3. Place the template, which is usually supplied with a cylinder lock, on the face of the door at the proper height and in alignment with the layout lines and mark the centers of the holes to be drilled. A typical template is shown in *Figure 11-11*.

Figure 11-11 – Drill template for locksets.

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.

1.3.3 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. Route out the marked outline with a chisel and also rout for the latch as shown in *Figure 11-12*. 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.

Figure 11-12 –Strike plate details.

1.3.4 Door Stops

You may now permanently nail in the stops that have been temporarily set during the fitting of the door and the hardware. Use finish nails or brads, 1 1/2 inches long. The stop at the lock side shown in *Figure 11-13* should be nailed first, setting it tightly against the door face when the door is latched. Space the nails in pairs 16 inches apart.

Figure 11-13 – Door stop details.

Nail the stop behind the hinge side next, with a 1/32 inch clearance from the door face allowed to prevent scraping as the door is opened. Then nail the head jamb stop in place. Remember that painting the door and trim will take up some of the clearance.

1.4.0 Commercial and Industrial Hardware

The items of commercial and industial door hardware shown in *Figure 11-14* are usually installed in commercial or industrial buildings, not residential housing. These items are used in new construction or in alterations or repairs of existing facilities. Most of these items are made for use on metal doors, but some are made for wood doors.

NOTE

Follow the manufacturer's installation instructions.

Figure 11-14 – Commercial hardware.

Recommended door hardware locations for standard steel doors are shown in *Figure 11-15*. Standard 7 foot doors are normally used in commercial construction.

Figure 11-15 – Location of hardware for steel doors.

2.0.0 WINDOW CASING

The casing around the window frames on the interior of a structure should have 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, shown in *Figure 11-16, view A*. Another method of using trim around windows has the entire opening enclosed with casing, as shown in *Figure 11-16, view B*. The stool serves as a filler trim member between the bottom sash rail and the bottom casing.

Figure 11-16 – Installation of window trim.

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 install and is notched and fitted against the edge of the jamb and plaster line, with the outside edge flush against the bottom rail of the window sash. Blind nail the stool at the ends so that the casing and the stop cover the nailheads. Predrilling is usually necessary to prevent splitting. Also, nail the stool at the midpoint of the sill and to the apron with finishing nails. You may sometimes substitute or supplement face with toenailing of the outer edge to the sill.

Install and nail the window casing as described for doorframes, shown in *Figure 11-4, 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. Then nail the window stops to the jambs so that the window sash slides smoothly. Channel type weather stripping often includes full width metal subjambs 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. Cut the apron to a length equal to the outer width of the casing line as shown in *Figure 11-16, View A*. Nail it to the windowsill and to the 2 by 4 inch framing sill below.

When you use casing to finish the bottom, sides, and top of the window frame, the narrow stool butts against the side window jamb. Miter the casing at the bottom comers as shown in *Figure 11-16, View B,* and nail it as previously described.

3.0.0 MOLDINGS

3.1.1 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, as shown in *Figure 11-17, 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 as shown in *Figure 11-17, 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 11-17 – Base moldings.

A single base molding without the shoe is sometimes placed at the wall and floor junction Most baseboards are finished with a 1/2 by 3/4 inch base shoe, as shown in *Figure 11-17, View A*, especially where carpeting might be used.

Install square edged baseboard with a butt joint at the inside comers and a mitered joint at the outside comers, as shown in *Figure 11-17, View D*. Nail it 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, square cut the first piece against the plaster or base and cope the second piece of molding. Do this by sawing a 45° miter cut and using a coping saw to trim the molding along the inner line of the miter, as shown in *Figure 11-17, View E*.

Nail the base shoe 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 scriber as shown in *Figure 11-18*. Use the same procedure when butting ends of the baseboard against the side casings of the doors.

Figure 11-18 – Butt joining baseboard at inside corners.

For miter joining at an outside comer, proceed as shown in *Figure 11-19*.

1. Set a marker piece of baseboard across the wall comer, as shown in *View A*, and mark the floor along the edge of the piece.
2. Set the piece to be mitered in place. Mark the point where the wall corner intersects the top edge and the point where the mark on the floor intersects the bottom edge.
3. Lay 45° lines across the edge from these points to make a 90° corner. Connect these lines with a line across the face as shown in *View B*, and miter to the lines as indicated.

Figure 11-19 – Miter joining at inside corners.

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.

NOTE

When installing vinyl base, follow the manufacturer’s recommended installation procedures for both the base and the adhesive.

3.2.0 Ceiling Molding

Ceiling moldings as shown in *Figure 11-20* 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 as shown in *Figure 11-20, View A*. This ensures a tight joint and retains a good fit if there are minor moisture changes.

Figure 11-20 – Ceiling moldings.

A cutback edge at the outside of the molding as shown in *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 as shown in *View C* might be desirable. Drive finish nails into the upper wall plates and also into the ceiling joists for large molding when possible.

3.3.0 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.

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.

4.0.0 MILLWORK

As a general term, millwork usually includes most wood products and components that require manufacturing. It not only includes the interior trim and doors, but also kitchen cabinets and similar units. Most of these units are produced in a millwork manufacturing plant and are ready to install. *Figure 11-21* shows an example of the dimensions you might be working with.

Figure 11-21 – Typical dimensions for cabinetwork.

4.1.1 Building Cabinets in Place

A common way to build cabinets, such as those shown in *Figure 11-22*, is to cut the

Figure 11-22 – Typical kitchen cabinets: wall (view A) and base (view B).

Figure 11-23 – Typical frame construction of a cabinet.

pieces shown in *Figure 11-23* and assemble them in place. Think of building in place cabinets as four steps:

1. Construct the base first. Use straight 2 by 4 lumber for the base. Nail the lumber to the floor and to a strip attached to the wall. If the floor is not level, place shims under the various members of the base. Later you can face any exposed 2 by 4 surfaces with a finished material, or the front edge can be made of a finished piece, such as base molding.

2. Cut and install the end panels. Attach a strip along the wall between the end panels and level with the top edge. Be sure the strip is level throughout its length. Nail it securely to the wall studs.

3. Cut the bottom panels and nail them in place on the base. Follow this with the installation of the partitions, which are notched at the back corner of the top edge so they will fit over the wall strip.

4. Plumb the front edge of the partitions and end panels. Secure them with temporary strips nailed along the top.

Wall units are made using the same basic steps as the base units. You should make your layout lines directly on the ceiling and wall. Nail the mounting strips through the wall into the studs. At the inside corners, end panels can be attached directly to the wall.

Remember to make your measurements for both base and wall units carefully, especially for openings for built-in appliances. Refer frequently to your drawings and specifications to ensure accuracy.

4.1.1 Shelves

Shelves are an integral part of cabinetmaking, especially for wall units. Cutting dadoes into cabinet walls to fit in shelves may actually strengthen the cabinet shown in *Figure 11-24*.

Figure 11-24 – End panels of a wall cabinet in place (view A) and completed framing with facing partially applied (view B).

Place shelving supports for 3/4 inch shelves no more than 42 inches apart. Shelves designed to hold heavy loads should have closer supports. To improve the appearance of plywood shelving, cover the laminated edge with a strip of wood that matches the stock used for the cabinet.

4.1.2 Cabinet Facing

After completing the frame construction and shelving, apply finished facing strips to the front of the cabinet frame. These strips are sometimes assembled into a framework, called a faceplate or face frame, by commercial sources before they are attached to the basic cabinet structure. The vertical members of the facing are called stiles, and the horizontal members are known as rails.

As for built in place cabinets, cut each piece and install it separately. Lay out the size of each piece by positioning the facing stock on the cabinet and marking it. Then make the finished cuts. Use a cut piece to lay out duplicate pieces.

Cabinet stiles are generally attached first, and then the rails, as shown in *Figure11-25*. Sometimes a Builder will attach a plumb end stile first, and then attach rails to determine the position of the next stile.

Use finishing nails and glue to install facing. When nailing hardwoods, drill nail holes where you think splitting might occur.

Figure 11-25 - Facing being placed on a cabinet.

4.1.3 Drawers

Seabees use many methods of building drawers. The most common are the multiple ***dovetail***, lock shouldered, and square shouldered methods shown in *Figure 11-26*.

Figure 11-26 – Three common types of joints used in drawer construction.

Several types of drawer guides are available. The three most commonly used are the side guide, the corner guide, and the center guide, shown in *Figure 11-27*.

Figure 11-27 – Types of drawer guides.

The two general types of drawer faces are the lip and flush faces shown in *Figure 11-28*. A flush drawer must be carefully fitted. A lip drawer must have a ***rabbet*** along the top and sides of the front. The lip style overlaps the opening and is much easier to construct.

Figure 11-28 – Types of drawer faces.

4.1.4 Cabinet Doors

The four types of doors commonly used on cabinets are flush, lipped, overlay, and sliding doors. A flush door, like the flush drawer, is the most difficult to construct. For a finished look, each type of door must be fitted in the cabinet opening within 1/16 inch clearance around all four edges. A lipped door is simpler to install than a flush door since the lip, or overlap, feature allows a certain amount of adjustment and greater tolerances. Form the lip by cutting a rabbet along the edge.

Overlay doors are designed to cover the edges of the face frame. Several types of sliding doors are used on cabinets. One type of sliding door is rabbeted to fit into grooves at the top and bottom of the cabinet. The top groove is always made to allow the door to be removed by lifting it up and pulling the bottom out.

4.2.0 Installing Premade Cabinets

To install premade cabinets, begin with either the wall or the base cabinets. The general procedures for each are similar.

4.2.1 Installing the Wall Cabinets First

When making layouts and locating wall studs, lift the wall units into position. Hold them with a padded T brace that allows you to stand close to the wall while making the installation. After securely attaching and checking the wall cabinets, move the base cabinets into place and then level and secure them.

4.2.2 Installing the Base Cabinets First

When base cabinets are installed first, the tops of the base cabinets can be used to support braces that hold the wall units in place while they are fastened to the wall.

4.2.3 Procedures

The following procedures are a simple way of installing premade cabinets:

1. Locate and mark the location of all wall studs where the cabinets are to be hung. Find and mark the highest point in the floor. This will ensure the base cabinet is level on uneven floor surfaces. Use shims to maintain the cabinet at its designated leveled height.
2. Start the installation of a base cabinet with a corner or end unit. After all base cabinets are in position, fasten the cabinets together at the sides. To get maximum holding power from screws, place one screw close to the top and one screw close to the bottom.
3. Starting at the highest point in the floor, level the leading edges of the cabinets. After leveling all the leading edges, fasten them to the wall at the studs to obtain maximum holding power.
4. Install the countertop on the base cabinets, making sure to drill or screw through the tops of the base cabinets.
5. Make a brace to help support the wall cabinets while they are being fastened. Start the wall cabinet installation with a corner or end cabinet. Make sure you check for plumb and level as you install these cabinets.
6. After installing the cabinets and checking for plumb and level, join the wall cabinets through the sides as you did with the base cabinets.
7. After they are plumb and level, secure the cabinets to the wall at the studs for maximum holding power.

Here are some helpful hints for the general construction of cabinets:

- Fasten cabinet parts together with screws or nails. Set them below the surface, and fill the holes with putty. Use glue at all joints. Use clamps to produce better fitting, glued joints.
- To make a better quality cabinet, rabbet it where the top, bottom, back, and side pieces come together, although you can also use butt joints. If panels are less

than 3/4 inch thick, use a reinforcing block with the butt joint. Dado fixed shelves into the sides.

- Screws should go through the hanging strips and into the stud framing. Never use nails. Toggle bolts are required when studs are inaccessible. Join units by first clamping them together and then, while they are aligned, install bolts and T nuts.

4.3.0 Counters and Tops

In cabinetwork, the counters and tops are covered with a 1/16 inch layer of high pressure plastic ***laminate***. Although this material is very hard, it does not possess great strength and is serviceable only when it is bonded to plywood, particle board, or wafer wood. This base, or core material, must be smooth and is usually 3/4 inch thick.

4.3.1 Working Laminates

Plastic laminates can be cut to rough size with a table saw, portable saw, or saber saw. Use a fine tooth blade, and support the material close to the cut. If no electrical power is available, use a finish handsaw or a hacksaw. When you cut laminates with a saw, place masking tape over the cutting area to help prevent chipping the laminate. Make cut markings on the masking tape.

Measure and cut a piece of laminate to the desired size. Allow at least 1/4 inch extra to project past the edge of the countertop surface. Mix and apply the contact bond cement to the underside of the laminate and to the topside of the countertop surface.

NOTE

Be sure to follow the manufacturer’s recommended directions for application.

4.3.2 Adhering Laminates

Allow the contact bond cement to set or dry. To check for bonding, press a piece of waxed brown paper on the cement coated surface. When no adhesive residue shows, it is ready to be bonded. Be sure to lay a full sheet of waxed brown paper across the countertop. This allows you to adjust the laminate into the desired position without permanent bonding. Now, you can gradually slide the paper out from under the laminate, and the laminate becomes bonded to the countertop surface.

Be sure to roll the laminate flat by hand, removing any air bubbles and getting a good firm bond. After sealing the laminate to the countertop surface, trim the edges by using either a router with a special guide or a small block plane. If you want to bevel the countertop edge, use a mill file.

Summary

Finish carpentry is undertaken after rough carpentry is completed. Doorframing applies to the interior side of exterior walls and for both sides of interior door. Installing hardware for doors is part of finishing doors. Window casing is similar to doorframing, and is applied to the interior of all windows. Moldings at the ceiling and floor, as well as other decorative treatments are part of finish carpentry. Installing millwork, including cabinets and tops, is also part of finish carpentry.

Review Questions (Select the Correct Response)

1. Rough openings for interior doors are usually framed how much (a) higher and (b) wider than the finished door size?

   A. (a) 2 inches (b) 3 inches
   B. (a) 2 1/2 inches (b) 3 1/2 inches
   C. (a) 3 inches (b) 2 1/2 inches
   D. (a) 3 1/2 inches (b) 3 inches

2. What is the proper name for the edge trim around an interior door opening?

   A. Casing
   B. Molding
   C. Jam
   D. Sill

3. Why are louvered doors the most suitable for use on closets?

   A. They are less expensive.
   B. They are more durable.
   C. They require less space.
   D. They allow ventilation.

4. How should hinged doors swing or open?

   A. Against a blank wall only
   B. Toward the natural entry only
   C. Both A and B above
   D. Into a hallway

5. When plumbing and leveling a door frame, which of the following materials should you use?

   A. Casing wedges
   B. Wood shingle wedges
   C. Wood shake wedges
   D. Hairpin wedges

6. What edge distance allowance is made when the casing is nailed to the jamb?

   A. 1/16 inch
   B. 1/8 inch
   C. 3/16 inch
   D. 3/8 inch

7. What should you do to a mitered casing joint to reduce the chance of its opening up as the casing material dries?

A. Use a glued spline
B. Install wood screws
C. Glue the joint
D. Use a wood filler

8. What size loose pin butt hinge should you use for a door 1 3/8 inches thick?

A. 5 inches extra heavy
B. 5 inches by 6 inches
C. 3 1/2 inches by 3 1/2 inches
D. 4 inches by 4 inches

9. A doorknob should be installed at what standard height?

A. 36 to 38 inches
B. 34 to 36 inches
C. 32 to 34 inches
D. 30 to 32 inches

10. To prevent scraping as a door is opened, what clearance is allowed for the doorstop on the hinge side of the door?

A. 1/64 inch
B. 1/32 inch
C. 1/16 inch
D. 1/8 inch

11. Which of the following devices holds the door in place by contact with the latch?

A. Rim
B. Vertical rod
C. Mortise
D. Strike plate

12. Which of the following members is NOT trim for a double hung window?

A. Apron
B. Sash stops
C. Stool
D. Window jamb

13. What should be the first inside window trim member to be installed?

A. Stop
B. Stool
C. Casing
D. Apron

14. Name the small strip molding used on the upper edge of a two piece baseboard.

A. Base cap
B. Base top
C. Chair rail
D. Bumper

15. Name the trim molding added to the baseboard at the floor and wall junction.

A. Corner
B. Rail
C. Shoe
D. Base

16. What type of joint should be used at inside corners of ceiling moldings?

A. Butt
B. Coped
C. Mitered
D. Lapped

17. When you build cabinets in place, what step follows installation of the base?

A. Cut the bottom panels and nail them in place
B. Cut end panels and install
C. Cut front edge and install
D. Cut counter top to length

18. You can increase the strength of a set of cabinets by using what type of joint for the shelves?

A. Blind mortise and tenon
B. Tongue and groove
C. Dado
D. Rabbet

19. When you use 3/4 inch material for shelves, what should be the maximum distance between shelf supports?

A. 16 in
B. 24 in
C. 36 in
D. 42 in

20. Which of the following drawer fronts, if any, is the easiest to construct?

A. Flush
B. Lip
C. Sliding
D. None of the above

21. Which of the following cabinet door types is designed to cover the edge of the face frame?

A. Overlay
B. Flush
C. Lipped
D. Sliding

22. What is the first thing you should do when installing premade cabinets base-first?

A. Locate wall studs and find the highest point on the floor
B. Install cabinet base and locate the wall studs
C. Locate the highest point on the floor and install the cabinet base
D. Locate the highest point on the floor, then level the leading edge of the cabinets

23. Which of the following fasteners should you use to hang cabinets on a wall?

A. Spiral nails
B. Annular nails
C. Screws
D. Stove bolts

24. When installing laminated counter tops, you should use base material that has which of the following characteristics?

A. 1/2 inch thick only
B. 3/4 inch thick only
C. Smooth, 1/2 inch thick
D. Smooth, 3/4 inch thick

25. **(True or False)** When cutting a piece of laminate, you should cut it at least 1/4 inch larger than the desired size.

A. True
B. False

Trade Terms Introduced in this Chapter

Butt joint	A square joint between two pieces of molding at right angles to each other.
Casing	The trim around doors and windows.
Coped joint	The intersection of two pieces of molding with one cut to fit the contour of the other.
Dado	A joint created by fitting the end of one piece of wood at a right angle into a groove cut across the width of another, to a depth of half its thickness.
Dovetail	In finish carpentry, an interlocking joint that is wider at its end than at its base.
Drywall	A system of interior wall finish using sheets of gypsum board and taped joints.
Laminate	Any material formed by bonding together several layers or sheets with adhesive under pressure and sometimes with nails or bolts.
Millwork	In woodworking, any material that has been machined, finished, and partly assembled at the mill.
Mitered joint	A butt joint of two members at equal angles.
Rabbet	A longitudinal edge joint formed by fitting together rabbeted boards.
Sash	The movable part of a window.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

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

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

Facilities Planning Guide, NAVFAC P-437, Naval Facilities Engineering Command, Alexandria, Va., 1982.

Operations Officer's Handbook, COMCBPAC/COMCBLANTINST 5200.2A, Commander, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, and Commander, Naval Construction Battalions, U.S. Atlantic Fleet, Norfolk, Va., 1988.

Seabee Planner's and Estimator's Handbook, NAVFAC P-405, Chapter 5, Naval Facilities Engineering Command, Alexandria, Va., 1983.

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Chapter 12

Moisture Protection

Topics

To hear audio, click on the box.

Overview

Moisture protection for buildings includes many components. The most obvious are the roofing and exterior wall coverings. Openings in the walls are sealed by doors and windows. Flashing helps protect areas where surfaces come together, such as chimneys and roofs. Gutters and downspouts move water from the roof to underground drains. Insulation and ventilation work together to prevent moisture from building up and damaging the building. Your job as a Builder is to incorporate all of these elements to prevent moisture from damaging the building.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Identify safety measures while working on roofing.
2. Identify various types of roof sheathing and describe their installation requirements.
3. Define roofing terms and identify roofing materials.

4. Identify the types of exterior wall coverings and describe procedures for installing siding.
5. Identify various types of flashing and describe installation procedures.
6. Identify various types of gutters and downspouts and describe their installation procedures.
7. Identify the types of exterior doors and describe basic exterior doorjamb installation procedures.
8. Identify the types of windows used in frame structures, and describe installation procedures.
9. Identify the different types of glass and glazing materials, and describe procedures for cutting, glazing, and installing glass.
10. Identify the types of insulation and describe the methods of installation.
11. Identify various types of ventilation and describe their installation procedures.

Prerequisites

None

This course map shows all of the chapters in Builder Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

Expeditionary Structures	↑	
Finishes		B
Moisture Protection		U
Finish Carpentry		I
Rough Carpentry		L
Carpentry Materials and Methods		D
Masonry		E
Fiber Line, Wire Rope, and Scaffolding		R
Concrete Construction		
Site Work		B
Construction Management		A
Drawings and Specifications		S
Tools		I
Basic Math		C

Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with an italicized instruction telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 SAFETY

Before we discuss working on roofing, it is important to review measures to keep your crew safe on the job. This includes fall protection and personal protective equipment (PPE).

1.1.0 Fall Protection

Roofs can be either sloped or flat. There are different considerations for working in these two environments.

1.1.1 Sloped Roofs

There are several components to fall protection systems used on sloped roofs:

- Full body harness
- Self retracting lanyard (SRL)
- Roof brackets/anchors for anchorage points
- Slide guards

The roof brackets/anchors can have single or multiple connections, and must be designed for 5,000 pounds per person.

1.1.2 Flat Roofs

On flat roofs with no ***parapet*** or guardrails, there are several safety considerations. When you are working within 6 feet of the edge, you need to use the following comoponents:

- Full body harness
- Restraining system and/or
- Self retracting lanyard (SRL)

Establish a warning line system six to ten feet away from the leading edge or temporary guardrails for workers without a fall arrest system. Personnel working inside the warning line system do not require fall protection.

1.2.0 Roof Loading

Many factors can affect how you load the materials for installation of a roof. Work directly with your Safety Officer to establish safe work loads. The Safety Plan needs to ensure that the structure will support the load.

2.0.0 ROOFING APPLICATIONS

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, exterior wall coverings, 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 materials 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. These topics are covered in a later chapter.

2.1.0 Roof Sheathing

Roof sheathing covers the rafters or roof joists. As a structural element 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.

2.1.1 Lumber

Roof sheathing boards are generally No. 3 common or better. These are typically softwoods, such as Douglas fir, redwood, hemlock, western larch, fir, and spruce. If you are 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.

2.1.2 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 12-1* shows the installation of both closed and open lumber roof sheathing.

Figure 12-1 – 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 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.

2.1.3 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 should the joints of adjoining boards be made over the same rafter space. Each board should bear on at least two rafters.

2.1.4 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 12-1*.

Table 12-1 – 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)	Maximum Span (Inches) [4]	Unsupported Edge – Max. Length (inches) [5]	ALLOWABLE ROOF LOADS (per square foot) [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)	45 (60)	35 (45)				
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 Assiciation 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 nails 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 where those 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 parantheses.
7. Allowable roof loads were established by laboratory tests and calculations assuming evenly distributed loads.

2.1.5 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 12-2 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.

Figure 12-2 – Two methods of starting the first sheet of roof sheathing at the eaves of a roof.
A. Flush with rafter
B. Overlapping rafter

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, *view* B, 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 sheathing 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.

2.1.6 Placing

Notice in *Figure 12-2* that sheathing is placed before the trim is applied. Always place sheathing from the lower (eaves) edge of the roof up toward the ridge. You can start from the left side and work toward the right, or from the right and work toward the left. Usually, you should start at the same end of the building from which you laid the rafters out.

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

Place the plywood 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 12-3* shows plywood panels laid perpendicular to the rafters with staggered joints.

CAUTION

Leave a small space between sheets to allow for expansion.

Butt the sheets that follow against spacers until you reach the opposite end. If there is any panel hanging over the edge, trim it after you fasten the panel in place. Snap a chalk line on the sheathing flush with the end of the house, and then cut the panel 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.

Figure 12-3 – Plywood roofing panel installation.

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 does not span two rafters, start the second course with a 4 by 4 half sheet of plywood.

It is important to stagger all vertical joints. All horizontal joints need blocking placed underneath, or a metal clip known as a 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, as shown in *Figure 12-3*.

Carry the pattern to the ridge. Fasten the final course in place, snap a chalk line at the top edge of the rafters, and cut off the extra material. Then sheet the opposite side of the roof using the same pattern.

2.1.7 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.

Test your Knowledge (Select the Correct Response)

1. Roof sheathing has what primary purpose?

   A. Appearance
   B. Base for nailing shingles
   C. Insulation
   D. Foundation for joining rafters

2.2.0 Roof Decking

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

2.2.1 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.

2.2.2 Installation

Install roof decking to a flat roof with the tongue away from you. Install roof decking to a sloping roof with the tongue up. Bevel cut the butt ends of the pieces at approximately a 2° angle, as shown in *Figure 12-4*. 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.

Figure 12-4 – Ends of roof decking cut at a 2° angle.

If there are three or more supports for the decking, a controlled random laying pattern, shown in *Figure 12-5*, 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.

Figure 12-5 – Plank decking span arrangements.

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 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, as shown in *Figure 12-5*.

2.2.3 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.

2.2.4 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. 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.

2.2.5 Installation

Lay out wood fiber roof decking with the tongue and groove joint at right angles to the support members. Start the decking at the eave 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.

2.2.6 Nailing

Nail the wood fiber roof panels through the face into the wood, rafters, or trusses, even though they have tongue and groove edges. 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 are not going to apply the finish roofing material immediately after the roof is sheeted, cover the deck with building felt paper. The paper will protect the sheathing in case of rain. Wet panels tend to separate.

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, as shown in *Figure 12-6*. When the projection is greater than 16 to 20 inches, special ladder framing is used to support the sheathing.

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. Alternate butt joints of the plywood sheets so they do not occur on the same rafter.

Figure 12-6 – Wood fiber roof decking at gable ends.

2.3.0 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 12-7* 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.

Figure 12-7 – Sheathing details at chimney and valley openings.

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***.

2.4.0 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 12-2*. The result will be the roof area.

Table 12-2 – 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		

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 a rise 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 underlayment, or shingles.

2.4.1 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, and then refer to *Figure 12-8*. Multiply the total area to be covered by the factor from the chart. For example, if 1 by 8 inch tongue and groove sheathing 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.

Figure 12-8 – Lumber Sheathing Specifications and Estimating Factor.

2.4.2 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.

2.4.3 Decking or Planking

To estimate plank decking, first determine the area to be covered, and then refer to the chart in *Table 12-3*. 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.

Table 12-3 – Plank Decking Estimating Factor.

Size	Area Factor
2” x 6”	2.40
2” x 8”	2.29
3” x 6”	3.43
4” x 6”	4.57

2.4.4 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.

3.0.0 ROOFING TERMS and 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 us first look at some of the most common terms used in roof construction.

3.1.0 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.

3.1.1 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.

3.1.2 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), or two (double coverage), or three (triple coverage) thicknesses of material over the roof surface. Shingles providing single coverage are suitable for reroofing 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.

3.1.3 Shingle Surfaces

The various surfaces of a shingle are shown in *view A* of *Figure 12-9*. 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.

Figure 12-9 – Roofing terminology.
A. Surfaces
B. Slope and pitch

3.1.4 Slope

Slope and pitch are often incorrectly used synonymously when referring to the incline of a sloped roof. *View B of Figure 12-9* 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 12-9, view B*, conveys this information.

3.1.5 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).

3.2.0 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 ***VDWXUDWHG 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.

3.2.1 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 underlayment commonly called roofing felt. Roofing felt is saturated with asphalt and serves three basic purposes.

1. It keeps the roof sheathing dry until the shingles can be applied.
2. After the shingles have been laid, it acts as a secondary barrier against wind-driven rain and snow.
3. 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, and 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.

Underlayment 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 underlayment and the roof sheathing. Underlayment requirements for different kinds of shingles and various roof slopes are shown in *Table 12-4*.

Table 12-4 – 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)	5/12 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]

Notes:

1. May be single layer on 4/12 slope in areas where outside design temperature is warmer than 0ºF
2. Square-butt strip shingles only; requires wind resistant shingles or cemented tabs
3. Recommended in areas subject to wind driven snow
4. Requires reduced weather exposure
5. May be desirable to increase insulation and to minimize air infiltration
6. May be desirable for protection of sheathing

Apply the underlayment as soon as the roof sheathing has been completed. For single underlayment, start at the eave line with the 15 pound felt. Roll across the roof with a top lap of at least 2 inches at all horizontal points and a 4 inch side lap at all end joints, as shown in *Figure 12-10, view A*. Lap the underlayment over all hips and ridges 6 inches on each side. A double underlayment can be started with two layers at the eave line, flush with the fascia board or molding. The second and remaining strips have 19 inch head laps with 17 inch exposures, as shown in *Figure 12-10, view B*. Cover the entire roof in this manner. Make sure that all surfaces have double coverage. Use only enough fasteners to hold the underlayment in place until the shingles are applied. Do not apply shingles over wet underlayment.

Figure 12-10 – Roofing underlayment.
A. Single coverage
B. Double coverage

In areas where moderate to severe snowfall is common and ice dams occur, melting snow refreezes at the eave line, as shown in *Figure 12-11, view A*. It is good practice to apply one course of 55 pound smooth surface roll roofing as a flashing at the eaves. It should be wide enough to extend from the roof edge to between 12 and 24 inches inside the wall line. Install roll roofing over the underlayment and metal drip edge. This will lessen the chance of melting snow backing up under the shingles and fascia board of closed cornices. Damage to interior ceilings and walls results from this water seepage. Eave flashing provides protection from ice dams. Cornice ventilation by means of ***soffit vents*** and sufficient insulation will minimize the melting, as shown in *Figure 12-11, view B*.

Figure 12-11 – Protection from ice dams.
A. Refreezing snow and ice.
B. Cornice ventilation.

Asphalt Felt – Roofing felts are used as underlayment 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.

3.2.2 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. 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, 1.19 inch thick aluminum, or 16 ounce copper.

Flashing is available in various shapes, as shown in *Figure 12-12*, formed from 26-gauge galvanized steel.

Figure 12-12 – Basic shapes of drip edges.

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 construction. At the eaves, the underlayment should be laid over the drip edge as shown in *Figure 12-13*.

Figure 12-13 – Drip edges at the eave.

At the rake, place the underlayment under the drip edge, as shown in *Figure 12-14*. 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 12-14 – Drip edges at the rake.

As you approach a soil stack, apply the roofing up to the stack and cut it to fit, as shown in *Figure 12-15*. 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.

Figure 12-15 – Flashing around a roof projection.

You can use the open or closed method to construct valley flashing. First, apply a valley underlayment strip of 15 pound asphalt saturated felt, 36 inches wide. Center the strip in the valley and secure it with enough nails to hold it in place. Cut the horizontal courses of underlayment 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. Place an 18 inch wide strip of mineral-surfaced roll roofing over the valley underlayment. Center it in the valley with the surfaced side down and the lower edge cut to conform to and be flush with the eave flashing. When it is necessary to splice the material, lay the ends of the upper segments to overlap the lower segments 12 inches and secure them with asphalt plastic cement. This method is shown in *Figure 12-16*. Use only enough nails to hold the strip smoothly in place 1 inch in from each edge.

Figure 12-16 – Open valley flashing using roll roofing.

Place another 36 inch wide strip over the first strip. Center it in the valley with the surfaced side up and secure it with nails. Lap it the same way as the underlying 18 inch strip.

Before applying shingles, snap a chalk line 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, as shown in *Figure 12-16*. The chalk lines serve as a guide in trimming the shingle units to fit the valley and ensure a clean, sharp edge. Clip the upper corner of each end shingle to direct water into the valley and prevent water penetration between courses. Cement each shingle 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. Place a valley lining made from a 36 inch wide strip of 55 pound or heavier roll roofing over the valley underlayment and center it in the valley, as shown in *Figure 12-17*.

Lay valley shingles over the lining by either of two methods:

Figure 12-17 – Closed valley flashing.

- Apply them on both roof surfaces at the same time, weaving each course, in turn, over the valley.

- Cover each surface to the point approximately 36 inches from the center of the valley and weave the valley shingles in place later.

In either case, lay the first course at the valley 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. Then carry the first course of the adjoining roof surface over the valley on top of the previously applied shingle. Succeeding courses are then laid alternately, weaving the valley shingles over each other.

Press the shingles tightly into the valley and nail as usual. Do not locate any nail closer than 6 inches to the valley center line, and use two nails 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 used for flashing, cut wood ***cant strips*** and install them above and at the sides of the chimney, as shown in *Figure 12-18*.

Cut the roll roofing flashing 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. Install the counterflashing when the chimney masonry work is done.

Figure 12-18 – Flashing around a chimney.

Where the roof intersects a vertical wall, install metal flashing shingles. They should be 10 inches long and 2 inches wider than the exposed face of the regular shingles. Bend the 10 inch length so it will extend 5 inches over the roof and 5 inches up the wall, as shown in *Figure 12-19*. Apply metal flashing with each course. This waterproofs the joint between a sloping roof and vertical wall, and is called step flashing.

Figure 12-19 – Step flashing.

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

3.2.3 Roof Cements

Roofing cements are used for installing eave 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***. Follow the recommendation of the shingle roofing manufacturer on the type and quality of materials and methods of application on a shingle roof.

3.2.4 Exterior

Exterior roof treatment consists of applying such products as shingles, roll roofing, tiles, slate, and bituminous coverings. Treatment also includes specific construction considerations for ridges, hips, and valleys.

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 may be 0.030 inch thick versus 0.055 inch thick for felt. Fiberglass based shingles are popular due to their low cost. The mat does not have to be saturated in asphalt. ASTM standards specify 3 pounds per 100 feet. The 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, as shown in *Figure 12-20*, with the exposed surface cut or scored to resemble three 9 by 12 by 2 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.

Figure 12-20 – A typical 12 by 36 inch shingle.

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 is 4:12 or greater. When special application methods are used, organic or inorganic base saturated or coatedstrip shingles can be applied to decks having a slope of 4:12, but not less than 2:12. *Figure 12-21* shows the application of shingles over a double layer of underlayment. Double underlayment is recommended under square tab strip shingles for slopes less than 4:12.

Figure 12-21 – Special shingle application.

When roofing materials are delivered to the building site, handle them with care and protect them from damage. Try to avoid handling asphalt shingles in extreme heat or cold. They are available in bundles that are one third of a square, containing 27 strip shingles per bundle. Store the bundles 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, as shown in *Figure 12-22*.

Figure 12-22 – Laying out a shingle roof.

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 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 12-23 shows standard nail designs for nominal 1 inch sheathing.

Table 12-5 shows recommended nail lengths 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.

Figure 12-23 – Nails suitable for installing strip shingles.

Table 12-5 – Recommended Nail Lengths for Nominal 1 inch Sheathing.

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”	–

The number of nails and their 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, as shown in *Figure 12-24, view A*. Specifications may require six nails per shingle, as shown in *Figure 12-24, view B*. 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.

Figure 12-24 – Nail placement for installing strip shingles.

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 12-6*.

Table 12-6 –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 12-25 shows the proper method of applying a wood shingle roof. Underlayment 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 eave line and 3/4 inch beyond the rake (gable) edge.
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.

Figure 12-25 – Installation of wood shingles.

3. Double the first course of shingles. In all courses, allow a 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 underlayment 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 eave 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 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 does not 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 Remans. Roofing tiles are durable, attractive, and resistant to fire; however, because of their weight, listed in Table *12-7*, they usually require additional structural framing members and heavier roof decks.

Table 12-7 – Weight of Roofing Materials.

Material	LB Weight/Square (100 square feet)	KG Weight/Square (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	1,200	544
Clay shingles	1,100-1,400	499-635
Spanish clay tile	1,900	862
laid in mortar	2,900	1,315

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, and Mission or Spanish style, as shown in *Figure 12-26*.

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 underlayment. 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 half units for exposed locations, such as gables and hips.

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.

Figure 12-26 – Types of clay roof tiles.

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 permits 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. 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 12 3/8 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 sheeted 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 the method of laying. The type of underlayment 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. 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 sealing 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 sealing 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 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 sealing, 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 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.

Test your Knowledge (Select the Correct Response)

2. What term is used for the area of a shingle that is not overlapped?

   A. Top lap
   B. Exposure
   C. Square
   D. Coverage

3.2.5 onstruction 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, as shown in *Figure 12-27*. 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.

Figure 12-27 – Finish at the ridge - Boston ridge with strip shingles.

A wood shingle roof should be finished with a Boston ridge, shown in *Figure 12-28.* Six inch wide shingles are altemately lapped, fitted, and blindnailed. 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.

Figure 12-28 – Finish at the ridge - Boston ridge with wood shingles.

A metal ridge can also be used on asphalt shingle or wood shingle roofs, as shown in *Figure 12-29*. 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.

Figure 12-29 – Finish at the ridge – metal ridge.

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, as shown in *Figure 12-30*. 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.

Figure 12-30 - Layout pattern for hip and valley shingles.

3.2.6 uilt 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 12-31 – Three ply built up roof over a nailable deck.

Figure 12-32 – Three ply built up roof over a non-nailable deck.

Application of Bitumens – The method of applying roofing depends on the type of roof deck. Some roof decks are nailable and others are not. Nailable decks include such materials as wood or fiberboard, poured or precast units of gypsum, and nailable lightweight concrete. Non nailable decks of concrete or steel require different techniques of roofing. *Figure 12-31* shows a three ply built up roof over a nailable deck, with a gravel or ***slag*** surface.

Figure 12-32 shows a three ply built up roof over a non nailable deck with a gravel or slag surface.

Figure 12-33 shows a four ply built up roof over insulation, with a gravel or slag surface.

Figure 12-33 – Four ply built up roof over insulation.

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 may be three ply, four ply, or five ply, depending on whether the roofing material can be nailed to the deck, or whether insulation is to be applied underneath it, as well as on 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 may be 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 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.

3.2.7 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.

3.2.8 old 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.

3.2.9 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.

3.2.10 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 12-34* shows how 32 inch building paper is laid over a wood sheathing roof to get five ply coverage at all points in the roof.

Figure 12-34 – Laying a five ply built up roof.

There are seven basic 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 procedures 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 the 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.

4.0.0 EXTERIOR WALL COVERINGS

In this section, we will continue our discussion of exterior finishing. We will examine the exterior finishing of walls, including exterior doors, windows, and glass.

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.

4.1.0 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 popular; and to a fair degree in Douglas fir and yellow pine.

4.1.1 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.

4.1.2 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, shown in *Figure 12-34*, is available in sizes from 1/2 by 4 inches to 1/2 by 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, as shown in *Figure 12-34.* Because it lies flat against the studs, it is sometimes used for garages and similar buildings without sheathing. Diagonal bracing is 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 *Figure12-34*. 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 groove (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.

4.1.3 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, as shown in *Figure 12-35*. 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 12-35 – Types of wood siding.

4.1.4 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.

4.1.5 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, as shown in *Figure 12-36*.

4.1.6 Sheet Materials

A number of sheet materials are available for use as siding. These include plywood in a variety of face treatments and species, and hardboard. Plywood or paper overlaid plywood (panel siding) is sometimes used without sheathing. Paper overlaid plywood has many of the advantages of plywood besides providing a satisfactory base for paint. Medium density overlaid plywood is not common. Stud spacing of 16 inches requires a minimum thickness of panel siding of 3/8 inch. However, 1/2 or 5/8 inch thick sheets perform better because of their greater thickness and strength.

Figure 12-36 – Vertical board siding.

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, as well as 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. When they are used, it is important that a good vapor barrier, well insulated, be used on the warm side of the insulated walls.

4.2.0 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.

4.2.1 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 line up 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.

4.2.2 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 rails will show rust spots through the putty and paint. Noncorrosive nails that will not cause rust are readily available.

Two types of nails commonly used with siding are the small head finishing nail and the moderate size flathead siding nail.

Set the small head finishing nail (driven with a nail set) about 1/16 inch below the face of the siding. Fill the hole with putty after applying the prime coat of paint. Nail the more commonly used flathead siding nail flush with the face of the siding and cover the head later with paint.

If the siding is to be natural finished with a water repellent preservative or stain, fasten it 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 annular (ring) threaded shank nail and the spiral 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, drive exposed nails 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, drive the nails so as not to damage the finished surface.

4.2.3 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, as shown in *Figure 12-37*. 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. This may not always be possible because of varying window heights and types that might be used in a structure.

Figure 12-37 – Installation of bevel siding.

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 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 1/3 inches each. The exposure distance above and below the window would be almost the same as shown in *Figure 12-37*.

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.

4.2.4 Installation

Siding should 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, as shown in *Figure 12-*

37. Each succeeding course should overlap the upper edge of the course below it. Nail siding to each stud or on 16 inch centers. When using plywood, wood sheathing, or spaced wood ***nailing strips*** over nonwood sheathing, you may use 7d or 8d nails for 3/4 inch thick siding. However, with gypsum or fiberboard sheathing, 10d nails are recommended to properly penetrate the stud. For 1/2 inch thick siding, you may use nails 1/4 inch shorter than those used for 3/4 inch siding.

Locate the nails far enough up from the butt to miss the top of the lower siding course, as shown in *Figure 12-38*. 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.

Figure 12-38 – Nailing the siding.

4.2.5 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 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, as shown in *Figure 12-38*. The length of the nail depends on the type of sheathing used, but penetration into the stud or through the wood backing should beat least 1 1/2 inches.

4.2.6 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 – Use a corrosion resistant finishing nail to blind nail horizontally applied matched paneling in narrow widths at the tongue,as shown in *Figure 12-38*. For widths greater than 6 inches, use an additional nail, as shown.

Other materials, such as plywood, hardboard, or medium density fiberboard, are used horizontally in widths up to 12 inches. Apply them in the same manner as lap or drop siding, depending on the pattern. Apply repackaged siding according to the manufacturer's directions.

Vertically – Nail vertically applied siding and sidings with interlapping joints in the same manner as those applied horizontally. Nail them to blocking used between studs or to wood or plywood sheathing. Space blocking from 16 to 24 inches OC. With plywood or nominal 1 inch board sheathing, space nails on 16 inch centers only.

When using the various combinations of boards and battens, you should also nail them to blocking spaced from 16 to 24 inches OC between studs, or closer for wood sheathing. Fasten the first boards or battens with nails at each blocking to provide at least 1 1/2 inches of penetration. For wide underboards, you may use two nails spaced about 2 inches apart rather than the single row along the center, as shown in *Figure 12-38.* Nails of the top board or batten should always miss the underboards and should not be nailed through them, as shown in *Figure 12-38*. In such applications, space double nails 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. Drive the nails over the studs; 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.

Caulk the joints of all types of sheet material with ***mastic*** unless the joints are of the interlapping or matched type of battens. It is good practice to place a strip of 15 pound asphalt felt under joints.

Test your Knowledge (Select the Correct Response)

3. Which of the following properties is/are essential for wood siding?

   A. Weathers easily
   B. Paints easily only
   C. Works easily only
   D. Paints and works easily

4.3.0 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.

4.3.1 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.

Figure 12-39 – Corner 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, shown in *Figure 12-39,* ensures a good tight joint. Tack a strip of building paper over the corner before nailing the corner board 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.

4.3.2 Interior Corners

Interior corners, shown in *Figure 12-40*, 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.

Figure 12-40 – Siding details - interior corners.

4.3.3 Mitered Corners

Mitering the corners of bevel and similar sidings, as shown in *Figure 12-41*, is often not satisfactory unless it is carefully done to prevent openings. A good joint must fit tightly the full depth of the miter. You should also treat the ends with a water repellent preservative before nailing.

Figure 12-41 – Siding details – mitered corners.

4.3.4 Metal Corners

Metal corners, shown in *Figure 12-42*, 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 of various types and sizes, shown in *Figure 12-39*, may be used for horizontal sidings of all types. They also provide a satisfactory termination for plywood and similar sheet materials. Terminate vertical matched paneling or boards and battens by lapping one side and nailing it to the lapped member, as well as to the nailing members beneath.

Figure 12-42 – Siding details - metal corners.

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.

4.3.5 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, as shown in *Figure 12-43*. Siding that is cut for a tight fit against the shingles retains moisture after rains, which 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.

Figure 12-43 – Siding details - siding return against roof.

4.4.0 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 ensure good drainage. For example, when vertical boards and battens are used at the gable end and horizontal siding below, use a drip cap or similar molding, as shown in *Figure 12-44*. Use flashing over and above the drip cap so that moisture cannot enter this transition area.

Figure 12-44 – Gable end finish (material transition).

4.5.0 Patterns

Apply wood shingles and shakes in a single or double course pattern over either wood or plywood sheathing. When sheathing with 3/8 inch plywood, use threaded nails. For nonwood sheathing, use 1 by 3 inch or 1 by 4 inch wood nailing strips as a base.

In the single course method, simply lay one course over the other as you apply lap siding. The shingles can be second grade because only one half or less of the butt portion is exposed, as shown in *Figure 12-45*. Do not soak shingles before application but lay them out with about a 1/8 to 1/4 inch space between adjacent shingles to allow for expansion during rainy weather. When a siding effect is desired, lay shingles so that they are in contact, but only lightly. Pre-stained or treated shingles provide the best results.

Figure 12-45 – Single coursing of sidewalls (wood shingles and shakes).

In a double course system, apply the undercourse over the wall, and nail the top course directly over a 1/4 to 1/2 inch projection of the butt, as shown in *Figure 12-46*. Nail the first course only enough to hold it in place while you apply the outer course. The first shingles can be a lower quality. Because much of the shingle length is exposed, the top course should be first grade shingles.

Apply shingles and shakes with rust resistant nails long enough to penetrate into the 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.

Figure 12-46 – Double coursing of sidewalls (wood shingles and shakes).

5.0.0 FLASHING

Flashing should be installed at the junction of material changes, chimneys, and roof and wall intersections. It should also be used over exposed doors and windows, over 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. One wall area that requires flashing is the intersection of two types of siding materials. A stucco finish gable end and a wood siding lower wall should be flashed as shown in *Figure 12-47*. 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 as shown in *Figure 12-47*.

Figure 12-47 – Flashing of material changes - stucco above, siding below.

Figure 12-48 – Flashing of material changes - vertical siding above, horizontal below.

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, as shown in *Figure 12-48*. 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, shown in *Figure 12-44*, is sometimes used as a terminating molding.

5.1.0 Door and Window Flashing

The same type of flashing shown in *Figure 12-47* 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 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, as shown in *Figure 12-49*. Where a metal roof is used, turn the metal up on the wall and covered it with the siding. Allow a clearance at the bottom of the siding to protect against melted snow and rain.

6.0.0 GUTTERS and DOWNSPOUTS

Several types of gutters are available to carry the rainwater to the downspouts and away from the 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 at the junctions of the gutter, as shown in *Figure 12-50*.

Figure 12-49 – Flashing at the intersection of an exterior wall and a flat or low pitched roof.

Figure 12-50 – Parts of a metal gutter system.

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 shown in *Figure 12-51, 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, as shown in *Figure 12-51, 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.

Figure 12-51 – Gutters and downspouts.
A. Half round gutter
B. K style gutter
C. Round downspout
D. Rectangular downspout

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, as shown in *Figure 12-52, views A* and *B.* Spike and ferrule hangers are also used with formed gutters, as shown in *view C*. Gutter hangers should be spaced 3 feet OC.

Figure 12-52 – 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

Gutter splices, corner joints, and downspout connections should be watertight. Fasten downspouts to the wall with leaderstraps, as shown in *Figure 12-53*, or hooks. Install one strap at the top, one at the bottom, and one at each intermediate joint. Use an elbow at the bottom to guide the water to a splash block, shown in *Figure 12-53, 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, as shown in *view B*.

Figure 12-53 – Downspout installation.
A. Downspout with splash block
B. Drain to storm sewer

7.0.0 EXTERIOR DOORS

Many types of exterior doors are available to provide access, protection, safety, and privacy. Wood, metal, plastic, glass, or a combination of these materials is 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.

7.1.0 Door Types

Better quality exterior doors are of solid core construction. The core is usually fiberglass, or the 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.

7.1.1 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, as shown in *Figure 12-54*. 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.

Figure 12-54 – Parts of a six-panel door.

7.1.2 Sash Doors

Panel doors in which one or more panels are glass are classed as sash or glazed doors. Fully glazed panel doors with only a 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.

7.1.3 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 widely used in flush door construction are shown in *Figure 12-55*. 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. It is subject to excessive expansion and contraction unless it is sealed with an impervious skin, such as a plastic laminate.

Figure 12-55 – Three types of solid core doors.

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, shown in *Figure 12-55*, 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, which is 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.

7.2.0 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.

7.2.1 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.

7.2.2 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, as shown in *Figure 12-56*.

Figure 12-56 – Parts of an exterior doorframe.

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 jambs 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, shown in *Figure 12-57*, covers the joint between the sill and the finished floor.

Figure 12-57 – Thresholds.

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 12-58*. Manufacturers furnish detailed instructions for installation.

Figure 12-58 – Thresholds providing weatherproof seals.

7.3.0 Door Swings

Of the various types of doors, the swinging door shown in *Figure 12-59* is the most common. 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

Figure 12-59 – Determining door swings.

doors. A Dutch door is one that is cut and hinged so that top and bottom portions open and close independently.

7.4.0 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 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, you may need to install flashing over the bottom of the opening. Then set the assembled frame 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, 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.

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, as shown in *Figure 12-60*.

Figure 12-60 – Plumbing an exterior doorjamb.

⚠ CAUTION ⚠

When setting doorframes, never drive any of the nails completely into the wood until all nails are in place and you have made a final check 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, lightly tack a piece of 1/4 or 3/8 inch plywood 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 are described in the Finish Carpentry chapter.

7.5.0 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. Do not remove the spacer shims, located between the frame and door, 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 you install a prehung exterior door unit, remove the door from the hinges and carefully store it. A temporary door can be used until final completion of the project.

Test your Knowledge (Select the Correct Response)

4. A main entrance door is normally what size?

   A. 1 1/2 inches thick, 2 feet 8 inches wide, 6 feet 8 inches high
   B. 1 1/2 inches thick, 3 feet 0 inches wide, 7 feet 0 inches high
   C. 1 3/4 inches thick, 2 feet 8 inches wide, 7 feet 0 inches high
   D. 1 3/4 inches thick, 3 feet 0 inches wide, 6 feet 8 inches high

8.0.0 WINDOWS

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, and 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 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 with its own advantage. The principal types are double hung, casement, stationary, awning, and horizontal sliding. In this chapter, we will cover only the first three.

8.1.0 Double Hung Windows

The double hung window, shown in *Figure 12-61*, is perhaps the most familiar type of window. It consists of upper and lower sashes 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.

Figure 12-61 – Typical double hung window.

The jambs and the 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 are sloped at about 3 inches in 12 inches for good drainage. Wooden sash is normally 1 3/8 inches thick. *Figure 12-62* shows an assembled window ***stool*** and ***apron***.

The 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.

Figure 12-62 – Window stool with apron.

Place assembled frames in the rough opening over strips of building paper put around the perimeter to minimize air infiltration. Plumb the frame and nail it 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 or 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.

8.2.0 Casement Windows

Casement windows consist of a side hinged sash, usually designed to swing outward, as shown in *Figure 12-63*. 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.

Figure 12-63 – Out-swinging casement sash.

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 can be used, but it has low insulating value, so should be installed carefully to prevent condensation and frosting on the interior surfaces during cold weather. A full storm window unit may be necessary to eliminate this problem in cold climates.

8.3.0 STATIONARY WINDOWS

Stationary windows, used alone or in combination with double hung or casement windows as shown in *Figure 12-64*, 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 insulated glass.

Figure 12-64 – Typical use of stationary window in combination with other types.

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 resistant windows, as shown in *Figure 12-65*.

Figure 12-65 – Fixed glass in wood stops.

9.0.0 GLASS

It is surprising how many types of glass and glasslike materials are used in construction. Each has its own characteristics, advantages, and best uses. In this section, we will cover the various types of glass and materials, and the methods used in assembling glass features, known as glazing.

9.1.0 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.

9.1.1 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.

9.1.2 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.

9.1.3 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.

9.1.4 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.

9.1.5 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 by using 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.

9.1.6 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.

9.1.7 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 heat strengthened 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.

9.1.8 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.

9.1.9 Patterned

Patterned glass has the same composition as window and plate glass. It is semi-transparent 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.

9.1.10 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.

9.1.11 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.

9.1.12 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.

9.1.13 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.

9.2.0 GLAZING MATERIALS

In this section, we will discuss the various types of sealers you'll need to install, hold fast, and seal a window in its setting.

9.2.1 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 oxidizes, 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.

9.2.2 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.

9.2.3 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.

9.2.4 Polybutane Tape

Polybutane tape is a non-drying 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.

9.2.5 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.

9.2.6 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.

9.3.0 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. Lightly oil the cutting wheel with a thin machine oil or lubricating fluid, as shown in *Figure 12-66, view A*. Hold the cutter by resting your index finger on the flat part of the handle, as shown in *view B*.

Figure 12-66 – Glass cutting.

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 along the surface of the glass with the side of the cutter pressed against the straightedge, as shown in *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, as shown in *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.

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, as shown in *view F*. Next, grasp the glass on each side of the line and gently snap off the waste piece, as shown in *view G*. Press downward away from the score mark. If the strip does not break off cleanly, nibble it off with the pliers, as shown in *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.

All heat absorbing glass must be clean cut. Nibbling to remove flares or to reduce oversized dimensions of heat absorbing glass is not permitted.

9.4.0 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 12-8* lists the thicknesses, weights, and recommended maximum sizes.

Table 12-8 – Weight and Maximum Sizes of Sheet Glass.

Thickness (inch)	Thickness (millimeters)	Weight (ounces/ square foot)	Weight (kilograms/ square meter)	Maximum Size (inches)	Maximum Size (millimeters)
Window Glass					
SS 3/32	2.4	19	5.8	40 x 50	1,020 x 1,270
DS 1/8	3.2	26	7.9	60 x 80	1,520 x 2,030
Thick Sheet Glass					
3/16	4.8	40	7.2	120 x 84	3,050 x 2,130
7/32	5.6	45	9.7	120 x 84	3,050 x 2,130
1/4	6.3	52	15.9	120 x 84	3,050 x 2,130
3/8	9.5	77	23.5	160 x 84	4,060 x 2,130
7/16*	11.1	86	26.2	60 x 84	1,520 x 2,130
* Used for glass shelving and table tops					

Sheet glass comes in six grades as shown in *Table 12-9.*

Table12-9 – 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

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.

9.5.0 Sash Preparation

Attacth 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.

9.5.1 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, remove the dust, prime the putty runs, and allow them to dry. All new wood sashes should be pressure treated for decay protection.

9.5.2 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.

9.6.0 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.

9.6.1 Wood Sash

Most wood sash is face glazed. The glass is installed in rabbets, consisting of L-shaped recesses cut 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, as shown in *Figure 12-67*.

Figure 12-67 – Types of wood sash glazing.

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. Do not paint putty until it is thoroughly set. Apply a bead of putty or glazing compound between the glass and the frame as a bedding. You should usually apply the bedding to the frame before the glass is set. Then use back puttying to force putty into spaces that may have been left between the frame and the glass.

9.6.2 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 nonporous surface.

Figure 12-68 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, set flexible shims 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. Apply the tape to the frame and the glass holding ***stop*** before placing the glass 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.

Figure 12-68 – Types of metal sash glazing.

Test your Knowledge (Select the Correct Response)

5. **(True or False)** Heat loss through metal window frames is less than through wood window frames.

   A. True
   B. False

9.7.0 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. Thoroughly clean sash and door members 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, as shown in *Figure 12-69*. 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, set it with the concave side in. Set wire glass with the twist vertical. Press the glass firmly into place so that the bed putty will fill all irregularities.

Figure 12-69 – Setting glass with glazier's points and putty.

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 the bed putty on the revers side of the glass. When glazing or reglazing interior sash and transoms and interior doors, use 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.

Paint wood sash putty 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. Paint metal sash putty 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, exercise care to avoid breaking the paint seal at the putty edge.

After installing large glass units in buildings under construction, it is 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.

10.0.0 INSULATION

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, resulting in 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.

10.1.1 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:

- flexible insulation (blanket and batt)
- loose fill insulation
- reflective insulation
- rigid insulation (structural and nonstructural)
- 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.

10.1.1 Flexible

Flexible insulation is manufactured in two types, blanket and batt. Blanket insulation, shown in *Figure 12-70*, 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.

Figure 12-70 – Blanket insulation.

Figure 12-71 – Batt insulation.

Batt insulation, shown in *Figure 12-71*, 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.

10.1.2 Loose Fill

Loose fill insulation, shown in *Figure 12-72*, 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 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 in the Finishes chapter, should be used for vapor barriers when blown insulation is added to an existing house.

Figure 12-72 - Loose fill insulation.

10.1.3 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 12-73*, includes a reflective surface. When properly installed, it provides airspace between other surfaces.

Figure 12-73 – Insulation with reflective backing.

10.1.4 Rigid

Rigid insulation, shown in *Figure 12-74*, 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.

Figure 12-74 – Rigid insulation.

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.

10.1.5 Miscellaneous

Some insulations are not easily classified, such as 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.

10.2.0 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.

10.3.0 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, as shown in *Figure 12-75*. 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.

Figure 12-75 –Application of insulation with a vapor barrier.

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, as shown in *Figure 12-76, views A* and *B*. It covers the openings, window and door headers, and edge studs. This system is one of the best for resistance to vapor movement. It does not have the installation inconveniences encountered when tabs of the insulation are stapled over the edges of the studs. After the drywall is installed or plastering is completed, the film is trimmed around the window and door openings.

Figure 12-76 – Application of insulation without a vapor barrier.

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, as shown in *Figure 12-77*. 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 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, as shown in *Figure 12-77*.

Figure 12-77 – Precautions in insulating around a window.

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, as shown in *Figure 12-78*. Insulation should be placed behind electrical outlet boxes and other utility connections in exposed walls to minimize condensation on cold surfaces.

10.4.0 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

Figure 12-78 – Precautions in insulating at a joist header.

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.

10.4.1 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.

10.4.2 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 paint is quite effective. For rough plaster 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.

11.0.0 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 builtup roofs are highly resistant. The most practical method of removing the moisture is by adequate ventilation of roof spaces.

A warm attic that is inadequately ventilated and insulated may cause formation of ice dams at the cornice as shown in *Figure 12-79*. 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 back up at the eaves and into the wall and ceiling. Similar dams often form in roof valleys.

Figure 12-79 – Ice dam and damage.

Ventilation provides part of the solution to these problems. With a well insulated ceiling and adequate ventilation, as shown in *Figure 12-80*, 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 between ceiling joists below the attic or roof space to further retard heat flow into the rooms below improves comfort conditions. It is common practice to install louvered openings in the end walls of gable roofs for ventilation.

Figure 12-80 – Adequate ventilation to prevent ice dams.

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, as shown in *Figure 12-81, view A*, or ridge *view B*.

Figure 12-81 – Vents in soffit areas.

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, as shown in *Figure 12-82*.

Figure 12-82 – Turbine type ventilator.

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; 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. Use a linoleum cutter or a utility knife with a very stiff blade to 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, shown in *Figure 12-83*, 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 manually or thermostatically controlled.

Figure 12-83 – Openings for louvers and in-the-wall fans.

When installing a louver in an existing gable end wall, disturb the siding, sheathing, or framing members 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, shown in *Figure 12-84*, 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.

Figure 12-84 – Louvered and screened vent.

A continuous screened slot vent, which is often desirable, should be located near the outer edge of the soffit near the fascia, as shown in *Figure 12-85*. This location minimizes the chance of snow entering. This type of vent is also used on the overhang of flat roofs.

Figure 12-85 – Continuous screened slot vent.

Summary

This chapter covered the many aspects of moisture protection. You learned about roofing finishes, from sheathing to underlayment to final finishes such as shingles and built-up roofing. You learned about exterior wall finishes, including different types of siding. You learned about the importance of flashing to protect the transition from one surface to another. You learned how gutters and downspouts move water away from the surfaces of the building. You found out how to install doors and windows, including glazing windows. You discovered the importance of insulation and ventilation in keeping a building free of moisture.

Review Questions (Select the Correct Response)

1. Composition roof sheathing should be laid in which of the following ways?

   A. Closed
   B. Open, horizontally only
   C. Open, diagonally only
   D. Open, horizontally or diagonally

2. Board roof sheathing normally falls into which of the following categories?

   A. Matching tongue and groove only
   B. Shiplapped only
   C. Shiplapped and square edged only
   D. All of the above

3. Tongue and groove boards used for closed sheathing must be supported by what minimum number of rafters?

   A. One
   B. Two
   C. Three
   D. Four

4. When you are determining the plywood thickness for roof sheathing, which of the following factors should NOT be a consideration?

   A. Rafter spacing
   B. Weather conditions
   C. Insulating factor
   D. Type of roofing material to be used

5. In what direction relative to the rafters should the face grain of plywood sheathing run?

   A. Perpendicular
   B. Parallel
   C. Diagonal

6. When nailing 3/4 inch plywood sheathing to the rafters, what size nails should you use?

   A. 4d
   B. 6d
   C. 8d
   D. 10d

7. What is the purpose of the 2º bevel cut on the ends of plank roof decking?

   A. To allow for expansion
   B. To ensure a tight face joint
   C. To ensure space for adjustment
   D. To allow for quicker installation

8. What length nails should you use for fastening plank decking?

   A. Twice the nominal plank thickness
   B. Three times the nominal plank thickness
   C. Three and one half times the nominal plank thickness
   D. Four times the nominal plank thickness

9. Roof decking extending beyond a gable end wall should span at least how many rafters?

   A. One
   B. Two
   C. Three
   D. Four

10. **(True or False)** Butt joints of plywood sheets should be alternated so they do not occur on the same rafter.

   A. True
   B. False

11. Which of the following expressions is correct concerning the pitch of a roof with a 6 foot rise and a 32 foot run?

   A. 1/16
   B. 3/32
   C. 1/4
   D. 1/2

12. Using roofing felt over sheathing has what primary purpose(s)?

   A. To provide a secondary barrier against wind driven rain only
   B. To keep the sheathing dry until shingles are applied only
   C. To protect shingles against the effects of resinous materials released from the sheathing only
   D. All of the above

13. How many rolls of 30 pound felt are required to cover 48,400 square feet?

A. 121
B. 242
C. 363
D. 484

14. Which of the following materials should be used as an underlayment?

A. Coated felt
B. Laminated waterproof paper
C. Asphalt saturated felt
D. Polyethylene sheets

15. Along eave lines where ice dams might occur, what type of roofing material is recommended?

A. 15 pound felt
B. 30 pound felt
C. 55 pound mineral surface
D. 55 pound smooth surface

16. Forty-two and one third squares of strip shingles are contained in how many bundles?

A. 127
B. 381
C. 609
D. 1,143

17. 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?

A. 1/4 inch
B. 5/8 inch
C. 1 inch
D. 5 inches

18. Flashing has what primary purpose(s)?

A. Reflect heat only
B. Protect against water seepage only
C. Act as a vapor barrier only
D. Both A and B above

19. **(True or False)** The concealed nailing method of installing roll roofing is used when maximum service life is required.

A. True
B. False

20. A 24 inch long wood shingle on a roof with a 1/4 pitch should have what maximum exposure?

A. 5 inches
B. 5 1/4 inches
C. 5 3/4 inches
D. 7 1/2 inches

21. What is/are the primary difference(s) in the installation of wood shakes and wood shingles?

A. Shorter nails are used with wood shingles only.
B. Shingles have less exposure only.
C. An underlayment between each course of shakes only.
D. All of the above

22. What is the most common type of ridge used on asphalt shingle roofs?

A. Boston
B. Sheet metal
C. Tile
D. Prefabricated

23. Roofing asphalts are graded on what characteristics?

A. Color
B. Weight per pound
C. Temperature at which they begin to flow
D. Temperature at which they begin to soften

24. In built up roofing, which of the following types of felts may be used?

A. Organic only
B. Glass fiber only
C. Glass fiber and asphalt only
D. All of the above

25. What is the main purpose of using felt paper on a built up roof?

A. To hold the bitumens together
B. To insulate
C. To soak up excess asphalt
D. To act as a vapor barrier

26. Asphalt should be in what temperature range when applied?

A. 275ºF to 375ºF
B. 375ºF to 425ºF
C. 450ºF to 500ºF
D. 500ºF to 550ºF

27. The aggregate on a built up roof serves which of the following functions?

A. Protect the bitumen from sunlight only
B. Increase wind and fire resistance only
C. Permit use of a thick surface coating of bitumen only
D. All of the above

28. The first two layers of a five ply roof are referred to as what type of nailer?

A. Dry
B. Base
C. Bottom
D. Back

29. A kettle operator should perform what task first?

A. Fill the fuel tank.
B. Fill the kettle with pieces of asphalt.
C. Inspect the kettle, making sure it is dry inside.
D. Light-off the kettle.

30. In a kettle, how should you maintain hot binder at an even temperature?

A. Adjust the burner.
B. Add material at the same rate as the melted material is drawn off.
C. Adjust the fuel pressure.
D. Remove material faster than you add it.

31. If a kettle catches fire, which of the following actions should you take first?

A. Remove the burner.
B. Shut off the fuel.
C. Spray water on the kettle.
D. Close the lid.

32. The distance maintained between the mopper and the felt layer should not exceed what distance?

A. 3 feet
B. 5 feet
C. 7 feet
D. 9 feet

33. Which of the following horizontal sidings can be obtained with either shiplap or tongue and groove edges?

A. Drop
B. Bevel
C. Dolly Varden

34. **(True or False)** In the installation of vertical board siding, board widths range from 2 to 4 inches.

A. True
B. False

35. When installing 4 by 8 foot vertical plywood siding, which of the following materials should you apply to the joints to ensure maximum watertightness?

A. Battens only
B. Caulking only
C. Water repellent preservative and caulking only
D. All of the above

36. To present a uniform appearance, siding should line up with which of the following parts?

A. Drip caps of the doors and windows only
B. Bottoms of doors and windows only
C. Drip caps and bottoms of doors and windows
D. Sides of doors and windows

37. When wood siding has a natural finish, what type of nail should you use?

A. Aluminum only
B. Stainless steel only
C. Aluminum or stainless steel
D. Galvanized

38. What distance usually determines the average exposure of horizontal siding?

A. Underside of the windowsill to the top of the window drip cap
B. Bottom of the windowsill to the foundation wall
C. Bottom of the door to the drip cap of the door
D. Bottom of the door to the bottom of the windowsill

39. What should be the exposure of 8 inch siding installed on a building where the overall height of the windows is 68 inches?

A. 5 7/8 inches
B. 6 inches
C. 6 3/16 inches
D. 6 7/8 inches

40. The first installed course of bevel siding is usually blocked out with which of the following items?

A. Fridging
B. Flashing
C. Starter strip
D. Batten

41. How should you join siding that returns against a roof surface, such as a dormer?

A. Mitered corners
B. Metal corners
C. Flashing
D. Corner boards

42. When applying wood shingles where the siding effect is not a consideration, what spacing should you use to allow for expansion during rainy weather?

A. 1/16 to 1/8 inch
B. 1/8 to 1/4 inch
C. 1/4 to 1/2 inch

43. **(True or False)** Flashing should be used in a structure where rain or melted snow penetrarion is possible.

A. True
B. False

44. A 24 foot gutter should have what pitch?

A. 1 5/16 inches
B. 1 1/2 inches
C. 1 3/4 inches
D. 1 7/8 inches

45. Full height vertical members of a panel door are known by what term?

A. Muntins
B. Rails
C. Stiles
D. Runners

46. An exterior door made of thin plywood faces over a wood framework with a particle board core is what type?

A. Panel
B. Flush
C. Combination
D. Clad

47. Securing a doorframe to the framing members requires what nail (a) size and (b) type?

A. (a) 16d (b) casing
B. (a) 12d (b) common
C. (a) 10d (b) finish
D. (a) 8d (b) duplex

48. Where on each side of a jamb should shims be located?

A. Bottom only
B. Bottom and top only
C. Center only
D. Bottom, top, and center

49. The small wood members that separate the lights in a sash are known by what term?

A. Meeting rails
B. Parting beads
C. Muntins
D. Weather strips

50. Which of the following windows has a wood sash with a single large light?

A. Casement
B. Double hung
C. Hopper
D. Stationary

51. What advantage does a casement window have over a double hung window?

A. Provides more light
B. Provides better insulation
C. Provides better ventilation
D. Is easier to install

52. What feature best distinguishes sheet glass from plate glass?

A. Plate glass is polished flat on both sides.
B. Sheet glass is available in various colors.
C. Thickness of sheet glass is greater.
D. Only plate glass is manufactured in a continuous ribbon and then cut in large sheets.

53. Because of its high rate of expansion, what type of glass requires the most careful cutting, handling, and glazing?

A. Laminated
B. Wired
C. Tempered
D. Heat absorbing

54. Which of the following types of glass should be used where the hazard of flying glass must be avoided?

A. Wire
B. Laminated
C. Insulating
D. Safety

55. When cutting glass, what allowance should you deduct from the measurements to allow for expansion?

A. 1/16 inch
B. 1/8 inch
C. 3/16 inch
D. 1/4 inch

56. When scoring glass, what is the minimum number of strokes that you should use?

A. One
B. Two
C. Three
D. Four

57. Which of the following types of sash should be primed before glazing?

A. Old and new metal sash only
B. Old and new wood sash only
C. Both A and B

58. What is the primary purpose of putty used in glazing?

A. To make a weathertight joint
B. To hold the glass in the sash
C. To improve the appearance
D. To reduce glass separation

59. When you are mounting wire glass in a small wooden window frame, what should be the first step?

A. Insert the glass into the window frame with the wire twist in the vertical position.
B. Lay a continuous 1/6 inch thick bed of putty in the putty run.
C. Insert the glass into the window frame with the concave side facing out.
D. Lay a continuous bead of putty agains the perimeter of the glass.

60. To clean glass after glazing or painting, what material should you use?

A. Ammonia
B. Mineral spirits
C. Caustic soap
D. Acid solution

Trade Terms Introduced in this Chapter

Apron	On a window, a piece of finish trim placed under the stool.
Asphalt	A dark brown to black, solid or semi-solid, hydrocarbon produced from the residuum left after the distillation of petroleum. It comes in a wide range of viscosities and softening points, from about 135°F (dead – level asphalt) to 225°F.
Asphalt shingles	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.
Base sheet	The first layer of roofing applied on the deck. Also a dry or slip-sheet.
Binder	Hot melted pitch (or asphalt) applied between the layers of a built up roof to bind the layers of felt together.
Bitumens	The generic term for a semi-solid mixture of complex hydrocarbons derived from petroleum or coal. In the roofing industry there are two basic bitumens, asphalt and coal tar pitch.
Brooming	The act of sweeping in roofing felts with a broom.
Built up roof	A roof formed by a number of layers of roofing mopped together with hot asphalt or pitch, and surfaced with mineral aggregate or asphaltic materials (BUR).
Burner	An apparatus that emits flames used to heat a kettle.
Cant strip	Triangular-shaped material used under flashing to modify the angle at the point where the roof meets any vertical element of the structure.
Cap sheet	The top sheet of the BUR forming the finished surface of the roof.
Casings	The trim around doors and windows.
Coal tar pitch	Dark brown to black solid hydrocarbon obtained from the residuum of the distillation of coke-oven tar (soft coal). It is used as the waterproofing agent of dead level or low slope built up roofs. It comes in a narrow range of softening points, from 129 to 144°F.

Course	A continuous row or layer of shingles or other roofing materials.
Dead level	Absolutely horizontal or zero slope
Dressed and matched	Boards or planks machined with a tongue on one edge and a groove on the other edge.
Eaves	The part of a roof projecting over the sidewall.
Emulsions	An asphalt and water mixture used in damp proofing and roof coating. After drying, the asphalt remains.
Exposure	The portion of roofing exposed to the weather. The correct felt exposure in a shingled, multi ply roof is computed by dividing the felt width minus 2 inches by the number of plies (For example, for two plies of 36 inch-wide felt, the exposure is 36 – 2 divided by 2 = 17 inches.)
Flashing	Sheets of metal or other suitable material used to make watertight joints on roofs. Base flashing forms the upturned edges of the watertight membrane. Cap or counter-flashing shields the exposed edges and joints of the base flashing.
Flood coat	The top layer of bitumen in an aggregate surfaced built up roofing membrane. Correctly applied, it is poured, not mopped, to a weight of 60 pounds square for asphalt and 75 pounds per square for coal-tar pitch.
Glaze	The process of installing glass panes in window frames and doorframes and applying putty to hold the glass in position.
Glaze coat	The top layer of asphalt in a smooth-surfaced built up roof assembly. A thin protective coating of bitumen applied to the top of a built up membrane, when the top pouring and aggregate surfacing are delayed (phased application).
Joists	A member that makes up the body of the floor and ceiling frames.
Mastic	(1) A thick, bituminous adhesive used for applying floor and wall tiles. (2) A waterproof caulking compound used in roofing that retains some elasticity after setting.
Membranes	A flexible or semi-flexible roof covering, the weather resistant component of the roofing system.
Mopping	An application of bitumen with a mop or mechanical applicator to the substrate or to the felts of a built up roofing membrane.
Mullion	The division between multiple windows or screens.
Muntins	The small members dividing glass panes in a window frame; vertical separators between panels in a panel door.

Nailing strips	A strip of wood set in concrete along the eaves or gable of a roof.
Parapet	The part of a wall above the roof line; a low wall above the roof level.
Plywood	A flat panel made up of a number of thin sheets (veneers) of wood. The grain direction of each ply, or layer, is at right angles to the one adjacent to it. The veneer sheets are united under pressure by a bonding agent.
Primers	A thin asphalt base sprayed or brushed on a roof before applying asphalt.
Rafters	A sloping roof member supporting the roof covering and extending from the ridge or the hip of the roof to the eaves.
Rake	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.
Sash	The movable part of a window.
Saturated felt	A felt that has been impregnated with bitumen of low softening point, from 100 to 160°F.
Shakes	A rough, unshaven shingle.
Shiplapped	Lumber worked with a rabbeted joint on each edge to ensure snug fits.
Slag	A refuse product of the smelting of ores that is used on roofs for gravel.
Slope	The tangent of the angle between the roof surface and the horizontal in inches per foot. A. Dead level – to 1/4 inch per foot per foot B. Flat – over 1/4 inch up to 11/2 inch per foot C. Steep slope – over 11/2 inches per foot
Soffit	The underside of a subordinate member of a building.
Square	A unit of measure of roofing area equal to 100 square feet.
Starter strip	A strip of roofing used at the eaves of a roof under the first row of shingles.
Stool	On a window, a narrow interior shelf that runs across the lower part of the window opening and butts against the sill.

Stop	Molding nailed into a window frame to hold the bottom sash of a double hung window in place.
Tabs	The lower or butt end of a shingle
Terneplate	A steel plate coated with an alloy of lead and a small amount of tin.
Valley	The gutter or angle formed by the meeting of two roof slopes.
Vents	An opening for the circulation of air, etc., an outlet, as a vent pipe.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

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

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

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

Facilities Planning Guide, NAVFAC P-437, Naval Facilities Engineering Command, Alexandria, Va., 1982.

Fall-Protection Guide for Ashore Facilities, Department of the Navy, 2003.

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.

Operations Officer's Handbook, COMCBPAC/COMCBLANTINST 5200.2A, Commander, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, and Commander, Naval Construction Battalions, U.S. Atlantic Fleet, Norfolk, Va., 1988.

Seabee Crewleader's Handbook 3rd edition, CECOS, June 2003.

Seabee Planner's and Estimator's Handbook, NAVFAC P-405, Chapter 5, Naval Facilities Engineering Command, Alexandria, Va., 1983.

Wood Frame House Construction, L.O. Anderson, Forest Products Laboratory, U.S. Forest Service, U.S. Department of Agriculture, Washington, D.C., 1975.

http://www.safetycenter.navy.mil/bestpractices/ashore/fall_protection.htm

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Chapter 13

Finishes

Topics

To hear audio, click on the box.

Overview

The work on a building project is not complete when the foundation, framing, and sheathing are done. There are many finishes on a building that contribute to its durability, the comfort of its inhabitants, and its overall appearance

It is your responsibility as the Builder to coordinate with the other ratings on the project, and to be aware of the details drawings and finish schedules throughout the project prints and specifications. This applies to everything from specifications for the foundation to details of the bathroom hardware.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Identify the types of cornices and material used in their construction.
2. Describe drywall installation and finishing procedures, and identify various types of wall and ceiling coverings, and the tools, fasteners, and accessories used in installation.
3. Identify the composition of plaster, and state the procedures for mixing, applying, and curing plaster.
4. Identify the composition of stucco, and state the procedures for mixing, applying, and curing stucco.
5. Identify the different types of ceramic tile and associated mortars, adhesives, and grouts, and state the procedures for setting tiles.
6. Identify the materials used to install a suspended acoustical ceiling and explain the methods of installation.
7. Identify the common types of wood floor coverings and describe procedures for their placement.
8. Identify the common types of resilient floor coverings and describe procedures for their placement.
9. Identify the common types of carpeting and describe procedures for their placement.
10. State the purposes of the different types of structural coatings and finishes, and the characteristics and safe use of each.
11. Identify the common types of paneling and describe procedures for their placement.
12. Define hazardous materials and hazardous waste, and state the purpose of the Material Safety Data Sheets (MSDS).

Prerequisites

None

This course map shows all of the chapters in Builder Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

Expeditionary Structures	↑	
Finishes		B
Moisture Protection		U
Finish Carpentry		I
Rough Carpentry		L
Carpentry Materials and Methods		D
Masonry		E
Fiber Line, Wire Rope, and Scaffolding		R
Concrete Construction		
Site Work		B
Construction Management		A
Drawings and Specifications		S
Tools		I
Basic Math		C

Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with an italicized instruction telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 EXTERIOR TRIM

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, or 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 flat head. 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 side walls 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 add to the attractiveness of a building and also help protect the side walls 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.

1.1.0 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 eave usually has the simple cornice shown in *Figure 13-1*. 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 eave 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 13-1*.

Molding trim in this position is called crown molding. A roof with a rafter overhang may have an open cornice or a closed (also called a box) cornice.

Figure 13-1 – Simple cornice.

In open cornice construction shown in *Figure 13-2*, the undersides of the rafters and roof sheathing are exposed.

Figure 13-2 – Open cornice.

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.

The flat box 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 box cornice is shown in *Figure 13-3*.

Figure 13-3 – Flat box closed cornice.

Figure 13-4 – Sloped box closed cornice.

For a sloped box cornice, the soffit material is nailed directly to the underside of the rafters as shown in *Figure 13-4*. This design is often used on buildings with wide overhangs.

Figure 13-5 – Construction of a finish rake for a boxed cornice.

Figure 13-6 – Construction of a rake soffit of a sloped box cornice.

The basic rake trim pieces are the frieze board, trim molding, and the fascia and soffit material. *Figure 13-5* shows the finish rake for a flat box cornice. It requires a cornice return where the eave and rake soffits join. *Figure 13-6* shows the rake of a sloped box cornice. Always use rust-resistant nails for exterior finish work. They may be aluminum, galvanized, or cadmium-plated steel.

1.2.0 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 13-7* shows the typical installation configuration of the components. Soffit panels include a vented area and are available in a variety of lengths.

Figure 13-7 – Basic components of a 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.

Test your Knowledge (Select the Correct Response)

1. Which of the following wood characteristics is least important when selecting trim material?

   A. Knots
   B. Even grain
   C. Natural decay resistance
   D. Preservative pretreatment

2.0.0 DRYWALL AND TEXTURE

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.

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 shown in *Figure 13-8* 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.

Figure 13-8 – Strongback for alignment of ceiling joists.

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.

2.1.0 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, with widths of 16 and 24 inches, and lengths usually of 48 inches. Because of its availability in manageable sizes, it is 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 since the ends of the sheets are not 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 commonly used edge. Tapered round is a variation on this 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 untaped, gives a paneled look.

2.2.0 Tools

Commonly used tools in drywall application include a tape measure, a chalk line, a level, utility and drywall knives, a 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, comer trowel, and foot lift.

A tape measure, chalk line, and level are used for layout work. Utility and drywall knives, a straightedge, and squares are used for scoring and breaking drywall. A 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. A screw gun quickly sinks drywall screws to the adjusted depth and then automatically disengages. Several of these tools are shown in *Figure 13-9*.

Figure 13-9 – T square, drywall hammer, and screw gun.

A foot lift, shown in *Figure 13-10,* helps you raise and lower drywall sheets while you plumb the edges. Be careful when using the foot lift, as applying too much pressure to the lift can damage the drywall.

Figure 13-10 – Foot lift.

Drywall knives, shown in *Figure 13-11*, have a variety of uses. A 6 inch knife is used to bed the tape in the first layer of joint compound and to fill nail or screw dimples. A 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 drywall knives only for the purpose intended, to finish drywall.

Figure 13-11 – Drywall knives.

The drywall trowel shown in *Figure 13-12* 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, shown in *Figure 13-12,* is almost indispensable for making clean interior comers.

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 sanding, ensure you’re wearing the required personnel protective gear to prevent dust inhalation.

Figure 13-12 – Trowels for drywalling.

2.3.0 Fasteners

Which fasteners you use depends in part on 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 combination allows the installer to use fewer screws or nails, leaving fewer holes that require filling. For reasons noted shortly, you will find the drywall screw the most versatile fastener for attaching drywall to framing members.

2.3.1 Nails

Drywall nails shown in *Figure 13-13* are specially designed with oversized heads for greater holding power. ***Casing*** or ***common nail*** heads 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.

Figure 13-13 – Drywall nails.

Smooth shank, diamond head nails are commonly used to attach two layers of drywall, for example, when fireproofing a wall. Again, the mil 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.

2.3.2 Screws

Drywall screws shown in *Figure 13-14* 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.

Figure 13-14 – Drywall screws.

Type S screws, shown in *Figure 13-14,* 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 screws, shown in *Figure 13-14,* 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.

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 that resemble window screen are becoming popular. The mesh design and self-sticking factor eliminate the need for the first layer of bedding 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, although 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 are used to bond single-ply drywall directly to framing members, ***furring*** strips, masonry surfaces, insulation board, or other drywall. They must be used with nails or screws. Because adhesives are matched with specific materials, be sure to select the correct adhesive for the job. Read and follow the manufacturer's directions.

2.4.0 Accessories

A number of metal accessories have been developed to finish off or protect drywall. Corner beads, shown in *Figure 13-15,* 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.

Figure 13-15 – Corner bead.

Casing beads, also called stop beads, shown in *Figure 13-16*, 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.

Figure 13-16 – Casing beads.

2.5.0 Layout

When laying out a drywall job, keep in mind that each joint will require taping and sanding. You 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 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 13-17*.

Figure 13-17 – Single layer application of drywall.

The sides of drywall taper, but the ends do not, 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 as shown in *Figure 13-17*.

2.6.0 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.

Figure 13-18 – Cutting gypsum drywall.

Second, to cut drywall you only need to cut through the fine paper surface (*view A*) as shown in *Figure 13-18*. 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. Where walls are not square, you may have to trim anyway.

Fourth, snap chalk lines on the drywall to indicate joists or stud centers underneath for quicker attachment. 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 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.

2.7.0 Installation

When attaching drywall, hold it firmly against the framing to avoid nail pops and other weak spots. Nails or screws must fasten securely in a framing member. If a nail misses the framing, pull it out, dimple the hole, fill it in with compound, and 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.

Nail or screw drywall 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.

2.7.1 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 13-19*.

Figure 13-19 – Spacing for single and double nailing of gypsum drywall.

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 convex headed drywall hammers are available for this operation, a conventional claw hammer also works, as shown in *Figure 13-20*.

Figure 13-20 – Dimpling of gypsum drywall.

2.7.2 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 may be placed 16 inches OC for greater economy, without loss of strength. Do not double up screws except where the first screw seats poorly. Space screws around the edges the same as nails.

2.7.3 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. Do not 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. Do not 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 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.

2.7.4 Ceilings

Begin by 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.

2.7.5 Walls

Walls are easier to hang than ceilings, and one person can work alone 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 13-10* is useful for raising or lowering a sheet while you level its edge. After you have 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 so on. If you favor a clean, modem line without trim, manufactured metal or vinyl edges, called 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. Using the foot lift, level the top edge of the bottom sheet. Where studs are irregular, it is even more important that you note positions and chalk line stud centers onto the drywall face before hanging the sheet.

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. Do not piece together small sections in areas where you will 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.

2.8.1 Finishing

Finishing gypsum board drywall is generally a three coat application. Attention to drying times between coats prevents rework that involves cost as well as extra time.

Where sheets of drywall join, cover the joints with joint tape and compound as shown in *Figure 13-21*. The procedure is straightforward.

Figure 13-21 – Finishing drywall joints.

1. Spread a swath of bedding compound about 4 inches wide down the center of the joint as shown in *Figure 13-21, view A*. Press the tape into the center of the joint with a 6 inch finish knife as shown in *view B*. Apply another coat of compound over the first to bury the tape as shown in *view C*. As you apply the compound over the tape, bear down so you take up any excess. Scrape clean any excess, 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 as shown in *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 13-22 – Finishing an inside corner.

When finishing an inside corner as shown in *Figure 13-22*, cut your tape the length of the corner angle you are going to finish. Apply the joint compound evenly with a 4 inch knife about 2 inches on each side of the angle. Use sufficient compound to embed the tape. Fold the tape along the center crease as in *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 as shown in *view B*. When the first coat is dry, apply a second coat. A corner trowel shown in *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, as shown in *view D*.

When finishing an outside corner, as shown in *Figure 13-17*, 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 may be needed, depending on your

Figure 13-23 – Finishing an outside corner.

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.

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.

2.9.1 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 such as studs vary by more than 1/4 inch, build up low spots. There are three ways to create a flat nailing surface:

- Frame out a new wall, which is a radical solution. If the studs of partition walls are buckled and warped, it is often easier to rip the walls out and replace them. Where the irregular surface is a load-bearing wall, it may be 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 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 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, as shown in *Figure 13-24*. To make sure a furring strip does not 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.

Figure 13-24 – Furring strips backed with shims.

Regardless of type, finish material must be backed firmly at all nailing points, corners, and seams. Where you cover existing finish surfaces or otherwise alter the thickness of walls, it is usually necessary to build up existing trim. *Figure 13-25* shows how this might be done for a window casing. Electrical boxes must also be extended with box extensions or plaster rings.

Figure 13-25 – Building up an interior window casing.

Masonry surfaces must be smooth, clean, and dry. Where the walls are below grade, use mastic to attach a vapor barrier of polyethylene and install the furring strips. Use a powder-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, as 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 nails or screws where needed. Within 2 inches of a popped up nail, drive in another nail. Spackle both nails 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 a new 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 13-26*.

Figure 13-26 – Repairing a large hole in drywall.

First, cut the edges of the hole clean with a utility knife as shown in *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 as shown in *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. Fill the hole with plaster or joint compound as shown in *view C* and finish as shown in *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 this happens, mastic a replacement piece of drywall to the backing piece. To avoid a bulge around the filled in hole, 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.

Test your Knowledge (Select the Correct Response)

2. When you are attaching drywall, what is the recommended nailing procedure?

   A. Start at the top and work down.
   B. Start at the side joining the previous sheet and work across.
   C. Start at the center and work out.
   D. Start at the bottom and work up.

3.0.0 PLASTER

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.

A plaster mix, like a concrete mix, is made plastic by the addition of water to dry ingredients, including binders and aggregates. Also like in 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.

3.1.0 Gypsum Plaster

Gypsum is a naturally occurring sedimentary gray, white, or pink rock. The natural rock is crushed, and 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.

3.1.1 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.

3.1.2 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 increases dimensional stability during drying, and provides desirable setting properties and 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.

3.2.0 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. Magnesium lime is easily drowned, so be careful not to 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.

3.3.0 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 plasterizing 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.

3.4.0 Aggregates

As mentioned earlier, there are three main aggregates used in plaster: sand, vermiculite, and perlite. Less frequently used aggregates are wood fiber and pumice.

3.4.1 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 overextended 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.

3.4.2 Vermiculite

Vermiculite is a micaceous mineral in which 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; 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.

3.4.3 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.

3.4.4 Wood Fiber and Pumice

Although sand, vermiculite, and perlite make up 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.

3.5.0 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.

Add only the amount of water required to attain workability 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 could accelerate setting. Avoid stagnant water; it may contain organic material that can retard setting and possibly cause staining.

3.6.0 Plaster Bases

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.

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.

3.6.1 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 13-27* 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 13-27 – Wood lath with joints staggered every sixth course.

Figure 13-28 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. Do not 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 13-28 - Wood lath with keys.

3.6.2 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.

There is also a special fire-retardant gypsum lath, called type X. It has a specially formulated core that contains 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 13-29* shows back and side views of a completed application.

Figure 13-29 – Keys formed with perforated gypsum board.

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.

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.

3.6.3 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).

Diamond Mesh– The terms diamond mesh and expanded metal refer to the same type of lath shown in *Figure 13-30*. 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).

Figure 13-30 – Diamond mesh (expanded metal) lath.

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 shown in *Figure 13-31* 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.

Figure 13-31 – Expanded rib lath.

Wire Mesh – Woven wire lath, shown in *Figure 13-32,* 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.

3.7.0 Installation

Let's now look at the basic installation procedures for plaster bases and accessories.

Figure 13-32 – Woven wire lath.

3.7.1 Gypsum Lath

Gypsum lath is applied horizontally with staggered end joints, as shown in *Figure 13-33*.

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, staples have gained wider use (due mainly to the ready availability of power guns).

Figure 13-33 – Lath joints.

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, and 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.

3.7.2 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 comer.

3.7.3 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 screens 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 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 comers, provide dividing strips between plaster and the edges of baseboard or other trim, and define plaster edges at unframed openings.

Comer beads fit over gypsum lath outside corners to provide a true, reinforced comer. They are available in either small nose or bullnose types, with flanges of either solid or perforated metal as shown in *Figure 13-34*. They are available with expanded metal flanges.

Casing beads are similar to comer beads and are used both as finish casings around openings in plaster walls and as screens 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.

Figure 13-34 – Perforated flanged corner bead.

Base or parting screens are used to separate plaster from other flush surfaces, such as concrete. Ventilating expansion screen is used on the underside of closed soffits and in protected vertical surfaces for ventilation of enclosed attic spaces. Drip screens act as terminators of exterior Portland cement plaster at concrete foundation walls. They are also used on external horizontal comers of plaster soffits to prevent drip stains 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 screen.

3.7.4 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 as shown in *Figure 13-35*. A 10 to 20 inch strip is placed diagonally across each upper comer of the opening and tacked in place.

Figure 13-35 – Metal lath used to minimize cracking over door and window openings.

Figure 13-36 – Metal lath used to minimize cracking.

Strip reinforcement should also be used under flush ceiling beams as shown in *Figure 13-36* 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 as shown in *Figure 13-37* 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 comer 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.

Figure 13-37 7-8 – Plaster reinforcing at corners.

Control joints as shown in *Figure 13-38* 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.

Figure 13-38 - Control joint.

3.7.5 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, shown in *Figure 13-39, 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 finish. They are removed after the plaster has dried. Narrow strip grounds shown in *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. The inside edges of the side and head jambs 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, as shown in *View C*. These are normally left in place and covered by the casing.

Figure 13-39 – Plaster grounds.

A similar narrow ground or screen 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 screen is also left in place after the plaster has been applied.

3.7.6 Mixing

Some plaster comes ready mixed, requiring only the addition of enough water to attain minimum required 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 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 13-1*. Also shown in *Table 13-1* are proportions for three-coat work on a masonry base and proportions for work on metal lath.

Table 13-1 – Base Coat Proportions for Different Types of Work.

Ingredient	Proportion
Two-coat Masonry Work[1]	
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 Base[2]	
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

For three-coat work on gypsum lath, the recommended base coat proportions for gypsum plaster are shown in *Table 13-2*.

Table 13-2 – Recommended Base Coat Proportions for Gypsum Plaster.

Coat	Proportion
Scratch coat	1:2
Brown coat	1:3
Both coats	1:2.5

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. 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.

For a trowel finish coat using lime Keene's cement plaster, the recommended proportions for a medium hard finish are 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.

3.7.7 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.

3.7.8 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.

NOTE

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 by 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, you acquire 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, and then thoroughly blend the materials. If sand is used, it is added last and mixed in.

Machine Mixing – For a quicker, more thorough mix, use a plaster mixing machine. A typical plaster mixing machine, shown in *Figure 13-40,* consists primarily of a metal drum containing mixing blades mounted on 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.

Figure 13-40 – Plaster mixing machine.

When using a plaster mixer, add the water first, and 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.

3.7.9 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. Report any susceptibility of skin to cement and lime bums to your supervisor immediately.

Do not 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 comer, 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 also be set back one bag every five tiers.

During unpiling, 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.

3.8.0 Plaster Application Tools and Techniques

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.

Plastering requires the use of a number of tools, some specialized, including trowels, hawks, floats, straight and feather edges, darbys, scarifiers, and plastering machines.

3.8.1 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 13-41*. The rectangular trowel, with a blade approximately 4 1/2 inches wide by 11 inches long, serves as the principal conveyor and manipulator of plaster. The pointing trowel, 2 inches wide and about 10 inches long, is used in places where the rectangular trowel does not 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 comer angles formed by adjoining right angle plaster surfaces.

Figure 13-41 – Plastering trowels.

3.8.2 Hawk

The hawk, shown in *Figure 13-42*, 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.

Figure 13-42 – Plastering hawk.

3.8.3 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 13-43*. The wood float has a wood blade 4 to 5 inches wide and about 10 inches long. The angle float has a stainless steel or aluminum blade. The sponge float is faced with foam rubber or plastic, intended to attain a certain surface texture.

In addition to these floats, other floats are also used in plasterwork. A carpet float is similar to a sponge float, but is faced with a layer of carpet material. A cork float is faced with cork.

Figure 13-43 – Plastering floats.

3.8.4 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, as shown in *Figure 13-44*. 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.

Figure 13-44 – Straightedge and featheredge.

The featheredge, shown in *Figure 13-44*, 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 comers where walls intersect.

3.8.5 Darby

The darby, shown in *Figure 13-45*, 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 completed, to level plaster screens 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.

Figure 13-45 – Darby.

3.8.6 Scarifier

The scarifier, shown in *Figure 13-46*, 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.

Figure 13-46 – Scarifier.

3.8.7 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.

3.9.0 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.

3.10.0 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 recommended minimum increases. As a result, the tendency to crack increases as thickness increases. 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.

3.10.1 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 screens, if required.
7. Apply the brown coat to a depth of the screens.

8. Using the screens 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.

3.10.2 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.

3.10.3 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 spray cured for 48 hours. The finish coat should not be applied for at least 7 days after the brown coat. It should also be spray cured for 48 hours.

3.11.0 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.

3.11.1 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 fine aggregates 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 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 water with the brush, while moving the float in the other hand in a circular motion immediately behind the brush.

3.11.2 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.

Test your Knowledge (Select the Correct Response)

3. For plaster application, what must be installed between structural members to form a continuous surface?

   A. Plaster planes
   B. Insulation
   C. Lath
   D. Fire blocking

4.0.0 STUCCO

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.

4.1.0 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, and weather-resistant; it 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.

4.2.0 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 13-47* applied to a masonry surface.

Figure 13-47 – Masonry with two-coat work directly applied.

On open frame construction, shown in *Figure 13-48*, 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.

Figure 13-48 – Open frame construction.

Furring nails, shown in *Figure 13-49*, 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.

Figure 13-49 – Several types of furring nails.

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 may be 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 set up 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 may be applied by hand or machine. Stucco finishes are available in a variety of textures, patterns, and colors.

4.2.1 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 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. 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.

NOTE

Add muriatic acid to the water; never add water to the acid.

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, shown in *Figure 13-50*, 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.

Figure 13-50 – Power driven roughing machine.

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.

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.

4.2.2 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 using only the required amount of ingredients in the specified mix.

4.2.3 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, such as laps or interruptions.

4.2.4 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 to 3 days instead of 7. Air entraining cement is used to resist freezing action.

4.3.1 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
- Corrosion and rust from flashing or other metal attachments and failure to provide drips and washes on sills and projecting trim

Test your Knowledge (Select the Correct Response)

4. A brown coat of stucco should be moist cured for how many hours?

   A. 8
   B. 16
   C. 24
   D. 48

5.0.0 CERAMIC TILE

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.

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.

5.1.0 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.

5.2.0 Sizes

Tile is available in square sizes including 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. They are available from the manufactures in both sheet and roll form. Often large tile is scored by the manufacturer to resemble small tiles.

5.3.0 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 which is nonvitreous, 7 to 9 percent absorption, with a vitreous glaze 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 which are slightly rounded, as shown in *Figure 13-51*. The lugs assure easy setting and uniform joints. The edges available vary with the size of the tile and the manufacturer.

Figure 13-51 – Tile edges.

Margins, corners, and base lines are finished with trimmers of various shapes, as shown in *Figure 13-51*. 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.

Figure 13-52 – Trimmer shapes.

5.4.0 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).

5.4.1 Cement Mortar

Cement mortar for setting ceramic tiles is composed of a mixture of Portland cement and sand. The mix proportions for floors vary from 1:3 to 1:6 by volume. For walls, a Portland cement, sand, and hydrated lime mix 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 bond strength of 100 to 200 pounds per square inch. A waterproof backing is sometimes required, and the mortar must be damp cured.

5.4.2 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 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.

5.4.3 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 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. Bond strength of over 1,000 pounds per square inch is obtained with this installation method.

5.4.4 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.

5.5.0 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 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 alkalies. 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.

5.6.0 Tools

A selection of special tools, shown in *Figures 13-53* through *13-56*, 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 notched on one side and smooth on the other is preferred. Different sized trowels are available.

Figure 13-53 – Tile-setting trowels.

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.

Figure 13-54 – Tile cutter.

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.

Figure 13-55 – Tile nippers.

A rubber-surfaced trowel is used to force grout into the joints of the tile.

Figure 13-56 – Rubber-surfaced trowel.

5.7.0 Application Techniques

There are three primary steps in tile installation: applying a mortar bed, applying adhesive, and setting tiles in place.

5.7.1 Mortar

Before applying a mortar bed to a wall with wooden studs, you first tack a layer of waterproof paper to the studs. 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 or less than 24 hours before setting the tile.

The float coat should be composed of 1 part cement, 1 part hydrated lime, and 3 1/2 parts sand. It should be brought flush with screens 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.

5.7.2 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.

5.7.3 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 this line level across the entire width of the room. Refer to the bathroom wall example in *Figure 13-57* as you study the following steps:

Figure 13-57 – Steps used for squaring a wall.

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, shown in *Figure 13-58*, 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 as shown in *Figure 13-57*. Apply tiles to the squared off area first. Then cut and apply fractional tiles.

Another method for figuring fractional tile (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, as shown in *Figure 13-58, 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, as shown in *Figure 13-58, View B*.

Figure 13-58 – Layout for installing ceramic wall tile.

Use a level to establish a line perpendicular to the horizontal starting line, as shown in *Figure 13-59, 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 an approximately 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 comer 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.

Test your Knowledge (Select the Correct Response)

5. Ceramic tile is normally divided into what two classifications?

   A. Interior and exterior
   B. Exposure and location
   C. Wall and floor
   D. Interior and floor

6.0.0 ACOUSTIC CEILING

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. 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 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.

6.1.0 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 material requirements.

Figure 13-59 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 13-60*.

Figure 13-59 – Ceiling grid system components.

Figure 13-60 – Grid layout for main tees.

6.1.1 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 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.

6.1.2 Material Requirements

As indicated in *Figure 13-59*, 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 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.

6.2.0 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.

6.2.1 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 the wall angle height and to serve as a level reference. Mark continuously to insure that the lines at intersecting walls meet. On gypsum board, plaster, or paneled walls, install wall angles as shown in *Figure 13-61* with nails, screws, or toggle bolts. On masonry walls, use anchors or concrete nails spaced 24 inches apart.

NOTE

Make sure the wall angle is level.

Figure 13-61 – Wall angle installation.

Overlap or miter the wall angle at corners, as shown in *Figure 13-62*. After the wall angles are installed the next step is to attach the suspension wires.

Figure 13-62 – Corner treatment.

Figure 13-63 – Suspension wire installation.

6.2.2 Suspension Wires

Suspension wires are required every 4 feet along main tees and on each side of all splices, as shown in *Figure 13-63*.

Attach wires to the existing ceiling with nails or screw 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 main 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.

6.2.3 Tees

In an acoustical ceiling, the panels rest on metal members called tees. The tees are suspended by wires.

Main Tees – Install main tees of 12 feet or less by resting the ends on opposite wall angles and inserting the suspension wires, as shown in *Figure 13-64*. 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.

Figure 13-64 – Main tee suspension.

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 and resting the end on the opposite wall angle. Steel splices are shown in *Figure 13-65* and those for aluminum in *Figure 13-66.* After the main tees are installed, leveled, and secured, install the cross tees.

Figure 13-65 – Steel splice.

Figure 13-66 – Main tee and aluminum tee splice.

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 13-67*. At the opposite wall angle, cut off the low tab of the border tee 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 13-68*. The final step after completion of the grid system is the installation of the acoustical panels.

Figure 13-67 – Aluminum cross tee assembly.

Figure 13-68 – Steel cross tee assembly.

6.2.4 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.

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, since the color, pattern, or texture might vary slightly; also, 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.

6.2.5 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*****,** as shown in *Figure 13-69, view A*. These are 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.

Figure 13-69 – Ceiling tile assembly.

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 positioned 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, as shown in *Figure 13-69, 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.

Since 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.

Test your Knowledge (Select the Correct Response)

6. In what order should the following items be installed?

    a. Acoustic panels
    b. Cross tees
    c. Wall angles
    d. Suspension wires
    e. Main tees

    A. a, b, c, d, e
    B. b, e, c, a, d
    C. c, d, e, b, a
    D. d, e, b, c, a

7.0.0 WOOD FLOORING

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, although 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 considered 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.

7.1.0 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. It is less dense and less wear-resistant than the hardwoods, 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, as shown in *Figure 13-70*.

Figure 13-70 – Hardwood strip flooring.

Strips are of random length 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, shown in *Figure 13-71*, 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.

Figure 13-71 – Thin strip flooring.

Square-edged strip flooring, shown in *Figure 13-72,* 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.

Figure 13-72 – Square-edged strip flooring.

7.1.1 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 the location of the joists with a chalk line on the paper. Plywood subflooring does not normally require building paper.

Strip flooring should normally be laid crosswise to the floor joists, as shown in *Figure 13-73*.

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 13-73 – Application of strip flooring.

7.1.2 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.

7.1.3 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 may be too light, causing excessive deflection; sleepers over concrete slabs may not be held down tightly; there may be 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.

7.1.4 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 recommendations as to size and diameter for specific uses. Flooring ***brads*** are also available with blunted points to prevent splitting the tongue.

Figure 13-74 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, as shown in *Figure 13-75*.

Figure 13-75 shows in detail how nails should be driven into the tongue of the flooring at an angle of 45° to 50°. Do not drive the nails flush; this prevents damaging the edge by the hammer head, as shown in *Figure 13-76*. These nails should be set with a nail set.

Figure 13-74 – Nailing the first strip.

Figure 13-75 –Driving nails into tongue.

Figure 13-76 – Damage from hammer.

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 just like the first strip so that the base or shoe covers the set nailheads, as shown in *Figure 13-74*.

7.1.5 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. An alternate method must be used when the concrete is already in place, as shown in *Figure 13-77*.

Figure 13-77 – Floor detail for existing concrete construction.

Figure 13-78 – Base for wood flooring on a slab with vapor barrier.

A system of preparing a base for wood flooring when there is a vapor barrier under the slab is shown in *Figure 13-78*.

Treated 1 by 4 inch furring strips should be 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 underlayment is placed over the 1 by 4s as a base.

7.2.0 Wood Block Flooring

Wood block (parquet) flooring, shown in *Figure 13-79*, 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.

Figure 13-79 – Wind block (parquet) laminated flooring.

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.

7.3.0 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 underlayment 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 underlayment 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 underlayment is usually installed as soon as wall and ceiling surfaces are complete.

7.3.1 Hardboard and Particleboard

Hardboard and particleboard both meet the requirements of an underlayment board. The standard thickness for hardboard is 1/4 inch. Particleboard thicknesses range from 1/4 to 3/4 inch.

This type of underlayment material will bridge small cups, gaps, and cracks. Larger irregularities should be repaired before the underlayment 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 underlayment panel. The direction of the continuous joints should be at right angles to those in the subfloor. Be especially careful to avoid aligning any joints in the underlayment with those in the subfloor. Leave a 1/32 inch space at the joints between hardboard panels. Particleboard panels should be butted lightly.

Fasteners – Underlayment panels should be attached to the subfloor with approved fasteners. Examples are shown in *Figure 13-80*.

For hardboard, space the fasteners 3/8 inch from the edge. Spacing for particleboard varies for different thicknesses. Be sure to drive nail heads flush. When fastening underlayment 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.

Figure 13-80 – Fasteners for underlayment.

Special adhesives can also be used to bond underlayment to subfloors. They eliminate the possibility of nail-popping under resilient floors.

7.3.2 Plywood

Plywood is preferred by many for underlayment. 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 13-81*.

To install plywood underlayment, 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 underlayment.

Figure 13-81 – Alignment of finish flooring materials.

Test your Knowledge (Select the Correct Response)

7. What factor usually causes cracks to appear in finish floors several months after the floor has been laid?

   A. Expansion of subfloor material
   B. Absorption of moisture after delivery
   C. Poor nailing
   D. Weak floor joists

8.0.0 RESILIENT FLOORING

Resilient flooring can be made of several different materials, including vinyl, rubber, and linoleum. It is available in tiles and rolls.

8.1.0 Resilient Floor Tile

After the underlayment 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 such as vinyl, rubber, and linoleum. Over a period of time, these materials will telegraph, or 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 underlayment 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.

8.1.1 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 setting up a right triangle, as shown in *Figure 13-82*, 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.

Figure 13-82 – Establishing center for laying floor tile.

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 it is too heavy, the adhesive will bleed between the joints.

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.

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, as shown in *Figure 13-83*.

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

Figure 13-83 – Layout of a border tile.

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.

8.1.2 Estimating Floor Tile Materials

Use *Table 13-3* when estimating resilient floor tile materials. This table gives you approximate square feet coverage per gallon of different types of primer and adhesives.

Table 13-3 – Estimating Adhesive for Floor Tile.

Adhesive for Floor Tile	
Type and Use	**Approximate Coverage in Square Feet 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 t0 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

Be sure to read and follow the manufacturer’s directions. *Table 13-4* 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 to find the number of tiles needed, then add the waste factor.