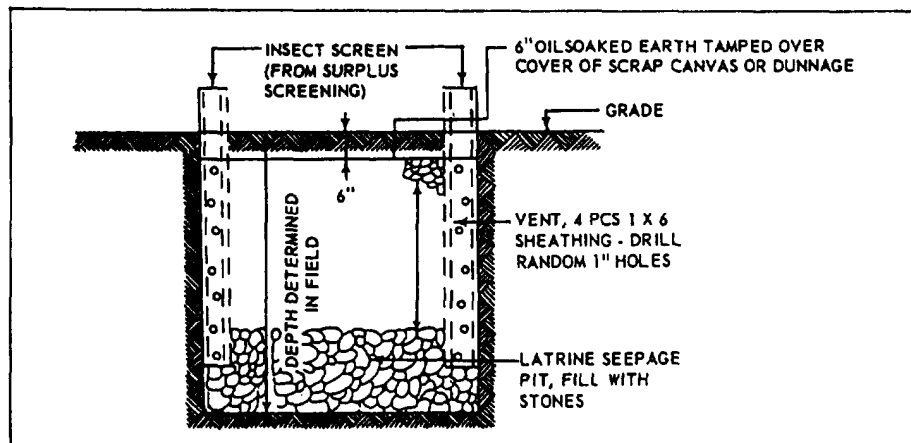


Figure 9-27. Urinal seepage pit.

Burnout Type

A complete plan view of a four-hole burnout field-type latrine is shown in figure 9-28. The waste goes into removable barrels. The waste is then disposed of at another location. This type of latrine is used at most advanced or temporary bases. The burnout latrine is kept in an orderly condition (daily) by the camp maintenance personnel or the assigned sanitation crew. It can be easily maintained by spreading lime over the waste material or using diesel fuel to bum the waste material.

MAINTENANCE

Once wood frame facilities are completed and occupied by the tenants, maintenance becomes the major priority. The life span of a facility is greatly increased with proper maintenance. Even though the majority of these buildings are temporary in nature, most can be dismantled and reassembled at another site. Establishment of a regularly scheduled maintenance program ensures the buildings are in a consistent state of readiness.

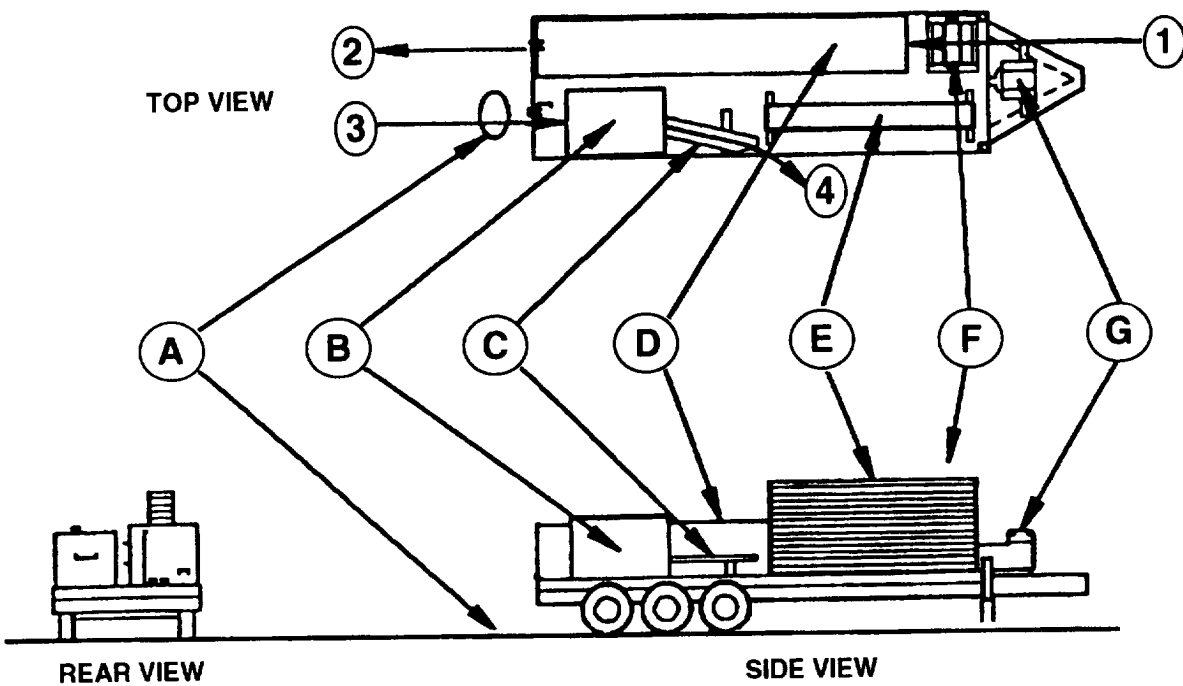
K-SPAN BUILDING

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the components of, preparation procedures for and procedures used in the erection of a K-span building.

The K-span building is a relatively new form of construction in the Seabee community. The intended uses of these buildings are as flexible as the SEA huts discussed earlier. Training key personnel in the operation of the related equipment associated with the K-span is essential. These same personnel, once trained, can instruct other members of the crew in the safe erection of a K-span. The following section gives you some, but not all, of the key elements associated with K-span construction. As with other equipment, always refer to the manufacturers' manuals.

OPERATING INSTRUCTIONS

The main component of the K-span system is the trailer-mounted machinery shown in figure 9-29. This



- A. Operator's station
- B. Panel curving machine
- C. Primary curving run-out table
- D. Straight panel roll forming machine
- E. Run-out tables in transporting rack
- F. Coil stock pay-out reel and stand
- G. Engine/hydraulic pump primary power unit

General Operation (Top View)

1. Coil stock enters panel forming machine
2. Formed straight panel
3. Straight panel entry to panel curving machine
4. Curved building panel

Figure 9-29. Trailer-mounted machinery.

figure shows the primary components of the trailer as well as general operations. The key element is the operator's station at the rear of the trailer (shown in fig. 9-30). The individual selected for this station must be able to understand the machine operations and manuals. From here, the operator controls all the elements required to form the panels. The operator must remain at the controls at all times. The forming of the panels is a complex operation that becomes easier with a thorough understanding of the manuals. From the placement of the trailer on site, to the completion of the curved panel, attention to detail is paramount.

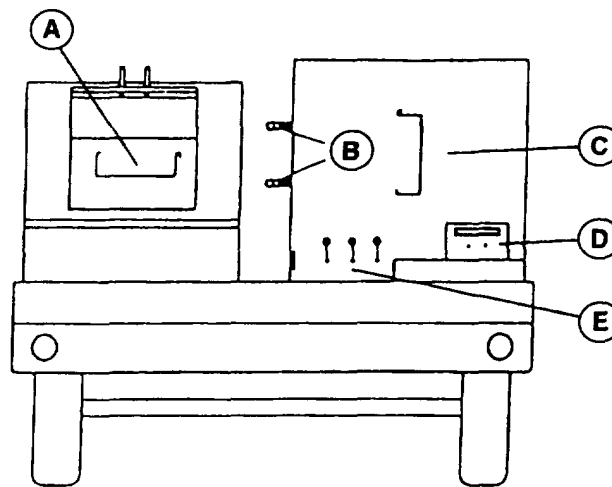
As you operate the panel, you will be adjusting the various machine-operating components. Make adjustments for thickness, radius, and the curving machine according to the manuals. **Do not permit short cuts in adjustments.** Any deviations in adjustments, or disregard for the instructions found in the operating manuals, will leave you with a pile of useless material and an inconsistent building.

MACHINERY PLACEMENT

To avoid setup problems, preplanning of the site layout is important. Uneven or sloped ground is not a concern as long as the bed of the trailer aligns with the general lay of the existing surface conditions. Using

figure 9-31 as a guide, consider the following items when placing the machinery:

- Maneuvering room for the towing of the trailer, or leave it attached to vehicle (as shown at A);
- Length of unit is 27 feet 8 inches long by 7 feet 4 inches wide (B);
- Allow enough room for run-out stands to hold straight panels. Stands have a net length of 9 feet 6 inches each (C);
- Find point X: From center of curve, measure distance equal to radius in line with front of curved frame. From point X, scribe an arc equal to radius. This arc will define path of curved panel. Add 10 feet for run-out stands and legs (D);
- Storage area required to store coil stock and access for equipment to load onto machine (E);
- Direction curved panels must be carried after being formed (F);
- Level area required to lay panels on ground for seaming. Building will not be consistent if panels are not straight when seaming (G); and
- Space required for crane operations (H).



Operator's Station, at rear of trailer :

- A. Straight panel exit and cut-off
- B. Curving machine radius adjustments and dials
- C. Straight panel entrance to curving machine
- D. Engine remote control panel
- E. Hydraulic controls

Figure 9-30.-Rear of K-span trailer.

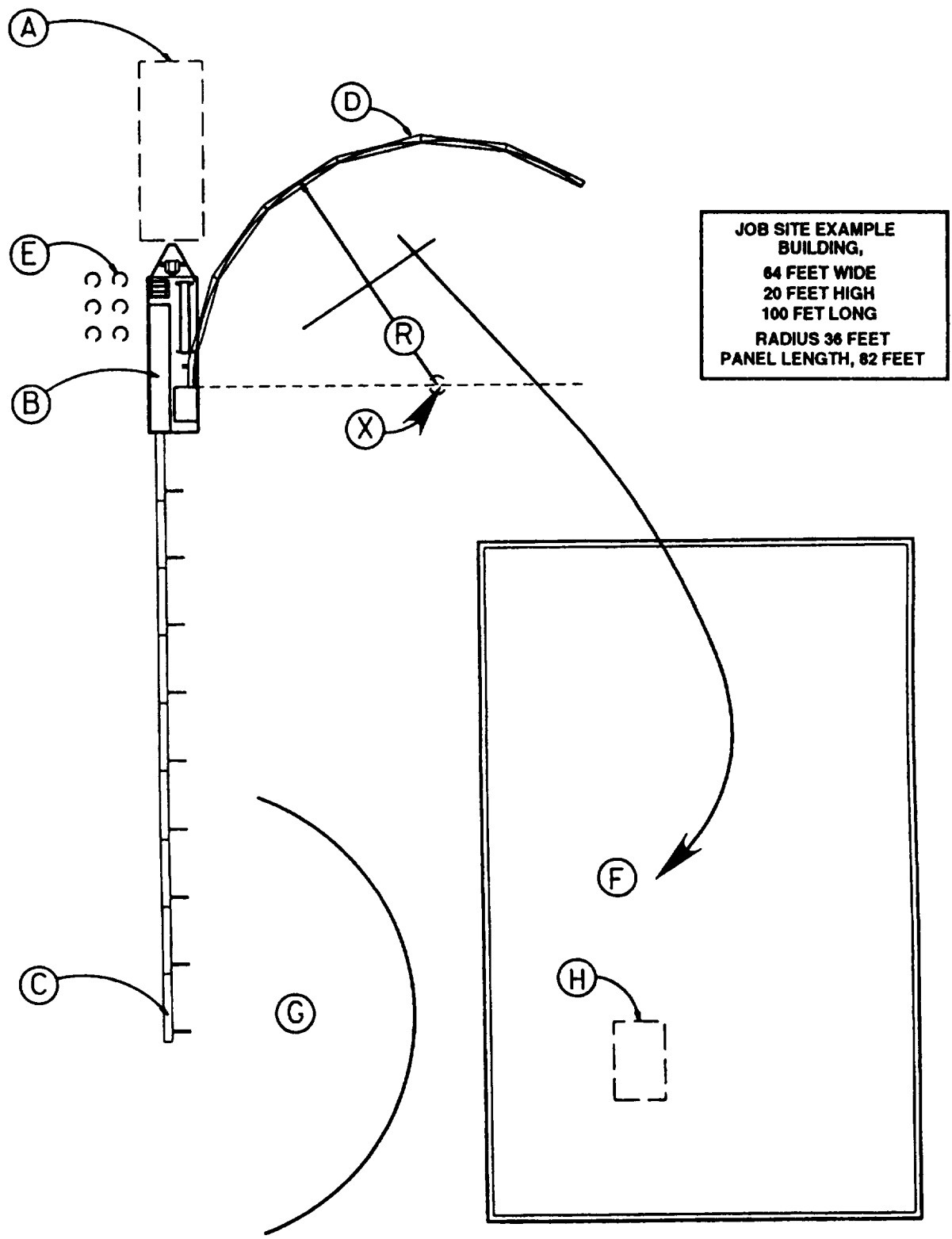


Figure 9-31.-Machinery placement calculations.

FOUNDATIONS

The design of the foundation for a K-span building depends on the building's size, existing soil conditions, and wind load. The foundations for the buildings are simple and easy to construct. With the even distribution of the load in a standard arch building, the size of the continuous strip footing is smaller and more economical than the foundations for conventional buildings.

The concrete forms and accessories provided are sufficient to form the foundations for a building 100 feet long by 50 feet wide. When a different configuration is required, forms are available upon request from the manufacturer.

The actual footing construction is based, as all project are, on the building plans and specifications. The location of the forms, placement of steel, and the psi (pounds per square inch) of the concrete are critical. Since the building is welded to the angle in the footer prior to the concrete placement, all aspects of the footer construction must be thoroughly checked for alignment and square. Once concrete is placed, there is no way to correct mistakes.

As mentioned above, forms are provided for the foundation. Using table 9-1 as a guide, figure 9-32 gives you a simple foundation layout by parts designation. As

noted in figure 9-32, the cross pipes are not provided in the kit. They are provided by the contractor.

With the foundation forms in place, and the building panels welded to the attaching angle (fig. 9-33) at 12 inches OC, you are ready to place the concrete. When placing the concrete, remember it is extremely important that it be well-vibrated. This helps eliminate voids under all embedded items. As the concrete begins to set, slope the top exterior portion of the concrete cap about 5 inches (fig. 9-34) to allow water to drain away from the building. The elevation and type of interior floor are not relevant as long as the finish of the interior floor is not higher than the top of the concrete cap.

BUILDING ERECTION

With the placement of the machinery and forming of the building panels in progress, your next considerations are the placement and the weight-lifting capabilities of the crane. Check the crane's weight-lifting chart for its maximum weight capacity. This dictates the number of panels you can safely lift at the operating distance. As with all crane operations, attempting to lift more than the rated capacity can cause the crane to turn over.

Table 9-1.-Concrete Forms Included in Kit

DESCRIPTION (Each set of forms is sufficient to erect a building 100 feet long by 50 feet wide)	PART NUMBER
Side form panels, 1' × 10', 12-gauge steel Transition panels, 1' × 12", 12-gauge steel Transition panels, 1' × 28", 12-gauge steel End- wall caps, 1' × 15", 12-gauge steel Side- wall caps, 1' × 19", 12-gauge steel	F-1 F-2 F-3 F-4 F-5
Filler form, 1' × 12', 12-gauge steel Sidewall inside stop, 1' × 12", 12-gauge steel End wall inside stop, 1' × 12", 12-gauge steel Stakes, 1/4" diameter, bar steel All-thread rod, 1/2-13 × 18"	F-6 F-7 F-8 F-9 F-10
Hex nuts, 1/2-13 Hex bolts, 1/8-16 × 1-1/2" Hex nuts, 3/8-16 Flat washers, 1/8" SAE Corner angles, 2" × 2" × 12", steel angle	F-11 F-12 F-13 F-14 F-15

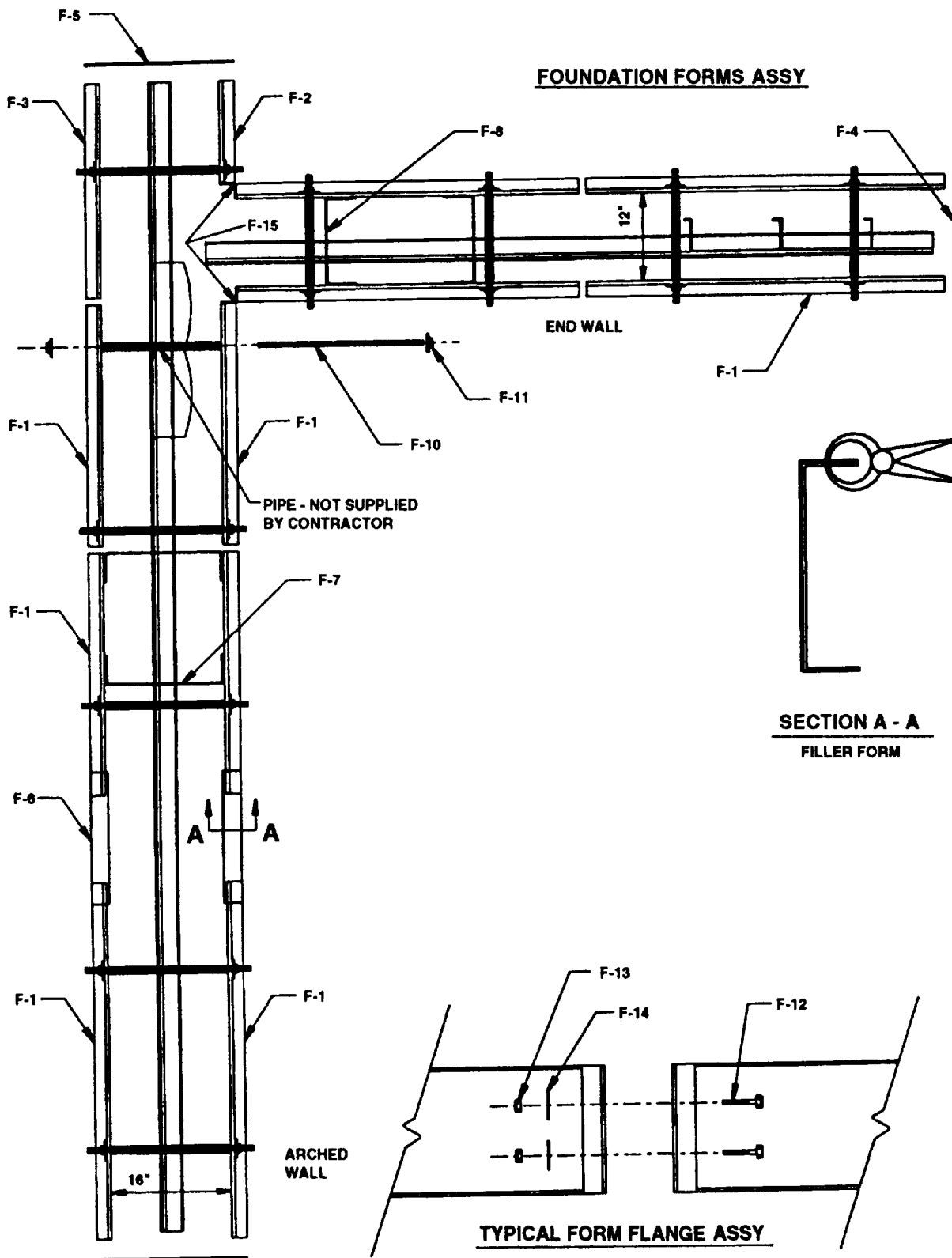


Figure 9-32. Simple form assembly.

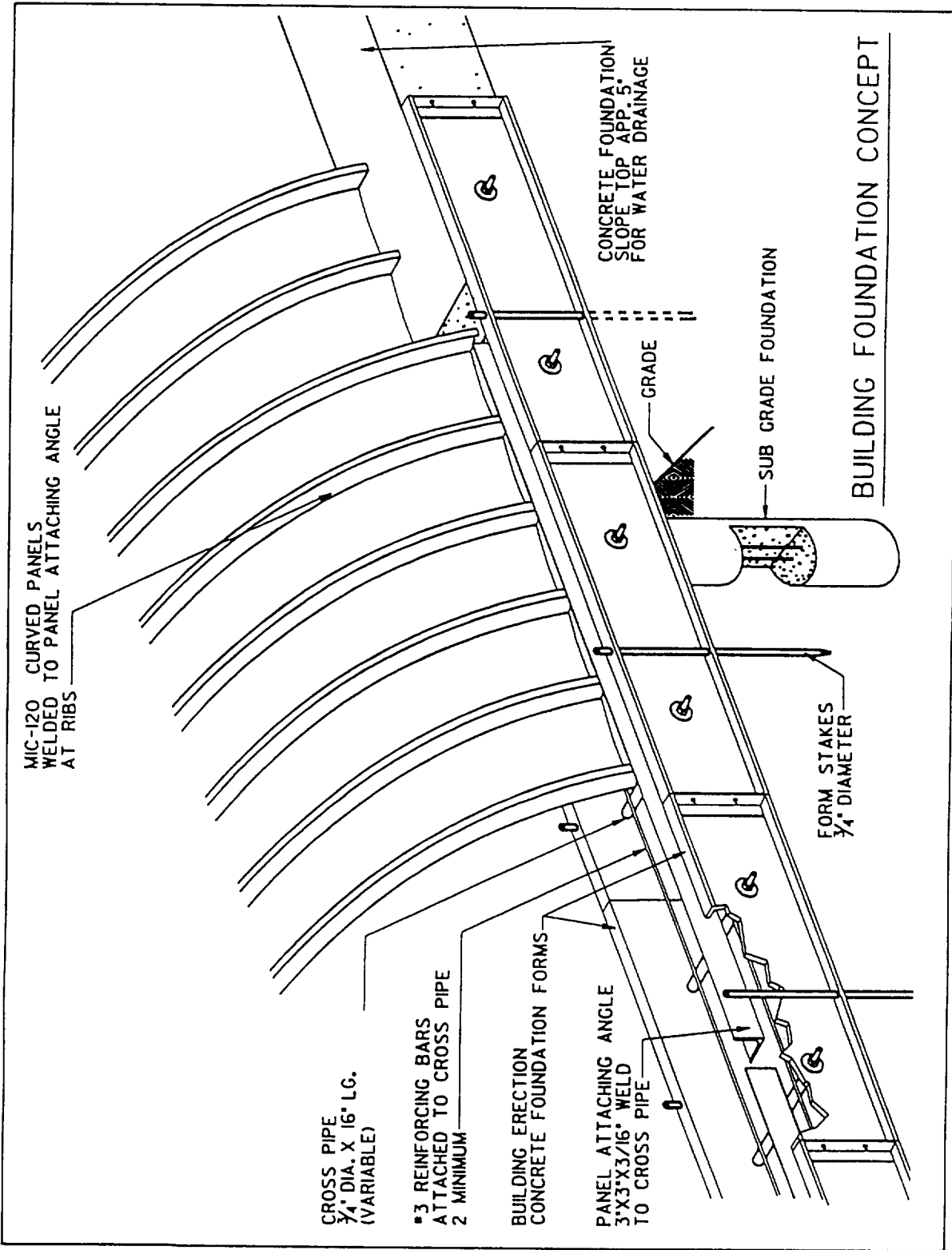


Figure 9-33.—Building foundation concept.

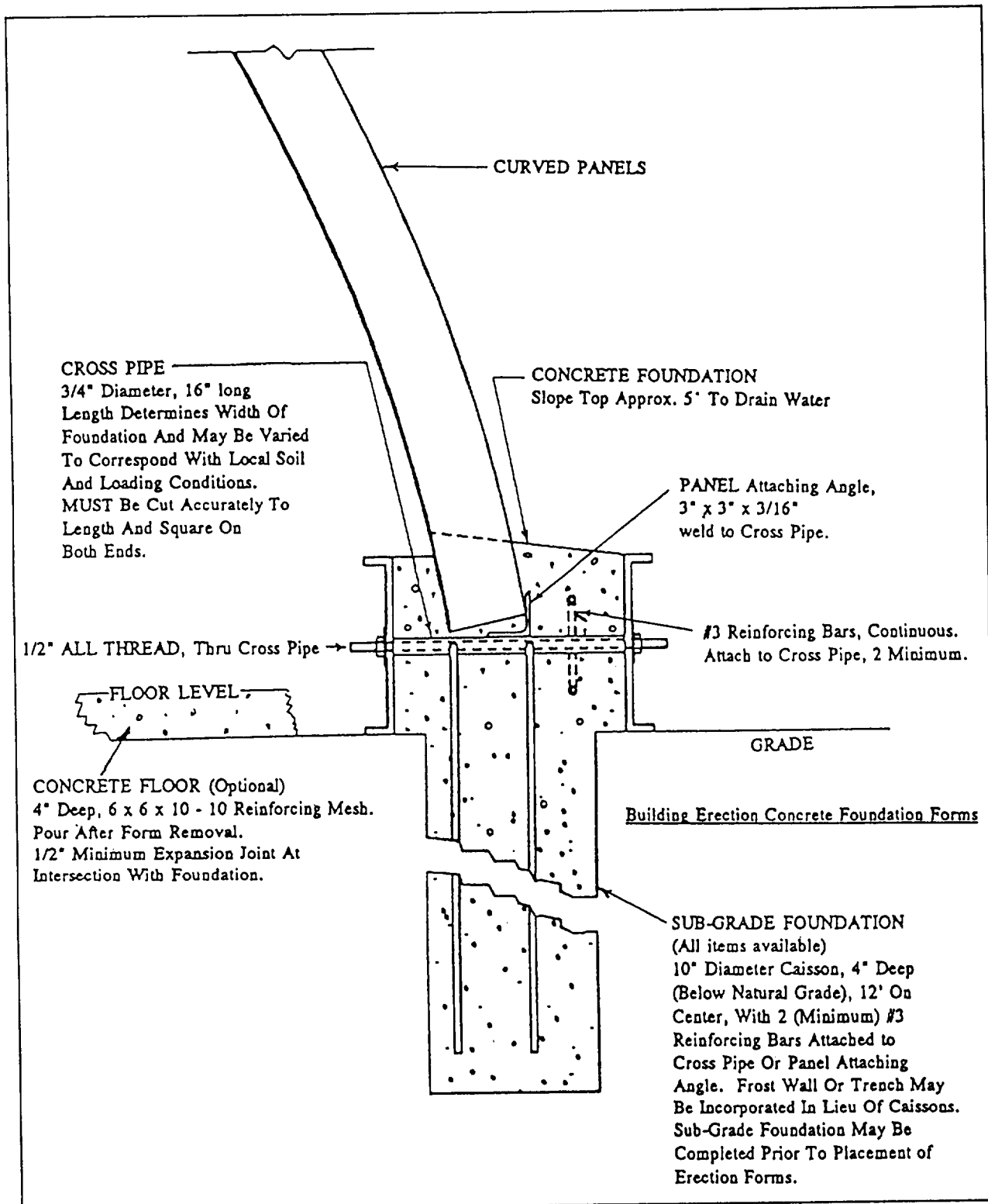


Figure 9-34.-Concrete foundation.

Attaching the spreader bar (fig. 9-35) to the curved formed panels is a critical step; failure to tightly clamp the panel can cause the panels to slip and fall with potential harm to personnel and damage to the panel.

With guide ropes attached (fig. 9-36) and personnel manning these ropes, lift panels for placement. When lifting, lift only as high as necessary, position two men at each free end to guide in place, and remind

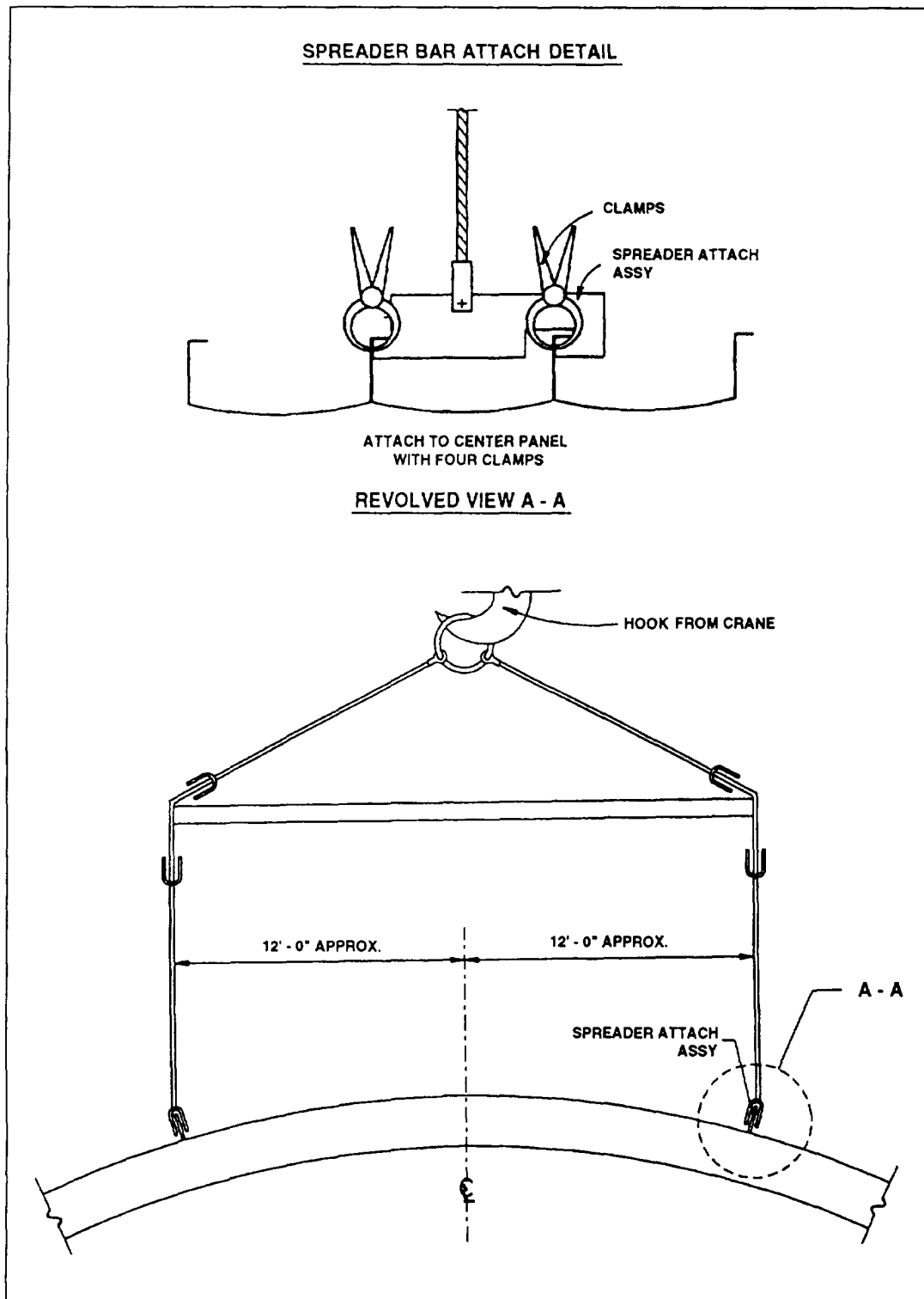


Figure 9-35. Spreader bar attachment.

crewmembers to keep their feet from under the ends of the arches. Never attempt lifting any sets of panels in high winds.

Place the first set of panels on the attaching angle of foundation and position so there will be room for

the end-wall panels. After positioning the first set of panels, clamp them to the angle, plumb with guide ropes, and secure the ropes to previously anchored stakes. Detach the spreader bar and continue to place panel sets. Seam each set to standing panels before detaching spreader bar.

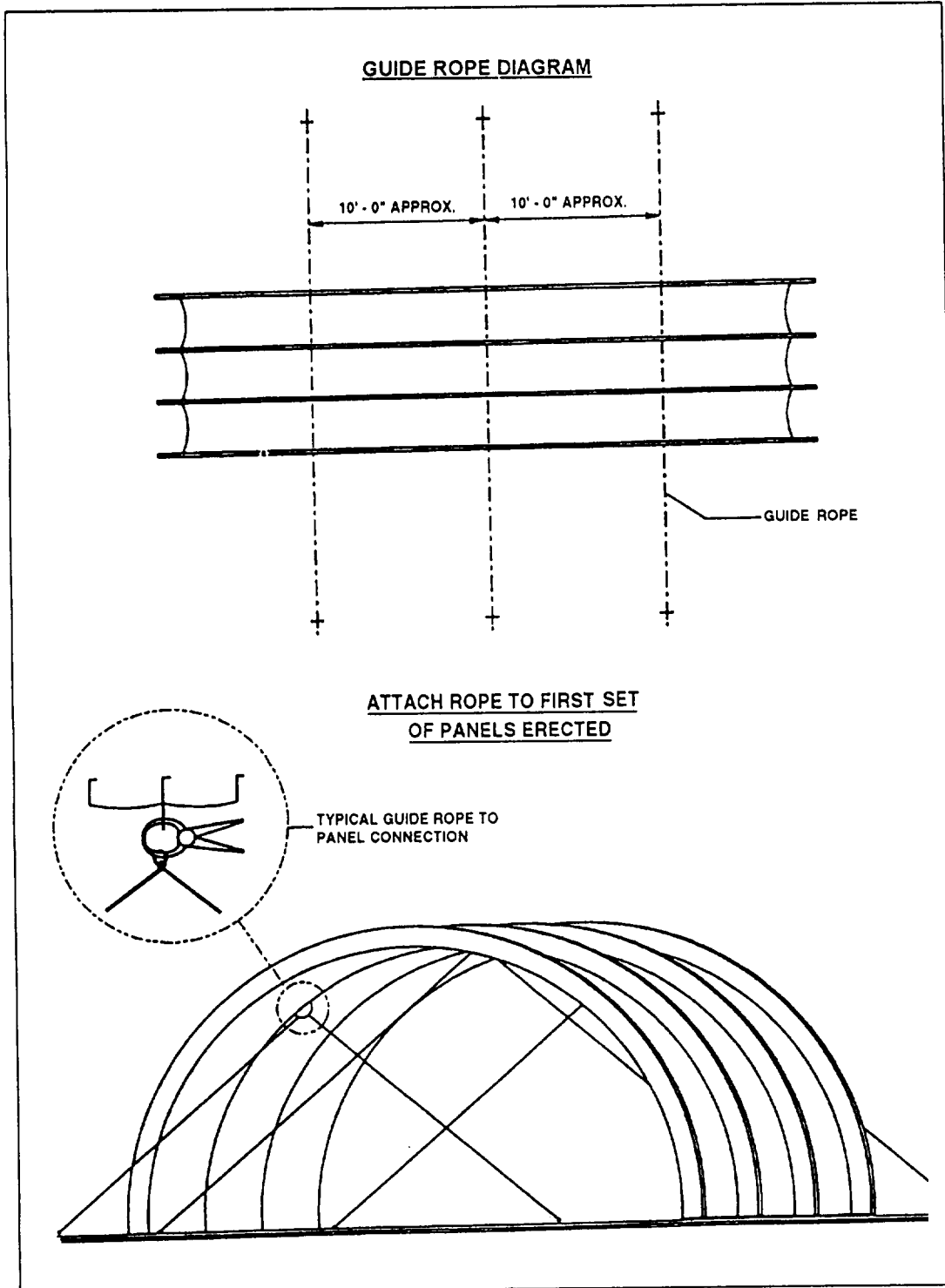


Figure 9-36.-Guide rope diagram.

After about 15 panels (3 sets) are in place, measure the building length at both ends (just above forms) and at the center of the arch. This measurement will seldom be exactly one foot per panel (usually slightly more), but should be equal for each panel. Adjust the ends to equal the center measure. Panels are flexible enough to adjust slightly. Check these measurements periodically during building construction. Since exact building lengths are difficult to predict, the end wall attaching angle on the finishing end of building should not be put in place until all panels are set.

After arches are in place, set the longest end-wall panel in the form, plumb, and clamp it in place. Work from the longest panel outward and be careful to maintain plumb.

CONSTRUCTION DETAILS

The K-span building system is similar to other types of preengineered or prefabricated buildings in that windows, doors, and roll-up doors can be installed only when erection is completed. When insulation of the building is required, insulation boards (usually 4 by 8 feet) may be of any semirigid material that can be bent to match the radius of the building. The insulation is installed using clips, as shown in figure 9-37.

When the integrity of the end-wall panels is continuous from ground to roof line, the end walls become self-supporting. The installation of windows (fig. 9-38), and aluminum and wood doors (figs. 9-39 and 9-40, respectively), presents no problem since the integrity of the of the wall system is not interrupted.

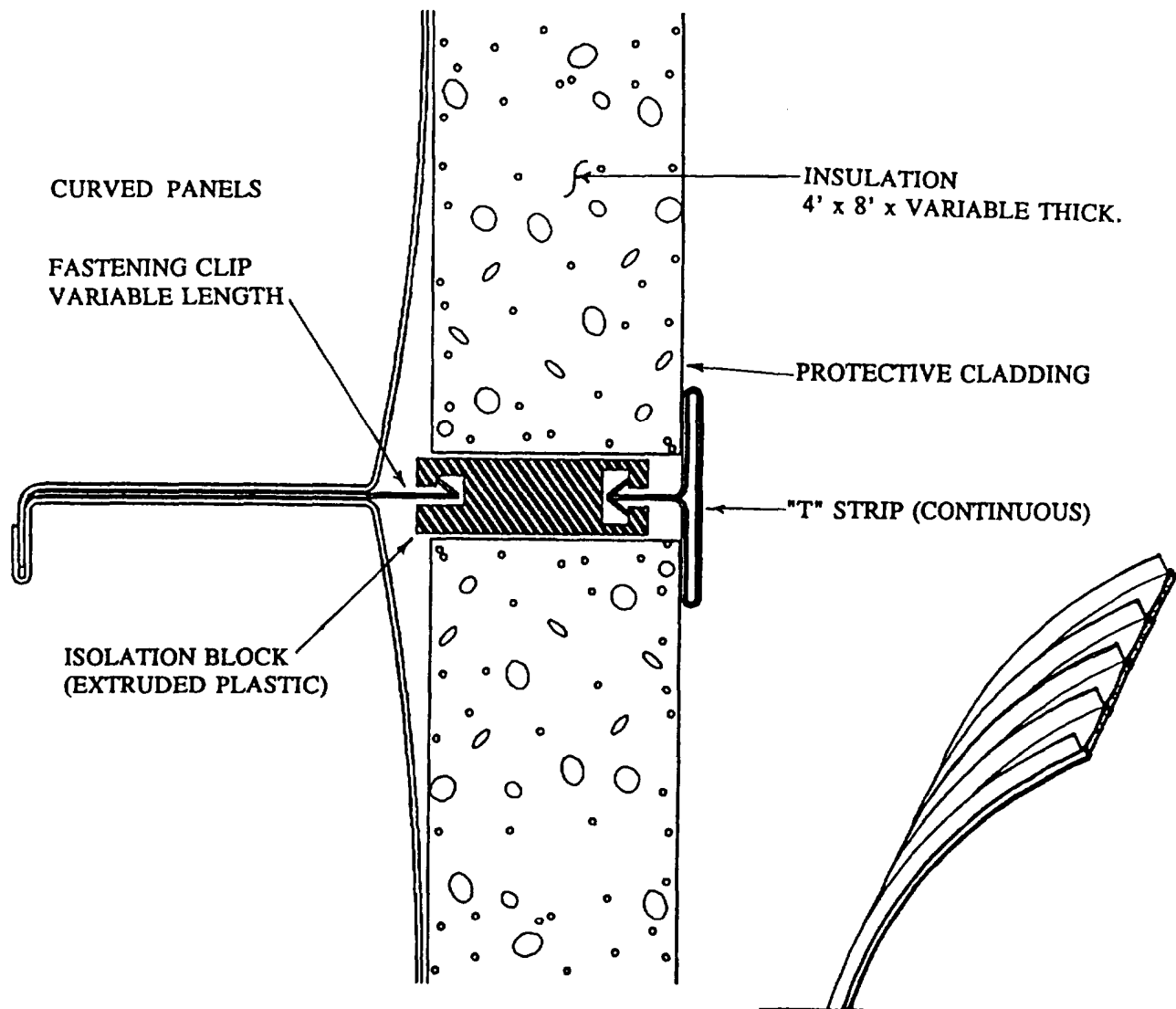


Figure 9-37.-Insulation.

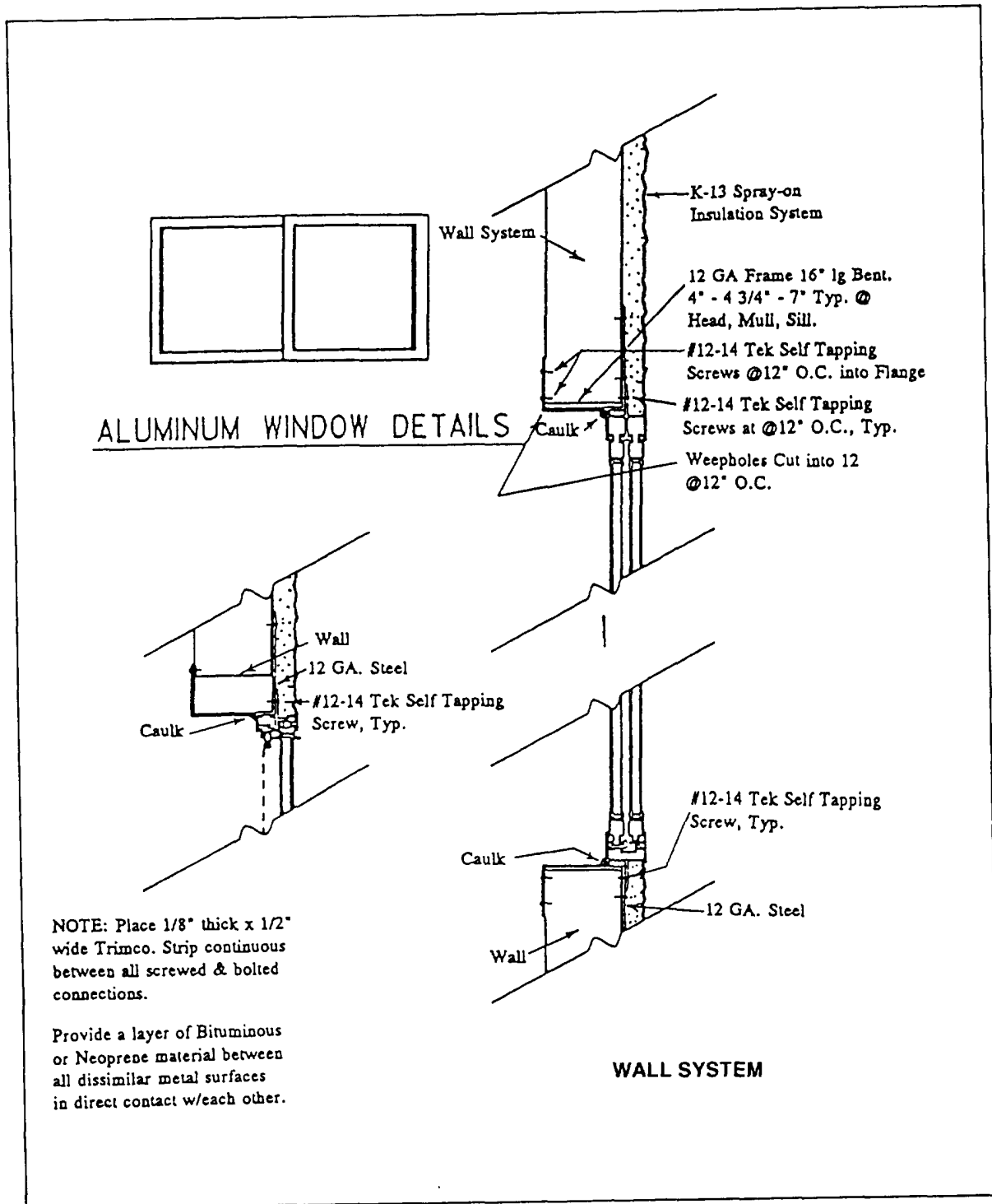


Figure 9-38. Aluminum window installation.

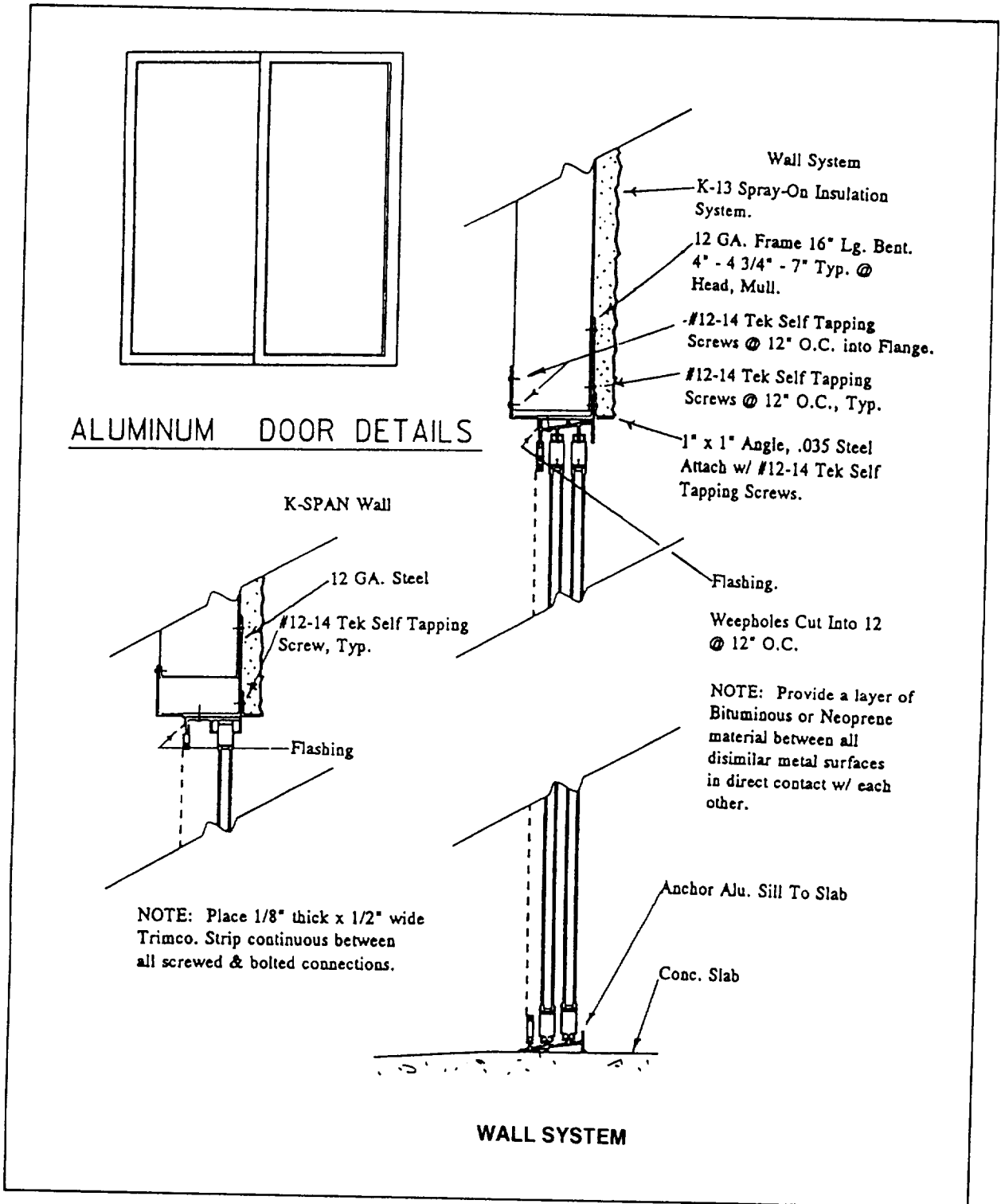


Figure 9-39.-Aluminum door installation.

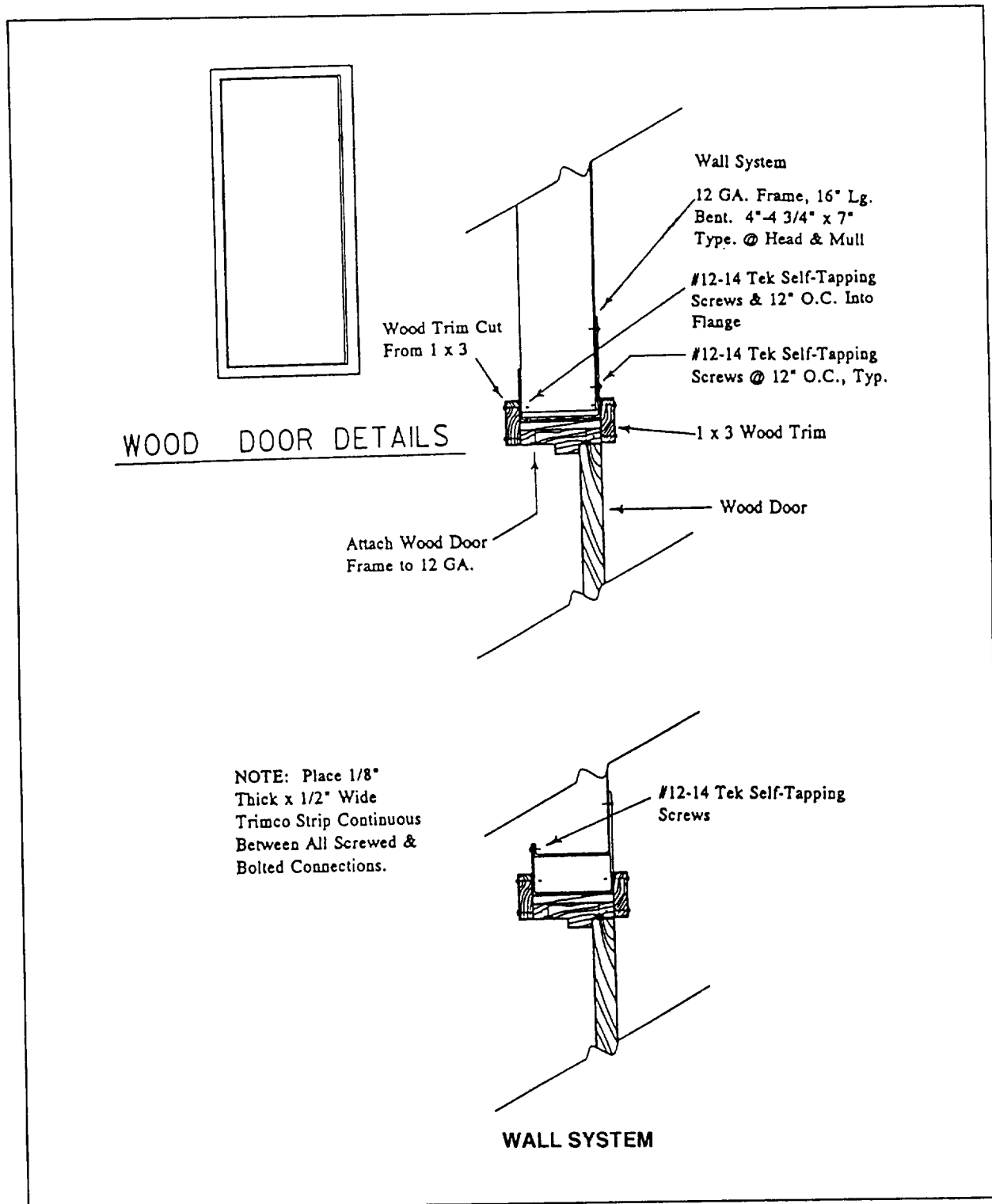


Figure 9-40.-Wood door installation.

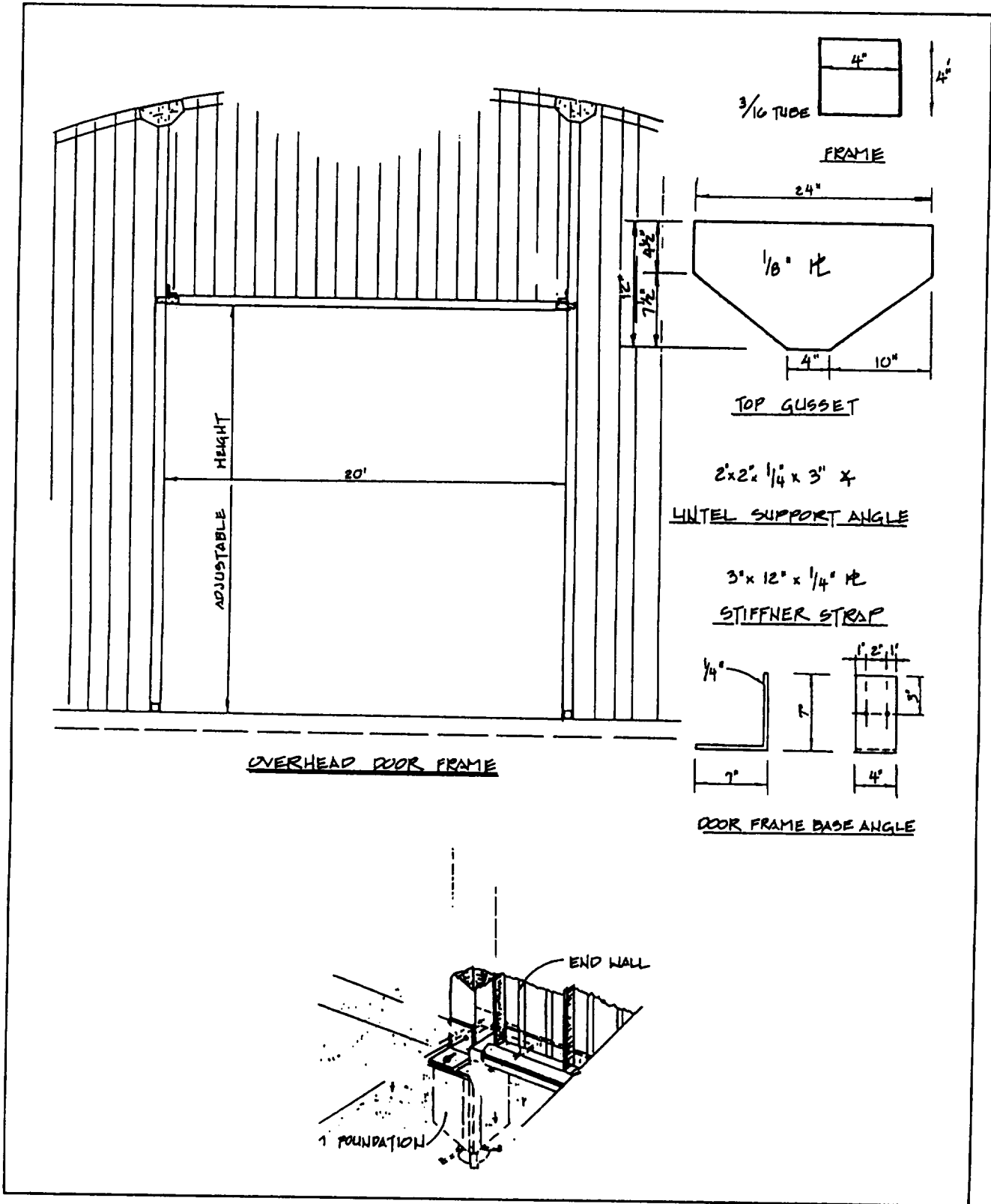


Figure 9-41.-Overhead door frame.

The installation of the overhead door (fig. 9-41) does present a problem in that it does interrupt the integrity of the wall system. This situation is quickly overcome by the easily installed and adjustable (height and width) door frame package that supports both the door and end wall. This door frame package is offered by the manufacturer.

Keep in mind that the information provided in this section on the K-span building is minimal. During the actual construction of this building, **you must consult the manufacturer's complete set of manuals.**

EMBARKATION

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the procedures and techniques used in preparing material for embarkation.

For a smooth, expedient mount-out, careful pre-planning and organizing are required. Embarkation, whether by air, land, sea, or any combinations thereof, is an all-hands evolution. A successful move requires 100-percent support.

Flexibility is extremely important. Proper embarkation depends to a large extent on the mutual understanding of objectives and capabilities, and full cooperation in planning and execution by both the unit mobilizing and the organization providing the lift. Whenever possible, early communication and coordination between the two is extremely important.

PLANNING

Embarkation planning involves all measures necessary to assure timely and effective out-loading of the amphibious task force and portions thereof. Planning for embarkation also applies to all unit moves, regardless of the method used for movement. These measures are determined by the availability of transportation and the transportation requirements of the unit moving. In amphibious embarkation, the OPNAV level in the chain of command determines overall shipping requirements and the embarkation schedules. This enables subordinate units to prepare detailed loading plans for individual ships. Planning requires constant coordination between commanders in the Navy and the Air Force; they must have a mutual understanding of the problems of each support group. However, in the final analysis, the embarkation plan must support the tactical deployment plan of the unit. In the case of an amphibious landing, it must support

the tactical plan for landing and the scheme of maneuvers ashore.

Embarkation planning requires detailed knowledge of the characteristics, capabilities, and limitations of ships, aircraft, and amphibious vehicles, and their relationships to the troops, supplies, and equipment to be embarked. The planner must be familiar with transport types of amphibious ships, Military Sealift Command (MSC) ships, merchant ships, and cargo aircraft. MSC ships and merchant ships pose certain problems; basically, they are not designed, equipped, or have a crew large enough for amphibious operations. But, their use must be anticipated. The additional requirements of hatch crews, winchmen, cargo-handling equipment, cargo nets, assault craft, and other facilities must be provided by the user.

Principles

Whether by ship during amphibious operations or by aircraft for assault force support operations, you must observe certain principles to ensure proper embarkation.

First, embarkation plans must support the plan for landing and the scheme of maneuvers ashore. Personnel, equipment, and supplies must be loaded so they can be unloaded at the time and in the sequence required to support operations ashore.

Second, embarkation plans must provide for the highest possible degree of unit self-sufficiency. Troops should not be separated from their combat equipment and supplies. Weapons crews should be embarked on the same ship or aircraft with their weapons; radio operators with their radios; and equipment operators with their equipment. In addition, each unit should embark with sufficient combat supplies, such as ammunition, gasoline, and radio batteries, to sustain its combat operations during the initial period in the operational area. All personnel should have sufficient water and rations to sustain themselves for 24 hours.

Third, plans must provide for rapid unloading in the objective area. This can be achieved by a balanced distribution of equipment and supplies.

Fourth, and last, plans must provide for dispersion of critical units and supplies among several ships or aircraft. The danger of not doing so is obvious. If critical units and supplies are not dispersed, loss of one ship, or a relatively few ships or aircraft, could result

in a major loss of combat capability. Accomplishment of the mission can be seriously jeopardized.

Team Planning

Effective embarkation planning by the embarkation team is dependent upon the early receipt of information from higher authority. Detailed planning begins with the determination of team composition and the assignment of shipping. The following information should be included in the team's embarkation planning:

- Designation of the team embarkation officer(s);
- Preparation and submission of basic loading forms by troop units of the embarkation team;
- Preparation of the detailed loading plan;
- Designation of the ship's platoon, billeting, messing, and duty officers during the period of the embarkation;
- Designation and movement of advance parties and advance details to the embarkation area;
- Establishment of liaison with the embarkation control office in the embarkation area;
- Preparation for the schedule for movement of troops, vehicles, equipment, and supplies to the embarkation area; and
- Preparation of plans for the security of cargo in the embarkation area.

Three basic embarkation plans are normally prepared by the various command levels within the landing force: the landing force embarkation plan, the group embarkation plan, and the unit embarkation plan.

LANDING FORCE EMBARKATION PLAN.— The landing force embarkation plan includes the organization for embarkation; supplies and equipment to be embarked; embarkation points and cargo assembly areas; control, movement and embarkation of personnel; and miscellaneous information. The landing force embarkation plan contains information from which the embarkation group commander prepares a more detailed plan.

GROUP EMBARKATION PLAN.— The group embarkation plan, prepared by the embarkation group commander, establishes the formation for embarkation units and assigns shipping to each embarkation unit. It contains the same information as the landing force embarkation plan, but in much greater detail. The group embarkation plan has attached to it or included within the embarkation organization a shipping assignment table.

UNIT EMBARKATION PLAN.— The unit embarkation plan prepared by the embarkation unit commander establishes the formation of embarkation teams and assigns each embarkation team to a ship. It contains, generally, the same information as the group embarkation plan, but in greater detail. Attached to the unit embarkation plan is the unit embarkation organization and shipping assignment table. Naval construction force (NCF) units embarking alone outside of the landing force, either by amphibious means or by air, should prepare an embarkation plan incorporating all of the information necessary for proper embarkation by the unit.

PACKAGING

Standard boxing procedures are required to minimize shipping, packing, and repacking of allowance items and to establish uniformity among the NCF units. Present mobility requirements necessitate being partially packed for redeployment at all times. The best method of obtaining this state of readiness is to use packing boxes for day-to-day storage and for dispensing all types of battalion allowance items. Each NCF unit must fabricate mount-out boxes according to the *Embarkation Manual*, COMCBPAC/COMCBLANTINST 3120.1, for all authorized allowance items within the unit's TOA that can be boxed. Existing boxes may be used if the color and marking codes conform with standard box markings.

Packing Lists

Packing lists must be prepared for each box. One copy is placed inside the box; one copy is mounted in a protective packet on the outside of the box; one copy is kept on file in the embarkation mount-out control center; and, one copy is retained by the department to which the supplies or equipment belong. Packing lists must be sufficiently detailed to locate needed items without having to open and search several boxes.

Mount-Out

When constructing mount-out boxes, observe the following considerations:

- Screw nails (or flathead screws) and glue must be used to assemble the boxes.
- Covers must be bolted to tapped metal inserts, as shown in COMCBPAC/COMCBLANT-INST 3120.1, or an equivalent bolting method.
- Box interiors may be compartmented to suit the contents.
- Gross weight of the boxes should be limited to 250 pounds each for easy handling without material-handling equipment.
- Boxes must be fabricated of 3/4-inch exterior-grade plywood, reinforced with 2 by 4 ends.
- Special boxes for large items are authorized, but should conform to the criteria set forth in COMCBPAC/COMCBLANATINST 3120.1.
- Metal comers or other protection may be installed to prevent shipping damage.

Pre-positioned Stocks and Supplies

Because of the mobile nature of the NCF, it is necessary to pre-position certain supplies and equipment in anticipation of use in contingency mount-outs.

These stocks include oil, gasoline, lubricants, rations, and ammunition, plus a full allowance of equipment. During a contingency mount-out, all or part of these pm-positioned stocks may be used. As part of the planning phase, NCF units should check the plan to be supported to determine the exact amount and types of supplies to be embarked and the location of the supplies.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Automatic Building Machine Type K-Span Operating Manual, MIC-120 ABM, M.I.C. Industries, Inc.

Naval Construction Force/Seabee Chief Petty Officer, NAVEDTRA 10600, Naval Education and Training Command, Pensacola, Fla., June 1989.

Naval Construction Force/Seabee Petty Officer First Class, NAVEDTRA 10601, Naval Education and Training Command, Pensacola, Fla., December 1989.

CHAPTER 10

HEAVY CONSTRUCTION

Heavy construction includes structures made of steel, timber, concrete, or a combination of these materials. Examples include trestles, timber piers, and waterfront structures. The requirement for heavy construction today is not as important as in earlier years; however, the need to understand this type of construction still remains.

In this chapter, we'll examine the materials used in building heavy structures. We'll also discuss the methods and techniques of heavy construction, including shoring and excavation. In addition, we'll look at the procedures used in maintaining the structures.

TIMBER TRESTLES

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the parts of a trestle, and describe the procedures for erecting bents and superstructures.

A trestle is a braced framework of timbers, piles, or steel members. It is typically built to carry a roadway across a depression, such as a gully, a canyon, or the valley of a stream. The two main parts of a trestle

are the substructure, consisting of the supporting members, and the superstructure, consisting of the decking and the stringers on which the decking is laid.

The substructure of a timber trestle is a series of transverse frameworks called bents. Trestle bents are used on solid, dry ground, or in shallow water with a solid bottom. Pile bents are used in soft or marshy ground, or where the water is so deep or the current so swift that the use of trestle bents is impossible. The posts of a pile bent are bearing piles or vertical members driven into the ground.

NOMENCLATURE

The following terms are common to timber trestle construction:

Abutment— The ground support at each of the extreme ends of a trestle superstructure. Examples are shown in figures 10-1 and 10-2.

Bracing— The timbers used to brace a trestle bent, called transverse bracing, or the timbers used to brace bents to each other, called longitudinal

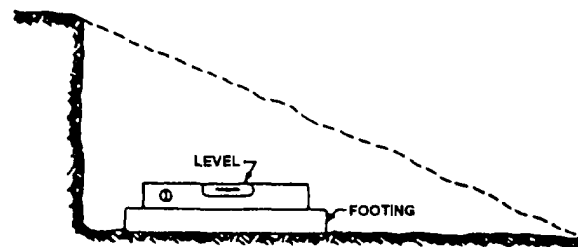
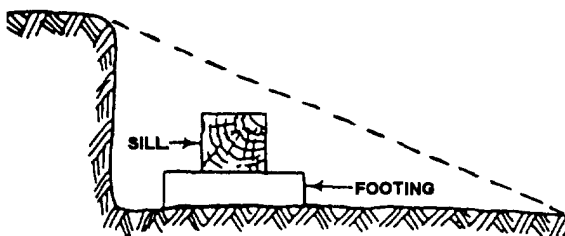
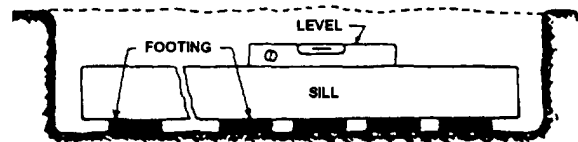
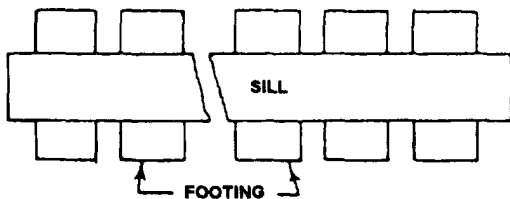


Figure 10-1.-Abutment sill and footing and abutment excavation.

Figure 10-2.-Placing and leveling abutment footings and abutment sill.

bracing. Figure 10-3 shows both types for a two-story trestle bent.

Cap— The uppermost transverse horizontal structural member of a bent. It is laid across the tops of the posts.

Decking— The structure laid on the girders to form the roadway across the trestle. It consists of a lower layer of timbers (flooring) and an upper layer of timbers (treadway).

Footing— The supports placed under the sills. In an all-timber trestle, the footings consist of a series of short lengths of plank. Whenever possible, however, the footings are made of concrete.

Girder— One of a series of longitudinal supports for the deck, which is laid on the caps. Also called a stringer.

Post— One of the vertical structural members.

Sill— The bottom transverse horizontal structural member of a trestle bent, on which the posts are anchored, or transverse horizontal member, which supports the ends of the girders at an abutment.

Substructure— The supporting structure of braced trestle bents, as distinguished from the superstructure.

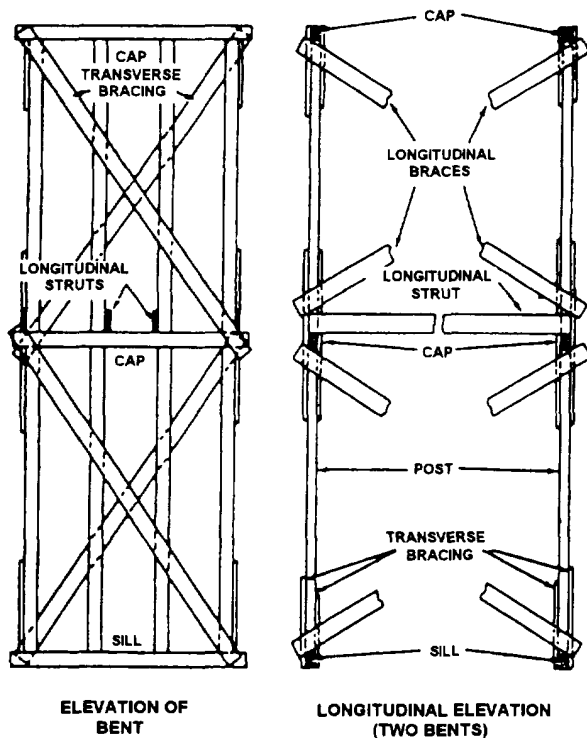


Figure 10-3.-Two-story trestle bent.

Superstructure— The spanning structure of girders and decking, as distinguished from the substructure.

Trestle Bent— A single-story bent or a multistory bent and the support framework or substructure of a trestle. The parts of a single-story bent are shown in figure 10-4. A two-story bent is shown above in figure 10-3.

CONSTRUCTION

After the center line of a trestle has been determined, the next step is to locate the abutment on each bank at the desired or prescribed elevation. The abutments are then excavated to a depth equal to the combined depths of the decking and the stringers, less an allowance for settlement. The abutment footings and the abutment sills are then cut, placed, and leveled (as in fig. 10-2).

The horizontal distance from an abutment sill to the first bent and from one bent to the next is controlled by the length of the girder stock. It is usually equal to the length of the stock, minus about 2 feet for overlap. Girder stock is usually in 14-foot lengths. The center-to-center horizontal distance between bents is usually 14 minus 2, or 12 feet.

To determine the locations of the seats for the trestle bents and the heights of the bents (fig. 10-5), first stretch a tape from the abutment along the center line. Use a builder's level or a line level to level the tape. Drop a plumb bob from the 12-foot mark on the tape to the ground. The position of the plumb bob on the ground will be the location of the first bent. The vertical distance from the location of the bob to the horizontal tape,

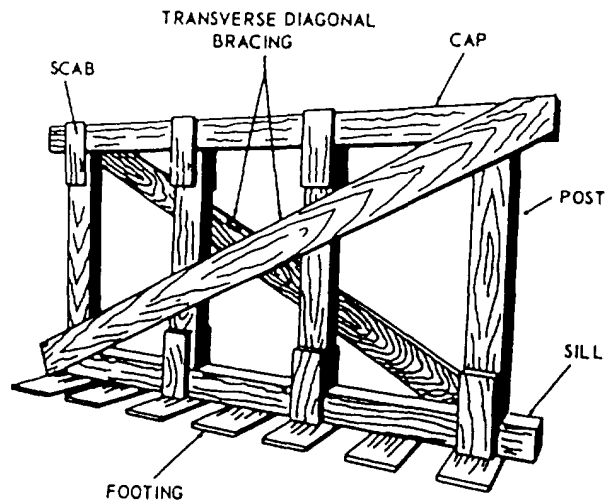


Figure 10-4.-Components of a single-story trestle bent.

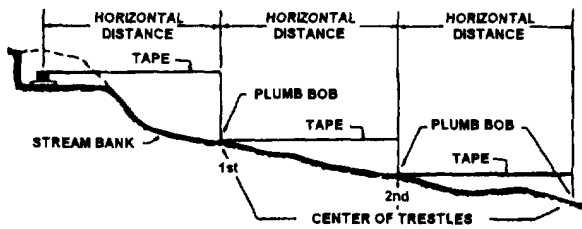


Figure 10-5.-Locating seats for trestle bents.

less the thickness of a footing, will be the height of the first bent.

Next, stretch the tape from the location of the first bent, level it as before, and again drop a plumb bob from the 12-foot mark. The position of the plumb bob will be the location of the section bent. The vertical distance from the location of the bob to the horizontal tape, plus the height of the first bent, less the thickness of the footing, will be the height of the second bent.

Finally, stretch the tape from the location of the second bent and proceed as before. The vertical distance from the location of the bob to the horizontal tape, plus the height of the second bent, less the thickness of a footing, will be the height of the third bent, and so on.

CONSTRUCTING A TRESTLE BENT

When a trestle bent is laid out and constructed, the length of the posts is equal to the height of the bent, less the combined depths of the cap and sill. In a four-post bent, the centers of the two outside posts are located from 1 to 2 1/2 feet inboard of the ends of the sill, and the centers of the two inner posts are spaced equally distant between the other two.

Sills, caps, and posts are commonly made of stock that ranges in size from 12 by 12s to 14 by 16s. If a sill or cap is not square in a cross section, the larger dimension should be placed against the ends of the posts. The usual length for a sill or cap is 2 feet more than the width of the roadway on the trestle. The minimum width for a single-lane trestle is 14 feet; for a two-lane trestle, 18 feet.

Layout

Part of the terrain at an assembly site may be graded flat and used as a framing yard, or a low platform may be constructed for use as a framing platform. To assemble a bent, lay the posts out parallel and properly spaced, and set the cap and sill in position against the ends. Bore the holes for the driftpins through the cap and the sill into the ends of the posts, and drive in the driftpins. Cut a pair of 2- by 8- by 18-inch scabs for each joint and then spike, lag-screw, or bolt the scabs to the joints.

Finally, measure the diagonals to determine the lengths of the transverse diagonal braces. Cut the braces to length and spike, lag-screw, or bolt them to the sills, caps, and posts. Transverse diagonal bracing is usually made of 2 by 8 stock.

Trestle Bent Erection

After assembly, the trestle bent is moved to the abutment, and set in place on the footings at the seat. Carefully plumb the bent and temporarily brace it with timbers running from the top of the bent to stakes driven at the abutment. Lay the superstructure (girders and decking) from the abutment out to the top of the first bent. The second bent is then brought out to the end of the superstructure and set in place. Plumb the second bent and measure the diagonals to determine the lengths of the longitudinal diagonal braces between the first and second bents. Then, cut the braces and spike, lag-screw, or bolt them in place.

The superstructure is then earned out to the second bent, after which the third bent is brought to the end of the superstructure. This procedure is repeated, usually by parties working out from both abutments, until the entire span is completed.

SUPERSTRUCTURE

Timber girders are usually 10 by 16s, 14 feet long, spaced 3 feet 3 1/2 inches on center (OC). Various methods of fastening **timber stringers** to timber caps are shown in figure 10-6, view A. Various methods of fastening **steel girders** to timber caps are shown in view B. This view also shows three ways of fastening a

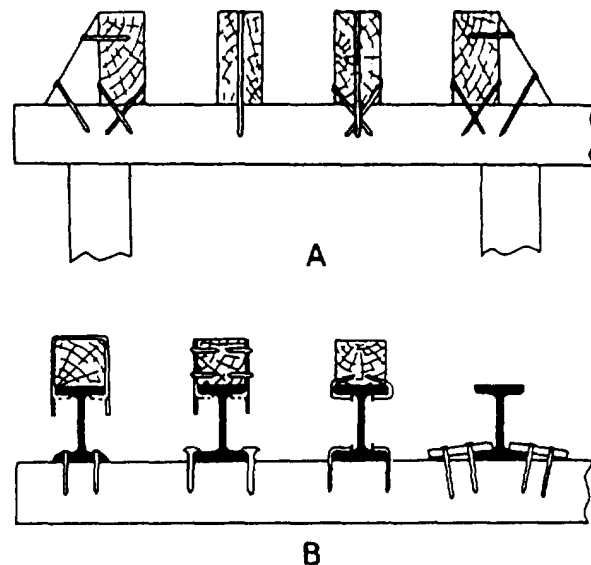


Figure 10-6.-Methods of fastening timber stringers and steel girders to timber caps.

timber-nailing anchorage for flooring to the top of a steel girder.

Timber decking consists of two layers of 3-inch planks. The lower layer, called the flooring, is laid at right angles to the stringers and nailed with two 60d spikes to each stringer crossing. The upper layer, called the tread (fig. 10-7), is laid securely and nailed at a 90° angle to the flooring.

Most of the flooring planks and all of the tread planks are cut to lengths that will bring the ends of the planks flush with the outer faces of the outside stringers. However, at 5-foot intervals along the superstructure, a flooring plank is left long enough to extend 2 feet 8 inches beyond the outer faces of the outside stringers. The extension serves as support for the curb risers, the curb, and the handrail posts, as shown in figure 10-7. The curb risers consist of 3-foot lengths of 6 by 6 timbers, one of which is set in front of each handrail post as shown. A continuous 2 by 6 handrail is nailed to 4 by 4 handrail posts. Each handrail post is supported by a 2 by 4 knee brace, as shown.

An end dam, such as that shown in figure 10-8, is set at each end of the superstructure. This prevents the approach of the road to the trestle from washing out or eroding between the abutment and the girders.

PILE DRIVING TERMINOLOGY AND TECHNIQUES

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types of piles used in heavy construction and state the procedures for constructing a timber pier.

The principal structural members in many waterfront structures are piles. There are different types of and uses for piles. The common terms used with piles and pile driving are explained below.

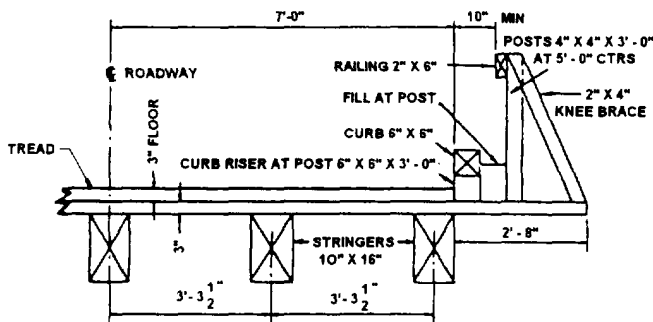


Figure 10-7.-Details of superstructure of a timber trestle.

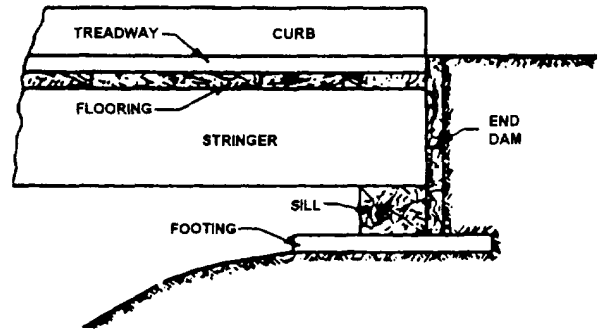


Figure 10-8.-End dam.

TYPES OF PILES

A pile is a load-bearing member made of timber, steel, concrete, or a combination of these materials. It is usually forced into the ground to transfer the load to underlying soil or rock layers when the surface soils at a proposed site are too weak or compressible to provide enough support.

Timber Bearing

Timber bearing piles are usually straight tree trunks cut off above ground swell with the branches closely trimmed and the bark removed. Occasionally, sawed timbers may be used as bearing piles.

CHARACTERISTICS.— A good timber pile has the following characteristics:

- It is free of sharp bends, large or loose knots, shakes, splits, and decay.
- It is uniformly tapered from butt to tip.
- The centers of the butt and tip are end points of a straight line that lies within the body of the pile.

Cross-section dimensions for timber piles should be as follows:

- Piles shorter than 40 feet, tip diameters between 8 and 11 inches, and butt diameters between 12 and 18 inches.
- Piles longer than 40 feet, tip diameters between 6 and 8 inches, and butt diameters between 13 and 20 inches. The butt diameter must not be greater than the distance between the pile leads.

PREPARATION FOR DRIVING.— Timber piles can be damaged while being driven, particularly under hard-driving conditions. To protect a pile against damage, cut the butt of the pile squarely (so the pile hammer will strike it evenly) and chamfer it. When a

driving cap is used, the chamfered butt must fit the cap. When a cap is not used, the top end of the pile is wrapped with 10 or 12 turns of wire rope at a distance of about one diameter below the head of the pile (fig. 10-9, views A and B). When a hole is bored in the butt of the pile, double wrappings are used (view C). The pile can also be wrapped or clamped if the butt is crushed or split. As an alternative to wrapping, two half-rings of 3/8-inch steel are clamped around the butt (view D).

The tip of the pile is cut off perpendicular to its axis. When driven into soft or moderately compressible soil, the tip of the pile may be left unpointed. A blunt-end pile provides a larger bearing surface than a pointed-end pile when used as an end-bearing pile. When driven, a blunt-end pile that strikes a root or small obstruction may break through it.

Where soil is only slightly compressible and must be displaced, the tip of the pile is usually sharpened to the shape of an inverted truncated pyramid (fig. 10-9, view A). The blunt end is about 4 to 6 inches square; the length of the point is 1 1/2 to 2 times the diameter of the pile at its foot. A crooked pile maybe pointed for driving, as shown in view B.

For hard driving, steel shoes are used to protect the pile tips. A manufactured shoe is shown in view C, and an improvised steel shoe is shown in view D.

Steel Bearing

Steel ranks next to timber in importance, especially where the construction must accommodate

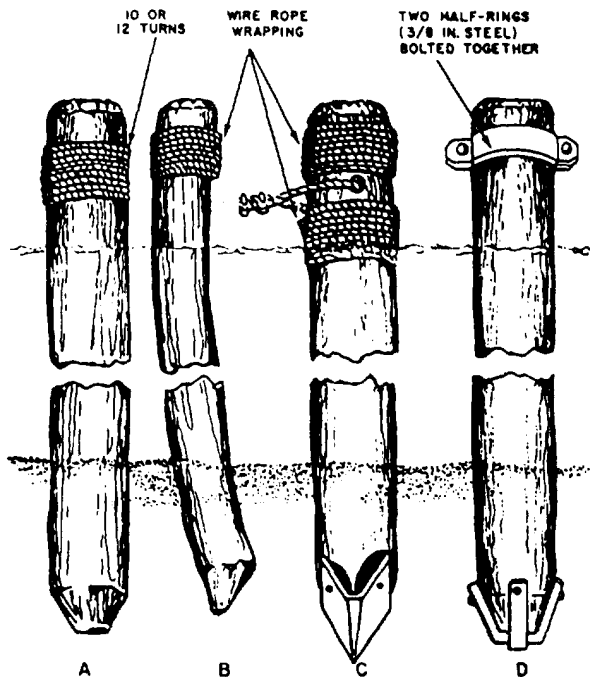


Figure 10-9.-Preparation of timber piles for driving.

heavy loads or the foundations are expected to be used over a long period of time. Steel is best suited for use as bearing piles where piles must be driven under any of the following conditions:

- Piles are longer than 80 feet.
- Column strength exceeds the compressive strength of timber.
- To reach bedrock for maximum bearing surface through overlying layers of partially decomposed rock.
- To penetrate layers of coarse gravel or soft rock, such as coral.
- To attain great depth of penetration for stability (for example, driving piles in a rock-bedded, swiftly flowing stream where timber piles cannot be driven deeply enough for stability).

One of the most common types of steel bearing piles is the pipe pile. An open-end pipe pile is open at the bottom. A closed-rid pipe pile is closed at the bottom. Another common type of steel pile is the H-type, often seen as HP. When driving HPs, a special driving cap (shown in fig. 10-10) is used.

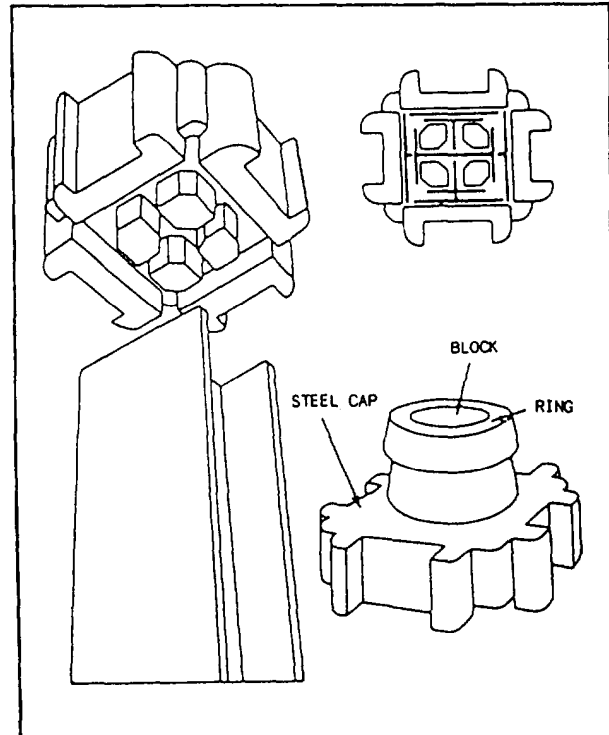


Figure 10-10.-HP-bearing pile and special cap for driving

Concrete

A concrete bearing pile may be cast in-place or precast. A cast-in-place concrete pile may be a shell type or a shell-less type.

A shell type of cast-in-place pile is constructed as shown in figure 10-11. A steel core, called a mandrel, is used to drive a hollow steel shell into the ground. The mandrel is then withdrawn, and the shell is filled with concrete. If the shell is strong enough, it may be driven without a mandrel.

A shell-less cast-in-place concrete pile is made by placing the concrete in direct contact with the earth. The hole for the pile may be made by driving a shell or a mandrel and shell, or it may be simply bored with an earth auger. If a mandrel and shell are used, the mandrel, and usually also the shell, are removed before the concrete is poured. In one method, however, a cylindrical mandrel and shell are used, and only the mandrel is removed before the concrete is poured. The concrete is poured into the shell, after which the shell is extracted. This sequence of events is shown in figure 10-12.

Casting in place is not usually feasible for concrete piles used in waterfront structures. Concrete piles for waterfront structures are usually precast. The cross section of precast concrete piles is usually either square or octagonal (eight-sided). Square-section

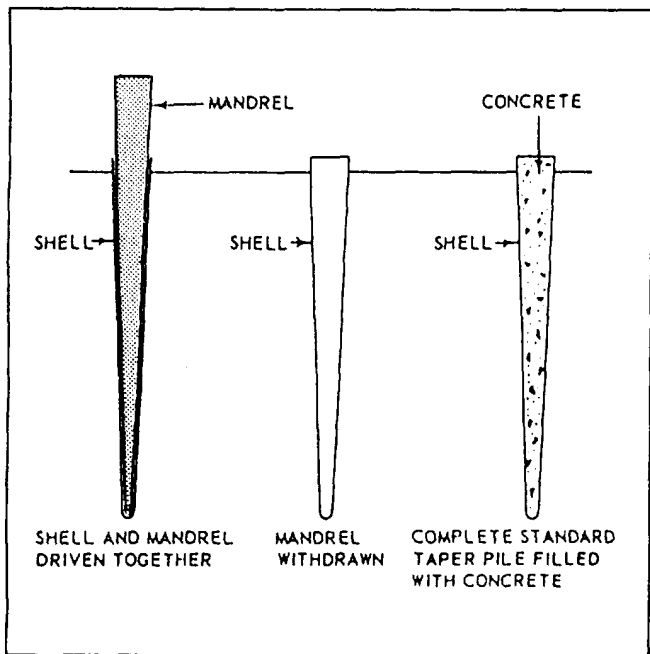


Figure 10-11.-Shell type cast-in-place concrete pile.

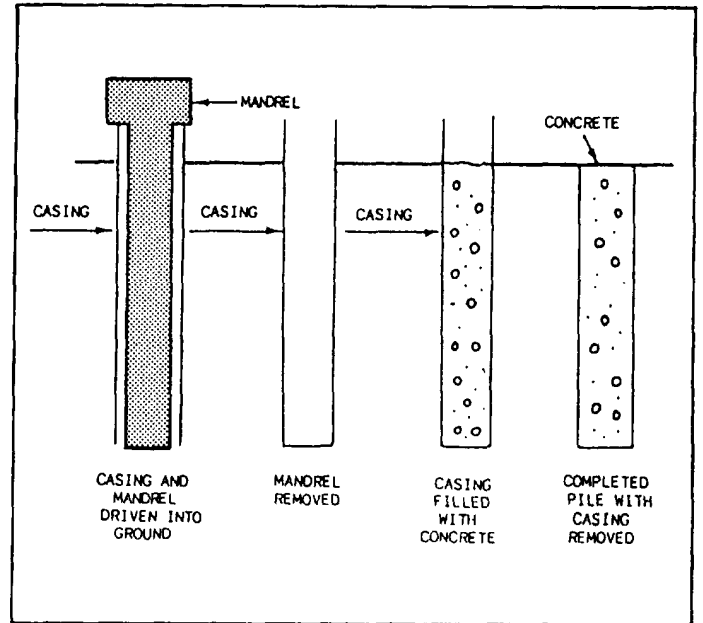


Figure 10-12.-Procedure for cast-in-ground concrete piles.

piles run from 6 to 24 inches square. Concrete piles more than 100 feet long can be cast, but are usually too heavy for handling without special equipment.

Sheet

Sheet piles are special shapes of interlocking piles made of steel, wood, or formed concrete. They are widely used to form a continuous wall to resist horizontal pressures resulting from earth or water loads. Examples include retaining walls, cutoff walls, trench sheathing, cofferdams, and bulkheads in wharves, docks, or other waterfront structures. Cofferdams exclude water and earth from an excavation so that construction can proceed easily. Cutoff walls are built beneath water-retaining structures to retard the flow of water through the foundation.

Sheet piles may also be used in the construction of piers for bridges and left in place. Here, steel piles are driven to form a square or rectangular enclosure. The material inside is then excavated to the desired depth and replaced with concrete.

Timber Pier Piles

Working drawings for advanced base timber piers are contained in *Facilities Planning Guide*, Volume I, NAVFAC P-437. Figure 10-13 shows a general plan; figure 10-14, a part plan; and

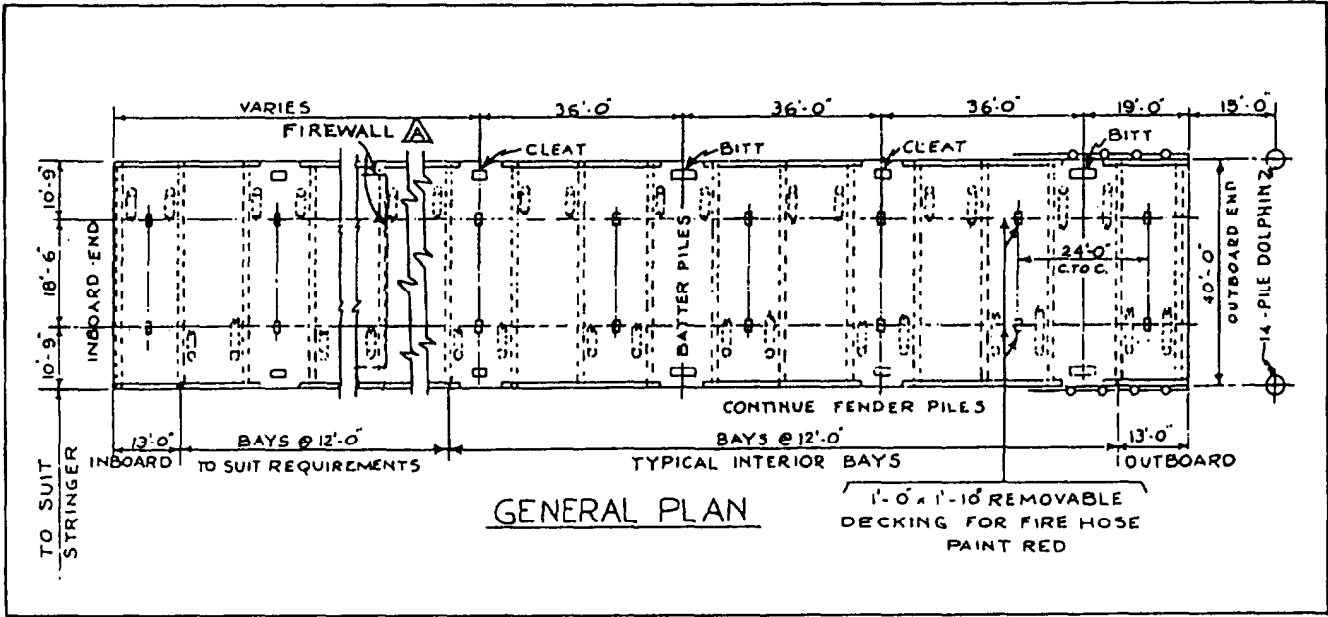


Figure 10-13.-General plan of an advanced base 40-foot-timber pier.

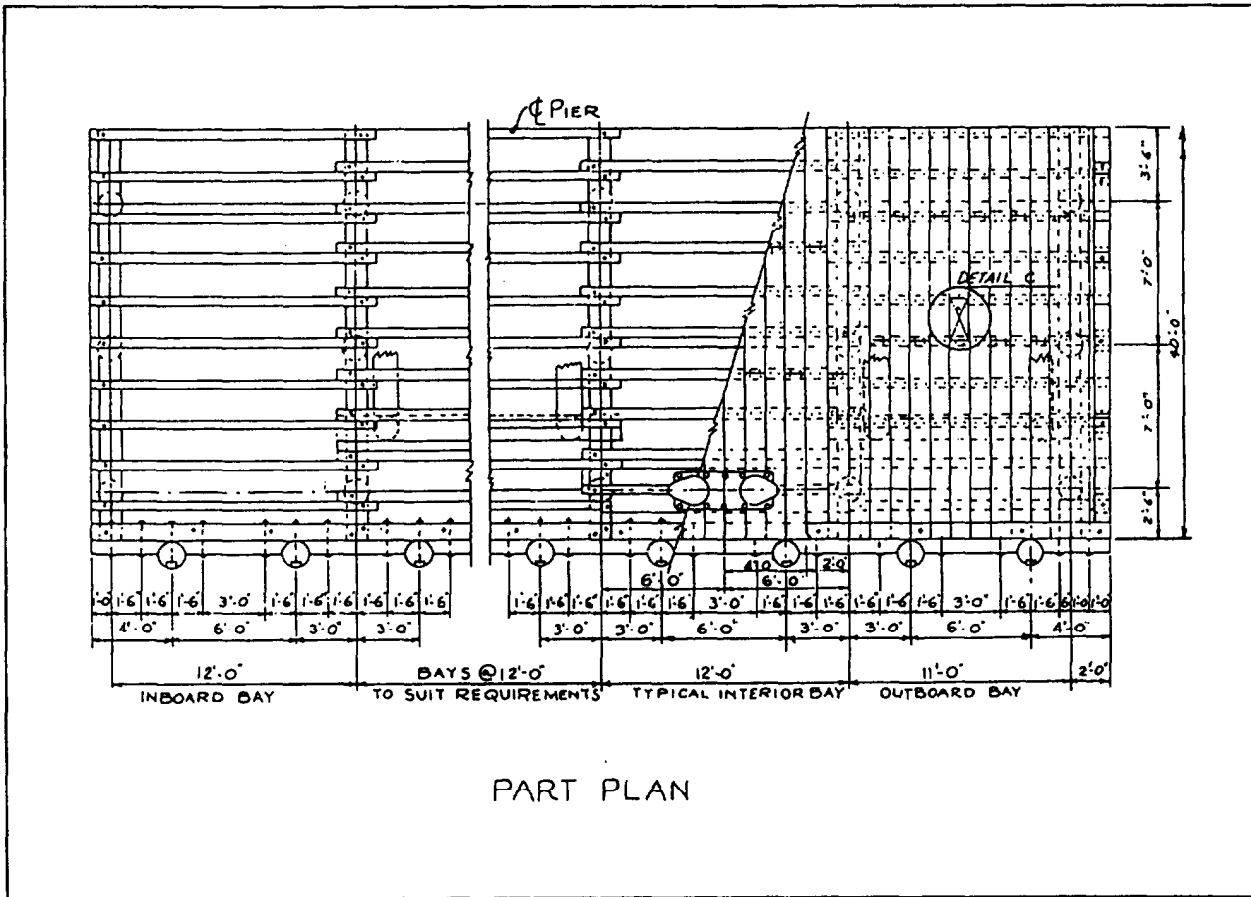


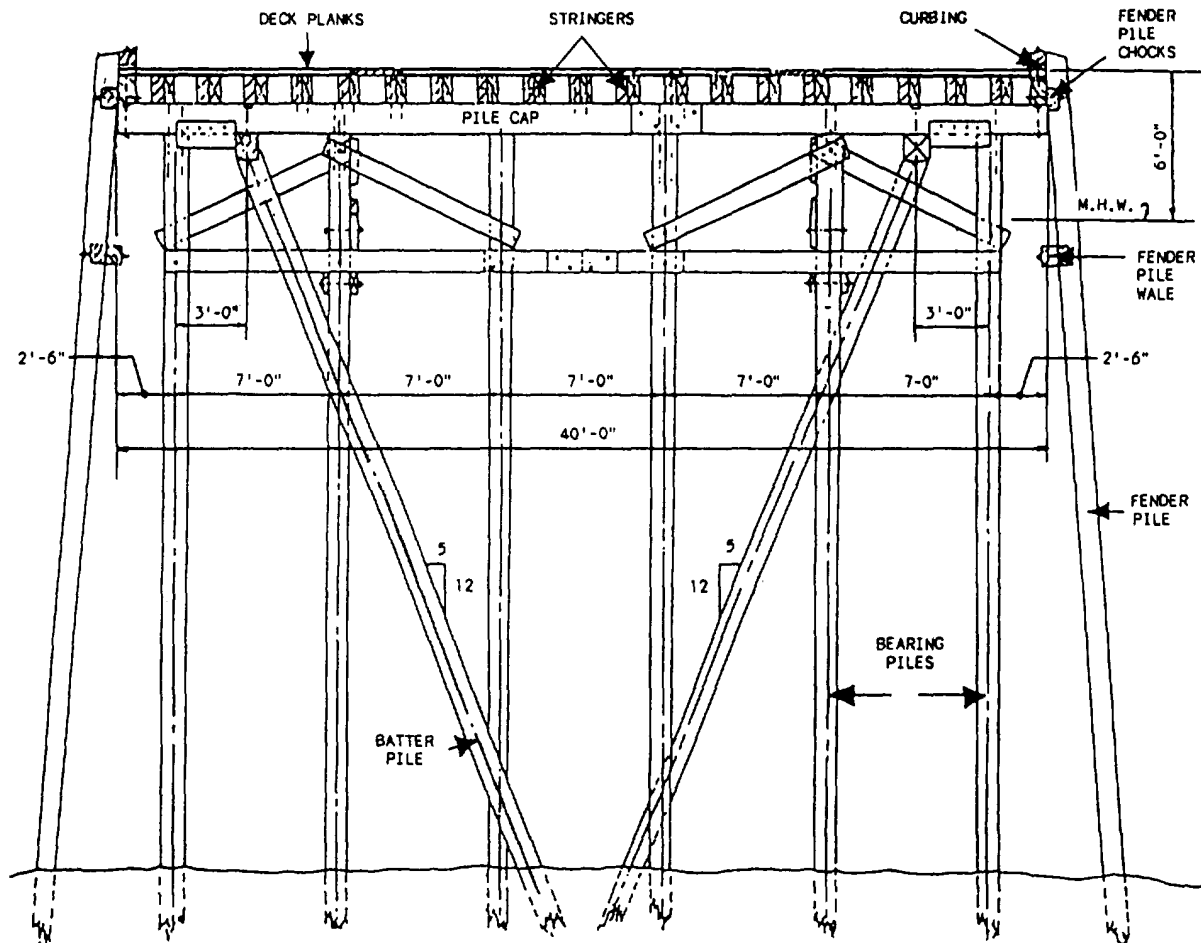
Figure 10-14.-Part plan of an advanced base timber pier.

figure 10-15, a cross section for a 40-foot pier. The drawings (examples are shown in figs. 10-13, 10-14, and 10-15) include a bill of materials, showing the dimensions and location of all structural members, driftpins, bolts, and hardware. Figures 10-13 and 10-14 are parts of NAVFAC Drawing No. 6028173; figure 10-15 is a part off NAVFAC Drawing 6028174.

The size of the pier is designated by its width. The width is equal to the length of a bearing-pile cap.

Each part of a pier lying between adjacent pile bents is called a bay, and the length of a bay is equal to the OC spacing of the bents. The general plan (fig. 10- 13) shows that the advanced base 40-foot timber pier consists of one 13-foot outboard bay, one 13-foot inboard bay, and as many 12-foot interior bays as needed to meet requirements.

The cross section (fig. 10- 15) shows that each bent consists of six bearing piles. The bearing piles are braced transversely by diagonal braces. Additional transverse bracing for each bent is provided by a pair of batter piles. The batter angle is specified as 5 in 12. One pile of each pair is driven on either side of the bent, as shown in the general plan. The butts of the batter piles are joined to 12-inch by 12-inch by 14-foot longitudinal batter-pile caps. Each of these is bolted to the undersides of two adjacent bearing-pile caps with bolts in the positions shown in the part plan (fig. 10- 14). The batter-pile caps are placed 3 feet inboard of the center lines of the outside bearing piles in the bent. They are backed by 6- by 14-inch batter-pile cap blocks, each of which is bolted to a bearing-pile cap. Longitudinal bracing between bents consists of 14-foot lengths of 3 by 10 planks, bolted to the bearing piles.



CROSS SECTION

Figure 10-15.-Cross section of an advanced base timber pier.

The superstructure (fig. 10-15) consists of a single layer of 4 by 12 planks laid on 19 inside stringers measuring 6 inches by 14 inches by 14 feet. The inside stringers are fastened to the pile caps with driftbolts. The outside stringers are fastened to the pile caps with through-bolts. The deck planks are fastened to the stringers with 3/8- by 8-inch spikes. After the deck is laid, 12-foot lengths of 8 by 10s are laid over the outside stringers to form the curbing. The lengths of curbing are distributed as shown in the general plan. The curbing is bolted to the outside stringers to form the curbing. The lengths of curbing are distributed as shown in the general plan. The curbing is bolted to the outside stringers with bolts.

The pier is equipped with a fender system for protection against shock, caused by contact with vessels coming or lying alongside. Fender piles, spaced as shown in the part plan, are driven along both sides of the pier and bolted to the outside stringers with bolts. The heads of these bolts are countersunk below the surfaces of the piles. An 8 by 10 fender wale is bolted to the backs of the fender piles with bolts.

Lengths of 8 by 10 fender pile chocks are cut to fit between the piles and bolted to the outside stringers and the fender wales. The spacing for these bolts is shown in the part plan. As indicated in the general plan, the fender system also includes two 14-pile dolphins, located 15 feet beyond the end of the pier. A dolphin is an isolated cluster of piles, constructed as shown in figure 10-16. A similar cluster attached to a pier is called a pile cluster.

PILE DRIVING TECHNIQUES

When driving piles of any type, always watch both the pile and equipment. Care must be taken to avoid damaging the pile or the driving hammer. Watch the piles carefully for any indications of splitting or breaking below ground. The next section covers some of the more common problems you might encounter.

Springing and Bouncing

Springing means that the pile vibrates too much laterally. Springing may occur when a pile is crooked, when the butt has not been squared off properly, or

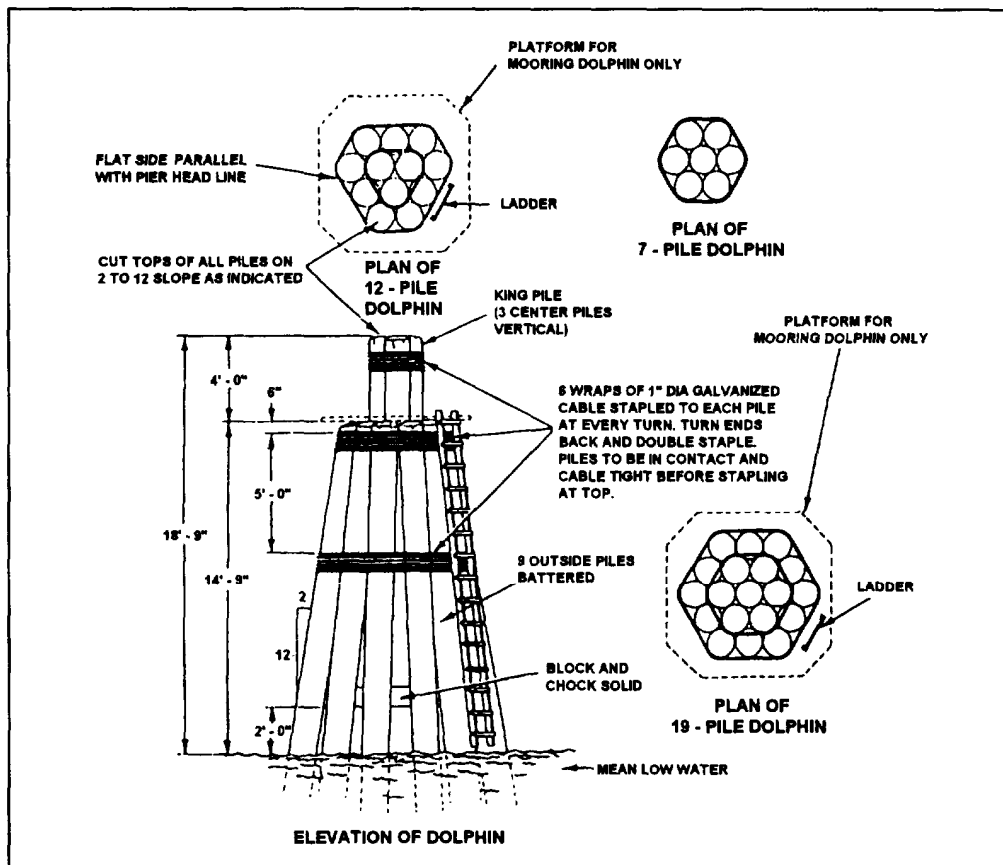


Figure 10-16.-Dolphins.

when the pile is not in line with the fall of the hammer. Always make sure the fall of the hammer is in line with the pile axis. Otherwise, the head of the pile and the hammer may be severely damaged and much of the energy of the hammer blow lost.

Excessive bouncing may be caused by a hammer that is too light. However, it usually occurs when the butt of the pile becomes crushed or broomed, as when the pile meets an obstruction or penetrates to a solid footing. When a double-acting hammer is being used, bouncing may result from too much steam or air pressure. With a closed-end diesel hammer, if the hammer lifts on the upstroke of the ram piston, the throttle setting is probably too high. Back off on the throttle control just enough to avoid this lifting. If the butt of the timber pile has been crushed or broomed more than an inch or so,

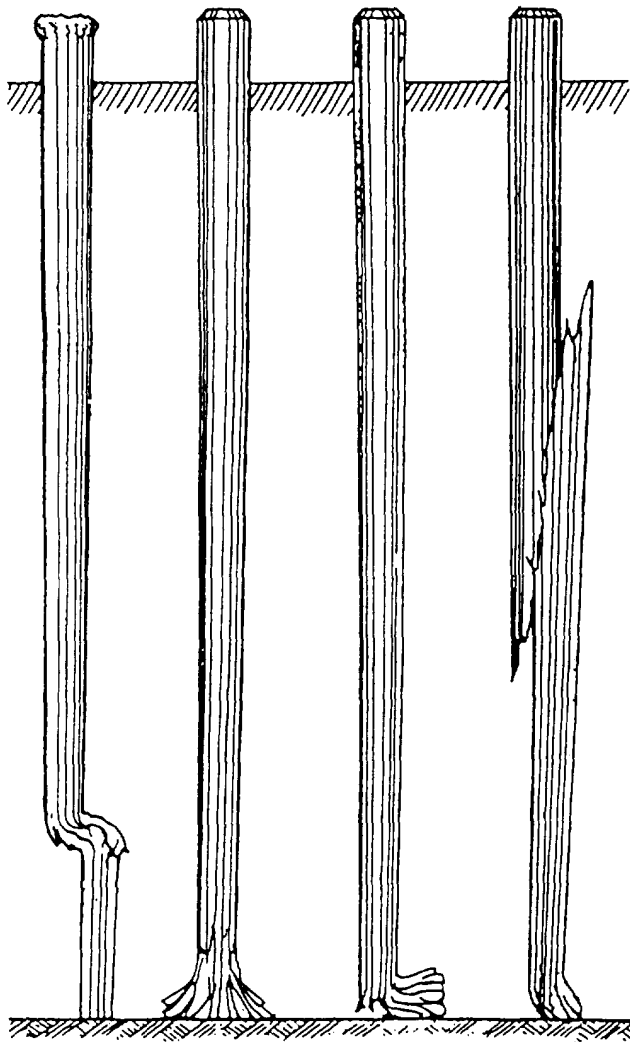


Figure 10-17.-Types of pile damage caused by overdriving timber piles.

it should be cut back to sound wood before you drive it any more.

Obstruction and Refusal

When a pile reaches a level where 6 blows of a drop hammer or 20 blows of a steam or air hammer do not drive it more than an average of 1/8 inch per blow, the pile has either hit an obstruction or has been driven to refusal. In either case, further driving is likely to break or split the pile. Examples of typical damage are shown in figure 10-17.

If the lack of penetration seems to be caused by an obstruction, 10 or 15 blows of less than maximum force may be tried. This may cause the pile to displace or penetrate the obstruction. For obstructions that cannot be disposed of in this manner, it is often necessary to pull (extract) the pile and clear the obstruction.

When a pile has been driven to a depth where deeper penetration is prevented by friction, the pile has been driven to refusal. It is not always necessary to drive a friction pile to refusal. Such a pile needs to be driven only to the depth where friction develops the required load-bearing capacity.

Straightening

Piles should be straightened when any misalignment is noticed during driving. The accuracy of

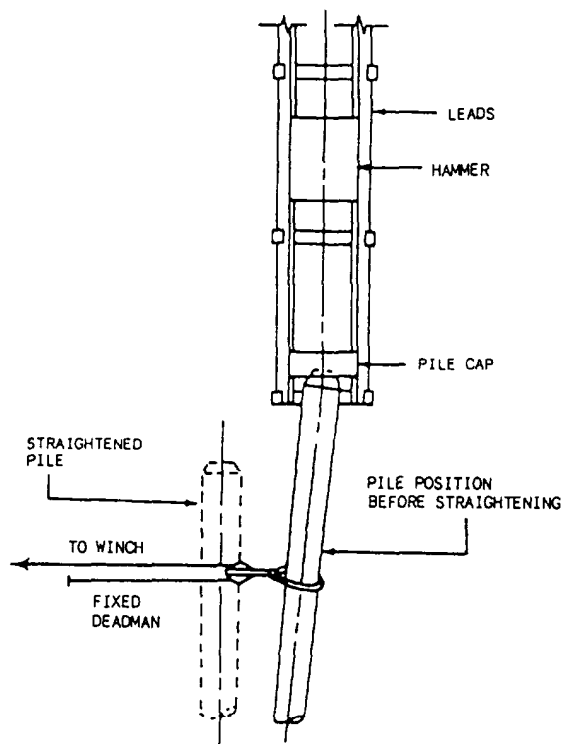


Figure 10-18.-Realigning pile by pull on a line to a winch.

alignment desirable for a finished job depends on various factors. Generally, though, a pile more than a few inches out of its plumb line should be tried. The greater the penetration along the wrong line, the harder to get the pile back into plumb. There are several methods of realigning a pile.

One method of realignment is to use pull from a block and tackle, with the impact of the hammer jarring the pile back into line (fig. 10-18). The straightening of steel bearing piles must include twisting the individual piles to bring the webs of the piles parallel to the center line of the bent.

Another method of realignment is to use a jet (fig. 10-19), either alone or with either of the other two methods. Jetting a pile can be done with either water or air.

When all piles in a bent have been driven, they can be pulled into proper spacing and alignment with a block and tackle and an aligning frame, as shown in figures 10-20 and 10-21.

Pulling

A pile that has hit an obstruction, has been driven in the wrong place, has been split or broken in driving, or is to be salvaged (steel sheet piles are frequently salvaged for reuse) is usually pulled (extracted). Pulling should be done as soon as possible after driving. The longer the pile stays in the soil, the more compact the soil becomes, and the greater the resistance to pulling will be.

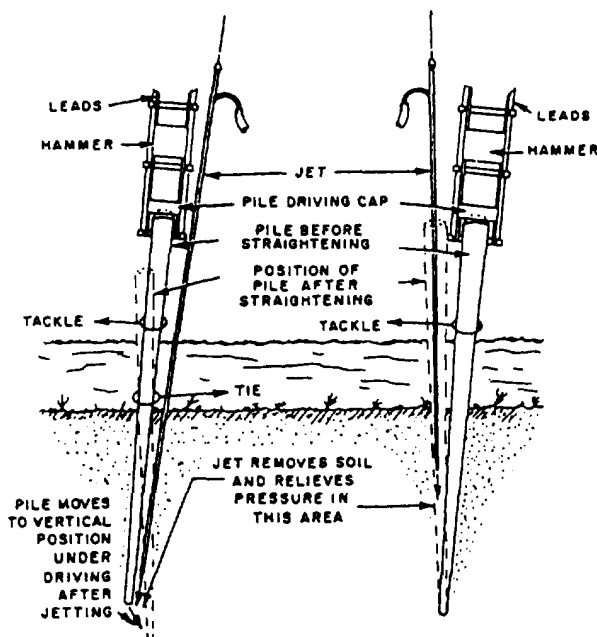


Figure 10-19.-Realigning pile by jetting.

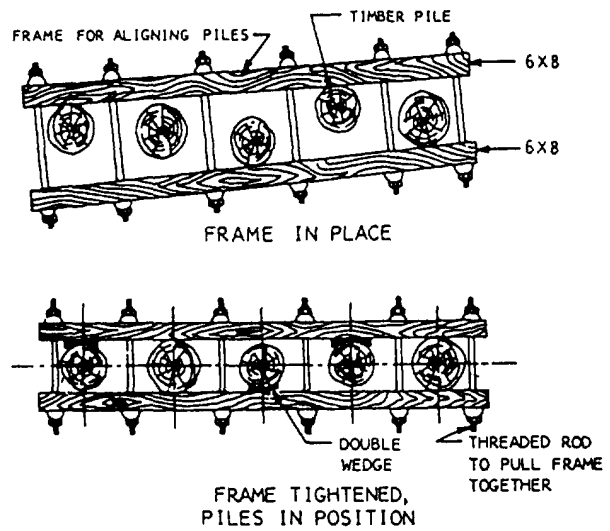


Figure 10-20.-Aligning framing used for timber pile bent.

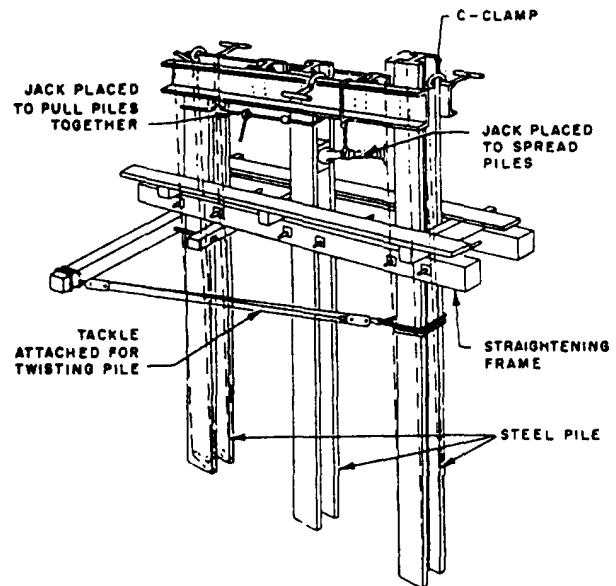


Figure 10-21.-Aligning and capping steel pile bents.

WATERFRONT STRUCTURES

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe the uses of and construction methods for offshore, alongshore, wharfage, and below the water table construction.

Waterfront structures are broadly divided into three main categories: offshore structures creating a sheltered harbor; alongshore structures establishing and maintaining a stable shoreline; and wharfage structures allowing vessels to lie alongside for loading or unloading.

OFFSHORE

Offshore structures include breakwaters and jetties. They are alike in construction and differ mainly in function.

Breakwaters and Jetties

In an offshore barrier, the breakwater interrupts the action of the waves of open water to create an area of calm water between it and the shore. A jetty works to direct and confine a current or tidal flow into a selected channel.

The simplest type of breakwater or jetty is the rubble mound (also called rock mound). An example is shown in figure 10-22. The width of its cap may vary from 15 to 70 feet. The width of its base depends on the width of the cap, height of the structure, and slope of the inner and outer faces.

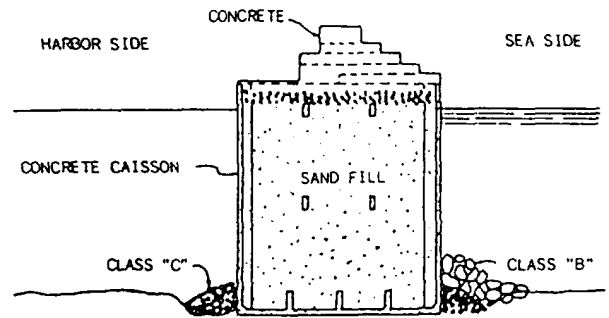


Figure 10-24.-Caisson breakwater/jetty.

Rubble-mound breakwaters or jetties are constructed by dumping rock from either barges or railcars (running on temporary pile-bent structures) and by placing upper rock and cap rock with floating cranes.

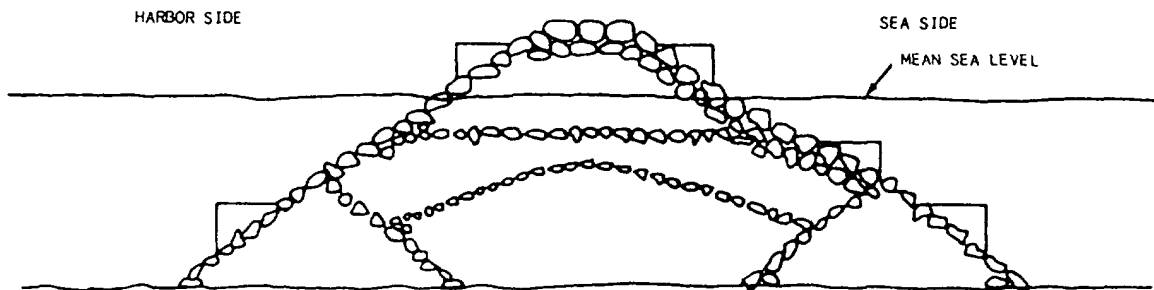


Figure 10-22.-Rubble-mound breakwater/jetty.

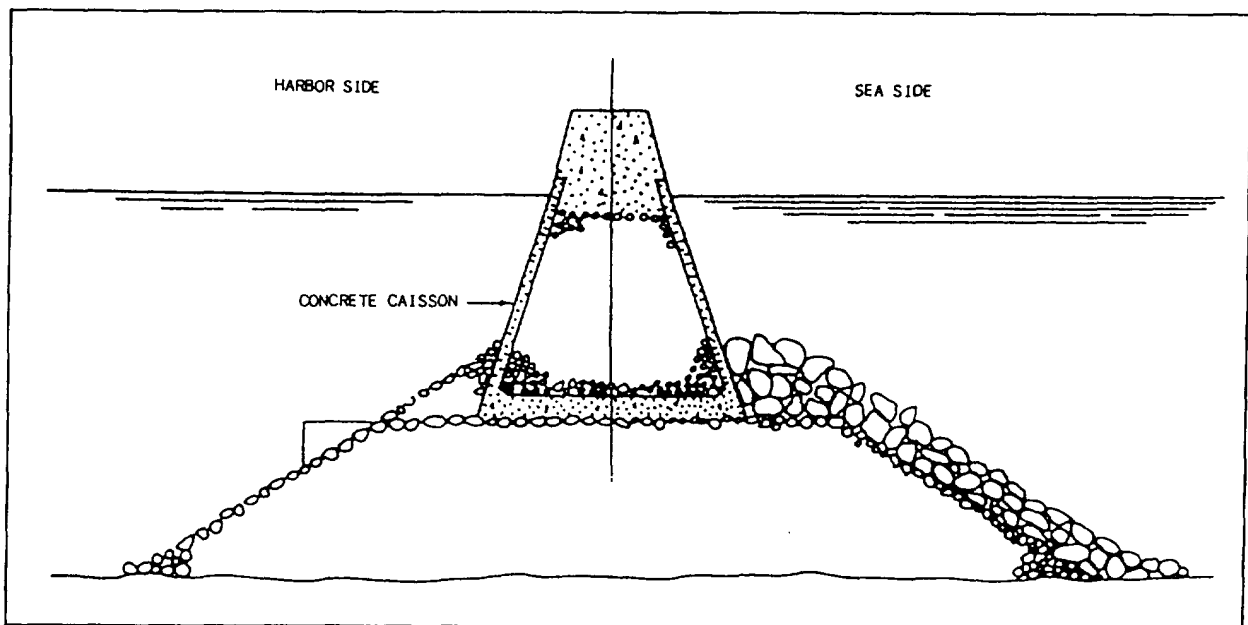


Figure 10-23.-Composite breakwater/jetty.

For a deepwater site or one with an extreme range between high and low tides, a rubble-mound breakwater or jetty may be topped with a cap structure to form the composite type shown in figure 10-23. In this case, the cap structure consists of a series of precast concrete boxes called caissons, each of which is floated over its final location and sunk into place by filling with rock. A single-piece concrete cap is then cast in place on the top of each caisson. Breakwaters and jetties are sometimes built entirely of caissons. A typical caisson breakwater/jetty is shown in figure 10-24. A jetty may also be constructed to serve as a wharfage structure. If so, it is still called a jetty.

ALONGSHORE

Alongshore structures include seawalls, groins, and bulkheads. Their main purpose is to stabilize a shoreline.

Seawalls

Seawalls vary widely in details of design and materials, depending on the severity of the exposure, the value of the property to be protected, and other considerations. Basically, though, they consist of some form of barrier designed to break up or reflect the waves and a deep, tight cutoff wall to preclude washing out of the sand or soil behind and under the barrier. The cutoff wall is generally constructed of timber, steel, or concrete sheet piling. Figure 10-25

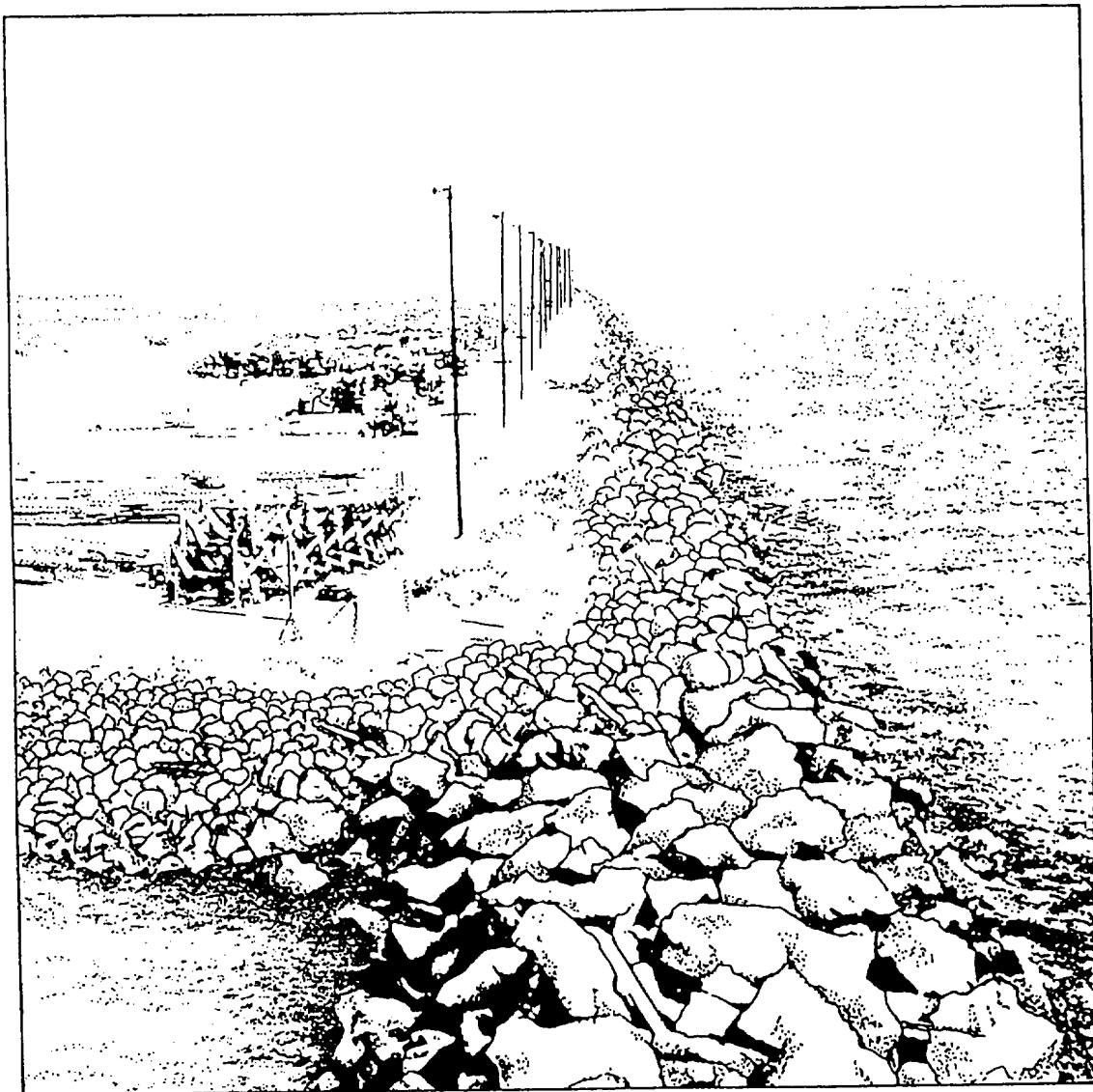


Figure 10-25.-Riprap seawall.

shows a rubble-mound seawall. The stone protecting the shoreline against erosion is called riprap. Therefore, a rubble-stone seawall is called a riprap seawall.

Various types of cast-in-place concrete seawalls are the vertical-face, inclined-face, curved-face, stepped-face, and combination curved-face and stepped-face. The sea or harbor bottom along the toe (bottom of the outside face) of a seawall is usually protected against erosion (caused by the backpull of receding waves) by riprap piles against the toe.

Groins

Groins, built like breakwaters or jetties, extend outward from the shore. Again, they differ mainly in function. A groin is used where a shoreline is in danger of erosion caused by a current or wave action running obliquely against or parallel to the shoreline. It is placed to arrest the current or wave action or to deflect it away from the shoreline.

Groins generally consist of tight sheet piling of creosoted timber, steel, or concrete, braced with wales and with round piles of considerable length. Groins are usually built with their tops a few feet above the sloping beach surface that is to be maintained or restored.

Bulkheads

A bulkhead has the same general purpose as a seawall: to establish and maintain a stable shoreline. But, whereas a seawall is self-contained, relatively thick, and supported by its own weight, a bulkhead is a relatively thin wall supported by a series of tie wires

or tie rods, running back to a buried anchorage (deadman). A timber bulkhead for a bridge abutment is shown in figure 10-26. It is made of wood sheathing (square-edged, single-layer planks), laid horizontally.

Most bulkheads, however, are made of steel sheet piles, an example of which is shown in figure 10-27. The outer ends of the tie rods are anchored to a steel wale running horizontally along the outer face of the bulkhead.

This wale is usually made up of pairs of steel channels bolted together, back to back. A channel is a structural steel member with a U-shaped section. Sometimes the wale is placed on the inner face of the bulkhead, and the piles are bolted to it.

The anchorage shown in figure 10-27 is covered by backfill. In stable soil above the groundwater level, the anchorage may consist simply of a buried timber, a concrete deadman, or a row of driven and buried sheet piles. A more substantial anchorage for each tie rod is used below the groundwater level. Two common types of anchorages are shown in figure 10-28. In view A, the anchorage for each tie rod consists of a timber cap, supported by a batter pile. In view B, the anchorage consists of a reinforced concrete cap, supported by a pair of batter piles. As indicated in the figure, tie rods are supported by piles located midway between the anchorage and the bulkhead.

Bulkheads are constructed from working drawings like those shown in figure 10-29. The detail plan for the bulkhead shows that the anchorage consists of a row of sheet piles to which the inner ends

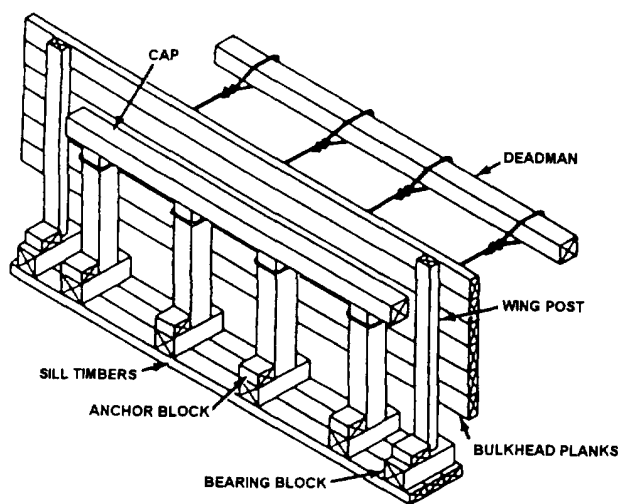


Figure 10-26. Timber bulkhead for bridge abutment.

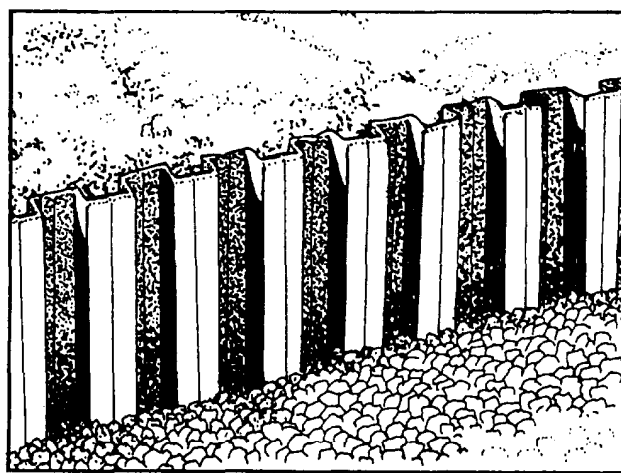
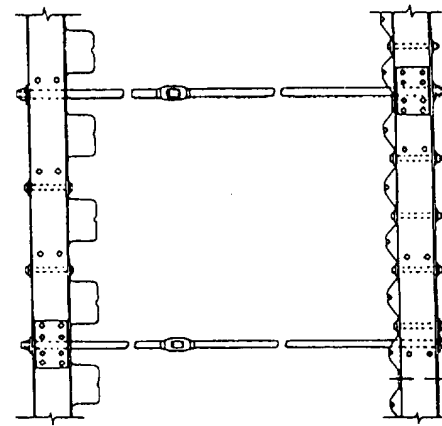
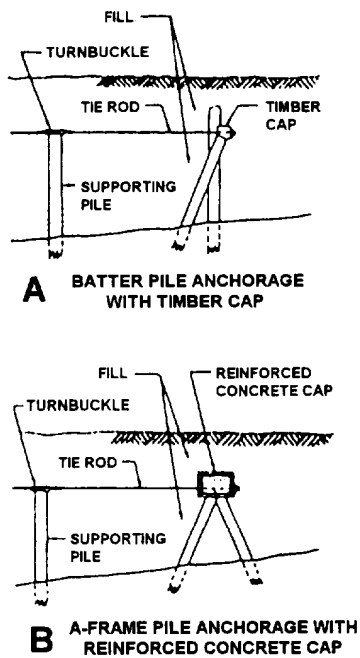


Figure 10-27. Constructed steel sheet pile bulkhead.



DETAIL PLAN OF BULKHEAD

SECTION THRU BULKHEAD

Figure 10-29. Working drawings for a steel sheet pile bulkhead.

Figure 10-28. Two types of tie-rod anchorages for bulkheads.

of the tie rods are anchored by means of a channel wale.

In the figure, the construction sequence begins when the shore and bottom are first excavated to the level of the long, sloping dotted line. The sheet piles for the bulkhead and the anchorage are then driven. The supporting piles for the tie rods are driven next, after which the tie rods between the bulk and the anchorage are set in place and the wales are bolted on. The tie rods are prestressed lightly and uniformly, and the backfilling then begins.

The first backfilling operation consists of placing fill over the anchorage, out to the dotted line shown in the plan. The turnbuckles on the tie rods are then set to bring the bulkhead plumb, and the rest of the backfill is worked out to the bulkhead. After the backfilling is completed, the bottom outside the bulkhead is dredged to the desired depth.

WHARFAGE

As mentioned earlier, wharfage structures allow vessels to lie alongside for loading or unloading. Moles and jetties are the most typical forms.

Moles and Jetties

A mole is simply a breakwater that serves as a wharfage structure. The only difference is that its inner or harbor face must be vertical and its top must function as a deck. In a similar way, jetties also serve as wharfage structures.

BELOW THE WATER TABLE

When construction is carried on below the groundwater level, or when underwater structures like seawalls, bridge piers, and the like, are erected, it is usually necessary to temporarily keep the water out of the construction area. This is typically done with well points, cofferdams, or caissons.

Well Points

Well points are long pipes thrust into the ground down to the level at which the water must be excluded.

They are connected to each other by a pipeline system that heads up at a water pump. Well point engineers determine the groundwater level and the direction of flow of the groundwater, and the well point system is placed so as to cut off the flow into the construction area. Well pointing requires highly specialized personnel and expensive equipment.

Cofferdams

The cofferdam is a temporary structure, usually built in place, and tight enough so that the water can be pumped out of the structure and kept out while construction on the foundations is in progress. Common cofferdam types are earthen, steel sheeting, wooden sheathing, and crib. Figure 10-30 shows a cofferdam under construction.

An earthen cofferdam is built by dumping earth fill into the water, shaped to surround the construction area without encroaching upon it. Because swiftly moving currents can carry the material away, earthen cofferdams are limited to sluggish waterways where the velocities do not exceed 5 feet per second. Use is also limited to shallow waters; the quantities of material required in deep waters would be excessive due to the flat slopes to which the earth settles when

deposited in the water. For this reason, the earthen type is commonly combined with another type, such as sheathing or cribbing, to reduce the quantities of earthwork.

Steel is commonly used for cofferdam construction. Sheet piling is manufactured in many interlocking designs and in many weights and shapes for varying load conditions. The piling is driven as sheeting in a row to form a relatively tight structure surrounding the construction area. This pile wall is supported in several ways. It may be supported by a framework of stringers and struts. A cofferdam wall can consist of a double row of piles tied together with heavy steel ties and filled with earth. This can square, rectangular, circular, or oval shape for stability around the construction area.

Wooden sheathing, instead of steel, is similarly used in cofferdam constructions. Interlocking timber sheathing is driven as a single wall and supported by stringers and cross struts between walls, or it is driven in double rows as a wall. The sheathing in each row is connected and tied with braces.

Wooden or concrete cribbing may be used in cofferdam construction. The cribbing offers stability

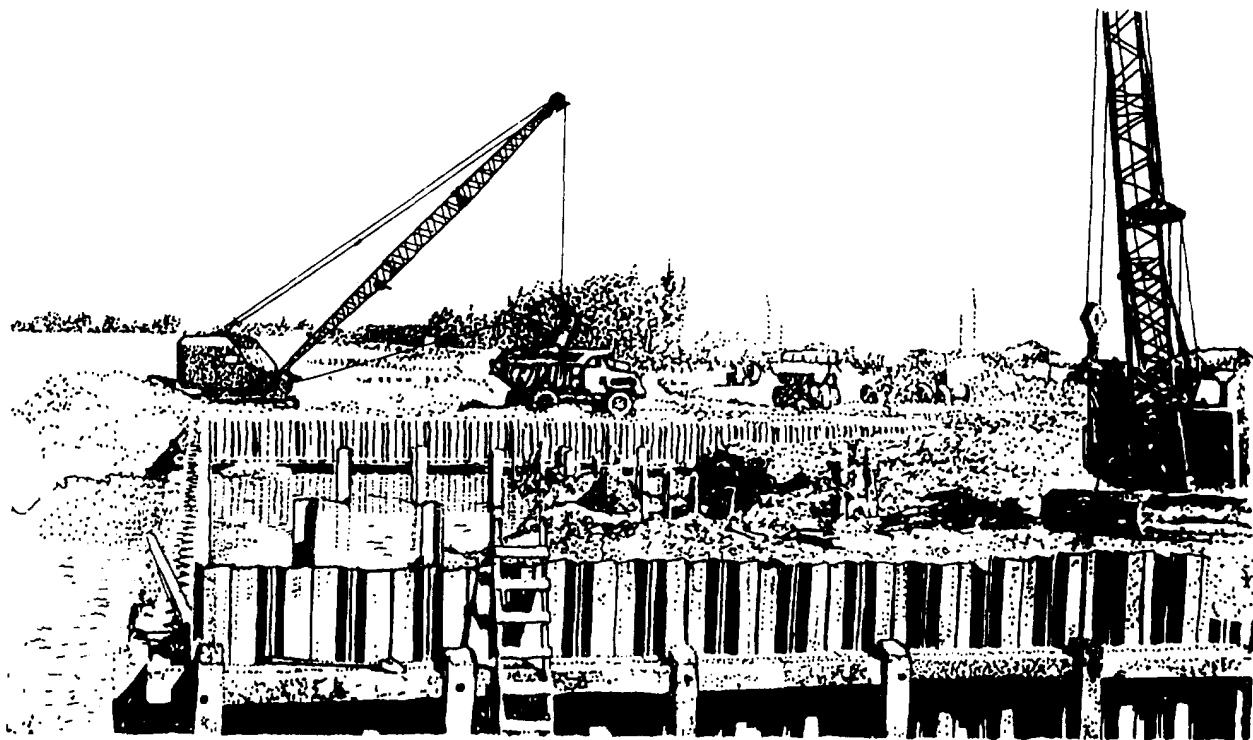


Figure 10-30.-Cofferdam under construction.

to the cofferdam wall. It also provides watertightness when filled with earth and rock.

Movable cofferdams of timber, steel, or concrete have been built, but their uses and designs are very similar to those discussed under boxes and open caissons, below.

Caissons

Caissons are boxes or chambers used for construction work underwater. There are three forms of caissons used in constructing foundations underwater: box, open, and pneumatic caisson. If the structure is open at the top and closed at the bottom, it is called a box caisson. If it is open both at the top and the bottom, it is an open caisson. If it is open at the bottom and closed at the top, and compressed air is used, it is a pneumatic caisson.

It is sometimes difficult to distinguish between a cofferdam and caisson. In general, if the structure is self-contained and does not depend upon the surrounding material for support, it is a caisson. However, if the structure requires such support as sheathing or sheet piling, it is a cofferdam. Retaining walls and piers may be built of boxes of wood, steel,

or reinforced concrete, floated into place and then filled with various materials. These are known as floating caissons. Open caissons may be constructed of wood or steel sheet piling.

The preceding information provides only a basic understanding of heavy construction. As with other phases of construction, specialized tools and equipment will be required. The Table of Allowance (TOA) at your command will have these items. Follow all safety rules and manufacturers' recommendations for operations and maintenance.

RECOMMENDED READING LIST

NOTE

Although the following reference was current when this TRAMAN was published, its continued currency cannot be assured. You therefore need to ensure that you are studying the latest revision.

Pile Construction, Field Manual 5-134, Headquarters, Department of the Army, Washington, D.C., 1985.

APPENDIX I

GLOSSARY

A

ABUTMENT—Masonry, timber, or timber and earth structures supporting the end of a bridge or an arch.

ACOUSTICAL TILE—Any tile composed of materials that absorb sound waves.

ALLIGATORING—A defect in a painted surface, resulting from the application of a hard finish coat over a soft primer. The checked pattern is caused by the slipping of the new coat over the old coat. The old coat can be seen through the cracks.

ANCHOR BOLTS—Bolts used to fasten columns, girders, soleplates, or other members to concrete or masonry.

ANCHORS—Devices giving stability to one part of a structure by securing it to another part, such as toggle bolts holding structural wood members to a masonry block wall.

AS-BUILT DRAWINGS—Drawings made during or after construction, illustrating how various elements of the project were actually installed.

ASPHALT SHINGLE—A type of composition shingle made of felt and saturated with asphalt or tar pitch.

ASTRAGAL—A closure between the two leaves of a double-swing or double-slide door to close the joint. This can also be a piece of molding.

B

BEARING PILE—A pile carrying a superimposed vertical load.

BERM—An artificial ridge of earth.

BINDER—Hot melted pitch (or asphalt) applied between the layers of a built-up roof to bind the layers of felt together.

BIRD'S-MOUTH—A notch cut in the lower edge of a rafter, to fit over the top wall plate. Formed by a level line and a plumb cut.

BREAKWATER—A barrier constructed to shield the interior waters of a harbor from wave forces.

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

BULKHEAD—A retaining wall, generally vertical.

C

CAISSON—A watertight box structure surrounding work below water.

CANTILEVER—A projecting beam supported only at one end.

CASING—The trim around doors and windows.

CHASE—A vertical recess in a wall for pipes.

COFFERDAM—A watertight enclosure.

COMPOSITE PILES—Piles formed of one material in the lower section and another in the upper.

CONCRETE PILES—Piles made of concrete, either cast in place or precast.

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

CREOSOTE—A coal tar distillate used for preserving wood.

CRIPPLE—Any frame member shorter than a regular member.

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

D

DOLPHIN—A group of piles in water driven close (clustered) together and tied so that the group is capable of withstanding large lateral forces from vessels and other floating objects.

DRESSING—Trimming or planing; usually applied to lumber.

DRY ROT—Fungus growth making wood soft or brittle.

DRYWALL—A system of interior wall finish using sheets of gypsum board and taped joints.

E

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

EFFLORESCENCE—A white powdery substance forming on masonry surfaces. It is caused by calcium carbide in the mortar.

END-BEARING PILE—A bearing pile deriving practically all its support from firm underlying stratum.

ESSEX BOARD MEASURE—A method for rapidly calculating board feet.

F

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

FERROUS—Any metal containing a high percentage of iron.

FOOTING—An enlargement at the lower end of a wall to distribute the load.

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

G

GAIN—An area removed by chiseling where hinges and locks can be mounted flush with a surface.

GIRDER—A supporting beam laid crosswise to the building; a long tress.

GIRT—A horizontal brace; used on outside walls covered with vertical siding.

GLAZE—The process of installing glass panes in window frames and doorframes and applying putty to hold the glass in position.

GROIN—A bulkhead, generally made of piling, built out from the shoreline perpendicular to the direction of the current or drift to cut off and prevent the carrying of beach materials along the shore.

GUSSET—A plate connecting members of a truss together.

H

HYDRATION—The chemical reaction between cement and water causing the cement paste to harden and to bind the aggregates together to form mortar or concrete.

J

JETTING—A method of forcing water around and under a pile to displace and lubricate the surrounding soil.

JETTY—A term designating various types of small wharf structures, such as a small boat jetty or a refueling jetty. In harbor—protection works, a rock mound or other structure extending into a body of water to direct and confine the stream or tidal flow to a selected channel.

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

L

LINTEL—A support beam placed over an opening in a wall.

M

MILLWORK—In woodworking, any material that has been machined, finished, and partly assembled at the mill.

MITER—A butt joint of two members at equal angles.

MOLE—A massive stone or masonry breakwater constructed of concrete or steel sheet pile and constructed on the inner side of a jetty for unloading and loading ships.

MULLION—The division between multiple windows or screens.

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

P

PARAPET—The part of a wall above the roof line.

PEB—Preengineered building.

PIGMENT—An insoluble coloring substance, usually in powder form, mixed with oil or water to color paints.

PILE—Load—bearing member made of timber, steel, concrete, or a combination of these materials; usually forced into the ground.

PILE BENT—Two or more piles driven in a row transverse to the long dimension of the structure and fastened together by capping and (sometimes) bracing.

PILE BUTT—The larger end of a tapered pile; usually the upper end as driven.

PILE CAPS—A structural member placed on top of a pile to distribute loads from the structure to the pile.

PURLIN—Horizontal members of a roof supporting common railers. Also, members between trusses supporting sheathing.

Q

QUAY—A margin wharf adjacent to the shore and generally of solid filled construction.

R

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

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

RIDGE—The long joining members placed at the angle where two slopes of a roof meet at the peak.

RISE—In a roof, the vertical distance between the plate and the ridge. In a stair, the total height of the stair.

S

SASH—The movable part of a window.

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

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

SPAN—The shortest distance between a pair of rafter seats.

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

STUD—The vertical members of wooden forms or frames.

T

TRUSS—A combination of members, such as beams, bars, and ties; usually arranged in triangular units to form a rigid framework for supporting loads over a span.

W

WAINSCOT—A wall covering for the lower part of an interior wall; can be wood, glass, or tile.

APPENDIX II

REFERENCES USED TO DEVELOP THE TRAMAN

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revisions.

Chapter 1

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

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

Exterior and interior Trim, John E. Ball, Delmar Publishers, Inc., Albany, N.Y., 1975.

Chapter 2

Basic Roof Framing, Benjamin Barnow, Tab Books, Inc., Blue Ridge Summit, Pa., 1986.

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Basic Roof Framing, Benjamin Barnow, Tab Books, Inc., Blue Ridge Summit, Pa., 1986.

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Exterior and Interior Trim, John E. Ball, Delmar Publishers, Inc., Albany, N.Y., 1975.

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Chapter 9

Facilities Planning Guide, NAVFAC P-437 (Revised), Naval Facilities Engineering Command, Department of the Navy, Alexandria Va., 1989.

Chapter 10

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Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

ASSIGNMENT 1

Textbook Assignment: Chapter 1 - Light Floor and Wall Framing

- 1-1. In wood frame construction, what is the lowest member resting on the foundation?
1. Platform
 2. Plank
 3. Stud
 4. Sill plate
- 1-2. The edge of a sill is usually set back from the outside edge of the foundation by what distance?
1. The thickness of the sheathing
 2. The thickness of the header joist
 3. The thickness of the siding
 4. Twice the thickness of the sheathing
- 1-3. After bolt holes are drilled and the sill properly fitted, what is normally the next step?
1. Install the header joist
 2. Place the sill sealer
 3. Install the floor joists
 4. Install the washers and nuts
- 1-4. When information is not provided in the specifications, anchor bolt spacing is normally 6 feet.
1. True
 2. False
- 1-5. Which of the following items is/are considered a dead load?
1. Furniture
 2. Floor joists
 3. Appliances
 4. People
- 1-6. When placing a girder in the pocket of a concrete wall, the minimum bearing should be
1. 1 in.
 2. 2 in.
 3. 3 in.
 4. 4 in.
- 1-7. Header joists prevent common joists from rolling or tipping.
1. True
 2. False
- 1-8. Which of the following joist types is used when the a joist projects out over the wall below?
1. Common
 2. Trimmer
 3. Cantilevered
 4. Cripple
- 1-9. Which of the following joist spans requires more than one row of bridging?
1. 16 ft
 2. 14 ft
 3. 12 ft
 4. 10 ft
- 1-10. When installed in a straight line, which of the following bridging types provides an additional nailing base for the subfloor?
1. Diagonal
 2. Herringbone
 3. Solid
 4. Cross
- 1-11. Before placing floor joists, which of the following members must be marked to show joist nailing points?
1. Soleplate and top plate only
 2. Sill plate and girders only
 3. Common joists and doubled joists only
 4. All of the above
- 1-12. Floor joists are always placed 16 inches OC.
1. True
 2. False

- 1-13. When joists are laid out 16 inches OC, the distance from the edge of the building to the first joist should be
1. 14 1/2 in.
 2. 15 1/4 in.
 3. 16 in.
 4. 16 3/4 in.
- 1-14. What is the main reason for special framing around large floor openings?
1. Appearance
 2. Provide additional nailing surface
 3. Strength
 4. Prevent floor squeaks
- 1-15. A pair of joists placed at each end of an opening and supporting a header is called what type of joist?
1. Trimmer
 2. Double
 3. Tail
 4. Common
- 1-16. When placing a joist, the crown should be turned in what direction?
1. Left
 2. Right
 3. Down
 4. Up
- 1-17. Any board can be used as a joist regardless of the size of the crown.
1. True
 2. False
- 1-18. Plywood subflooring with an index mark of 32/16 can be used over what maximum OC joist spacing?
1. 48 in.
 2. 32 in.
 3. 24 in.
 4. 16 in.
- 1-19. Which of the following framing members tie the entire wall together?
1. Studs
 2. Posts
 3. Sills
 4. Plates
- 1-20. What component is required at the intersections and ends of a wall?
1. Corner post
 2. Cripple stud
 3. Diagonal brace
 4. Header
- 1-21. When you are rough framing a window opening, the trimmer studs are installed between what two components?
1. Double top plate and header
 2. Top plate and subfloor
 3. Header and bottom plate
 4. Header and subfloor
- 1-22. A header is supported by which of the following studs?
1. Trimmer
 2. Cripple
 3. Common
 4. Header
- 1-23. What is the standard wall height in wood framed construction?
1. 7 ft 10 in.
 2. 8 ft
 3. 8 ft 1 in.
 4. 8 ft 6 in.
- 1-24. What type of wall strength is increased by diagonal bracing?
1. Lateral
 2. Compressive
 3. Tensile
 4. Flexural
- 1-25. Which of the following is the strongest type of diagonal bracing?
1. Cut-in bracing
 2. Let-in bracing
 3. Diagonal sheathing
 4. Horizontal bracing

- 1-26. Diagonal bracing is most effective when installed at which of the following angles?
1. 25° to 35°
 2. 45° to 60°
 3. 65° to 75°
 4. 80° to 90°
- 1-27. What is/are the main purpose(s) of a fire stop in a wall?
1. Slow the travel of fire inside a wall only
 2. Provide additional backing for nailing the edges of dry wall or plywood only
 3. Both 1 and 2 above
 4. Stop a fire inside a wall
- 1-28. The locations of walls constructed in the horizontal layout method are found in which of the following sources?
1. Floor plans
 2. Specifications
 3. Table of measures
 4. Measurement-conversion chart
- 1-29. When laying out studs 16 inches OC, why should you place the first stud 15 1/4 inches from the corner?
1. To allow for the corner post
 2. To provide additional nailing surface for sheathing
 3. To allow for 3/4-in. error when laying off the remaining studs
 4. To allow for the sheathing edges to fall on the centers of the studs
- 1-30. To determine the length of studs, cripples and trimmers, you should use which of the following layouts?
1. Vertical
 2. Horizontal
 3. Wall
 4. Top plate
- 1-31. The measurement from the subfloor to the bottom of the door header can also be used to establish which of the following measurements?
1. Rough opening width for door openings
 2. Rough opening height for windowsills
 3. Rough opening height for window openings
 4. Overall wall height
- 1-32. Which way should the crown of a stud be turned on an exterior wall?
1. Up
 2. Down
 3. Side
- 1-33. The minimum distance between butt joints in the top plate and the double top plate should be
1. 24 in.
 2. 32 in.
 3. 48 in.
 4. 96 in.
- 1-34. What is the recommended order in raising walls?
1. Long exterior, short exterior, partitions
 2. Partitions, long exterior, short exterior
 3. Short exterior, long exterior, partitions
 4. Long exterior, partitions, short exterior
- 1-35. To accurately plumb a wall, you need which of the following tools?
1. Straightedge only
 2. Level only
 3. Straightedge and level
 4. Plumb

- 1-36. Compared to other exterior finishes, plywood panels have what advantage(s)?
1. They provide additional strength only
 2. They shorten installation time only
 3. They eliminate the need for diagonal bracing only
 4. All of the above
- 1-37. What size nail is recommended for installing 5/8-inch sheathing?
1. 4d
 2. 6d
 3. 8d
 4. 10d
- 1-38. When nailing plywood panels in place, you should leave gaps at the joints to allow for expansion.
1. True
 2. False
- 1-39. What type of wall is usually constructed when large pipes must pass vertically through it?
1. Reinforced
 2. Bearing
 3. Partition
 4. Chase
- 1-40. What is the purpose of corner and casing beads?
1. Protect and reinforce corners and edges of drywall
 2. Add additional support for nonbearing walls
 3. Allow for expansion
 4. Improve the appearance of the finished wall
- 1-41. The size of a ceiling joist is determined by what two factors?
1. Height of walls and span from wall to wall
 2. Weight it must carry and span from wall to wall
 3. Height of bearing wall and OC spacing
 4. OC spacing and span from wall to wall
- 1-42. All joists must run in the same direction.
1. True
 2. False
- 1-43. Ceiling joists supported by a bearing partition should overlap what minimum distance?
1. 16 in.
 2. 12 in.
 3. 8 in.
 4. 4 in.
- 1-44. Which of the following components can be used to help support a ceiling joist at the center of its span?
1. Strongback
 2. Joist hanger
 3. Ribband
 4. Diagonal brace
- 1-45. Double joists and headers are required when an attic scuttle is larger than what minimum size?
1. 5 ft by 5 ft
 2. 2 ft by 2 ft
 3. 3 ft by 3 ft
 4. 4 ft by 4 ft
- 1-46. The lowest framing member resting on the foundation is called
1. a box sill
 2. the nailing base for joists
 3. the sill plate
 4. the foundation wall
- 1-47. When placing anchor bolts in a reinforced concrete wall, the bolt should be embedded at least 7 inches.
1. True
 2. False

- 1-48. Which of the following statements is generally true of wood posts?
1. They are placed directly below wood girders
 2. The width of the post should be equal to the girder it supports
 3. They are always embedded in concrete
- 1-49. The crawl space for a structure should have what minimum distance between the ground and the bottom of the girder?
1. 24 in.
 2. 18 in.
 3. 16 in.
 4. 12 in.
- 1-50. In platform framing, a floor joist rests directly on which of the following components?
1. Top plate only
 2. Sill plate only
 3. Either 1 or 2 above
 4. Exterior foundation
- 1-51. What is the recommended method for connecting header and floor joists?
1. Face-nailing with 12d nails
 2. Face-nailing with 16d nails 16-in. OC
 3. Face nailing with 10d nails 16-in. OC
 4. End nailing with 16d nails
- 1-52. What is the correct sequence for securing a subfloor and cross bridging to the floor joists?
1. Nail the subfloor, then the top and bottom of the bridging
 2. Nail the top of bridging, then the subfloor, and finally the bottom of the bridging
 3. Nail the top and bottom of the bridging, then the subfloor
 4. Nail the bottom of the bridging, then the subfloor, and finally the top of the bridging
- 1-53. Which of the following structural components serve to tie the entire wall together?
1. Studs
 2. Corner posts
 3. Top or bottom plates
 4. Trimmers
- 1-54. Bottom plate layout should include marks for which of the following framing members?
1. Floor joists only
 2. Corner posts only
 3. Header joists only
 4. All of the above
- 1-55. Temporary bracing used for wall alignment should be removed at what point during construction?
1. After wall alignment is completed
 2. After exterior sheathing is completed
 3. Before the ceiling joists are placed
 4. After all framing and sheathing are completed
- 1-56. What is the main structural function of a ceiling frame?
1. Support the finished ceiling
 2. Support the top of nonbearing partitions walls
 3. Tie the exterior walls together
 4. Support the weight of the rafters
- 1-57. Backing at the top of walls serves what purpose?
1. Tie the walls together
 2. Provide additional nailing area for joists
 3. Keep the studs spaced properly
 4. Provide nailing surface for the edge of finish ceiling materials

ASSIGNMENT 2

Textbook Assignment: Chapter 2 - Roof Framing

- 2-1. Which of the following types of roof is most commonly used in the Navy?
1. Shed
 2. Hip
 3. Gable
 4. Intersecting
- 2-2. Which of the following types of roof is considered strongest?
1. Shed
 2. Hip
 3. Gable
 4. Intersecting
- 2-3. A roof having only one slope is considered what type?
1. Shed
 2. Hip
 3. Gable
 4. Intersecting
- 2-4. In roof construction, the ratio of unit of rise to unit of span is known by what term?
1. Total run
 2. Line length
 3. Total rise
 4. Pitch
- 2-5. In roof construction, the hypotenuse of a triangle whose base equals the total run and whose altitude equals the total rise is known by what term?
1. Total run
 2. Line length
 3. Total rise
 4. Span
- 2-6. What members make up the main body of a roof framework?
1. Double top plates
 2. Joists
 3. Ceiling framework
 4. Rafters
- 2-7. Rafters are a functional part of both walls and roof.
1. True
 2. False
- 2-8. What type of rafter does not extend the full distance from the plate to the ridgeboard?
1. Jack
 2. Valley
 3. Hip
 4. Common
- 2-9. What type of jack is nailed between hip and valley rafters?
1. Valley
 2. Cripple
 3. Hip
 4. Eave
- 2-10. Which of the following terms describe(s) that portion of a rafter extending beyond the outer edge of the plate?
1. Eave only
 2. Tail only
 3. Overhang only
 4. All of the above
- 2-11. When the blade of a framing square is 24 inches long, the tongue usually varies within which of the following overall lengths?
1. 12 to 16 in.
 2. 16 to 24 in.
 3. 14 to 18 in.
 4. 18 to 24 in.

- 2-12. The hypotenuse is the longest side of a right triangle.
1. True
 2. False
- 2-13. Which of the following framing square scales is NOT used in roof framing?
1. Octagon
 2. Hundredths
 3. Tenths
 4. Twelfths
- 2-14. On a framing square, the longest lines on the hundredths scale indicate how many hundredths of an inch?
1. 5
 2. 10
 3. 25
 4. 50
- 2-15. On a framing square, where is the octagon scale located?
1. Back side of the tongue
 2. Down the face of the tongue
 3. Down the face of the blade
 4. Down the middle of the back side of the blade
- 2-16. To use the octagon scale on a framing square, you set one leg of the divider on the first dot of the scale, and the other leg of the divider/dividers on the dot whose number corresponds to what dimension of the piece to be cut?
1. Width in inches divided by eight
 2. Width in inches divided by four
 3. One-half the length of the center line
 4. Width in inches
- 2-17. How many tables does a framing square have?
1. One
 2. Two
 3. Three
 4. Four
- 2-18. Which of the following framing square features is primarily used for estimating board feet?
1. Brace table
 2. Essex-board table
 3. Rafter table
 4. Octagon scale
- 2-19. On a framing square, where is the brace table located?
1. Back of the blade
 2. Face of the blade
 3. Face of the tongue
 4. Back of the tongue
- 2-20. A gable roof slopes in how many directions?
1. One
 2. Two
 3. Three
 4. Four
- 2-21. The run of an overhang should be measured between what two points?
1. From the top plate to the bottom of the ridgeboard
 2. From the building line to the plumb line of the ridgeboard
 3. From the building line to the tail cut on the rafter
 4. From the ridgeboard to the tail cut on the rafter
- 2-22. A bird's-mouth is formed by what two cuts?
1. Tail and heel
 2. Ridge and tail
 3. Seat and ridge
 4. Heel and seat
- 2-23. The length of a rafter from the heel plumb line to the shortened plumb line is known as what type?
1. Actual
 2. Theoretical
 3. Line
 4. Common

- 2-24. What angle should a hip rafter form with the building line?
1. 90°
 2. 60°
 3. 45°
 4. 30°
- 2-25. The unit of rise is always the same for hip and common rafters, but the unit of run for a hip rafter is different.
1. True
 2. False
- 2-26. With a hip rafter framed against a common rafter, the shortening allowance should be what dimension?
1. One-half of the 45° thickness of the ridge
 2. One-fourth of the 45° thickness of a common rafter
 3. One-half of the 45° thickness of a common rafter
 4. One-half of the thickness of the ridge
- 2-27. What feature is required when a hip rafter joins the ridge or the ridge ends at other than 90°?
1. Bird's mouth
 2. Angle cut
 3. Tail cut
 4. Side cut
- 2-28. What procedure should you use on a hip rafter to keep it level with a common rafter?
1. Plane the top of the hip rafter
 2. Bevel the top edges only
 3. Deepen the bird's-mouth only
 4. Either 2 or 3 above
- 2-29. On an intersecting roof, the area where two or more sloped roof sections intersect is known by what term?
1. Valley
 2. Ridge
 3. Hip
 4. Gable
- 2-30. Which of the following features can run from valley rafters to both ridges?
1. Hip jack
 2. Valley jack
 3. Supporting valley
 4. Common rafter
- 2-31. Which of the following features can run at a 45° angle to the exterior walls
1. Valley rafter
 2. Hip jack
 3. Supporting valley
 4. Hip
- 2-32. Which of the following techniques should be used in constructing an intersecting roof that has one long and one short valley rafter?
1. Frame both valley rafters up against the main ridge
 2. Frame both valley rafters against the intersecting ridge
 3. Frame the long valley rafter up against the intersecting ridge and the short rafter up against the main ridge
 4. Frame the long valley rafter up against the main ridge and the short valley rafter up against the long valley rafter
- 2-33. What is the shortening allowance of a valley rafter when a dormer without sidewalls is framed between double headers with a combined actual thickness of 3 1/4 inches?
1. One-half of the 45° thickness of the inside upper double header only
 2. One-half of the 45° thickness of the common rafter only
 3. Both 1 and 2 above
 4. One-half of the total thickness of the upper and lower double headers

- 2-34. In an equal-pitch framing situation, the unit of rise of a jack rafter is always the same as the unit of rise of a common rafter?
1. True
 2. False
- 2-35. Which of the following jack rafter types extends from a hip rafter to a valley rafter?
1. Valley
 2. Cripple
 3. Valley cripple
 4. Hip-valley cripple
- 2-36. When erecting a gable roof, what components are constructed first?
1. Cripple and jack rafters
 2. Gable-end rafters and the ridge
 3. Hip rafters
 4. Valley rafters
- 2-37. How long should the temporary bracing used in roof erection be left in place?
1. Until sufficient sheathing has been installed to hold the rafters in place
 2. Until the wind has died down
 3. 3 days
 4. 4 days
- 2-38. Which of the following features is used to support loads over a long span without intermediate support or supports?
1. Dormer
 2. Valley rafter
 3. Roof truss
 4. Common rafter
- 2-39. When building with trusses, double top plates and double floor joists are required.
1. True
 2. False
- 2-40. Which of the following truss components acts as a ceiling joist?
1. Gusset
 2. Top cord
 3. Bottom cord
 4. Web
- 2-41. Which of the following structural components is eliminated because trusses are self-supporting?
1. Interior bearing partitions
 2. Gussets
 3. Double top plates
 4. Floor joists
- 2-42. In frame construction, what truss type(s) is/are most commonly used?
1. King post only
 2. W-type only
 3. Scissors and W-types only
 4. All of the above
- 2-43. Which of the following trusses consists of top and bottom chords tied together with web members?
1. W-type only
 2. Fink only
 3. W-type and Fink
 4. Scissors
- 2-44. The load carried by a roof truss is directly transferred to what other structural component(s)?
1. Floor
 2. Foundation
 3. Outside walls
 4. Interior walls
- 2-45. Which of the following item is/are not consideration(s) in truss design?
1. Materials
 2. Snow and wind loads
 3. Weight of roof itself
 4. Slope of roof

- 2-46. Each part of a truss is in a state of compression or tension. Which of the following states, if any, describe(s) the pushing-together force?
1. State of tension only
 2. State of compression only
 3. All of the above
 4. None of the above
- 2-47. In what positions should trusses be (a) handled and (b) stored?
1. (a) Horizontal (b) horizontal
 2. (a) Horizontal (b) vertical
 3. (a) Vertical (b) horizontal
 4. (a) Vertical (b) vertical
- 2-48. Which of the following features is/are necessary to resist wind uplift force?
1. Temporary bracing
 2. Gussets
 3. Trusses anchored to outside walls
 4. Blocking at lower chords
- 2-49. Toenailing is the most satisfactory method of securing a truss to an outside wall?
1. True
 2. False
- 2-50. A partition can be nailed directly to the lower chord under which of the following conditions, if any?
1. A partition runs at right angles to the bottom of the truss chord
 2. Partitions are erected after ceiling finish is applied
 3. A partition runs parallel with the bottom chord
 4. None of the above
- 2-51. Which of the following scales on a framing square is graduated in inches and provides various shortcuts in problem solving?
1. Tenths
 2. Twelfths
 3. Hundredths
 4. Octagon
- 2-52. In a gable roof, why is a ridgeboard placed at the peak of the roof?
1. Provide a nailing surface for the top ends of the common rafter
 2. Provide a nailing surface for one end of the common rafter
 3. Provide a starting point for the peak of the roof
 4. Provide the starting point for roof sheathing
- 2-53. All common rafters for a gable roof are the same length.
1. True
 2. False
- 2-54. Which of the following terms is another name for the notch formed by the seat and heel cut?
1. Overhang
 2. Projection
 3. Bird's mouth
- 2-55. When installing a roof where the ridgeboard is longer than one piece, where should the break between the boards occur?
1. Between the rafters
 2. Center of a rafter
 3. At the end of a rafter
- 2-56. When working with gable or double-pitch roofs which of the following is/are normally considered for additional horizontal reinforcement?
1. Ceiling joists
 2. Gable studs
 3. Collar ties
 4. Ridgeboard
- 2-57. When framing a roof, the scaffold should be set no lower than what distance below the level of the main-roof ridge?
1. 1 ft
 2. 2 ft
 3. 3 ft
 4. 4 ft

2-58. Which of the following structural members connects the joints on roof trusses?

1. Gussets
2. Templates
3. Collar ties
4. Truss ties

2-59. When working with roof trusses, double top and bottom plates on interior partitions can be eliminated.

1. True
2. False

2-60. What is the estimated material savings when using roof trusses?

1. 10%
2. 20%
3. 30%
4. 40%

2-61. Which of the following basic components of a roof truss also acts as a ceiling joist?

1. Top chord
2. Bottom chord
3. Web members

ASSIGNMENT 3

Textbook Assignment: Chapter 3 - Roof Construction and Trim Carpentry
Chapter 4 - Exterior Finish of Walls

- 3-1. Roof sheathing has what primary purpose?
1. Appearance
 2. Nailing base for shingles
 3. Insulation
 4. Tying rafters together
- 3-2. Composition roof sheathing should be laid in which of the following ways?
1. Closed
 2. Open, horizontally only
 3. Open, diagonally only
 4. Open, horizontally or diagonally
- 3-3. Board roof sheathing normally falls into which of the following categories?
1. Matched tongue and groove only
 2. Shiplapped only
 3. Shiplapped and square edged only
 4. Any of the above
- 3-4. Tongue-and-groove boards used for closed sheathing must be supported by what minimum number of rafters?
1. One
 2. Two
 3. Three
 4. Four
- 3-5. When you are determining the plywood thickness for roof sheathing, which of the following factors should NOT be a consideration?
1. Rafter spacing
 2. Weather conditions
 3. Insulating factor
 4. Type of roofing material to be used
- 3-6. In what direction relative to the rafters should the face grain of plywood sheathing run?
1. Perpendicular
 2. Parallel
 3. Diagonal
- 3-7. When nailing 3/4-inch plywood sheathing to the rafters, what size nails should you use?
1. 10d
 2. 8d
 3. 6d
 4. 4d
- 3-8. What is the purpose of the 2° bevel cut on the ends of plank roof decking?
1. To allow for expansion
 2. To ensure a tight face joint
 3. To ensure space for adjustment
 2. To allow for quicker installation
- 3-9. What length should nails should you use for fastening plank decking?
1. Twice the nominal plank thickness
 2. Three times the nominal plank thickness
 3. Three and one-half times the nominal plank thickness
 4. Four times the nominal plank thickness
- 3-10. Roof decking extending beyond a gable-end wall should span at least how many rafters?
1. One
 2. Two
 3. Three
 4. Four

- 3-11. Butt joints of plywood sheets should be alternated so they do not occur on the same rafter.
1. True
 2. False
- 3-12. What is the recommended clearance between masonry and wood framing members at a chimney?
1. 1 in.
 2. 2 in.
 3. 3 in.
 4. 4 in.
- 3-13. Which of the following wood characteristics is least important when selecting trim material?
1. Knots
 2. Even grain
 3. Natural decay-resistance
 4. Preservative pretreatment
- 3-14. For exterior trim fasteners, which of the following types of screws or nails is/are preferred?
1. Galvanized steel only
 2. Stainless steel only
 3. Aluminum only
 4. All of the above
- 3-15. What part of a gable roof projects beyond the end wall on an upward slope?
1. Rake
 2. Eave
 3. Fascia
 4. Ledger
- 3-16. On a roof with no overhang, what type of cornice is normally used?
1. Open
 2. Gable
 3. Closed
 4. Simple
- 3-17. In closed-cornice construction, the underside of the eaves is exposed.
1. True
 2. False
- 3-18. Which of the following components provides a nailing base for soffit material?
1. Lookout
 2. Frieze board
 3. Rafter
 4. Plancier
- 3-19. Wood soffit panels should be fastened using nails in what (a) size and (b) spacing?
1. (a) 6d (b) 6 in.
 2. (a) 6d (b) 8 in.
 3. (a) 4d (b) 8 in.
 4. (a) 4d (b) 6 in.
- 3-20. What problem occurs when galvanized nails are used with aluminum sheet metal?
1. Spalling
 2. Electrolysis
 3. Rusting
 4. Peeling
- 3-21. What is the area of a shingle that is not over-lapped called?
1. Top lap
 2. Exposure
 3. Square
 4. Coverage
- 3-22. Which of the following expressions is correct concerning the pitch of a roof with a 6-inch-per-foot rise and a 32-foot span?
1. $1/8$
 2. $1/4$
 3. $1/2$
 4. $3/16$
- 3-23. Using roofing felt over sheathing has what primary purpose(s)?
1. To provide a secondary barrier against wind-driven rain only
 2. To keep the sheathing dry until shingles are applied only
 3. To protect shingles against the effects of resinous materials released from the sheathing only
 4. Each of the above

- 3-24. How many rolls of 30-pound felt are required to cover 48,400 square feet?
1. 121
 2. 242
 3. 363
 4. 484
- 3-25. Which of the following materials should be used as an underpayment?
1. Coated felt
 2. Laminated waterproof paper
 3. Asphalt-saturated felt
 4. Polyethylene sheets
- 3-26. Along cave lines where ice dams might occur, what type of roofing material is recommended?
1. 15-lb felt
 2. 30-lb felt
 3. 55-lb mineral surface
 4. 55-lb smooth surface
- 3-27. Forty-two and one-third squares of strip shingles are contained in how many bundles?
1. 127
 2. 381
 3. 609
 4. 1,143
- 3-28. When applying asphalt shingles, how far past the drip edge should you extend the first course to prevent water from backing up under the shingles?
1. 1 in.
 2. 5 in.
 3. 5/8 in.
 4. 1/4 in.
- 3-29. Flashing has what primary purpose(s)?
1. Reflect heat only
 2. Protect against water seepage only
 3. Both 1 and 2 above
 4. Act as a vapor barrier
- 3-30. The concealed nailing method of installing roll roofing is used when maximum service life is required.
1. True
 2. False
- 3-31. A 24-inch-long wood shingle on a roof with a 1/4 pitch should have what maximum exposure?
1. 5 in.
 2. 5 1/4 in.
 3. 5 3/4 in.
 4. 7 1/2 in.
- 3-32. What is/are the primary difference(s) in the installation of wood shakes and wood shingles?
1. Shorter nails are used with wood shingles only
 2. Shingles have less exposure only
 3. An underpayment between each course of shakes only
 4. All of the above
- 3-33. What is the most common type of ridge used on asphalt shingle roofs?
1. Boston
 2. Sheet metal
 3. Tile
 4. Prefabricated
- 3-34. Roofing asphalts are graded on what characteristic?
1. Color
 2. Weight per pound
 3. Temperature at which they begin to flow
 4. Temperature at which they begin to soften
- 3-35. In built-up roofing, which of the following types of felts should be used?
1. Organic only
 2. Glass fiber only
 3. Glass fiber and asphalt only
 4. Any of the above

- 3-36. What is the main purpose of using felt paper on a built-up roof?
1. To hold the bitumens together
 2. To insulate
 3. To soak up excess asphalt
 4. To act as a vapor barrier
- 3-37. Asphalt should be in what temperature range when applied?
1. 275°F to 375°F
 2. 375°F to 425°F
 3. 450°F to 500°F
 4. 500°F to 550°F
- 3-38. The aggregate on a built-up roof serves which of the following functions?
1. Protect the bitumen from sunlight only
 2. Increase wind and fire resistance only
 3. Permit use of a thick surface coating of bitumen only
 4. Each of the above
- 3-39. The first two layers of a five-ply roof are referred to as what type of nailer?
1. Dry
 2. Base
 3. Bottom
 4. Back
- 3-40. A kettle operator should perform what task first?
1. Fill the fuel tank
 2. Fill the kettle with pieces of asphalt
 3. Inspect the kettle, making sure it is dry inside
 4. Light-off the kettle
- 3-41. In a kettle, how should you' maintain hot binder at an even temperature?
1. Adjust the burner
 2. Add material at the same rate as the melted material is drawn off
 3. Adjust the fuel pressure
 4. Remove material faster than you add it
- 3-42. If a kettle catches fire, which of the following is an action you should take first?
1. Remove the burner
 2. Shut off the fuel
 3. Spray water on the kettle
 4. Close the lid
- 3-43. The distance maintained between the mopper and the felt layer should not exceed
1. 9 ft
 2. 7 ft
 3. 3 ft
 4. 5 ft
- 3-44. Which of the following properties is/are essential for wood siding?
1. Weathers easily
 2. Paints easily only
 3. Works easily only
 4. Paints and works easily
- 3-45. Which of the following horizontal sidings can be obtained with either shiplap or tongue-and-groove edges?
1. Drop
 2. Bevel
 3. Dolly Varden
- 3-46. In the installation of vertical board siding, board widths range from 2 to 4 inches.
1. True
 2. False
- 3-47. When installing 4- by 8-foot vertical plywood siding, which of the following materials should you apply to the joints to ensure maximum watertightness?
1. Battens only
 2. Caulking only
 3. Water-repellent preservative and caulking only
 4. Any of the above

- 3-48. To present a uniform appearance, siding should line up with which of the following parts?
1. Drip caps of the doors and windows only
 2. Bottoms of doors and windows only
 3. Drip caps and bottoms of doors and windows
 4. Sides of doors and windows
- 3-49. When wood siding has a natural finish, what type of nail should you use?
1. Aluminum only
 2. Stainless steel only
 3. Aluminum or stainless steel
 4. Galvanized
- 3-50. What distance usually determines the average exposure of horizontal siding?
1. Underside of the windowsill to the top of the window drip cap
 2. Bottom of the windowsill to the foundation wall
 3. Bottom of the door to the drip cap of the door
 4. Bottom of the door to the bottom of the windowsill
- 3-51. What should be the exposure of 8-inch siding installed on a building where the overall height of the windows is 68 inches?
1. 5 7/8 in.
 2. 6 in.
 3. 6 3/16 in.
 4. 6 7/8 in.
- 3-52. The first installed course of bevel siding is usually blocked out with which of the following items?
1. Fridgeing
 2. Flashing
 3. A starter strip
 4. A batten
- 3-53. How should siding that returns against a roof surface, such as a dormer, be joined?
1. Mitered corners
 2. Metal corners
 3. Flashing
 4. Corner boards
- 3-54. When applying wood shingles where the "siding effect" is not a consideration, what spacing should you use to allow for expansion during rainy weather?
1. 1/16 to 1/8 in.
 2. 1/8 to 1/4 in.
 3. 1/4 to 1/2 in.
- 3-55. Flashing should be used in a structure where rain or melted snow penetration is possible.
1. True
 2. False
- 3-56. A 24-foot gutter run should have what pitch?
1. 1 7/8 in.
 2. 1 3/4 in.
 3. 1 1/2 in.
 4. 1 5/16 in.
- 3-57. Full height vertical members of a panel door are known by what term?
1. Muntins
 2. Rails
 3. Stiles
 4. Runners
- 3-58. An exterior door made of thin plywood faces over a wood framework with a particle board core is what type?
1. Panel
 2. Flush
 3. Combination
 4. Clad

- 3-59. A main entrance door is normally what size?
- 1 1/2 in. thick, 2 ft 8 in. wide, 6 ft 8 in. high
 - 1 3/4 in. thick, 3 ft 0 in. wide, 6 ft 8 in. high
 - 1 3/4 in. thick, 2 ft 8 in. wide, 6 ft 8 in. high
 - 1 3/4 in. thick, 3 ft 0 in. wide, 7 ft 0 in. high
- 3-60. Securing a doorframe to the framing members requires what nail (a) size and (b) type?
- (a) 16d (b) casing
 - (a) 12d (b) common
 - (a) 10d (b) finish
 - (a) 8d (b) duplex
- 3-61. Where on each side of a jamb should shims be located?
- Bottom only
 - Bottom and top only
 - Center only
 - Bottom, top, and center
- 3-62. Heat loss through metal window frames is less than through wood window frames.
- True
 - False
- 3-63. The small wood members that separate the lights in a sash are known by what term?
- Meeting rails
 - Parting beads
 - Muntins
 - Weather strips
- 3-64. Which of the following windows has a wood sash with a single large light?
- Casement
 - Double hung
 - Hopper
 - Stationary
- 3-65. What advantage does a casement window have over a double-hung window?
- Provides more light
 - Provides better insulation
 - Provides better ventilation
 - Is easier to install
- 3-66. What feature best distinguishes sheet glass from plate glass?
- Plate glass is polished flat on both sides
 - Color
 - Thickness
 - Only plate glass is manufactured in a continuous ribbon and then cut in large sheets
- 3-67. Because of its high rate of expansion, what type of glass requires the most careful cutting, handling, and glazing?
- Laminated
 - Wired
 - Tempered
 - Heat absorbing
- 3-68. Which of the following types of glass should be used where the hazard of flying glass must be avoided?
- Wire
 - Laminated
 - Insulating
 - Safety
- 3-69. When cutting glass, what allowance should you deduct from the measurements to allow for expansion?
- 1/16 in.
 - 1/8 in.
 - 3/16 in.
 - 1/4 in.

- 3-70. What is the required minimum equipment needed to cut glass efficiently?
1. A glass cutter and straightedge only
 2. A glass cutter and tape measure only
 3. A glass cutter, straightedge, flat solid table, and tape measure
 4. A glass cutter, straightedge, and a honing stone
- 3-71. When scoring glass, you should use what minimum number of strokes?
1. One
 2. Two
 3. Three
 4. Four
- 3-72. Which of the following types of sash should be primed before glazing?
1. Old and new metal sash only
 2. Old and new wood sash only
 3. Both 1 and 2 above
- 3-73. What is the primary purpose of putty used in glazing?
1. To make a weathertight joint
 2. To hold the glass in the sash
 3. To improve the appearance
 4. To reduce glass expansion
- 3-74. When you are mounting wire glass in a small wooden window frame, what should be the first step?
1. Insert the glass into the window frame with the wire twist in the vertical position
 2. Lay a continuous 1/6-in.-thick bed of putty in the putty run
 3. Insert the glass into the window frame with the concave side facing out
 4. Lay a continuous bead of putty against the perimeter of the glass
- 3-75. To clean glass after glazing or painting, what material should you use?
1. Ammonia
 2. Mineral spirits
 3. Caustic soap
 4. Acid solution

ASSIGNMENT 4

Textbook Assignment: Chapter 5 - Interior Finish of Walls and Ceilings
Chapter 6 - Interior Finish of Floors, Stairs, Doors, and Trim

- 4-1. In drywall construction, "nail pops" result from which of the following factors?
1. Stud misalignment
 2. Studs drying out
 3. Improper size nails
 4. Chemical reaction with coatings in nails
- 4-2. To align ceiling joists in an unfinished attic, what type of structural member should you use?
1. Ribbon board
 2. Ledger
 3. Strongback
 4. Ridge beam
- 4-3. The most common size gypsum board has what (a) thickness and (b) type edges?
1. (a) 1/2 in. (b) tapered
 2. (a) 1/2 in. (b) beveled
 3. (a) 5/8 in. (b) beveled
 4. (a) 5/8 in. (b) square
- 4-4. What type of drywall is also called greenboard or blueboard?
1. PB
 2. WR or MR
 3. BB
 4. X
- 4-5. What type of drywall edge(s) may be left exposed?
1. Tapered
 2. Square only
 3. Beveled only
 4. Square and beveled
- 4-6. When studs are spaced 24 inches OC, what thickness of drywall is recommended for quality wall construction?
1. 5/8 in.
 2. 1/2 in.
 3. 3/8 in.
 4. 1/4 in.
- 4-7. What is best reason for using a convex head hammer when driving drywall nails?
1. To leave the nailhead flush with the surface
 2. To dimple the material without tearing the paper
 3. To drive the nail at an angle
 4. To countersink the nail
- 4-8. For the best drywall finish, you should apply the topping coat with which of the following drywall tools?
1. Finishing trowel
 2. Bow trowel
 3. 6 in. knife
 4. 12 in. knife
- 4-9. What length of smooth-shanked nail should be used when installing double layers of 1/2-inch drywall?
1. 1 in.
 2. 1 3/4 in.
 3. 2 in.
 4. 2 1/4 in.
- 4-10. What minimum length Type W screw you should use when installing 1/2-inch drywall to wood studs?
1. 5/8 in.
 2. 3/4 in.
 3. 1 in.
 4. 1 1/8 in.

- 4-11. Which of the following metal beads is installed to protect drywall from edge damage?
1. Stop
 2. Corner
 3. Casing
 4. Edge
- 4-12. When you are attaching drywall, what is the recommended nailing procedure?
1. Start at the top and work down
 2. Start at the side joining the previous sheet and work across
 3. Start at the center and work out
 4. Start at the bottom and work up
- 4-13. Single-nailed drywall should be installed with what OC nail spacing on the (a) walls and (b) ceiling?
1. (a) 6 in. (b) 8 in.
 2. (a) 8 in. (b) 6 in.
 3. (a) 7 in. (b) 8 in.
 4. (a) 8 in. (b) 7 in.
- 4-14. After the first application of joint compound to a joint, what should be the next step?
1. Allow the joint compound to dry
 2. Feather the joint
 3. Tape the joint
 4. Sand the joint
- 4-15. Select from the following list the proper sequence for taping a gypsum drywall joint.
- A. Apply a coat of joint compound to bury tape
 - B. Press tape into center of joint
 - C. Allow compound to dry
 - D. Sand edges
 - E. Spread a bed of joint compound about 4-in. wide
1. B, E, D, A, C
 2. E, B, A, C, D
 3. A, B, E, D, C
 4. B, A, E, C, D
- 4-16. When you are repairing gypsum drywall, holes larger than what minimum diameter should be cut back to the center of the nearest studs?
1. 6 in.
 2. 2 in.
 3. 8 in.
 4. 4 in.
- 4-17. What is the recommended minimum thickness of plywood panels used directly over framing members?
1. 1/4 in.
 2. 3/8 in.
 3. 1/2 in.
 4. 5/8 in.
- 4-18. When you are installing vertical board panels, what is the maximum spacing of furring strips?
1. 16 in.
 2. 24 in.
 3. 36 in.
 4. 48 in.
- 4-19. Most acoustical ceilings have what main purpose?
1. Sound absorption
 2. Light reflection
 3. Flame resistance
 4. Appearance enhancement
- 4-20. Assume the dimensions of a ceiling are 16 feet 8 inches by 10 feet 2 inches. When calculating the material requirements, what dimensions should you use?
1. 16 ft 0 in. by 10 ft 0 in.
 2. 16 ft 8 in. by 10 ft 2 in.
 3. 17 ft 0 in. by 11 ft 0 in.
 4. 18 ft 0 in. by 12 ft 0 in.
- 4-21. Assume you are laying out the grid pattern for a ceiling. How should the main tees run?
1. Parallel to the joists
 2. At a 45° angle to the joists
 3. Perpendicular to the joists
 4. In a crisscross pattern between the joists

- 4-22. In what order should the following items be installed?
- A. Acoustic panels
 - B. Cross tees
 - C. Wall angles
 - D. Suspension wires
 - E. Main tees
1. A, B, C, D, E
 2. B, E, C, A, D
 3. C, D, E, B, A
 4. D, E, B, C, A
- 4-23. Assume a new acoustical ceiling will be installed 14 inches lower than the old ceiling. The suspension wires should be cut with what minimum length?
1. 14 in.
 2. 16 in.
 3. 18 in.
 4. 20 in.
- 4-24. In a suspension ceiling system, where on the main tee should the first tie wire be installed?
1. 2 ft from either end
 2. 4 ft from either end
 3. At the first cross-tee connection
 4. At the center
- 4-25. When installed, which of the following components require the use of splice plates?
1. Aluminum main tees only
 2. Steel main tees only
 3. Aluminum and steel main tees
 4. Aluminum cross tees
- 4-26. When installing acoustical panels, why should you work from several cartons at the same time?
1. All the panels may not be the same direction
 2. Every other panel in a carton has a different edge cut
 3. The color, pattern, or texture may vary slightly
 4. Not all panels can be cut or used as border panels
- 4-27. When installing 12-inch-square ceiling tile in a 15-foot 8-inch-wide room, what pattern should you use in terms of rows and size?
1. 15 full rows and two 4-in. tiles
 2. 15 full rows and one 8-in. tile
 3. 14 full rows and one 10-in. tile
 4. 14 full rows and two 10-in. tiles
- 4-28. Insulating materials are usually installed in which of the following locations?
1. Walls and ceilings only
 2. Ceilings and floors only
 3. Floors and walls only
 4. All of the above
- 4-29. Into which of the following categories should insulation be grouped?
1. Blanket and loose fill only
 2. Loose fill and rigid only
 3. Rigid and blanket only
 4. All of the above
- 4-30. The primary function of the asphalt sheet material attached to blanket-type insulation is to resist
1. water vapor
 2. heat
 3. cold
 4. insects
- 4-31. Which of the following methods is normally used for installing loose-fill insulation?
1. Pouring only
 2. Blowing only
 3. Hand packing only
 4. Each of the above

- 4-32. To be effective, reflective insulation must have what minimum air space?
1. 1/2 in.
 2. 3/4 in.
 3. 1 in.
 4. 3 1/2 in.
- 4-33. Rigid insulation may be used for which of the following structural purposes?
1. Sheathing and building boards only
 2. Building boards and roof decking only
 3. Roof decking and sheathing only
 4. All of the above
- 4-34. Which of the following substances is sometimes mixed with plaster to reduce heat transmission?
1. Vermiculite or perlite
 2. Rock or glass wool
 3. Sawdust
 4. Shredded bark
- 4-35. To reduce moisture and protect wood frame members, what type of material should you use as ground cover in crawl spaces?
1. Roll roofing only
 2. Polyethylene only
 3. Roll roofing or polyethylene
 4. Blanket insulation
- 4-36. When structures are built on slabs, it is a good practice to install a vapor barrier under the slab.
1. True
 2. False
- 4-37. When insulation is used without a vapor barrier, what material is normally used to envelop the entire exposed wall and ceiling?
1. Building paper
 2. Plastic film
 3. Building board
 4. Fiber glass
- 4-38. When placing fill insulation over ceilings, which of the following devices should you use to ensure uniform thickness?
1. Carpenter's level
 2. String line
 3. Bottom board
 4. Leveling board
- 4-39. Which of the following materials are effective vapor barriers against condensation?
1. Aluminum foils only
 2. Asphalt-laminated papers only
 3. Plastic films only
 4. Each of the above
- 4-40. The system in which wall-height rolls of plastic film are applied to produce a positive seal against water vapor is known by what term?
1. Enveloping
 2. Vapor proofing
 3. Moisture proofing
 4. Positive sealing
- 4-41. What is the most practical way to remove moisture from roof spaces?
1. Heating the air
 2. Adding more insulation
 3. Ventilating
 4. Installing a dehumidifier
- 4-42. How are hip roofs best ventilated?
1. By inlet ventilators along the rake and outlet ventilators along the soffits
 2. By inlet ventilators along the ridge and outlet ventilators along the soffits
 3. By inlet ventilators along the soffits and outlet ventilators along the ridge
 4. By inlet and outlet ventilators along the ridge

- 4-43. Which of the following inlet ventilation systems is recommended for use on low-pitched flat roofs with overhangs?
1. Continuous slot
 2. Ridge
 3. Louvered
 4. Wall
- 4-44. What is the primary advantage of softwood flooring over hardwood flooring?
1. Less dense
 2. Lower cost
 3. Improved wear resistance
 4. Easier to maintain
- 4-45. Subfloor boards are normally laid over joists in what direction?
1. Parallel
 2. Diagonal
 3. Perpendicular
- 4-46. Building paper is used over subfloors to reduce
1. noise and dust only
 2. dust and air flow only
 3. air flow and noise only
 4. all of the above
- 4-47. What factor usually causes cracks to appear in finish floors several months after the floor has been laid?
1. Expansion of subfloor material
 2. Absorption of moisture after delivery
 3. Poor nailing
 4. Weak floor joists
- 4-48. At which of the following angles should nails be driven through the tongue of tongue-and-groove flooring?
1. 30° to 35°
 2. 35° to 40°
 3. 40° to 45°
 4. 45° to 50°
- 4-49. How can you prevent splitting the tongue when nailing tongue-and-groove flooring?
1. By using cut nails
 2. By predrilling the nail holes
 3. By using chisel-point nails
 4. By waxing the nail shanks
- 4-50. A vapor barrier is installed under a concrete slab before it is poured. Is any further preparation required for the later installation of wood flooring?
1. Yes
 2. No
- 4-51. What is the expansion allowance for hardboard underpayment when laid next to a vertical surface?
1. 1/8 to 3/8 in.
 2. 3/8 to 1/2 in.
 3. 1/2 to 5/8 in.
 4. 5/8 to 3/4 in.
- 4-52. Nail spacing for 1/2-inch plywood underpayment should not exceed what OC (a) edge and (b) field spacing?
1. (a) 4 in. (b) 8 in.
 2. (a) 5 in. (b) 8 in.
 3. (a) 6 in. (b) 10 in.
 4. (a) 8 in. (b) 10 in.
- 4-53. What is the result of too heavily applied tile adhesive?
1. Tile will not adhere
 2. Adhesive will not set
 3. Ties will "telegraph"
 4. Adhesive will bleed between tile

- 4-54. Before laying vinyl tile on a floor surface, you should square off the floor, apply the adhesive, and then begin laying the tile from the
1. center of the floor working towards the walls
 2. center of a continuous wall working towards the center of the floor
 3. corner of the floor working towards the opposite corner
 4. stairway or door opening working towards the opposite wall
- 4-55. Which of the following factors is an advantage of using carpeting instead of other types of floor covering?
1. It absorbs sound
 2. It lasts longer
 3. It reduces maintenance
 4. It is cheaper
- 4-56. How many square yards of carpet are required to cover a room 24 feet by 48 feet?
1. 76
 2. 98
 3. 114
 4. 128
- 4-57. When installing cushioned-backed carpeting, which of the following items is/are required?
1. Tack strips only
 2. Double-faced tape only
 3. Additional padding only
 4. All of the above
- 4-58. Rough openings for interior doors are usually framed how much (a) higher and (b) wider than the finished door size?
1. (a) 2 in. (b) 3 in.
 2. (a) 2 1/2 in. (b) 3 1/2 in.
 3. (a) 3 in. (b) 2 1/2 in.
 4. (a) 3 1/2 in. (b) 3 in.
- 4-59. What is the proper name for the edge trim around an interior door opening?
1. Casing
 2. Molding
 3. Jam
 4. Sill
- 4-60. Why are louvered doors the most suitable for use on closets?
1. They are less expensive
 2. They are more durable
 3. They require less space
 4. They allow ventilation
- 4-61. How should hinged doors swing or open?
1. Against a blank wall only
 2. Toward the natural entry only
 3. Both 1 and 2 above
 4. Into a hallway
- 4-62. When plumbing and leveling a doorframe, which of the following materials should you use?
1. Casing wedges
 2. Wood shingle wedges
 3. Wood shake wedges
 4. Hairpin wedges
- 4-63. What edge-distance allowance is made when the casing is nailed to the jamb?
1. 1/16 in.
 2. 1/8 in.
 3. 3/16 in.
 4. 3/8 in.
- 4-64. What should you do to a mitered casing joint to lessen the chance of its opening up as the casing material dries?
1. Use a glued spline
 2. Install wood screws
 3. Glue the joint
 4. Use a wood filler

- 4-65. Which of the following door hardware finishes is the most common
1. Brass
 2. Bronze
 3. Nickel
 4. Stainless steel
- 4-66. As you stand facing a door, you notice that the door is hinged on the left and swings away from you. What type of door is it?
1. Left-hand reverse
 2. Left hand
 3. Right-hand reverse
 4. Right hand
- 4-67. What size loose-pin butt hinge should you use for a door 1 3/8 inches thick?
1. 5 in. extra heavy
 2. 5 in. by 6 in.
 3. 3 1/2 in. by 3 1/2 in.
 4. 4 in. by 4 in.
- 4-68. A doorknob should be installed at what standard height?
1. 36 to 38 in.
 2. 34 to 36 in.
 3. 32 to 34 in.
 4. 30 to 32 in.
- 4-69. To prevent scraping as a door is opened, what clearance is allowed for the doorstop on the hinge side of the door?
1. 1/64 in.
 2. 1/32 in.
 3. 1/16 in.
 4. 1/8 in.
- 4-70. Which of the following devices holds the door in place by contact with the latch?
1. Rim
 2. Vertical rod
 3. Mortise
 4. Strike plate
- 4-71. Which of the following members is NOT trim for a double-hung window?
1. Apron
 2. Sash stops
 3. Stool
 4. Window jamb
- 4-72. What should be the first inside window trim member to be installed?
1. Stop
 2. Stool
 3. Casing
 4. Apron
- 4-73. Name the small strip molding used on the upper edge of a two-piece baseboard.
1. Base cap
 2. Base top
 3. Chair rail
 4. Bumper
- 4-74. Name the trim molding added to the baseboard at the floor-wall junction.
1. Corner
 2. Rail
 3. Shoe
 4. Base
- 4-75. What type of joint should be used at inside corners of ceiling moldings?
1. Butt
 2. Coped
 3. Mitered
 4. Lapped

ASSIGNMENT 5

Textbook Assignment: Chapter 7 - Plastering, Stuccoing, and Ceramic Tile
Chapter 8 - Structural Coatings and Preservatives

- 5-1. Which of the following plaster binding materials should NOT be exposed to severe moisture?
1. Portland cement
 2. Lime
 3. Gypsum
- 5-2. Which of the following statements best describes gypsum gauging plaster?
1. Contains lime putty which increases the dimensional stability of the plaster while drying and provides initial surface hardness
 2. Has a high density, yields a highly polished surface, and provides crack resistance when used with fine sand
 3. Contains finely ground gypsum with or without aggregate
 4. Contains no admixtures and is designed to reduce sound
- 5-3. Gauging material is added to lime plaster for which of the following reasons?
1. To induce shrinkage and produce early strength only
 2. To induce late strength and counteract shrinkage tendencies only
 3. To produce early strength and counteract shrinkage tendencies only
 4. All of the above
- 5-4. Portland cement plaster should NOT be applied directly over what type of walls?
1. Exterior masonry
 2. Interior masonry
 3. Interior or exterior metal-lath covered
 4. Gypsum tile or plasterboard
- 5-5. When the aggregate material is excessively fine grain, why is the plaster strength reduced?
1. The smaller quantity of water required raises the water to cement ratio and increases the dry set time
 2. The greater quantity of water required raises the cement to water ratio and reduces the dry set density
 3. Less binder paste is used because of the lack of space between particles of the fines, resulting in a weak mixture
 4. More binder paste is needed to coat all particle surfaces, resulting in sufficient fines to close all voids and leaving a rich but unstable mixture
- 5-6. Which of the following aggregates should be used in acoustical plaster?
1. Perlite only
 2. Vermiculite only
 3. Perlite or vermiculite
 4. Sand
- 5-7. For plaster application, what must be installed between structural members to form a continuous surface?
1. Plaster planes
 2. Insulation
 3. Lath
 4. Fire blocking
- 5-8. To provide a good key, wood lath plaster base should have what minimum spacing?
1. 1/4 in.
 2. 3/8 in.
 3. 1/2 in.
 4. 5/8 in.

- 5-9. What is the main purpose of the 3/4-inch holes in perforated gypsum lath?
1. To allow for easy installation
 2. To allow for expansion of the mortar
 3. To provide ventilation for interior walls
 4. To provide a mechanical key for the mortar
- 5-10. What type of lath is considered the most versatile?
1. Metal
 2. Gypsum
 3. Wood
 4. Insulation
- 5-11. What length of blued gypsum lath nail is recommended for installing 1/2-inch gypsum lath?
1. 1 in.
 2. 1 1/8 in.
 3. 1 3/16 in.
 4. 1 1/4 in.
- 5-12. What is the minimum end lap for wire lath?
1. 1 in.
 2. 2 in.
 3. 3 in.
 4. 2 1/2 in.
- 5-13. What is the purpose of a casing bead?
1. To reinforce the lath and inside corners
 2. To reinforce the door and window casings
 3. To provide room for expansion between plaster edges and the edges of baseboards
 4. To provide a finished edge around openings
- 5-14. To minimize shrinking and cracking around the upper corners of doors and windows, you should install which of the following items?
1. Plaster grounds
 2. Expanded metal lath strips
 3. Base screeds
 4. Casings beads
- 5-15. Which of the following components serve as temporary guides around window and door openings and are removed after the plaster has set?
1. Cornerites
 2. Corner beads
 3. Plaster grounds
 4. Lath strips
- 5-16. What is the recommended type and proportions for two-coat plaster used on a masonry or concrete base?
1. Gypsum plaster 1:2.5
 2. Lime plaster using lime putty 1:3.5
 3. Portland cement 1:5
 4. Lime plaster using hydrate lime 1:7.5
- 5-17. You should not apply a lime finish to which of the following base coats?
1. Gypsum
 2. Portland cement
 3. Gypsum-vermiculite
 4. Lime
- 5-18. When mortar materials are mixed by hand, what is the maximum time that mixing should continue after all the materials have been blended?
1. 5 min
 2. 10 min
 3. 15 min
 4. 20 min

- 5-19. After all ingredients for plaster have been added, what minimum time should a mixing machine be allowed to mix?
1. 7 min
 2. 5 min
 3. 3 min
 4. 10 min
- 5-20. Normally, what is the specified flatness tolerance of a plastered surface?
1. 1/16 in. in 4 ft
 2. 1/8 in. in 10 ft
 3. 1/4 in. in 8 ft
 4. 1/2 in. in 16 ft
- 5-21. What tool is used for carrying mortar?
1. A rectangular trowel
 2. A darby
 3. An angle trowel
 4. A hawk
- 5-22. To improve adhesive bonds, what tool should be used to make furrows between coats?
1. Darby
 2. Browning brush
 3. Cork float
 4. Scarifier
- 5-23. On a typical plastering crew, which of the following individuals normally mixes the plaster?
1. Crew leader
 2. Tender
 3. Plasterer
 4. Supervisor
- 5-24. Which of the following statements is applicable to the fog-spray curing of portland cement plaster?
1. The finish coat should be applied at least 3 days after the brown coat is applied
 2. The finish coat should be spray-cured for 48 hours after its application
 3. The brown coat should be fog-sprayed for 48 hours followed by the same treatment for the scratch coat
 4. The scratch coat should be fog-sprayed for 24 hours and the brown coat fog-sprayed for 36 hours
- 5-25. A putty coat plaster finish is ready for troweling at what point?
1. When the angles have been straightened
 2. When the surface has been doubled back
 3. When the skim coat has been applied
 4. When the plaster begins to set and the surface becomes dull
- 5-26. Throwing plaster on a surface with a brush produces which of the following textures?
1. Stippled
 2. Travertine
 3. Dash coat
 4. Pebble

- 5-27. Which of the following statements best defines stucco?
1. A combination of cement, sand, and water that, when applied, resembles concrete having a hard, strong, fire-resistant surface which resists rot and fungus and retains color
 2. A combination of masonry cement, sand, and water that, when applied, resembles cement having a medium-hard surface which requires frequent painting to prevent rot and fungus
 3. A combination of cement, sand, and water that, when applied, needs a plasticizing material to act as sealer in preventing rot and fungus
 4. A combination of masonry cement, sand, and water that, when applied, produces a smooth-hand surface which, if not painted immediately after application, will begin to mildew
- 5-28. A brown coat of stucco should be moist-cured for how many hours?
1. 8
 2. 16
 3. 24
 4. 48
- 5-29. When using an acid wash to prepare a concrete surface for stucco, you should use one part acid to how many of water?
1. 6
 2. 10
 3. 12
 4. 20
- 5-30. Which of the following factors is most likely to cause discoloration in a stucco finish coat?
1. Using stainless steel flashing
 2. Not retempering the mortar
 3. Failure to completely mix the finish coat materials
 4. Using different proportions of materials
- 5-31. Ceramic tile is normally divided into what two classifications?
1. Interior and exterior
 2. Exposure and location
 3. Wall and floor
 4. Interior and floor
- 5-32. How many basic ceramic tile installation methods are there?
1. One
 2. Two
 3. Three
 4. Four
- 5-33. What is the minimum soaking time for tile when using the cement-mortar installation method?
1. 1 hr
 2. 2 hr
 3. 30 min
 4. 45 min
- 5-34. Which of the following types of grout should be used when sanitation is important?
1. Latex
 2. Furan resin
 3. Epoxy
 4. Drywall
- 5-35. How many parts of hydrated lime and sand should be used with three parts of cement for a float coat of a mortar bed setting for ceramic tile?
1. 1 part lime and 7 parts sand
 2. 6 parts lime and 10.5 parts sand
 3. 3 parts lime and 10.5 parts sand
 4. 8 parts lime and 21 parts sand

- 5-36. In paint, which of the following ingredients provides the coloring?
1. Drier
 2. Pigment
 3. Thinner
 4. Vehicle
- 5-37. Which of the following paint ingredients acts as the binder?
1. Pigment
 2. Drier
 3. Vehicle
 4. Thinner
- 5-38. Which of the following chemical compounds are NOT synthetic resins?
1. Napthas
 2. Phenolics
 3. Epoxies
 4. Chlorinated rubbers
- 5-39. What is the purpose of a paint solvent?
1. Give more body to the paint
 2. Prevent blistering of the paint
 3. Add gloss to the paint
 4. Adjust the consistency of the paint
- 5-40. To increase resistance of oil-base paint to water and decrease drying time, you should add small amounts of what material to the paint?
1. Linseed oil
 2. Polyester
 3. Varnish
 4. Naptha
- 5-41. Which of the following ratios determines the level of gloss in enamel paints?
1. Pigment to binder
 2. Thinner to pigment
 3. Vehicle to binder
 4. Binder to drier
- 5-42. Of the following paint types, which is best suited to masonry surfaces?
1. Oil-base
 2. Enamel
 3. Epoxy
 4. Latex
- 5-43. In areas that require frequent washing, which of the following types of paint is normally preferable?
1. Portland cement
 2. Latex
 3. Aluminum
 4. Rubber-base
- 5-44. When a can of ready-mix aluminum paint is bulging, how should the pressure be released?
1. Carefully remove the lid
 2. Carefully puncture the lid
 3. Shaking the can in a vibrator
 4. Cool the can
- 5-45. Which of the following materials does NOT obscure the surface to which it is applied?
1. Varnish
 2. Primer
 3. Enamel
 4. Latex
- 5-46. Which of the following types of varnish is intended for exterior use?
1. Flat
 2. Spar
 3. Rubbing
 4. Color
- 5-47. Which of the following materials is often used as a sealant over wood knots to prevent bleeding?
1. Lacquer
 2. Stain
 3. Shellac
 4. Varnish

- 5-48. What type of stain contains alcohol as a vehicle?
1. Spirit
 2. Chemical
 3. Oil
 4. Water
- 5-49. Which of the following advantages is gained by proper surface preparation?
1. Minimum repair only
 2. Increased durability only
 3. Ease of repainting only
 4. Each of the above
- 5-50. You should prepare a galvanized iron surface for painting with which of the following types of cleaners?
1. Acid wash
 2. Solvent
 3. Silicone
 4. Latex emulsion
- 5-51. Dirt and fungus are best removed from concrete and masonry by washing with which of the following types of solutions?
1. Emulsion
 2. Alkaline
 3. Efflorescence
 4. Trisodium phosphate
- 5-52. During the process of removing efflorescence from concrete, what should you do after scrubbing with an acid solution?
1. Let the solution remain on the surface about 10 min
 2. Let the solution dry and then dry brush
 3. Rinse it thoroughly with clear water
 4. Apply a second coat of the solution, and let it remain on the surface for 30 min
- 5-53. What is the correct procedure for mixing muriatic acid and water?
1. Add the acid to the water
 2. Add the water to the acid
 3. Add 15-percent acid to 85-percent water
 4. Add half acid and half water
- 5-54. To repair large defects in a concrete or masonry surface, which of the following grout mixtures should you use?
1. Two parts mortar sand, 1 part portland cement, 1 part water
 2. Two parts portland cement, 2 parts mortar sand, 2 parts water
 3. Three parts mortar sand, 1 part portland cement, enough water to make a puttylike consistency
 4. Two parts mortar sand, 1 part portland cement, enough water to make a soupy consistency
- 5-55. Before painting, a plaster patch should set for what minimum time?
1. 1 day
 2. 2 days
 3. 3 days
 4. Until thoroughly dry
- 5-56. When preparing dirty wood surfaces for painting, which of the following methods should you follow?
1. Sweeping, dusting, and washing the surface with a solvent or water and soap
 2. Bleaching the surface with a solution of oxalic acid and water
 3. Sanding the surface to a uniform color
 4. Pretreating the surface with wood cleaner

- 5-57. Before painting, what is the procedure for sanding a rough wood surface?
1. Start with a No. 1 sandpaper; follow up with a No. 2; and finish with a No. 3x
 2. Start with a No. 2 sandpaper; follow up with a No. 1; and finish with a No.2/0 grit
 3. Start with a No. 3 sandpaper; follow up with a No. 2; and finish up with a No. 1
 4. Start with a No. 2 sandpaper and finish up with a No. 2 and 2/0 grit
- 5-58. When used on porous wood, concrete, and masonry, which of the following items produces a smooth finish floor coat?
1. Conditioner
 2. Sealer
 3. Filler
 4. Latex paint
- 5-59. When applied to chalky bases, which of the following items improves adhesion of water-based paints?
1. Conditioner
 2. Sealer
 3. Filler
 4. Latex paint
- 5-60. Which of the following items prevents resin from bleeding through applied paint coatings?
1. Conditioner
 2. Sealer
 3. Filler
 4. Latex paint
- 5-61. Before applying filler to open-grained wood, stain should be applied and allowed to dry for what minimum time?
1. 12 hr
 2. 24 hr
 3. 36 hr
 4. 48 hr
- 5-62. Before varnishing, you should use a filler on which of the following open-grained woods?
1. Beech
 2. Birch
 3. Maple
 4. Walnut
- 5-63. To mix two-package metallic paints, what method is recommended?
1. Shaker
 2. Manual
 3. Propeller
 4. Berate
- 5-64. During the paint mixing process, what is meant by "boxing the paint"?
1. Pouring it back and forth from one container to another
 2. Mixing it with a mechanical agitator
 3. Mixing it with a paddle
 4. Cutting it with a suitable thinner
- 5-65. What are the three primary or true colors that are the basis for all subsequent shades, tints, and hues?
1. Blue, red, and green
 2. Red, black, and white
 3. Black, yellow, and white
 4. Yellow, blue, and red
- 5-66. Before its application by roller, a ready-mix paint must be thinned.
1. True
 2. False
- 5-67. What is the recommended maximum amount of tint for 1 gallon of paint?
1. 1 oz
 2. 2 oz
 3. 3 oz
 4. 4 oz

- 5-68. Strong sunlight on paint surfaces is most likely to cause which of the following problems?
1. Peeling
 2. Blistering
 3. Alligatoring
 4. Chalking
- 5-69. Inadequate bonding and what other cause are the prime reasons for peeling?
1. High-surface temperature
 2. Improper mixing of paint
 3. Inferior paint
 4. Improper surface preparation
- 5-70. Temperature changes causing the substrate and overlaying paint film to expand and contract are most likely to result in which of the following conditions?
1. Checking and cracking
 2. Peeling
 3. Alligatoring
 4. Blistering
- 5-71. Accumulation of moisture under paint is most likely to cause which of the following problems?
1. Crawling
 2. Peeling
 3. Blistering
 4. Checking
- 5-72. Breaks in paint film extending through to-the substrate indicate what type of paint failure?
1. Checking
 2. Cracking
 3. Peeling
 4. Crawling
- 5-73. Spraying paint too thickly or moving the spray gun too slowly are most likely to cause which of the following paint failures?
1. Chalking
 2. Peeling
 3. Blistering
 4. Wrinkling
- 5-74. Failure of a gloss paint to attain its normal gloss is most likely to be caused by which of the following conditions?
1. Application in cold weather only
 2. Inadequate surface preparation only
 3. Application of the paint before the undercoat has dried only
 4. Any of the above
- 5-75. The degree of protection provided to wood by a wood preservative depends on which of the following conditions?
1. The type of wood only
 2. The moisture content of the wood only
 3. The length of time the wood is treated only
 4. All of the above

ASSIGNMENT 6

Textbook assignment: Chapter 9 - Advanced Base Field Structures and Embarkation
Chapter 10 - Heavy Construction

- 6-1. After an ABFC shipment is arranged in a storage area, what should be the next step?
1. Fit parts together
 2. Inventory
 3. Start erection process
 4. Report discrepancies
- 6-2. A PEB is shipped with all materials and instructions necessary for erection.
1. True
 2. False
- 6-3. In military construction, how many teams are recommended for the erection of a 20- by 48-foot PEB?
1. One
 2. Two
 3. Three
 4. Four
- 6-4. The 20- by 48-foot, rigid-frame, straight-walled building can easily be disassembled, moved, and erected again without waste or damage because of what feature?
1. Prestressed concrete pads
 2. Large metal C-clamps
 3. Bolted connections
 4. Fiberboard panels
- 6-5. Before placing concrete for the foundation piers of a rigid-frame building, which of the following tasks should you perform?
1. Bolt the frames together only
 2. Place templates and anchor bolts only
 3. Uncrate the paneling only
 4. All of the above
- 6-6. While the foundation is being prepared for a 20- by 48-foot rigid-frame building, which of the following work assignments can you perform?
1. Glaze the windows only
 2. Bolt the rigid-frame assemblies only
 3. Assemble the door leaves only
 4. Any of the above
- 6-7. Until ready to be used, which of the following materials should remain crated?
1. Girts
 2. Panels
 3. Eave struts
 4. Brace rods
- 6-8. What should you do to ensure building materials are accessible during assembly of a PEB?
1. Keep all building materials in one central location
 2. Keep the building materials on trucks
 3. Place the materials around the building site where they will be used
 4. Maintain at least 50 ft of clearance between the stockpiles of building materials
- 6-9. In PEBs, the high-strength bolts used to connect the rigid-frame assemblies are identified by what means?
1. A painted mark across the bolt threads
 2. A notch at the base of each bolt
 3. An embossed HS on each bolt head
 4. An embossed Y on each bolt head

- 6-10. Once all the parts have been laid out and checked, erection of a 20- by 48-foot PEB should begin with the center frame member.
1. True
 2. False
- 6-11. During the course of erecting a PEB, when is the framework first plumbed?
1. Before the sidewall girts are installed
 2. After the exterior panels are positioned
 3. Before the base angles are installed
 4. After all the brace rods are in position
- 6-12. Which of the following steps must be taken before the panels of a PEB are installed?
1. Install the furring strips
 2. Install the windows
 3. Straighten the girts
 4. Straighten the stringers
- 6-13. When placing the upper and lower wall panels of a PEB, which of the following operations is correct?
1. 1/4- by 1-in. machine screws are placed first
 2. Upper wall panels are placed before the lower wall panels
 3. Upper wall panels overlap the lower wall panels
 4. Lower wall panels overlap the upper wall panels
- 6-14. Where should the cave panels for a PEB be installed?
1. One row ahead of the ridge panels
 2. Two rows ahead of the ridge panels
 3. One row behind the ridge panels
 4. Two rows behind the ridge panels
- 6-15. When should the doorjambs of a PEB be installed?
1. After installing the interior lining
 2. After end-wall structural parts are completed
 3. After installing exterior end-wall panels
 4. After installing the roof panels
- 6-16. What kind of concrete nails should you use to nail the base furring to the concrete deck of a PEB?
1. 8d, box
 2. 2 in., No. 10
 3. 1 1/4 in., No. 9
 4. 3/4 in., No. 8 flathead
- 6-17. After placing the base, corner, and gable furrings of a PEB, what should you install next?
1. Hardboard liners
 2. Eave moldings
 3. Batten strips
 4. Vertical furring
- 6-18. When installing hardboard in a PEB, you should ensure the gap between panels is
1. 1/8 in.
 2. 1/4 in.
 3. 5/16 in.
 4. 3/8 in.
- 6-19. For the flooring of a wood-frame tent, what material should you use?
1. 3/8-in. fiberboard
 2. 5/8-in. pressboard
 3. 1/2-in. plywood
 4. 1/4-in. tempered Masonite™
- 6-20. Wall and roof framing members of a 16- by 32-foot wood-frame tent should have what spacing?
1. 1 ft OC
 2. 2 ft OC
 3. 3 ft OC
 4. 4 ft OC

- 6-21. When modified with a metal roof, extended rafters, and screened-in areas, a 16- by 32-foot wood-frame tent becomes what type of hut?
1. Southeast Asia
 2. Caribbean
 3. Wood-frame
 4. Tropical
- 6-22. When two 4-seat latrine boxes are set up side by side, what size pit is required?
1. 3 by 6 ft
 2. 2 by 6 ft
 3. 3 by 7 ft
 4. 4 by 8 ft
- 6-23. How many trough-type urinals should be furnished with an 8-seat latrine?
1. One
 2. Two
 3. Three
 4. Four
- 6-24. Which of the following conditions normally indicates the need for steel piles?
1. Driving through compressible soil
 2. The requirement for 95-ft piles
 3. Light loads must be supported
 4. A retaining wall is needed
- 6-25. Which of the following features is used to designate the size of a pier?
1. Length
 2. Height
 3. Width
 4. Diameter of the piling
- 6-26. A pier is protected against shock damage from a ship tied alongside by a system of
1. batter piles
 2. bearing piles
 3. stringers
 4. fender piles
- 6-27. The two main components of a timber trestle are
1. bents and abutments
 2. substructure and superstructure
 3. bracing and caps
 4. decking and footings
- 6-28. Which of the following conditions normally require(s) trestle bents?
1. Soft or marshy ground
 2. Swift currents
 3. Deep water
 4. Solid dry ground or shallow water
- 6-29. Which of the following is considered a vertical structural member?
1. Post
 2. Cap
 3. Sill
 4. Girder
- 6-30. How much overlap is figured in when calculating center-to-center horizontal distance between bents?
1. 1 ft
 2. 2 ft
 3. 3 ft
 4. 4 ft
- 6-31. What is the usual length of girder stock?
1. 10 ft
 2. 12 ft
 3. 13 ft
 4. 14 ft
- 6-32. What is the minimum width of a single-lane trestle?
1. 12 ft
 2. 14 ft
 3. 16 ft
 4. 18 ft

- 6-33. What size stock is used for transverse diagonal bracing?
1. 2 x 2
 2. 2 x 4
 3. 2 x 6
 4. 2 x 8
- 6-34. When placing timber girders, the OC spacing is what distance?
1. 3 ft 3 in.
 2. 3 ft 3 1/4 in.
 3. 3 ft 3 1/2 in.
 4. 3 ft 3 5/8 in.
- 6-35. How many layers of planking make up a timber deck?
1. One
 2. Two
 3. Three
 4. Four
- 6-36. The timber decking consists of 3-inch planks.
1. True
 2. False
- 6-37. At an abutment, which of the following items prevents the approach of road from washing out or eroding?
1. End cap
 2. End wall
 3. End dam
 4. End curb
- 6-38. Which of the following is a load-bearing member made of timber, steel, concrete, or a combination of these materials?
1. Cofferdamn
 2. Pile
 3. Trestle
 4. Pile bent
- 6-39. What is the tip diameter of a pile shorter than 40 feet?
1. 8 to 11 in.
 2. 9 to 12 in.
 3. 10 to 13 in.
 4. 11 to 14 in.
- 6-40. The butt diameter of piles longer than 40 feet can be greater than the distance between the pile leads.
1. True
 2. False
- 6-41. During a pile driving operation, which of the following actions is necessary to protect the pile from damage?
1. Cut the pile perpendicular to its axis
 2. Use steel shoes to protect the pile
 3. Sharpen the tip of the pile
 4. Cut the butt of the pile square and chamfer it
- 6-42. Which of the following piles is required when piles of 80 feet or longer are required?
1. Timber
 2. Steel
 3. Concrete
 4. Combination
- 6-43. Which of the following piles should be used to form a continuous wall to resist horizontal pressure resulting from earth or water loads?
1. Sheet pile
 2. Precast pile
 3. Cast-in-place pile
 4. Open-end pipe pile
- 6-44. Which of the following is constructed below water-retaining structures to retard the flow of water through the foundation?
1. Cofferdamns
 2. Bulkheads
 3. Cutoff walls
 4. Trench sheathing

- 6-45. The working drawings for timber piers contain which of the following information?
1. Bill of materials only
 2. Dimensions and location of all structural members only
 3. Required driftpins, bolts and hardware, and bill of materials only
 4. All of the above
- 6-46. When the use of batter piles is required, what is the specified angle?
1. 5 in 12
 2. 2 in 12
 3. 3 in 12
 4. 4 in 12
- 6-47. On a bridge, the inside stringers on the superstructure are fastened by what method?
1. Through bolts
 2. Driftbolts
 3. Spikes
 4. Nails
- 6-48. Which of the following conditions exist when a pile vibrates too much laterally?
1. Leaning
 2. Cracking
 3. Bouncing
 4. Springing
- 6-49. What is the minimum amount the butt of a wood pile can be crushed or broomed before you should cut it back to sound wood?
1. 1 in.
 2. 2 in.
 3. 3 in.
 4. 4 in.
- 6-50. It is always necessary to drive a friction pile to refusal.
1. True
 2. False
- 6-51. Waterfront structures are broadly divided into how many categories?
1. One
 2. Two
 3. Three
 4. Four
- 6-52. Breakwaters and jetties fall under which of the following categories?
1. Offshore structures
 2. Alongside structures
 3. Wharfage structures
 4. Deepwater structures
- 6-53. Which of the following structures works to direct and confine a current or tidal flow into a selected channel?
1. Breakwater
 2. Jetty
 3. Seawall
 4. Groin
- 6-54. Of the following structures, which has the stabilization of a shoreline as its main purpose?
1. Rubble-mound breakwater
 2. Caisson
 3. Seawall
 4. Jetty
- 6-55. How many various types of cast-in-place concrete seawalls are there?
1. Five
 2. Two
 3. Three
 4. Four
- 6-56. Which of the following structures is placed to arrest a current and deflect it away from a shoreline?
1. Breakwater
 2. Jetty
 3. Groin
 4. Seawall

6-57. Which of the following structures is a relatively thin wall supported by a series of tie rods running back to a deadman?

1. Groin
2. Bulkhead
3. Seawall
4. Caisson

6-58. How many types of caissons are used in constructing foundations underwater?

1. One
2. Two
3. Three
4. Four

