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ABSTRACT

This combination workbook and set of tests on plans and specifications is one in a series of nine individually bound units of instruction for roofing apprenticeship classes. The five topics covered are (1) regulations governing the roofing and waterproofing industry, (2) an overview of blueprints, (3) an overview of specifications, (4) mathematics, and (5) common measurement and calculation problems in roofing. For each topic these materials are provided: objectives, text, and a study assignment. Other contents include lists of required and recommended instructional materials, multiplication tables, and formulas for determining the areas of various types of roofs. The final section of this volume contains an objective test for each of the five topics of the workbook. (YLB)

Roofing

Workbook and Tests

Plans and Specifications

Compiled by

M. Duane Mongerson

Under the direction of the

CALIFORNIA EDUCATIONAL ADVISORY COMMITTEE FOR THE ROOFING INDUSTRY

and the

BUREAU OF PUBLICATIONS, CALIFORNIA STATE DEPARTMENT OF EDUCATION

A column labeled "Date Assigned" has been provided at the right-hand side of each page number in the contents. Whenever your instructor assigns a topic, he or she should write this date in the appropriate blank. When you have completed the topic satisfactorily, your instructor should place his or her initials next to the assignment date. If this procedure has been followed, and you should transfer from one school to another, you will have an accurate record of the work you have completed. It should never be necessary for you to duplicate work on topics already studied or to skip topics not previously assigned.

To provide other school records needed, be sure to fill in your name, home address, and telephone number below. Then ask your instructor to fill in the official date of your enrollment in his or her class and to sign his or her name.

NAME ______________________________

ADDRESS ______________________________

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DATE ENROLLED ______________________________

INSTRUCTOR(S) ______________________________

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The following titles, each containing workbook and tests in a single volume, are available in the roofing series:

Asphalt and Wood Shingling (1982)	$5.25
Built-up Roofing (1981)	$4
Cold-Applied Roofing Systems and Waterproofing and Dampproofing (1982)	$5.25
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Entering the Roofing and Waterproofing Industry (1980)	$4
First-Aid Training (1982)	$5.25
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A book on maintenance, repair, and reroofing is in preparation.

A complete list of publications available from the Department of Education, including instructional materials for some 23 other trades, is available from the address given above.

Questions and comments about existing apprenticeship materials or the development of new materials should be directed to:

Theodore R. Smith or Bob Klingensmith
Bureau of Publications
California State Department of Education
721 Capitol Mall
Sacramento, CA 95814
(916) 445-7608

Contents

Foreword

Technological advances in many fields today necessitate high-quality, up-to-date instructional materials for the training, and retraining, of a large part of the technical work force. These technological advances have resulted in the introduction of new materials, products, and processes in many professions. I understand that this is especially true in the roofing and waterproofing industry, where manufacturers are rapidly developing new types of roofing systems and the products and processes needed to install, maintain, and repair them. Each new product—each new system—increases the need for accurate information among roofing industry personnel, including apprentices.

The staff of the Department of Education's publications sales unit tells me that they receive requests for the materials in this roofing series from across the United States—from Florida to Alaska and Hawaii. This widespread use of the manuals attests, I believe, to their quality and usefulness. At the same time, it is also a tribute to the roofing industry's apprenticeship program in general, and to the California Educational Advisory Committee for the Roofing Industry specifically, for their dedication to ensuring that apprentice roofers receive the most thorough training possible. Because of such efforts, you will be among the best trained and most knowledgeable members of the roofing profession when you complete your apprenticeship training program.

On behalf of the Department, I want to take this opportunity to wish you success in your career as a roofer.

Bill Honig

Superintendent of Public Instruction

Preface

The California State Department of Education, through the Bureau of Publications, provides for the development of instructional materials for apprentices under provisions of the California Apprentice Labor Standards Act. These materials are developed through the cooperative efforts of the Department of Education and employer-employee groups representing apprenticeable trades.

This edition of *Plans and Specifications* was planned and prepared under the direction of the California Educational Advisory Committee for the Roofing Industry, with the cooperation of the State Joint Roofing Industries Apprenticeship Committee. The members of this committee include representatives of the Roofing Contractors Association of California and representatives of local unions. Employer representatives serving on the Educational Advisory Committee are Robert Culbertson, Sacramento; and Herman Little, San Jose. Representing employees are Joe Guagliardo, Fresno; Oscar Padilla, Los Angeles; and William Penrose, San Jose. M. Duane Mongerson, Oakland, served as Committee Adviser. Bob Klingensmith, Publications Consultant, Apprenticeship, coordinated activities for the Bureau of Publications.

Gratitude is expressed to the National Roofing Contractors Association and to Simpson Gumpertz & Heger, Inc., who contributed valuable information, drawings, and photographs used in this workbook.

This publication is one of a series of nine individually bound units of instruction for roofing apprenticeship classes. These books reflect the continuing cooperative effort of labor, management, local schools, and the Department of Education to provide the best instructional materials possible for California apprenticeship classes. They are dedicated to excellence in the training of roofing apprentices.

GILBERT R. MARGUTH, JR.
Deputy Superintendent
for Administration

THEODORE R. SMITH
Editor in Chief
Bureau of Publications

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Plans and Specifications

TOPIC 1 — REGULATIONS GOVERNING THE ROOFING AND WATERPROOFING INDUSTRY

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Describe the primary purposes of building codes and zoning regulations.**
- **Discuss the types and classifications of roofs.**
- **Define the term *bonded roof*.**
- **Describe the role of the Federal Housing Administration as it relates to the construction industry.**

Building Codes

The work of the construction industry affects the life of every individual in the nation. To survive, people must have shelter from the elements. Adequate structures with good roofs are essential parts of that protection at home, at work, everywhere. Quality construction and the safety of the public are two goals toward which the construction industry is constantly striving. The achievement of both is facilitated in part by the existence and ongoing modification of building codes—rules and regulations governing the construction, repair, and demolition of structures.

Currently there are four principal building codes in use in the United States:

1. *Uniform Building Code (UBC)*
2. *Building Officials and Code Administrators International (BOCA)*
3. *National Building Code (NBC)*
4. *Southern Building Code Congress International (SBCCI)*

The *Uniform Building Code*

Most towns and cities have their own building regulations, which are commonly referred to merely as local building codes. Many small towns and counties, however, do not have local codes. They commonly adhere to the principles set forth in a more general building code that is comprehensive enough to be applicable over large areas. In California the best known and most widely used of these is the *Uniform Building Code,* which was developed and is published by the International Conference of Building Officials. This organization also publishes related codes and materials, including *Dwelling Construction Under the Uniform Building Code.* This document deals only with residential structures and serves as a time-saving reference work for home builders. The roofing and waterproofing apprentice should become as familiar as possible with both of these publications.

Building Classification Under the *Uniform Building Code*

The *Uniform Building Code* and related codes are the result of attempts to standardize building rules and regulations on a national basis. Buildings are classified, for example, on the basis of several principles, two of which are described below:

1. *Use, or nature of occupancy*—The following ten groups are identified in this category:

Group	*Type of occupancy*
A	Large assembly buildings
B	Small assembly buildings
C	Schools
D	Jails
E	Public garages, planing mills, storage places for flammable materials
F	Stores, service stations
G	Factories
H	Hotels, motels, apartment houses
I	Dwellings
J	Private garages, fences over 6 feet (1.8 metres) high

2. *Type of building*—Five types (I, II, III, IV, and V) are identified in this category. Certain subclassifications exist in each category, depending on the fire-resistant qualities of the construction materials used. *NOTE:* These building types should not be confused with the classifications

that are used principally for insurance purposes—Class A, Class B, Class C, and so on; the designations are not interchangeable.

Zoning Regulations

Most cities have planning commissions whose duties include helping to ensure orderly growth and development through control of building placement, population density, area use, and types of structures. Like building codes, zoning regulations are intended partly to protect the health and ensure the safety of those in the community. The purposes of zoning regulations are defined in detail in the following excerpt from a typical zoning code:

> The purpose of this Article is to consolidate and coordinate all existing zoning regulations and provisions into one comprehensive zoning plan in order to designate, regulate, and restrict the location and use of buildings, structures, and land, for agriculture, residence, commerce, trade, industry, or other purposes; to regulate and limit the height, number of stories, and size of buildings and other structures hereafter erected or altered; to regulate and determine the size of yards and other open spaces and to regulate and limit the density of population; and for said purposes to divide the City into zones of such number, shape, and area as may be deemed best suited to carry out these regulations and to provide for their enforcement. Further, such regulations are deemed necessary in order to encourage the most appropriate use of land; to conserve and stabilize the value of property; to provide adequate open spaces for light and air, and to prevent and fight fires; to prevent undue concentration of population; to lessen congestion on streets; to facilitate adequate provisions for community utilities and facilities such as transportation, water, sewerage, schools, parks, and other public requirements; and to promote health, safety, and the general welfare, all in accordance with a comprehensive plan.

Building zone designations are generally uniform in cities throughout the United States. Listed below are various zones and the abbreviations that are commonly used for each:

A1, A2—Agricultural
AC—Agricultural commercial
RA, AS—Suburban
RE—Recreational, parks
R1—One family
R2—Two family, low density
R3, R4—Multiple family
P—Automobile parking
CR, C1—Limited commercial
C2, C3, C4, C5—Commercial
CM—Commercial and light manufacturing
M1—Light industrial
M2—General industrial
M3—Heavy industrial
TP—Trailer parking
RP—Residential and professional offices

All large cities are also divided into fire zones. These zones are designated in building codes as zones 1, 2, and 3. Buildings that are to be erected in a particular fire zone, moved to another fire zone, or moved within a fire zone must meet all the requirements for new buildings in the fire zone. Thus, a four-unit apartment house might be built as a Type V building in one fire zone but would have to be constructed as a Type I FR (fire-resistant) building or some other type of building in another fire zone.

In many locations, zoning regulations, and, thus, building code requirements, change frequently. This is especially true in areas where the population is increasing or new industries are being developed. The roofer must be constantly alert for changes in zoning and building code requirements. New zoning designations (for example, for atomic power plants and industrial plants using radioactive materials) may require changes in roofing operations, methods, or materials.

Types and Classifications of Roofs

Roofs are classified into two general categories: fire-retardant (fire-resistant) roofs and ordinary roofs. Fire-retardant roofs are required, by code, on all buildings in occupancy classifications A through G (large assembly buildings, schools, jails, stores, factories, and so forth). Ordinary roofs may be used on structures in occupancy classifications H, I, and J (hotels, apartment houses, dwellings, and so on).

Underwriters' Laboratories (UL) has established specifications for fire-retardant roofs, designated as Class A and Class B. Ordinary roofs are designated as Class C. All roofing material delivered from the factory with a UL label is Class C material (not to be confused with a Class C roof). Class A and Class B roofs are produced by combining certain combinations of felts, cap sheets, or gravel to meet the requirements established for the class of roof desired. (Some fiberglass shingles and asbestos shingles are acceptable for use on a fire-retardant roof.)

Guaranteed (Bonded) Roofs

Some roofs are guaranteed (bonded) by the materials manufacturer to last for a specified length of time, usually ten to 25 years. Such a guarantee is valid, however, only if the roof is installed in accordance with the manufacturer's specifications. The guarantee serves as a form of insurance for the customer. Typically, the guarantee on a bonded roof excludes failures because of design or structural problems, such as settlement, distortion, or cracking of the roof deck; vandalism; abuse; and hail, windstorms, and other natural disasters. If repairs are required during the warranty period, the costs may be borne by the manufacturer. If, however, it is determined that the roofing materials were not installed as stipulated by the manufacturer, the costs of the repairs must be paid by the roofing contractor who did the job. As a general rule, problems that would be covered under the warranty occur within the first two years after the roof is installed.

Bond specifications are usually referred to by number in the manufacturer's specifications manual. Roofers must interpret the requirements in a manner that will enable them to apply the roof to the satisfaction of the manufacturer. (An architect's specifications may also refer to the manufacturer's manual for bonded reroofing work.)

Architects or their clients frequently request *bondable* roofs for their structures. Unlike a bonded roof, a bondable roof carries no written guarantee from the manufacturer of the roofing materials. An independent roof inspector may be hired to ensure that the roof is installed in accordance with the specifications. Some firms specialize in furnishing roof inspectors.

The Federal Housing Administration

The Federal Housing Administration (FHA) is a government agency that guarantees to lenders the payment of home loans. The loan itself may be made by any private lending institution, in accordance with rules laid down by the agency. As a prerequisite to such a guarantee, the FHA has established certain minimum standards of construction. Those provisions lessen the possibility of the FHA's being responsible for poorly constructed or substandard houses. Whenever the FHA standards differ from those of state, county, or city governments, the stricter standards must prevail.

Federal Housing Administration minimum construction requirements vary from one part of the country to another. Whenever the term *minimum property standards* is referred to in the roofing series workbooks, it relates to the code applicable in the reader's geographical area. Most cities maintain a building department that provides assistance to the public, and information regarding building regulations and local ordinances may be obtained at such departments. Throughout the state, the FHA also maintains offices staffed by representatives who can supply all needed information on construction requirements.

Study Assignment

Obtain and examine copies of local building codes.

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TOPIC 2 — OVERVIEW OF BLUEPRINTS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Define the terms *blueprint* and *specifications*.**
- **Name and describe the various types of prints.**
- **Explain the importance of blueprint reading.**
- **Describe five kinds of views commonly found in a set of blueprints.**

The successful completion of a new building, road, bridge, or any other construction project is the result of teamwork between many persons and trades in the construction industry and in the fields of architecture and engineering. The architect or engineer provides direction for the project by preparing tracings that show exactly how the building is to be constructed and what it will look like when it is finished. Reproduced as a set of *blueprints,* these drawings tell the skilled tradesperson where and how the building is to be located on the site, the locations and sizes of the rooms and other features, the sizes of the materials, and the locations of the plumbing, electrical, and heating items.

A set of written *specifications* usually accompanies the prints. The specifications spell out in detail the requirements for kinds and quality of materials, methods of construction, and quality of workmanship expected on the job. As part of the construction team, the tradesperson must understand what is drawn in a set of plans and must know how to read the legal and descriptive material in the specifications.

Types of Prints

Various methods of printing and developing are used to make sets of prints from the architect's or engineer's tracings. The term *blueprint* is used in a general sense for all types of prints, but it also has a more precise meaning: a print in which the background is blue and the lines and lettering are white. Other types of prints the apprentice may see on the job are the *blueline,* a print that has blue lines on a white background; the *sepia* print, which normally has a light-brown background with heavier brown lines; and the *blackline,* which has black lines on a white background. Also common are the half-size black-and-white prints used by many governmental agencies; they are produced in printing plants by the same methods employed for printing the illustrations in a book.

Blueprint Reading

On some projects, the average tract job, for example, the tradesperson may never see a set of plans or specifications; only the superintendent, supervisor, or layout person may actually have a set. On other jobs, however, tradespeople may be very involved with the plans, and so they must know how to interpret and use them. How well they study and follow the plans goes a long way toward determining how well the finished product fulfills the concepts and requirements of the architect and the client.

The tradesperson has no right to make any change in the plans unless written authority for the change has been given. Doing so can make the individual liable to legal action. The tradesperson must also understand the building codes that prevail in the area, and if there seems to be a conflict between the codes and the plans, he or she must consult the architect or engineer before changing anything. What appears to the tradesperson as a conflict may not, in fact, be so.

Scales Used on Prints

Blueprint reading involves mathematics and requires knowledge of materials and the nomenclature of construction. Also, since the plans must be drawn smaller than full scale to fit the sheet (usually 24 inches by 36 inches [61 centimetres by 91.4 centimetres]), blueprint reading requires familiarity with the scales of reduction used by architects and engineers.* A scale of 1/4" = 1'0" (0.6 cm = 30.5 cm) is generally used for residential plans and elevations. Larger commercial plans and elevations may be drawn to a scale as small as 3/32" = 1'0" (0.2 cm = 30.5 cm). Sections and details are commonly drawn to larger scales, from 3/8" = 1'0" (1 cm = 30.5 cm) to 3" = 1'0" (7.6 cm = 30.5 cm). In some cases, the architect may decide to draw a small item—

*Metric equivalents given in this manual are approximations only. Although metric construction standards have not yet been developed, the apprentice should be aware that such standards are being formulated and that metric materials will probably be used extensively in the future.

say a piece of molding or trim—full size, in which case the drawing is called a full-scale detail (FSD).

The Architect's Scale

For laying out a drawing to a given scale, the architect uses a special rule called an architect's scale. Some of these scales are flat, but the type most commonly used is the three-cornered scale shown in Figure 2-1. It has six faces and 11 scales.

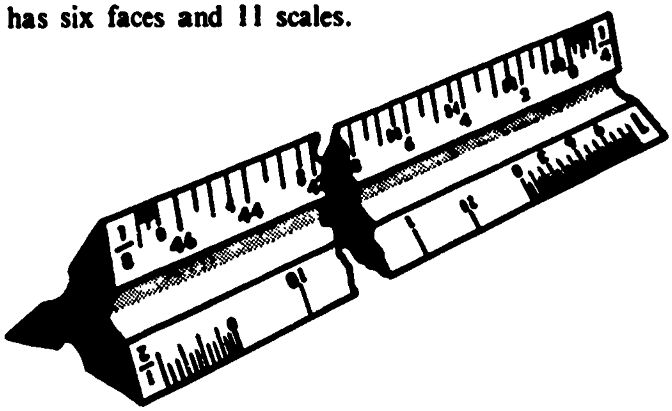


Fig. 2-1. An architect's scale

One face has a standard 12-inch (30.5-centimetre) scale, graduated in inches and sixteenths, which is used for routine measurements and for laying out full-scale details. Each of the remaining faces has two reducing scales, one reading left to right and the other reading right to left as follows:

- $^3/_{32}$ inch (0.2 centimetre) and $^3/_{16}$ inch (0.6 centimetre) to the foot (30.5 centimetres)
- $^1/_8$ inch (0.3 centimetre) and $^1/_4$ inch (0.6 centimetre) to the foot (30.5 centimetres)
- $^3/_8$ inch (1 centimetre) and $^3/_4$ inch (1.9 centimetres) to the foot (30.5 centimetres)
- $^1/_2$ inch (1.3 centimetres) and 1 inch (2.5 centimetres) to the foot (30.5 centimetres)
- $1^1/_2$" inches (3.8 centimetres) and 3 inches (7.6 centimetres) to the foot (30.5 centimetres)

In Figure 2-2, an architect's scale is being used to find an unknown dimension on a drawing made to a scale of $^1/_4$ inch (0.6 centimetre) to the foot (30.5 centimetres). This procedure, called "scaling" a drawing, is used quite often in estimating jobs. *However, it should never be used where precise measurement is required.* Prints often shrink during processing, and as a result distances on the print are reduced. Also, especially when the smaller scales are used, dimensions are difficult to lay out or measure with great accuracy with an architect's scale. On the $^3/_{32}$" = 1'0" (0.2 cm = 30.5 cm) scale, for example, the width of a pencil line may represent an actual distance of an inch (2.5 centimetres) or more. When a missing dimension must be determined accurately, it should be calculated.

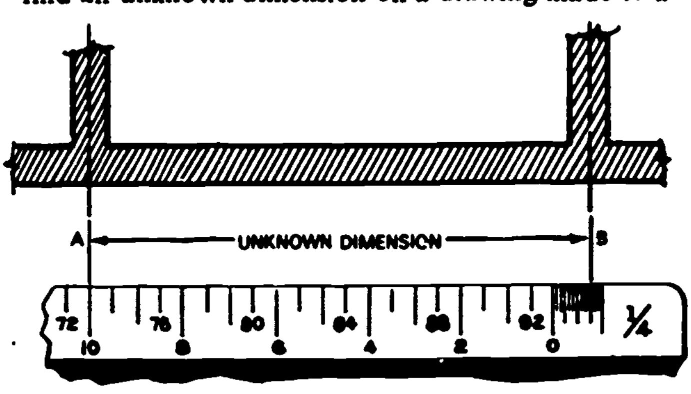


Fig. 2-2. Using an architect's scale

The dimension AB in Figure 2-2 can be found by placing the architect's scale as shown, with the scale mark corresponding to the number of whole feet in the dimension (10 feet [3.0 metres] in this instance) directly under Extension Line A. Extension Line B will then fall on the short graduated scale that extends to the right of zero on the architect's scale. Each of the small graduations to the right of zero on the $^1/_4$" = 1'0" (0.6 cm = 30.5 cm) scale represents 1 inch (2.5 centimetres); therefore, the dimension AB is found to be 10'9" (3.3 m).

Every foot increment is not indicated on every scale on an architect's scale. Furthermore, the scale marks do double duty; for example, the mark that indicates 10 feet (3.0 metres) on the $^1/_4$" = 1'0" (0.6 centimetre = 30.5 cm) scale also serves as the 73-foot (22.3-metre) mark on the $^1/_8$" = 1'0" (0.3 cm = 30.5 cm) scale (see Fig. 2-2). This may be momentarily confusing, but practice will soon make reading the scales easy. (*NOTE:* Metric scales of varing ratios are available, but because their use is still limited, no attempt will be made in this manual to explain how to use them.)

The Importance of Blueprints

The reading of blueprints is required in every step of a construction project, from estimating the job and preparing a bid to installing the finish items and checking the completed work. Blueprints must be consulted in designing and erecting concrete forms that will withstand the pressures of the pour. Determining the lengths of rafters requires knowledge of blueprint reading; so does laying out frame or masonry walls, framing for windows and doors, and framing for the plumbing, electrical, and heating and ventilating items installed by other trades.

Although roofers need not be concerned with the entire set of drawings for a job, they should still have knowledge of what the drawings cover and should be skilled in reading blueprints because:

- Roofers may, in addition to installing roofs, be called on to apply siding, foundation and wall waterproofing, floor membranes, and the like.

- Roofers should know the general layout of the buildings on the jobsite before going to the job and should have sufficient information on the structures to inspect them prior to roof installation.
- Roofers who are skilled in reading blueprints will make fewer errors in planning the job.
- The better the roofers' knowledge of blueprints, the better are their chances of success in the trade.
- Roofers who check the details shown in the blueprints will have a better understanding of how the details relate to the whole job.

Views Shown on Blueprints

A set of blueprints for a building usually consists of several sheets, which include different views of the structure and the jobsite. Included in the set may be the following:

1. Site plan, or plot plan
2. Foundation plan and, if applicable, basement plan
3. Floor plan
4. Elevation views
5. Section views
6. Detail views
7. Roof plan view
8. Door and window schedules
9. Electrical plan
10. Air conditioning plan
11. Plumbing systems plan
12. Framing plans

The Plot Plan

A plan view of an object is a view from directly above the object. A plot plan (see Fig. 2-3) is a plan view of the property showing the dimensions of the lot, the slope (if any) of the lot, and the outline, roof shape, and placement of the building to be constructed on the lot.

The Foundation Plan

The foundation plan (see Fig. 2-4) is a plan view showing the shape and size of the foundation walls and footings. In simple construction projects a basement plan may serve also as a foundation plan. Foundation plans for most residential projects are drawn to a scale of ¼" = 1'0" (0.6 cm = 30.5 cm). Commercial plans are often drawn to a smaller scale.

Foundation section drawings are included in the set of blueprints to show the construction of the foundation walls and footings. These section drawings are keyed to related locations on the foundation plan. This illustrates an important point in blueprint reading: The various drawings in a set of prints are closely related, and several drawings may have to be consulted to get all the information needed for a certain operation—for example, grading the lot or laying out and constructing the foundation forms.

The Floor Plan

The floor plan (see Fig. 2-5) provides a view of the building from above as if it were cut away on a horizontal plane over the floor. The floor plan usually contains more information than any other sheet in the set of blueprints. It shows the size and arrangement of the rooms and the location of walls, windows, doors, stairways, closets, cabinets, plumbing fixtures, electrical outlets, and many other items. Once the foundation is completed, the floor plan becomes the most important source of information for layout of the building.

Elevation Views

An elevation view (see Fig. 2-6)—usually called simply an elevation—is a view looking squarely at one side of a structure. Exterior elevations that show all sides of the building are normally included in a set of blueprints.

Section Views

The set of prints for a building usually contains one or more section views (see Fig. 2-7) that reveal the construction of the building from the foundation through the roof. Section views may be of a complete section of the building, or they may show only one wall, part of a wall, and so forth.

Detail Drawings

Detail drawings are usually required if special or unusual construction is involved in a project. Special roof features that may require detail drawings include drains, hatches, pipe penetrations, gravel stops, overflow scuppers, duct penetrations, vents, coping, skylights, relief joints, and walkways.

Roof Plan View

Roof plans show the locations of various roof components: drains, expansion joints, openings, duct and pipe penetrations, and the like. Also indicated are the slope of the roof and references to the locations of detail drawings of the components in the project blueprints. For example, a designation of 15-A6 for a roof hatch (with the designation placed in a small hexagon near the hatch on the roof plan) would indicate that the detail drawing of the hatch can be found as detail or section 15 on page A-6 of the set of blueprints.

Details about the roof are included in the specifications for the roof. A typical perspective view of a roof is presented in Figure 2-8, and a typical roof plan for a

(Continued on page 12)

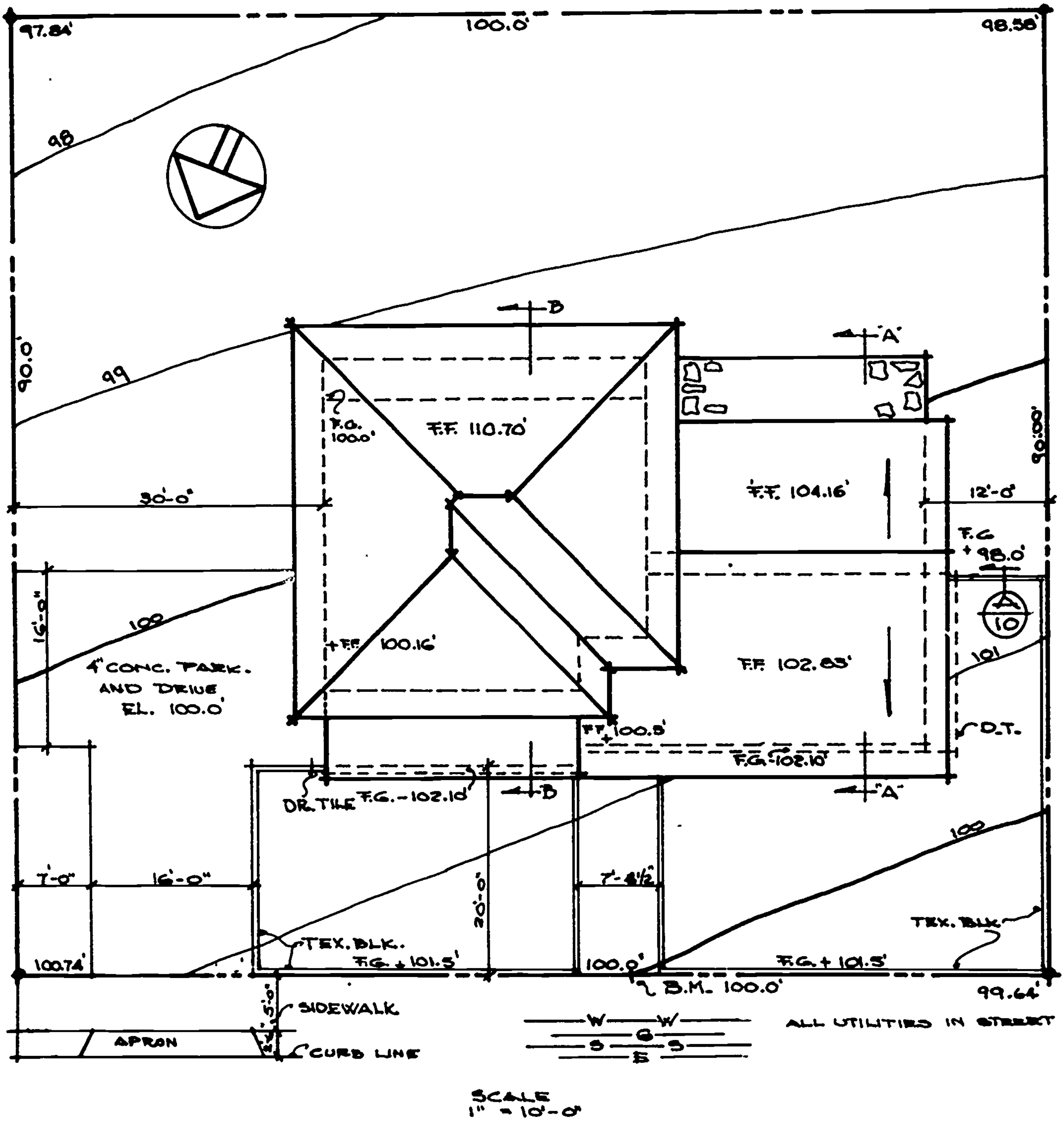


Fig. 2-3. A typical plot plan

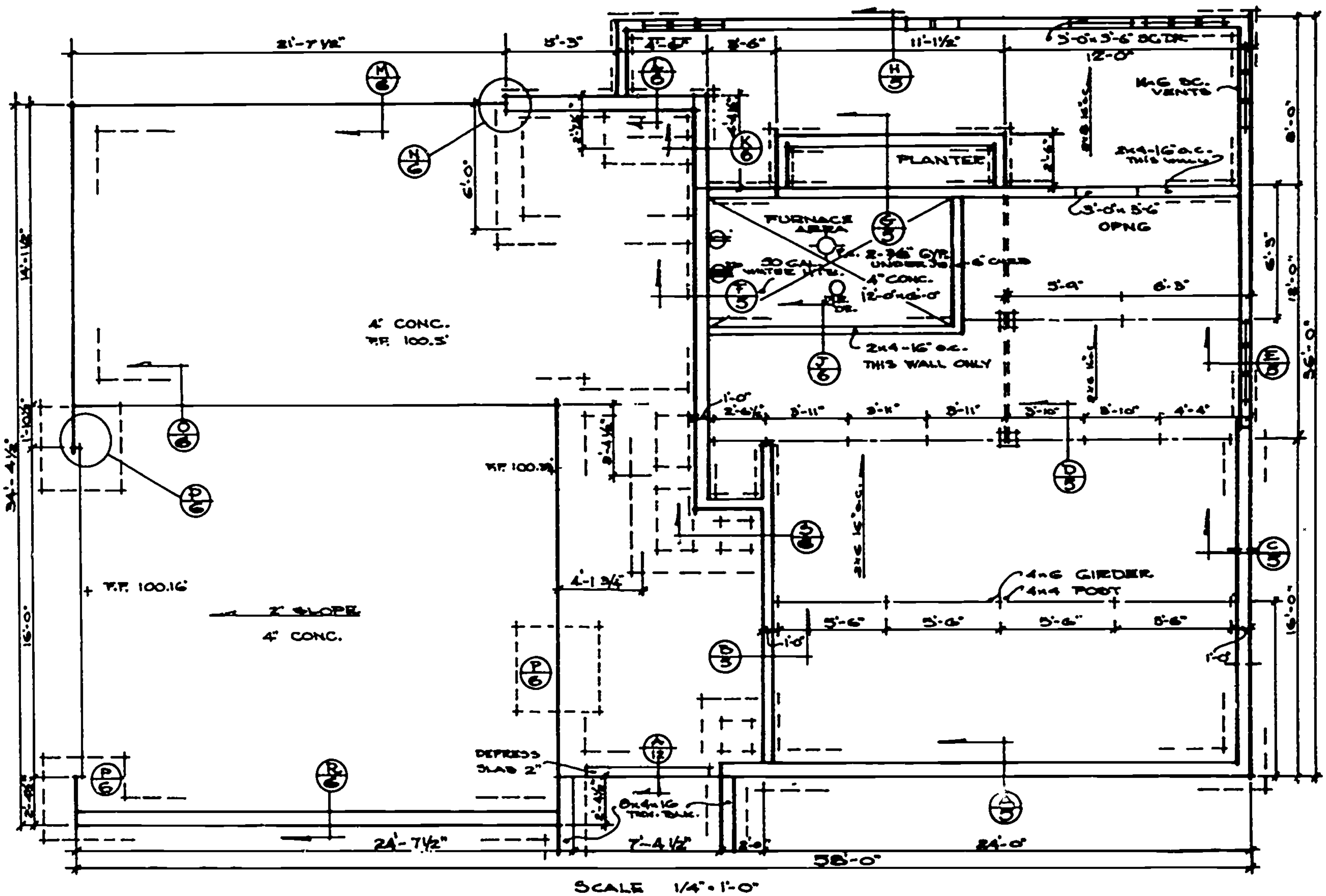


Fig. 2-4. A typical foundation plan

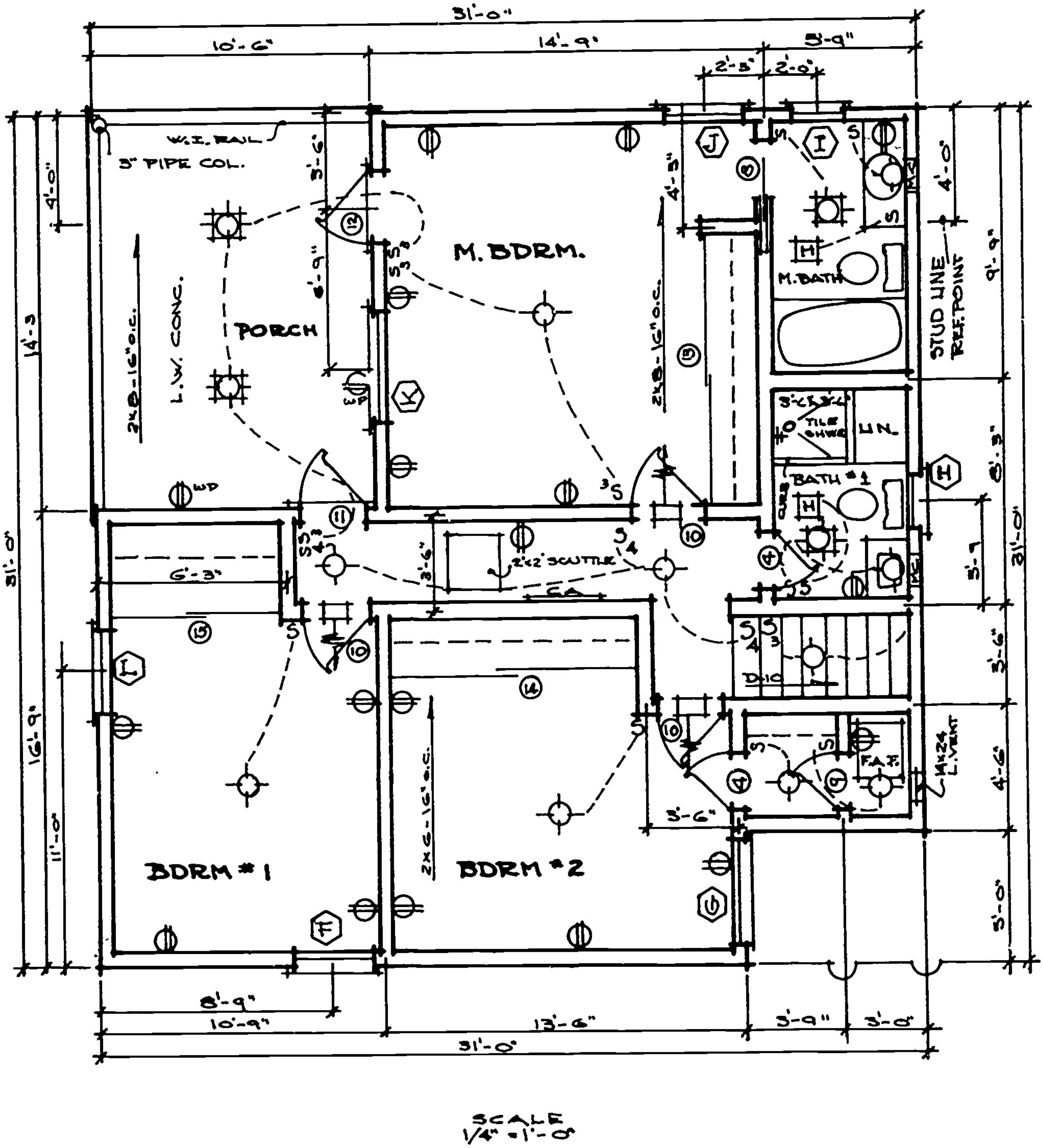
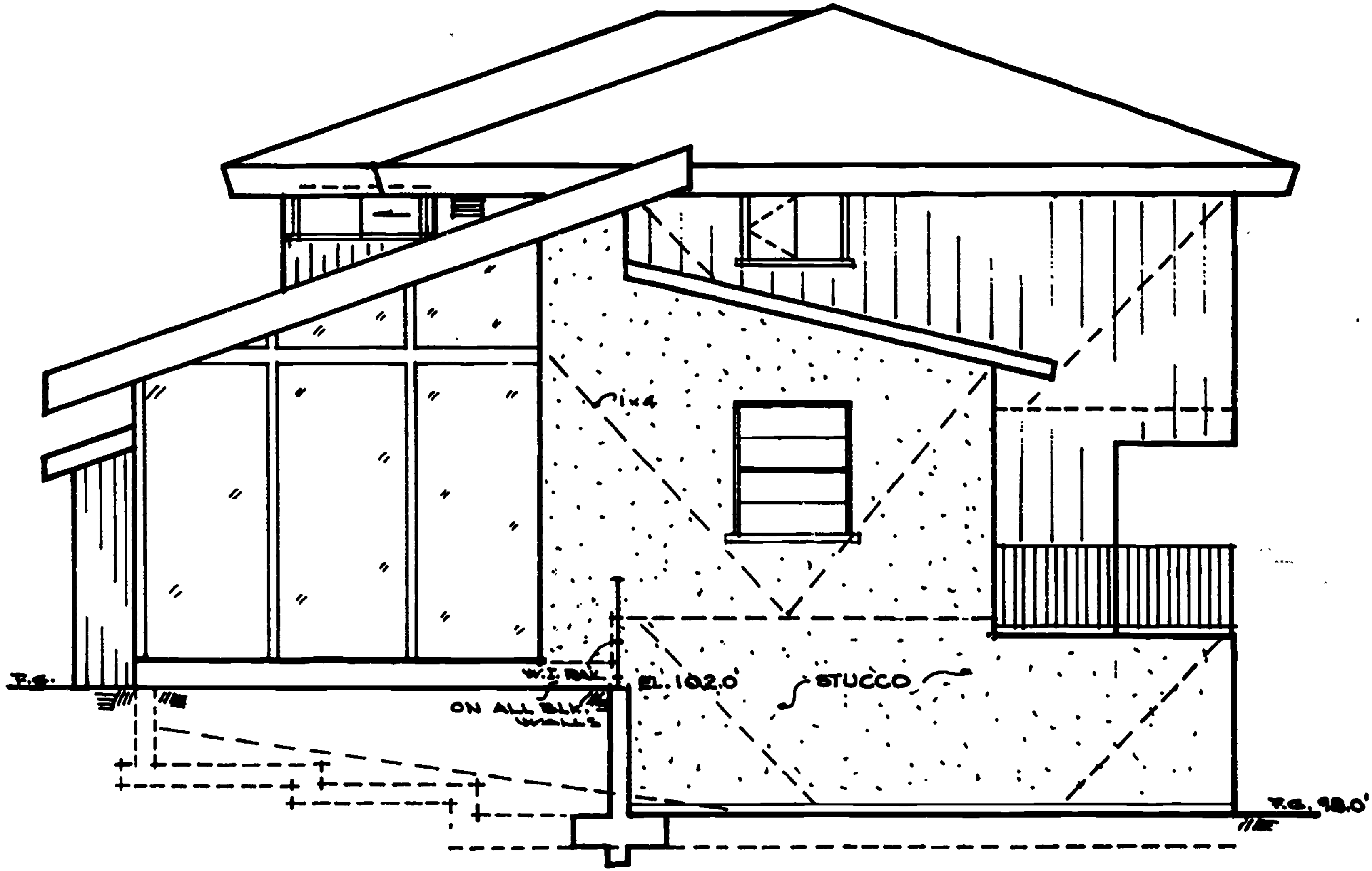


Fig. 2-5. A typical floor plan



SCALE
1/4" = 1'-0"

Fig. 2-6. A typical elevation view

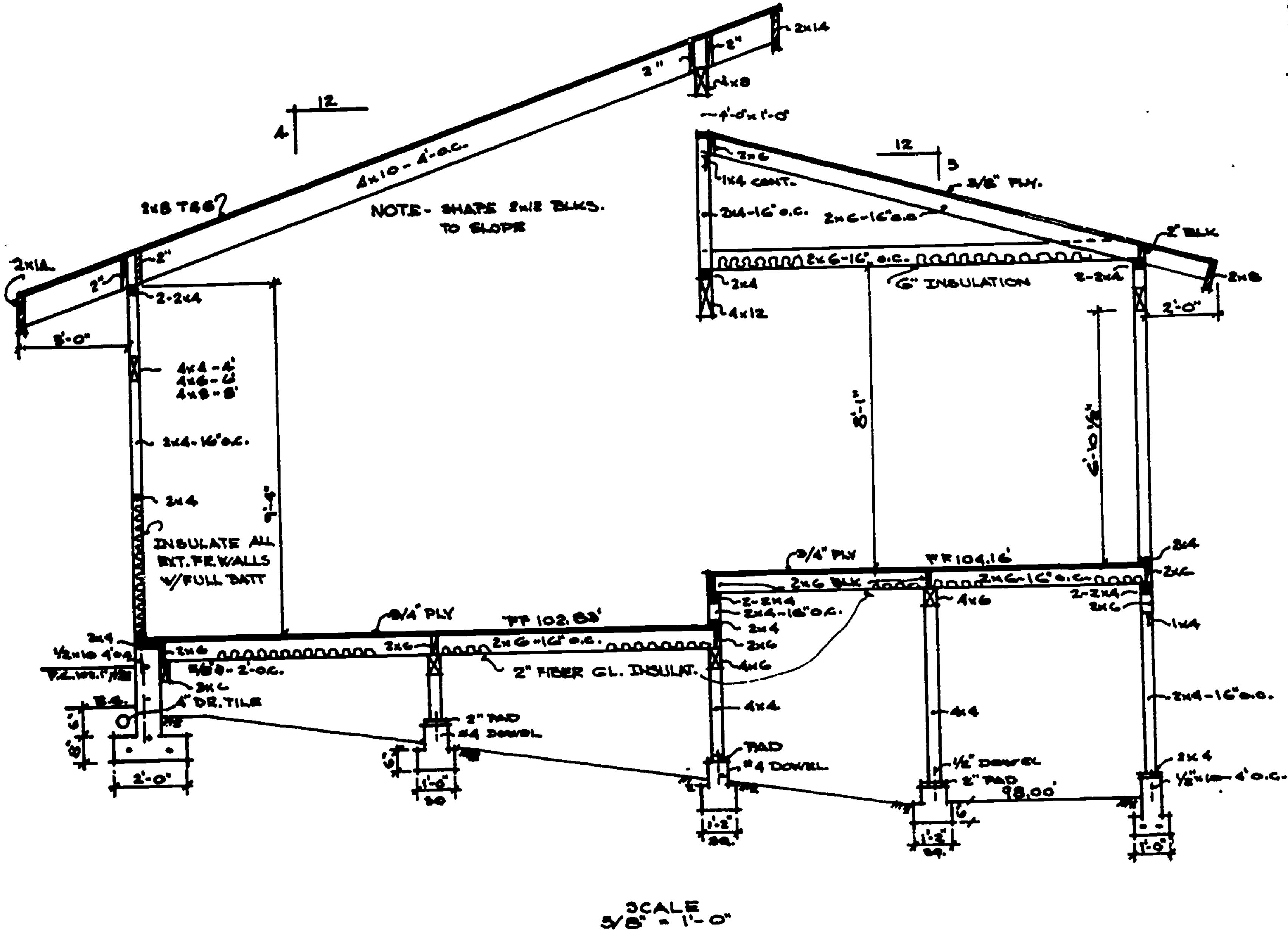


Fig. 2-7. A typical section view

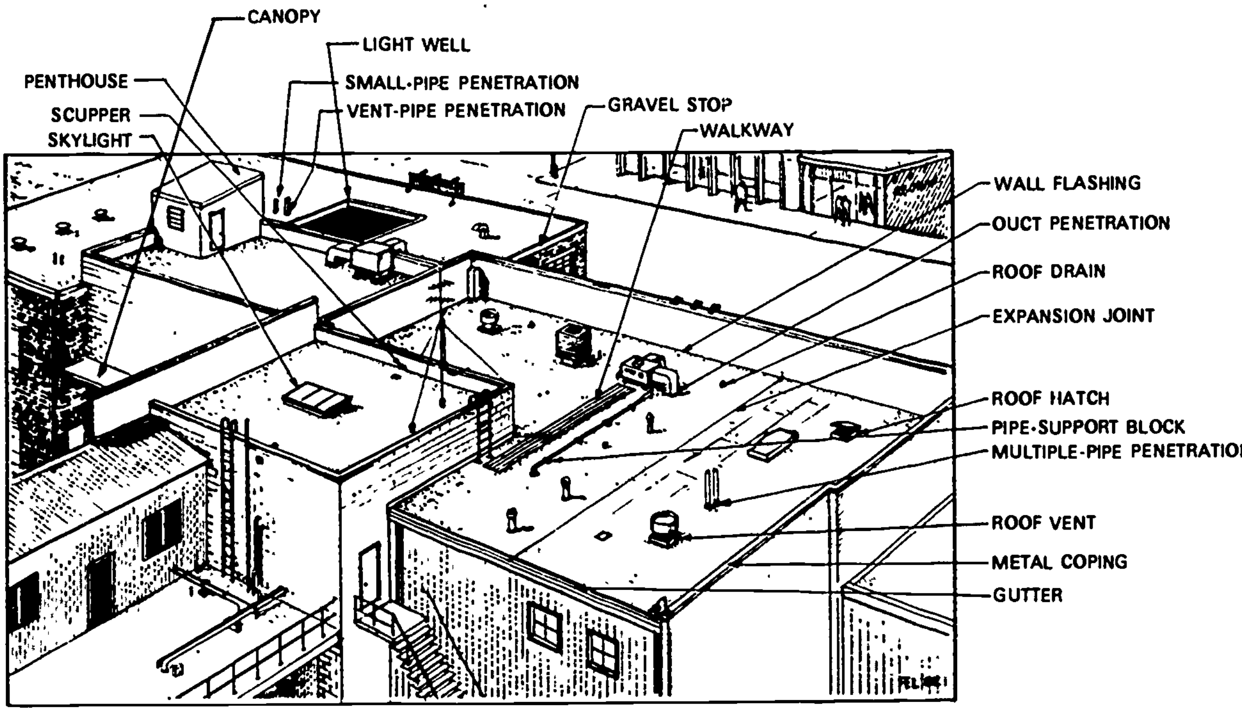


Fig. 2-8. A typical perspective view of a roof

built-up roof is shown in Figure 2-9. Detail drawings of the special features of the roof in Figure 2-9 are shown in Figure 2-10.

Door and Window Schedules

Although door and window schedules are not drawings, they are generally included in a set of working drawings. Door schedules are often shown on the plan drawings, and window schedules generally appear on the elevation drawings. The information provided in the schedules includes the quantity, size, and location of each type of door or window to be used. Special remarks about items may also be included.

The Electrical Plan

For the less complex construction jobs, the electrical plan may be included on the floor plan. For complex structures, however, a tracing is made of the floor plan, minus unnecessary details, and the electrical plan is shown separately. Included in the electrical plan are the locations of the meter, distribution panel, switches, convenience outlets, and any special outlets, including those for doorbells and telephones.

The Air Conditioning Plan

The air conditioning plan is usually included on the floor plan. For complex installations, a separate plan may be prepared, using a tracing of the floor plan. The air conditioning plan covers the heating and cooling systems.

The Plumbing System Plan

Frequently the plumbing fixtures are shown on the floor plan, especially for residences. Separate plans are often drawn up for more complex structures. Shown on the plumbing system plan are the layout of the hot and cold water piping system, the locations of plumbing fixtures, and the sewage disposal system.

Framing Plans

In many instances framing plans for the roof, floors, and various elevations may be included in the set of drawings, especially those for complex structures. For smaller, less complicated structures, they are often omitted.

Study Assignments

1. Obtain and study blueprints from an architect.
2. Review the various detail drawings in the other books in this series. Note especially those included in *Built-up Roofing* and *Rigid Roofing*.

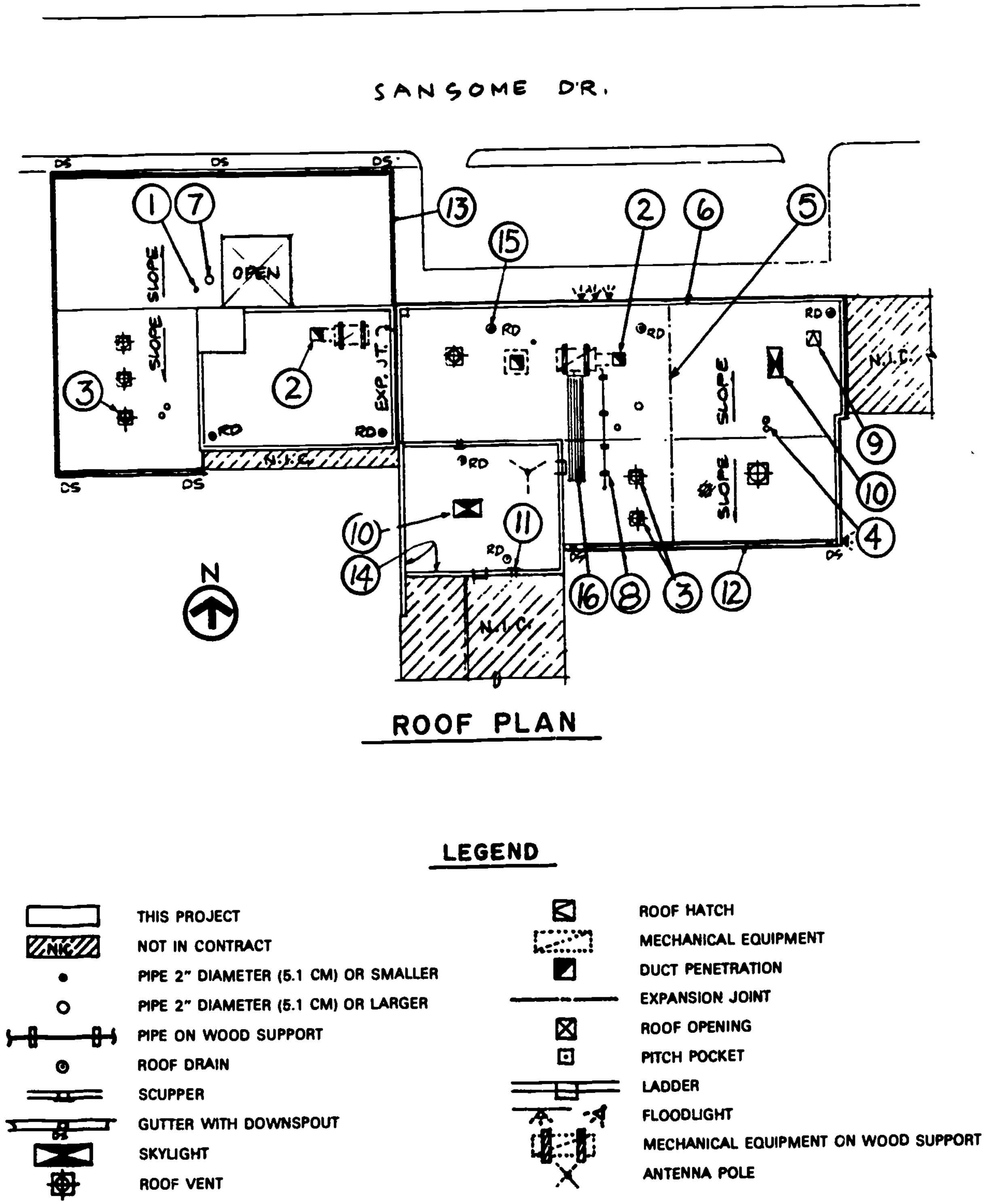
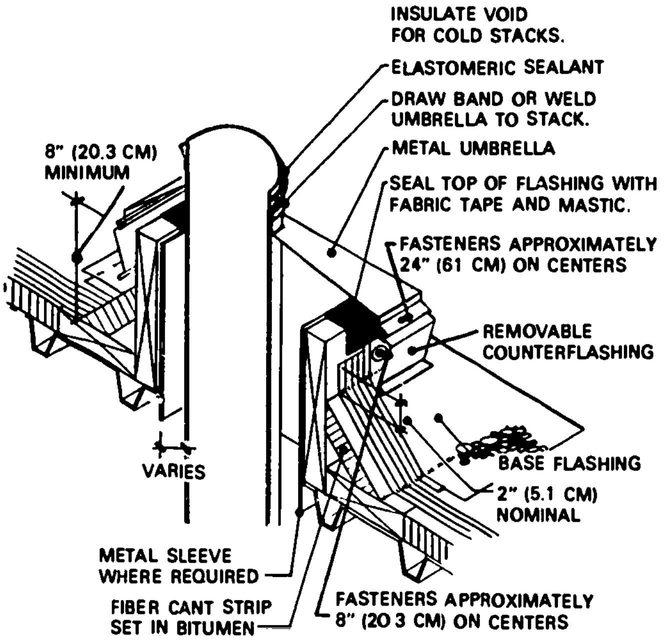
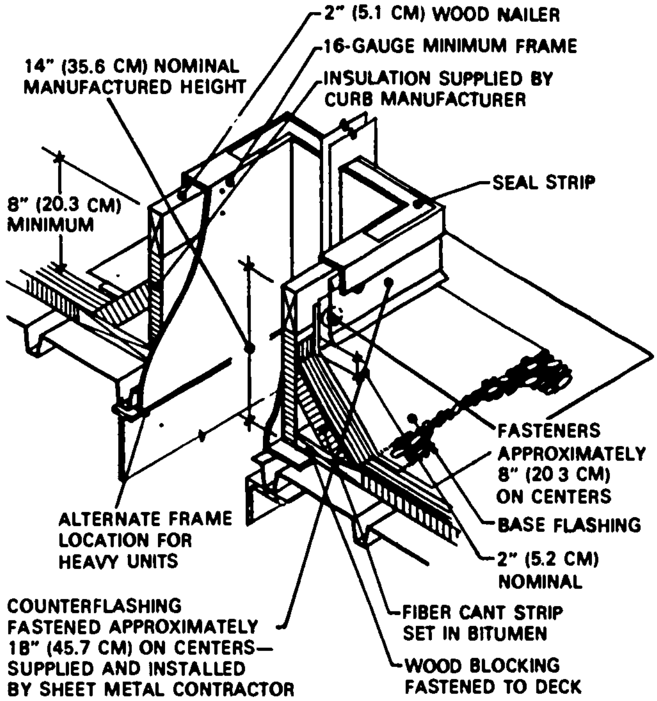


Fig. 2-9. A typical roof plan for a built-up roof



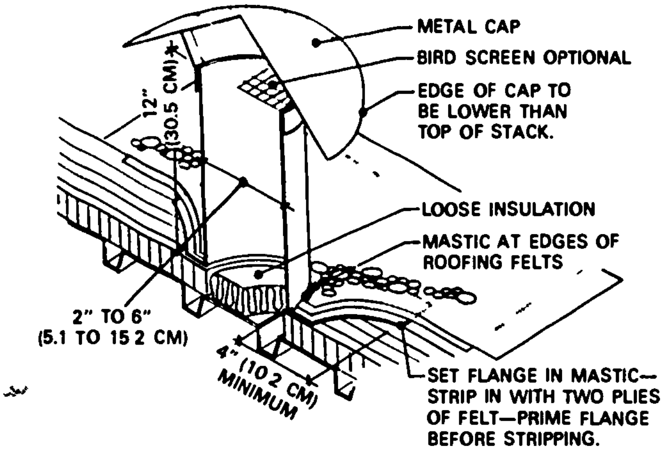
NOTE This detail allows the opening to be completed before the stack is placed The metal sleeve and the clearance necessary will depend on the temperature of the material handled by the stack

1. Small-pipe penetration



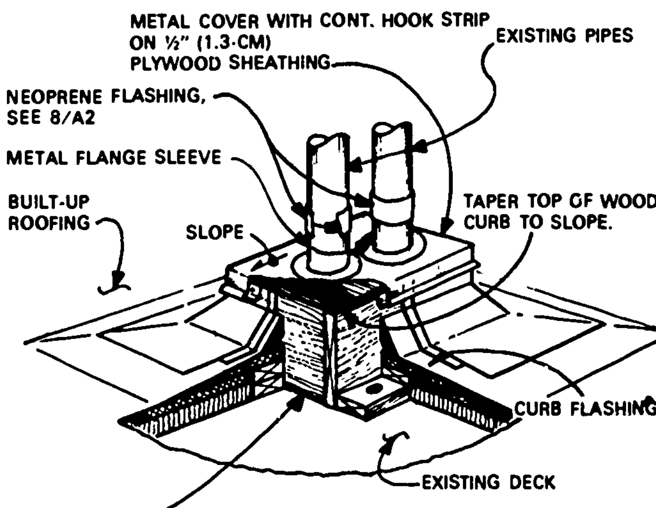
NOTE The curb, wood nailer, insulation, and seal strip are to be supplied by the curb manufacturer The nominal 14" (35 6-cm) curb height was effective as of January 1, 1981.

2. Duct penetration



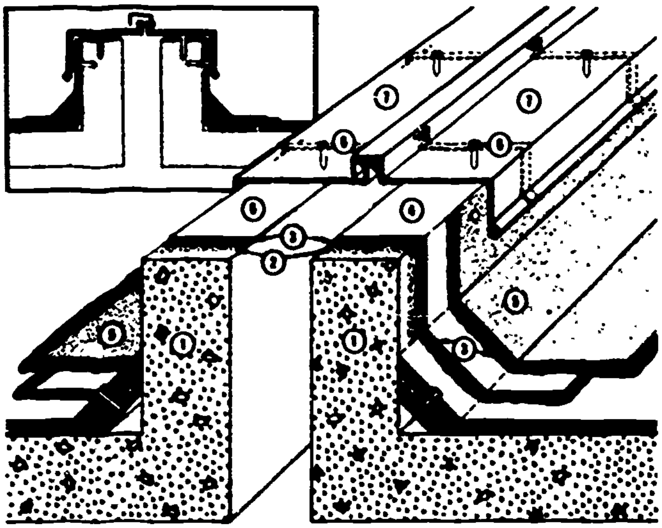
NOTE This procedure is used to relieve moisture vo, or pressure from insulation The moisture may have entered because of leaks or faulty vapor retarders or during construction The spacing of relief vents is determined by the type of insulation used and the amount of moisture to be relieved This procedure is sometimes used for new roofs when vapor retarders are used and a venting system is desired

3. Roof vent



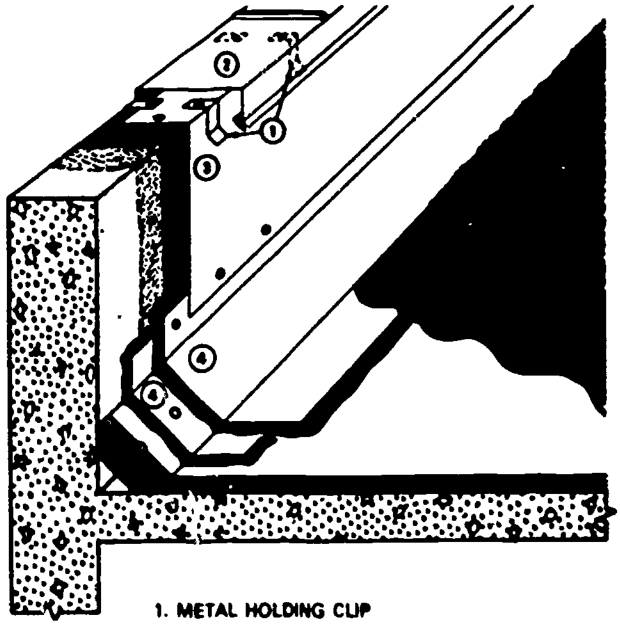
4. Multiple-pipe penetration

Fig. 2-10. Detail drawings of special features of a built-up roof



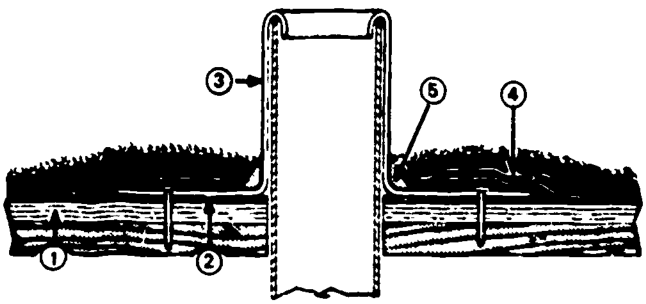
1. MASONRY CURBS
2. ASPHALT PRIMER
3. ASPHALT MOPPING
4. NO 15 ASPHALT FELT
5. MINERAL-SURFACE CAP SHEET
6. ANCHOR CLIPS
7. COPING

5. Expansion joint



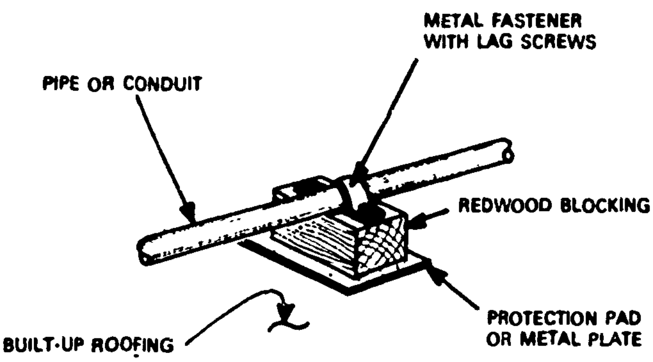
1. METAL HOLDING CLIP
2. STANDING SEAM METAL COPING
3. ROOFING FELT WALL COVERING
4. BASE FLASHING

6. Coping

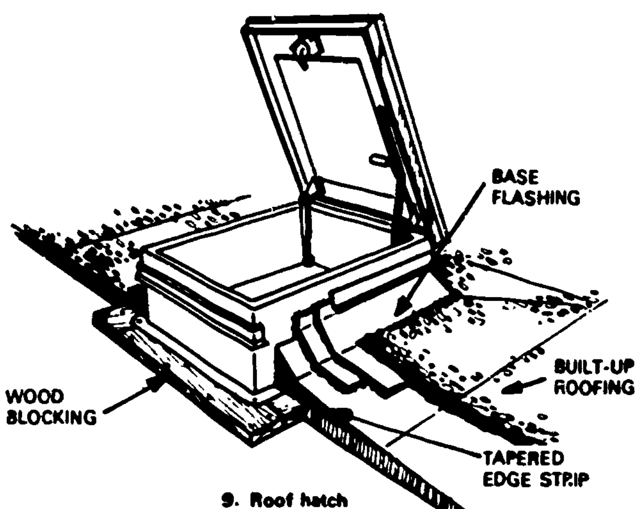


1. ROOFING FELTS
2. FLASHING COMPOUND (⅛" [0.3 CM] THICK)
3. LEAD VENT PIPE FLASHING IN BED OF FLASHING COMPOUND, TURNED DOWN INSIDE PIPE
4. TWO LAYERS OF FELT SET IN ASPHALT OVER FLANGE OF LEAD VENT PIPE FLASHING
5. BEAD OF FLASHING COMPOUND ENCIRCLING FLASHING

7. Vent-pipe penetration

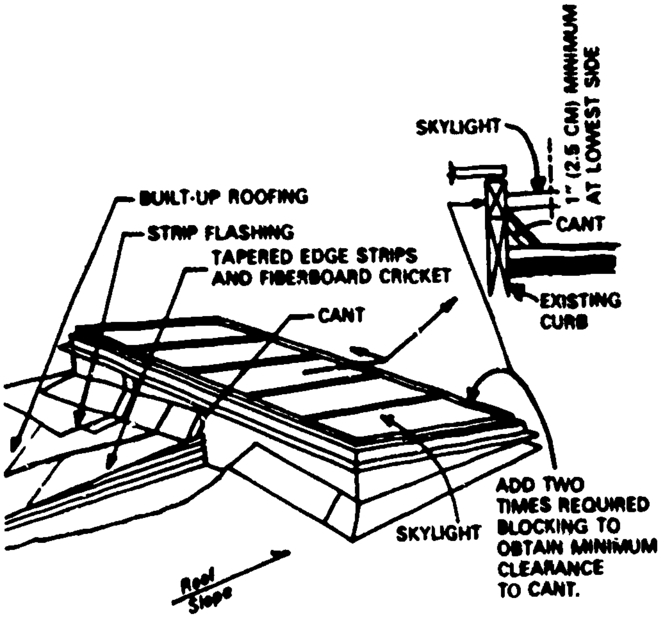


8. Pipe-support block

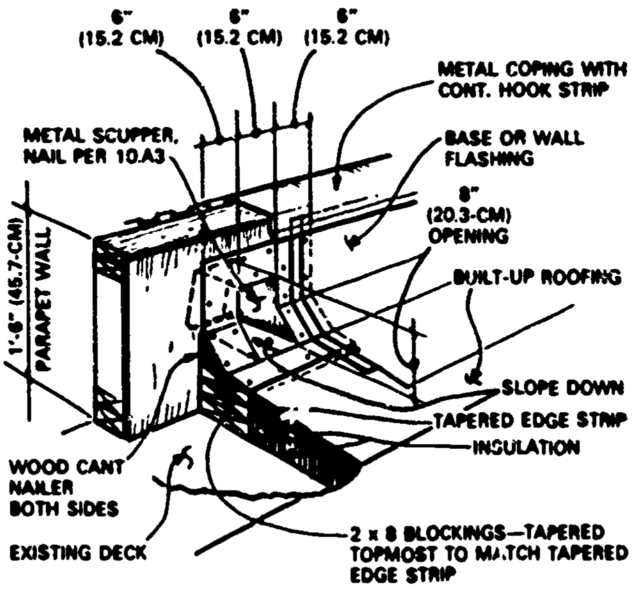


9. Roof hatch

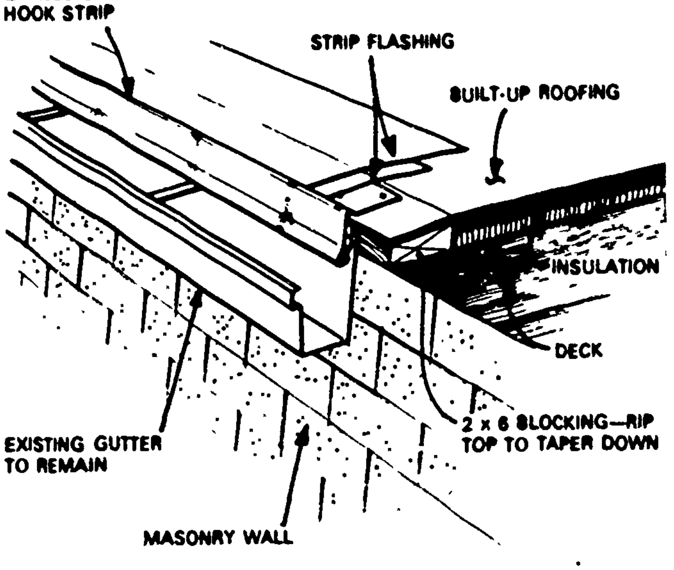
Fig. 2-10 (continued)



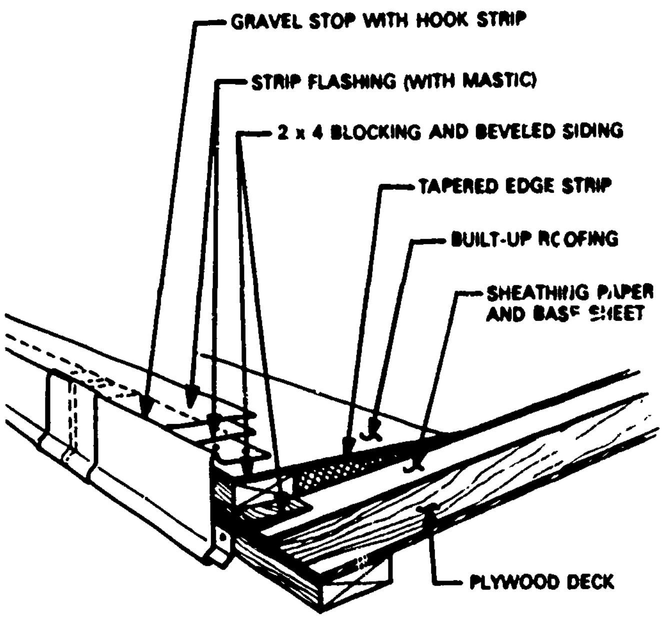
10. Skylight



11. Overflow scupper

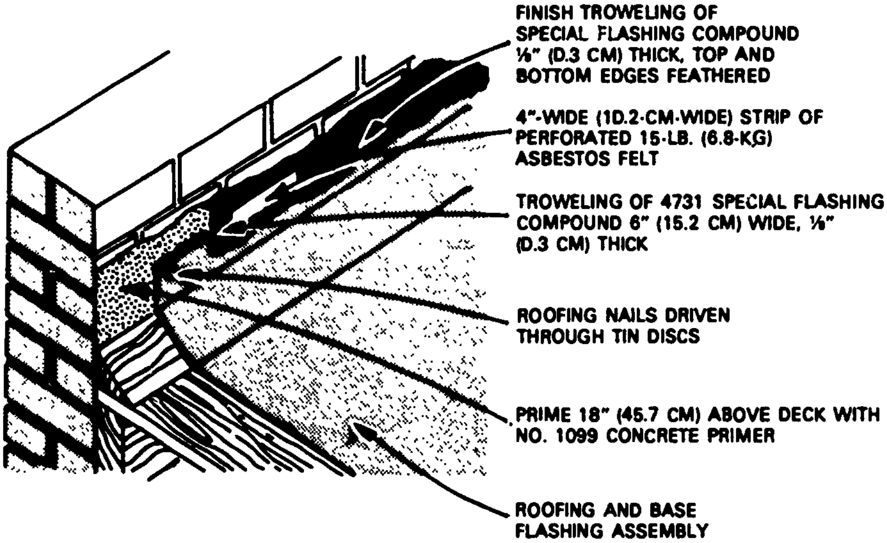


12. Gravel stop and gutter

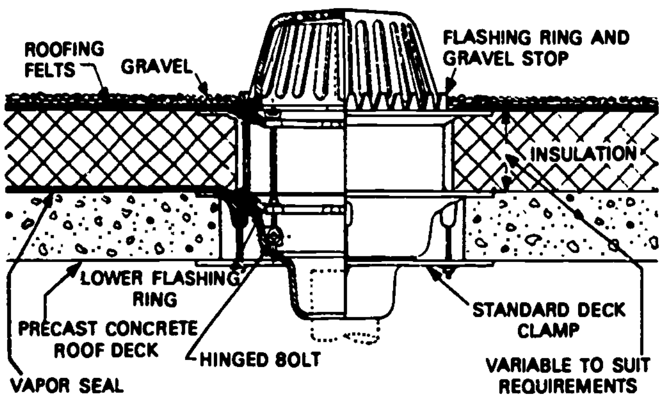


13. Gravel stop

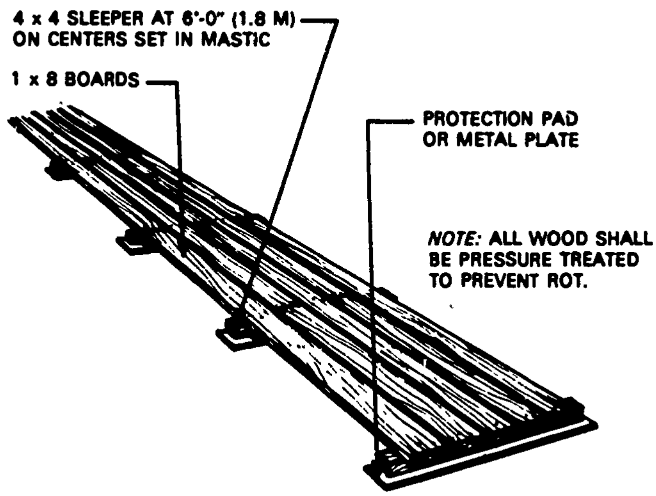
Fig. 2-10 (continued)



14. Wall flashing



15. Typical roof drain



16. Walkway

Fig. 2-10 (continued)

PLANS AND SPECIFICATIONS

TOPIC 3 — OVERVIEW OF SPECIFICATIONS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Explain the need for detailed specifications.**
- **Discuss specific types of information that specifications usually contain.**

Specifications are informative sheets that are gathered together in a pamphlet (or several large volumes in the case of a large building) and that cover a number of subjects in detail. Even the simplest type of construction project should include a set of specifications. Included in the specifications should be a description of the materials to be used, a statement of the work to be performed, and a description of the workmanship required. Together, the specifications, sketches, working drawings, and written contract become the basis for agreement between the owner and the contractor.

Content of Specifications

The specifications for a job contain information that cannot be shown conveniently on a set of blueprints. A major component of the specifications is the general conditions, or broad provisions, of the contract between the owner and the contractor. Described in the general provisions are the responsibilities of the architect, the contractor, and subcontractors, along with the guarantees of completion, performance, and quality of the work that is to be done.

Specifications are designed to supplement the working drawings by specifying the exact types or grades of equipment, materials, or fixtures to be used on the job and the methods to be used by each trade that works on the project. The information in the specifications should not conflict with that in the blueprints; if a discrepancy does exist, the specifications should be followed.

The responsibility for the content of the specifications rests with the architect, and nothing should be changed without the architect's approval. The inspection procedures that the architect is to use during construction should be detailed in the specifications.

Following the general conditions section, the other specifications usually are presented in the same sequence in which the various trades will commence work on the project. The first section usually contains a description of the demolition, site clearance, or excavation procedures, depending on which of these would best fit the particular job. Then the "rough and finish" work is described for each trade.

Uses of Specifications

Specifications serve different purposes for different parties involved in a construction project. Owners, for example, use the specifications to determine their part in the contract and to verify the things they specifically want in the finished building. Owners should review the guarantees of performance and workmanship for future reference in the event that the structure or equipment proves unsatisfactory.

The specifications provide the contractor and subcontractors with detailed information so that they know exactly what they are bidding on and can estimate the costs of labor and materials. Material suppliers can study the specifications to determine the quantity, quality, and types of materials to be used. The suppliers of fixtures or appliances can find detailed descriptions, including the catalog numbers or names, of the items they will need.

City or county building departments use the specifications and working drawings to determine compliance with fire and health standards.

Banks and loan agencies use the information in the specifications to help determine the value of the building. The Veterans Administration and the U.S. Department of Housing and Urban Development (HUD), which might provide part of the financing, require a copy of the specifications for their approval.

The importance of complete and concise specifications cannot be overemphasized, because they are part of the legal contract and may be used in court in the event of a lawsuit.

Before starting any roofing job, the roofer should carefully check the roof specifications for the job. This reduces the possibility of making errors when the time comes to determine the materials to be used, fastening methods, and so forth. All too frequently contractors who are low bidders on a job find out too late that the specifications were not interpreted correctly. It is recommended that a prejob interview be held among the roofing contractor, roofing supervisor, architect, owner, general contractors, and subcontractors to discuss the specifications and roof details.

TOPIC 4 — MATHEMATICS

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Discuss the importance of arithmetic calculations in the roofing industry.**
- **Describe some errors commonly made in addition.**
- **Discuss the arithmetic function that will allow him or her to find an unknown quantity when the whole and one of its parts are known.**
- **Name the best way to find the sum of several numbers when they are all the same.**
- **Identify the arithmetic function used to determine the number of times one number is contained in another number.**
- **Define the terms *fraction* and *mixed number*.**
- **Review the procedures for adding, subtracting, multiplying, and dividing fractions.**
- **Name the most common error made in work with decimals.**
- **Describe the steps involved in converting percents to fractions and decimals.**

The ability to do arithmetic calculations accurately is essential to the roofer who wants to succeed in the trade. Once the surface areas, linear measures, and so forth have been determined for a job, the amount of material needed for the job may be calculated easily. Most roofing material manufacturers supply guides and charts showing the quantities of materials required per square of roofing. With these aids, the roofer needs only simple arithmetic to determine the quantities required for the job. Topic 4 is devoted to a review of linear measure and addition, subtraction, multiplication, and division involving whole numbers, fractions, decimals, percents, and compound numbers. The focus of Topic 5 is on using this knowledge to calculate the number of squares in various types of roofs.

Linear Measure

The term *linear measure* refers to the measurement of the length of a straight line that lies between two points, lines, or surfaces. In the roofing and waterproofing industry, linear measure is usually expressed in terms of inches, feet, or yards.*

The most frequently used tool for determining linear measurement on the job is the steel tape. Its smallest unit of measure is the inch, which is divided into parts that may be either common or decimal fractions. The divisions of an inch on most steel tapes (see Fig. 4-1) represent ½s, 4ths, 8ths, 16ths, and 32nds of an inch. The tape used most commonly in the roofing trade for blueprint reading is one having inches divided into fractions as small as 1/16 of an inch; however, the roofer will not work with parts smaller than 1/8 inch.

*For purposes of clarity and simplification, metric equivalents are not included in this topic.

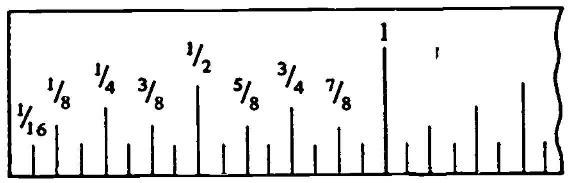


Fig. 4-1. Enlarged view of 1 inch (2.5 centimetres) on a steel tape

Whole Numbers

All numbers may be classified as either whole numbers or fractions. The following four sections deal with addition, subtraction, multiplication, and division of whole numbers. Fractions will be covered in subsequent sections of this topic.

Addition of Whole Numbers

The first mathematical operation to be learned by human beings was probably addition. The process of addition of whole numbers is generally well known and well understood, but errors in addition do occur, perhaps more through carelessness than through a lack of understanding of the operation.

Many errors in addition are also caused by faulty arrangement of numbers when a problem is written down. Care must be taken to arrange the columns of figures in the correct order, with units placed over units, tens over tens, hundreds over hundreds, and so forth (see Fig. 4-2).

The result of an addition problem is called the *sum*, and the numbers added are called *addends*. The accuracy of one's addition may be checked by adding the figures in the direction opposite from that first used. The result of an exercise in addition is not affected by

Digit or Place Names											
Millions	Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Units	*Decimal point*	Tenths	Hundredths	Thousandths	Tenthousandths
2	4	6	8	9	1	0	.	1	2	3	4

Fig. 4-2. Some commonly used place values

the order in which the addends are added. Problem: Determine the total square footage of a roof if the roof of the garage contains 328 square feet and the roof over the remainder of the house contains 1,299 square feet.

Garage	328 sq. ft.	(Addend)
Remainder of house	+ 1,299 sq. ft.	(Addend)
	1,627 sq. ft.	(Sum)

Subtraction of Whole Numbers

Subtraction, the reverse of addition, is valuable in determining an unknown quantity when the whole and one of its two parts are known.

In a subtraction problem, the number from which another is to be subtracted is called the *minuend*, the number to be subtracted is the *subtrahend*, and the result is called the *difference* or *remainder*. The result of a subtraction operation can be checked by adding the difference to the subtrahend; the answer should be equal to the minuend. Problem: Determine how many bundles of shingles were used on a job if a count shows that only 15 remain of the original 500 at the time the job is completed.

Bundles on hand at start of job	500	(Minuend)
Bundles left over at completion	− 15	(Subtrahend)
Number of bundles used	485	(Difference)

Multiplication of Whole Numbers

Multiplication can be thought of as a fast way to perform addition when all the numbers to be added are the same. A roofer may frequently use multiplication in calculating length, area, or volume. Accuracy and speed in multiplication depend to a great extent on mastery of the multiplication tables shown in Appendix A.

In a multiplication problem the number to be multiplied is called the *multiplicand*, and the number by which it is to be multiplied is the *multiplier*. Each of these numbers is also called a *factor* (any number used to determine the solution to a multiplication operation). The order in which the numbers are multiplied has no effect on the answer, called the *product*. Dividing the product by either factor is a method of checking in multiplication; the answer should be equal to the other factor. Problem: If the eave of a roof is 40 feet long and three nails are required per linear foot for metal drip edging, determine the total number of nails needed to mount the edging.

Total feet of edging	40	(Multiplicand)
Nails per foot	× 3	(Multiplier)
Total nails needed	120	(Product)

Division of Whole Numbers

The division process is used to determine how many times one number is contained in another number. Skill with this process is frequently needed by a roofer performing "layout" work, usually in a situation in which a great deal of accuracy is required. For example, a roofer would use division to determine the number of wooden battens to be used on a tile roof or to determine the unit cost of an item when the total cost and the number of units are known.

In any division problem the number to be divided is the *dividend*, and the number by which the dividend is to be divided is called the *divisor*. The solution to a division problem is called the *quotient*. In cases in which the dividend cannot be divided an exact number of times, the quantity left over is called the *remainder*. The accuracy of a quotient can be checked by multiplying the quotient by the divisor; the product should be equal to the dividend. Problem: If the asphalt shingles needed to cover a square of roofing area cost $27 and three bundles of shingles were purchased to cover that area, determine the cost of a single bundle of shingles.

		$9.00	(Quotient)
(Divisor)	3	)$27.00	(Dividend)

Fractions

The term *fraction* means a part or portion of a whole quantity. To use any form of measurement without having a way to express fractional parts is practically impossible. A roofer may be required to express fractional parts of many types of measurements, including fractional parts of a yard, foot, inch, or hour.

A fraction may be expressed in three ways without changing its value: as a common fraction ($\frac{3}{4}$), as a decimal fraction (0.75), and as a percent (75 percent).

Common Fractions

As the word *common* implies, a *common fraction* is the type that is used most often in measurement. It is made up of a *numerator* and a *denominator*. The numerator and denominator are two numbers separated by a line that indicates division. The upper number is the numerator, and the bottom number is the denominator. A common fraction may be written in either of the two ways shown below:

$$^3/_4 \text{ or } \frac{3}{4} \quad \begin{matrix}\text{(Numerator)}\\ \text{(Denominator)}\end{matrix}$$

The denominator of a fraction indicates the number of equal parts into which the whole unit or figure is to be divided; the numerator indicates the number of those parts needed or being considered. In the fraction $\frac{3}{4}$, a quantity is to be divided into four equal parts, and three of those parts are to be considered (see Fig. 4-3).

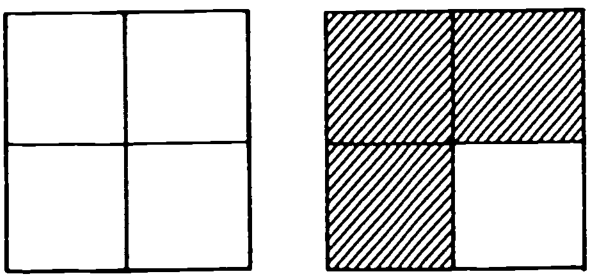


Fig. 4-3. The significance of the fraction $\frac{3}{4}$

Common fractions may be either proper or improper. In a *proper fraction*, the numerator is smaller than the denominator ($\frac{3}{4}$); an *improper fraction* has a numerator that is larger than the denominator ($\frac{4}{3}$).

Lowest Common Denominator

Some operations with fractions can be performed only when the fractions all have the same denominator. A like denominator for a number of fractions is called the lowest common denominator (LCD). It is the smallest number into which a number of denominators can be divided evenly. The lowest common denominator of $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{8}$, for example, is 8, the lowest number into which all three denominators can be divided evenly (without a remainder).

Lowest Terms

Working with fractions or with numbers that include fractions is much easier if the fractions are reduced to their lowest terms; that is, if the numerator and denominator are divided by the largest number that can be divided evenly into both of them. Whenever the solution to a problem or operation includes a fraction, the fraction should be reduced to lowest terms. The fraction $\frac{9}{12}$ can be reduced to lowest terms in the following manner:

$$\frac{9 \div 3 = 3}{12 \div 3 = 4} \text{ or } ^3/_4$$

Both the numerator and denominator of the fraction are divided by 3, the largest number that can be divided evenly into both of them. To reduce the numerator and denominator any further is impossible since the numerator and denominator cannot be divided evenly by any other common factor. The value of the fraction is not altered when the numerator and denominator are divided by the same number.

Addition of Fractions

Fractions can be added only when their denominators are the same; that is, when they have a common denominator.

Adding fractions with a common denominator. Fractions with a common denominator are added by combining their numerators and placing the sum over the common denominator. The fractions $\frac{1}{12}$ and $\frac{5}{12}$ are added in the following manner:

$$^1/_{12} + {}^5/_{12} = \frac{1+5}{12} = {}^6/_{12}$$

$$= {}^1/_2 \text{ (reduced to lowest terms)}$$

Adding fractions with unlike denominators. Fractions with unlike denominators can be added only when they have been changed to equivalent values having a common denominator. To establish equivalent values for the fractions, divide the denominator of each one into the lowest common denominator, and multiply each numerator by the respective quotient (answer). Then write each product over the common denominator. The new fractions have a common denominator and can be added as previously described. The fractions $\frac{1}{2}$ and $\frac{2}{3}$ can be added in the following manner:

$\frac{1}{2} = \frac{3}{6}$ ($6 \div 2 = 3$, and $\frac{1 \times 3}{2 \times 3} = \frac{3}{6}$)

$\frac{2}{3} = \frac{4}{6}$ ($6 \div 3 = 2$, and $\frac{2 \times 2}{3 \times 2} = \frac{4}{6}$)

$\frac{3}{6} + \frac{4}{6} = \frac{7}{6} = 1\frac{1}{6}$ (reduced to lowest terms)

The apprentice should note that an improper fraction, such as $\frac{7}{6}$, is reduced to lowest terms by dividing the numerator by the denominator.

Adding mixed numbers. The combination of a whole number and fraction, such as $1\frac{1}{4}$, is called a mixed number. To add mixed numbers, add the whole numbers, add the fractions, and combine the two sums. The mixed numbers $7\frac{7}{15}$ and $1\frac{4}{15}$ are added in the following manner:

$$7\tfrac{7}{15} + 1\tfrac{4}{15} = 7 + 1 + \frac{7 + 4}{15} = 8\tfrac{11}{15}$$

Subtraction of Fractions

Fractions can be subtracted only when they have a common denominator.

Subtracting fractions with a common denominator. Fractions with a common denominator are subtracted by finding the difference between the numerators and placing the result over the common denominator. The fraction $\frac{4}{9}$ can be subtracted from $\frac{7}{9}$ in the following manner:

$$\frac{7}{9} - \frac{4}{9} = \frac{7 - 4}{9} = \frac{3}{9}$$

$= \frac{1}{3}$ (reduced to lowest terms)

Subtracting fractions with unlike denominators. Fractions with unlike denominators must be converted to fractions having common denominators before one can be subtracted from the other. Subtraction is then carried out in the manner described above for subtracting fractions with a common denominator.

Subtracting mixed numbers. To subtract one mixed number from another, subtract the whole numbers and the fractions separately. If the numerator of the fraction in the subtrahend is larger than the numerator of the fraction in the minuend, "borrowing" must be carried out in the minuend. In the case of subtracting $5\frac{5}{8}$ from $9\frac{3}{8}$, a quantity of 1 ($\frac{8}{8}$) must be borrowed from the 9 and added to the $\frac{3}{8}$ to make the numerator in the minuend larger than the numerator in the subtrahend. This borrowing reduces the whole number 9 to 8. Subtraction is then carried out by subtracting whole numbers from whole numbers and fractions from fractions, as in the following:

$$\begin{array}{r} 9\frac{3}{8} \\ \underline{-5\frac{5}{8}} \end{array} = \begin{array}{r} 8\frac{11}{8} \\ \underline{-5\frac{5}{8}} \end{array} = 3\tfrac{6}{8} = 3\tfrac{3}{4} \text{ (reduced to lowest terms)}$$

Multiplication of Fractions

The multiplication of common fractions does not require that the fractions have a common denominator.

Multiplying two or more fractions. When fractions are multiplied by fractions, the numerators are multiplied by numerators, the denominators are multiplied by denominators, and the product of the numerators is written over the product of the denominators. The following example illustrates how $\frac{2}{3}$ is multiplied by $\frac{3}{4}$:

$$\frac{2}{3} \times \frac{3}{4} = \frac{2 \times 3}{3 \times 4} = \frac{6}{12}$$

$= \frac{1}{2}$ (reduced to lowest terms)

Multiplying mixed numbers. In problems involving the multiplication of a mixed number, the mixed number should be changed to an improper fraction before the multiplication is carried out. To do this, multiply the whole number by the denominator of the fraction, add the product to the numerator, and write the sum over the denominator. The fraction $2\frac{3}{4}$ is changed to an improper fraction as follows:

$$2\tfrac{3}{4} = \frac{(2 \times 4) + 3}{4} = \frac{11}{4}$$

Once the mixed number has been changed to an improper fraction, multiplication is carried out in the manner described for multiplying two or more fractions.

Cancelling in multiplying fractions. The multiplication of fractions can be simplified by cancelling—dividing any numerator and any denominator by some divisor that is common to both. The following example illustrates how cancelling can be done in the multiplication of $\frac{5}{8} \times \frac{2}{15}$:

$$\frac{\overset{1}{\cancel{5}}}{\underset{4}{\cancel{8}}} \times \frac{\overset{1}{\cancel{2}}}{\underset{3}{\cancel{15}}} = \frac{1 \times 1}{4 \times 3} = \frac{1}{12}$$

In this problem, the numerator 5 and the denominator 15 are both divided by 5, and the numerator 2 and the denominator 8 are divided by 2. Multiplication is then carried out in the manner for multiplying one fraction by another.

Division of Fractions

As in the multiplication of common fractions, division of common fractions does not require conversion to a common denominator.

Dividing fractions by fractions. When any fraction is to be divided by another fraction, the divisor must be inverted before the operation can be carried out. Inverting a fraction means turning it so that the numerator becomes the denominator and the denominator becomes the numerator. The fraction $^{9}/_{16}$ becomes $^{16}/_{9}$ when inverted. Once the divisor has been inverted, the fractions are *multiplied,* using the procedure previously shown for multiplication of fractions.

Dividing mixed numbers by mixed numbers. To divide one mixed number by another, change the mixed numbers to improper fractions, invert the divisors, and multiply the fractions in the manner previously described.

Decimals

Decimal fractions, or simply decimals, are fractions in which only the numerator is expressed. The denominator is understood to be 10 or some multiple of 10 (100, 1,000, 10,000, and so forth) and is represented by the use of the decimal point. The value of the unexpressed denominator in a decimal fraction depends on how many numbers occupy places to the right of the decimal point; that is, on how many numbers are in the numerator. The following are some examples of decimal fractions with different denominators:

0.3 = three tenths
0.03 = three hundredths
0.003 = three thousandths
0.0003 = three ten thousandths

Fractional parts of units are often expressed in decimals. Because the monetary system of the United States is based on the decimal system, a thorough understanding of decimals is essential for anyone who deals in dollars and cents. For roofers this understanding is vital also because of the many instances in which they must perform addition, subtraction, multiplication, and division with decimals.

Many of the errors that are made in work involving decimals are the result of misaligned or misplaced decimal points. Great care should be taken, therefore, to make sure that the decimal point is properly placed when a problem and its solution are written.

Addition of Decimals

Decimals are added in the same way that whole numbers are added, except that the decimal point is included in each of the addends and in the sum. The decimal points must be aligned vertically in the addends and in the sum. A good practice to follow in working with decimals is to add zeros where necessary to the right of the decimal point so that each number has the same number of decimal places. Addition of the numbers 3.73, 74.5, 0.05, and 1.25 is carried out in the following manner (note the addition of zero to 74.5 so that all numbers have the same number of decimal places):

$$\begin{array}{r} 3.73 \\ 74.50 \\ 0.05 \\ +\ 1.25 \\ \hline 79.53 \end{array}$$

Subtraction of Decimals

Decimals are subtracted in the same manner that whole numbers are subtracted, with the decimal points aligned vertically in the minuend, subtrahend, and remainder. Again, zeros should be added where necessary to the right of the decimal point to give both the minuend and subtrahend the same number of decimal places. The number 63.733 is subtracted from 98.55 in the manner shown below:

$$\begin{array}{r} 98.550 \\ -\ 63.733 \\ \hline 34.817 \end{array}$$

Multiplication of Decimals

Except for the special treatment required in placing the decimal point in the product, the multiplication process used with decimals is the same as that used for multiplying whole numbers. Placement of the decimal point in the product can be done only after the multiplication has been completed. The number of decimal places in the multiplicand and multiplier are counted, and the decimal point is then inserted that number of places from the right in the product. If the number of decimal places counted is greater than the number of digits in the product, enough zeros must be added at the left of the product so that the decimal point can be placed the correct number of places from the right. The example that follows shows how 85.5 is multiplied by 3.26:

$$\begin{array}{r} 85.5 \\ \times\ 3.26 \\ \hline 5130 \\ 1710 \\ 2565 \\ \hline 278.730 \end{array}$$

Note that the decimal point in the product is placed three numbers from the right, because there are three decimal places in the multiplicand and multiplier.

Division of Decimals

In division of decimals, the divisor should be converted to a whole number by moving its decimal point to the extreme right; the decimal point in the dividend should also be moved the same number of places to the right. If the dividend has fewer digits than the divisor, zeros are added to the dividend so that both have at least the same number of digits. Additional zeros can be added in the dividend if it is desired that the quotient be carried out to an even greater number of decimal places. The decimal point in the quotient is placed directly over the decimal point in the dividend, and division is carried out in the manner used for division of whole numbers. The following example indicates how 48 is divided by 0.08:

$$0.08\overline{)48} = 0.08.\overset{6.00}{\overline{)48.00.}}$$

Rounding Off of Decimals

Rounding off numbers is desirable in situations that require only an approximate figure; that is, in instances in which an extremely high degree of accuracy is not necessary. When any number is rounded off, the implication is that the number used is accurate enough for practical purposes.

The process of rounding off numbers is used most frequently with decimals. The number 647.42857, for example, is carried out five decimal places. This indicates a high degree of accuracy but may be more than is really required by certain circumstances. In a situation that calls for accuracy in tenths, a decision should be made as to whether the number is closer to being 647.4 or 647.5. The following rules for rounding off numbers can be used to reach a conclusion:

1. If the first digit to be dropped is less than five, the last digit to be kept is left as it is.
2. If the first digit to be dropped is greater than five, the last digit to be kept is increased by one.
3. If the first digit to be dropped is five, the last digit to be kept is generally increased by one.

The number 647.42857 rounded off to the nearest tenth is, therefore, 647.4; to the nearest hundredth, 647.43; to the nearest thousandth, 647.429. To the nearest whole number, 647.42857 is rounded off to 647.

Percent

The word *percent* is an abbreviation of the Latin *per centum* and literally means "for each hundred" or "by the hundred." The term *percentage* means the method of expressing a part of a whole as hundredths of a whole. Thus, 12 percent means 12 parts of a whole that is thought of as consisting of 100 parts; 100 percent means all 100 parts of the whole taken together; and 108 percent means all 100 parts of the whole, plus 8 more such parts.

Percents are often used in determining profit and loss, discounts, taxes, and interest on loans. Knowledge of the rules and procedures for solving the many kinds of percentage problems is, therefore, indispensable for the roofer.

Conversion of Percents to Common Fractions and Decimals

Since percents are expressions of the parts of a whole, they can be converted to common fractions or to decimals. Any percent can be changed to a fraction by removing the percent sign (if the sign is being used) and writing the number over the denominator 100. As a fraction, 25 percent is equivalent to $^{25}/_{100}$; 100 percent is equivalent to $^{100}/_{100}$ or 1.0; and 108 percent is equivalent to $^{108}/_{100}$ or $1^{8}/_{100}$ ($1^{2}/_{25}$ reduced to lowest terms).

To convert a percent to a decimal, remove the percent sign, and move the decimal point two places to the left (36% = 0.36). This process can be used in reverse to change a decimal to a percent. The decimal 0.06, for example, becomes 6% by moving the decimal point two places to the right and affixing the percent sign.

Conversion of Common Fractions to Percents

In the conversion of a common fraction to a percent, the fraction must first be changed to a decimal fraction by dividing the numerator by the denominator. For example, $^{1}/_{4} = 1.00 \div 4 = 0.25$. Conversion to a percent is then completed by moving the decimal point two places to the right and adding the percent sign, as previously described (0.25 = 25%).

Terms and Formulas Used in Percent Problems

A worker who must solve problems involving percents should be familiar with the following terms and definitions:

1. *Base (B)* is the number on which percent is computed. The base may be the rental price of an article, the total number of square feet to be covered, the principal amount of a loan, or the like.
2. *Rate (R)* is the number of hundredths of the base to be considered (the number with the percent sign).
3. *Percentage (P)* is the number of hundredths of the base as indicated by the rate. Percentage is the product obtained by multiplying the base by the rate.
4. *Difference (D)* is the remainder after the percentage is subtracted from the base.
5. *Amount (A)* is the sum of the base and the percentage. It is, for example, the total amount of material needed to cover a given area, including waste allowance, or the total amount to be repaid in the case of a loan (principal plus inter-

est). It may also be the total selling price, including costs, percent of profit, and so forth.

The task of determining the base, rate, percentage, difference, or amount in a percent problem can be much simplified through the use of some fundamental rules or formulas:

1. $B = P \div R$
2. $B = A \div (1.0 + R)$
3. $B = D \div (1.0 - R)$
4. $R = P \div B$
5. $P = B \times R$
6. $D = B - P$
7. $D = B \times (1.0 - R)$
8. $A = B + P$
9. $A = B \times (1.0 + R)$

Common Percent Problems

Three common types of percent problems that a roofer may have to solve are those that involve (1) percent of gain or loss; (2) amounts of materials to order, including waste allowance; and (3) discounts.

Determining percent of gain or loss. If finding the percent of gain or loss is desirable, the following procedure should be followed: (1) find the difference between the initial and final values; and (2) divide this difference by the final value. For example, the percent of gain on a lot that was purchased for $1,600 and later sold for $2,400 is 33⅓ percent ($2,400 − $1,600 = $800, and $800 ÷ $2,400 = 33⅓ percent).

Determining amounts of material to order. In computations to determine amounts of materials to order, including allowance for waste, the base (the number of square feet in the area under consideration) is multiplied by the percent of waste allowance; and this product (the percentage of waste) is then added to the base. For example, if the waste allowance of the material to be used is 10 percent and an area of 300 square feet is to be covered, a total of 330 square feet of material should be ordered (300 sq. ft. × 0.10 = 30 sq. ft. of waste, and 300 sq. ft. + 30 sq. ft. = 330 sq. ft.). *NOTE:* Although this method for determining amounts to order will yield a result that is not mathematically exact, the procedure is nevertheless accepted for use within the roofing trade. The percent of allowance for waste is set higher than that which will actually result, thereby ensuring that the amount of material to be ordered will be at least enough to cover the area.

Determining discounts. In the calculation of discount, the base price is multiplied by the rate of discount, and then the product of this operation (the percentage) is subtracted from the base price. The difference represents the actual selling price. For example, a roofer who receives a 20 percent discount on a shingling hatchet with a retail price of $15 will actually pay only $12 for the tool ($15 × 0.20 = $3, and $15 − $3 = $12).

Compound Numbers

The term *compound number,* as used in this topic, is defined as a number that includes more than one unit of measure, such as 6 feet 9 inches, 8 pounds 4 ounces, or 2 hours 10 minutes.

Addition of Compound Numbers

Two methods may be used to add compound numbers:

1. Reduce the given quantities to the smallest unit of measure in the problem, and then add the numbers. The result can be left as it is, or it can be converted to the greater unit of measure, whichever is desired.
2. Carry out the addition of the numbers as they are given, making any needed conversions or reductions during the process of adding.

If the first method described above is used to add 6 feet 9 inches and 2 feet 4 inches, both quantities should be expressed in inches before the addition is performed. The quantity 6 feet 9 inches becomes 81 inches (6 × 12 in. = 72 in., and 72 in. + 9 in. = 81 in.). In like manner, 2 feet 4 inches is then converted to 28 inches, and the two figures are added (81 in. + 28 in. = 109 in.). The sum, 109 inches, can be used as it is; or it can be converted to 9 1/12 feet or 9 feet 1 inch (109 in. ÷ 12 = 9 1/12 ft. or 9 ft. 1 in.).

In the use of the second method described above, inches are added to inches, the sum of the addition of inches is reduced (converted) if necessary, and then feet are added to feet, including any number of feet resulting from the conversion of the sum of the inches. In the addition of 6 feet 9 inches and 2 feet 4 inches, the sum of the inches is found to be 13 inches (9 in. + 4 in. = 13 in.). This sum is converted to 1 foot 1 inch (13 in. ÷ 12 = 1 ft. 1 in.); and the sum of the number of feet, including the 1 foot obtained in the conversion, is determined to be 9 feet (6 ft. + 2 ft. + 1 ft. = 9 ft.). The two sums are then combined to give a result of 9 feet 1 inch. This same problem might also be written as follows:

```
  (1)
  6 ft.  9 in
+2 ft.  4 in.
 8 ft. 13 in. = 9 ft. 1 in.
```

Subtraction of Compound Numbers

The ability to subtract one compound number from another can be very useful to roofers, especially when they may have to work with plans that do not include all needed dimensions. Given an overall dimension (for example, 10 ft. 9 in.) and a part (4 ft. 8 in., for example) of the overall dimension, a roofer can determine the unstated part of the overall dimension by subtracting the known part from the whole.

In the subtraction of one compound number from another, either of the two methods described for addition of compound numbers may be used; that is, the two quantities can be converted to the same unit of measure before subtraction is performed, or any necessary conversions can be made during the subtraction of the numbers as given. *NOTE:* In problems in which digits in the subtrahend are larger than corresponding digits in the minuend, borrowing (conversion) must be carried out before the subtraction can be performed. In the subtraction of 5 feet 9 inches from 19 feet 8 inches, the 9 inches in the subtrahend cannot be subtracted from the 8 inches in the minuend. Thus, 1 foot, or 12 inches, must be borrowed in the minuend. The 12 inches are added to the given number of inches, and the number of feet in the minuend is decreased by one. The problem can then be viewed as the subtraction of 5 feet 9 inches from 18 feet 20 inches, as shown below:

$$\begin{array}{r} 18 \text{ ft. } 20 \text{ in.} \\ -\ 5 \text{ ft. } \ 9 \text{ in.} \\ \hline 13 \text{ ft. } 11 \text{ in.} \end{array}$$

Multiplication of Compound Numbers

Multiplication is the mathematical process used to determine area, volume, and sometimes total length. For the roofer this process often involves one or more compound numbers.

In the multiplication of compound numbers, any necessary reductions or conversions can be made during or after the multiplication. The recommended procedure is to make reductions or conversions after the completion of the multiplication.

To multiply a compound number by a mixed number, multiply each unit of measure separately, and then reduce or convert if necessary. Multiplying 2 feet 3 inches by 5 is therefore accomplished by multiplying 3 inches by 5 (3 in. × 5 = 15 in.) and multiplying 2 feet by 5 (2 ft. × 5 = 10 ft.). The product, 10 feet 15 inches, is then converted to 11 feet 3 inches. If the solution to this problem were to be expressed to the next even foot (as in determining how many linear feet of a material to purchase), the product would be increased to 12 feet.

Mutliplying one compound number by another is more difficult than multiplying a compound number by a whole number. Before one compound number can be multiplied by another, both numbers *must* be converted to the same unit of measure. For example, to multiply 6 feet 9 inches by 7 feet 4 inches, convert the dimensions either to feet only or to inches only before multiplying.

The unit of measure desired in the answer will be the deciding factor in determining which unit to convert. If the problem stated above were one of calculating floor area, the preferred conversion would be to feet since floor area is generally expressed in square feet. The 6 feet 9 inches converted to feet would be $6\frac{9}{12}$ feet or $6\frac{3}{4}$ feet or 6.75 feet. The 7 feet 4 inches converted to feet would be $7\frac{4}{12}$ feet or $7\frac{1}{3}$ feet or 7.33 feet. The multiplication of the two measurements may be done by using fractions or decimals, but less difficulty is generally encountered if decimal fractions are used, as in the following:

$$\begin{array}{r} 6.75 \text{ ft.} \\ \times\ 7.33 \text{ ft.} \\ \hline 2025 \\ 2025 \\ +\ 4725 \\ \hline 49.4775 \end{array}$$

or 49.5 ($49\frac{1}{2}$) sq. ft.

For the purpose of *estimating* areas, roofers often convert dimensions to the nearest whole foot before multiplying. The dimension 6 feet 9 inches would be considered as 7 feet, and the 7 feet 4 inches would become 7 feet. The product 49 square feet (7 ft. × 7 ft. = 49 sq. ft.) is accurate enough as an estimate.

Division with Compound Numbers

In division involving compound numbers, generally a compound number is the dividend, and a whole number is the divisor. In very few instances are both the dividend and divisor compound numbers.

Before the division can be done, the compound number should be converted to a value expressed in a single unit of measure. The quantity 9 feet 8 inches, for example, can be converted to 116 inches (12 in. × 9 = 108 in., and 108 in. + 8 in. = 116 in.); to $9\frac{2}{3}$ feet (9 ft. 8 in. = $9\frac{8}{12}$ ft. = $9\frac{2}{3}$ ft.); or to 9.67 ft. ($9\frac{2}{3}$ ft. = $\frac{29}{3}$ ft. = 29 ÷ 3 = 9.67 ft.). The recommended procedure is to convert the feet and inches to inches only to avoid having to work with any type of fraction.

Metric Measurements and Conversion

Two standards of measurement are presently being used in the world—the British imperial system (English system) and the metric system.

The English system is based on the yard (36 inches), and the metric system is based on the metre (39.37 inches). The metric system is a decimal system, similar to the U.S. monetary system. All units in the metric system are based on the metre, which is divided into decimetres (tenths), centimetres (hundredths), and millimetres (thousandths). One metre, then, contains 10 decimetres, 100 centimetres, and 1 000 millimetres. Ten metres equals a decametre, 100 metres is a hectometre, and 1 000 metres is equal to a kilometre.

Both the apprentice and the journey-level worker would do well to learn as much as possible about the metric system because in the near future it will become the standard system of measurement in the United States. Naturally the changeover from the English system to the metric system will cause some difficulty for all workers because the units of one system are not evenly divisible by the units of the other. But this period of difficulty should exist only until one is able to think entirely in terms of the metric system; that is, until one no longer feels the need to "translate" a given metric quantity into its corresponding form in the English system. One of the principal benefits to be gained from utilization of the metric system is that the use of metric units will eventually eliminate the complications involved in calculating with common fractions. During the changeover period, perhaps the easiest and surest way of working with metric units is to use conversion tables such as those provided in tables 4-1 and 4-2.

Conversion of Metric Units to English Units

Metric units can be converted to English units by multiplying the given number of metric units by the corresponding factor for that unit shown in Table 4-1 and rounding off the product to the number of decimal digits needed for practical application. For example, converting 200 millimetres to inches can be done by multiplying 200 by 0.03937, the number of inches contained in a millimetre, and then rounding off the answer to the desired number of decimal places (200 × 0.03937 in. = 7.87400 in. = 7.87 in.). If a common fraction is more desirable or practical than a decimal fraction in the answer, the decimal can be converted to the *nearest* common fraction (7.87 in. = 7⅞ in.).

Conversion of English Units to Metric Units

The first step in converting English units to metric units is to change any fractional part of the English

TABLE 4-1

Conversion Factors for Metric to English Units

Type of measure	To change from	To	Multiply by
Linear	Millimetres (mm)	Inches	0.03937
	Centimetres (cm)	Inches	0.3937
	Centimetres (cm)	Feet	0.03281
	Decimetres (dm)	Inches	3.937
	Decimetres (dm)	Feet	0.3281
	Metres (m)	Inches	39.37
	Metres (m)	Feet	3.28083
	Metres (m)	Yards	1.0936
	Decametres (dkm)	Feet	32.80
	Hectometres (hm)	Feet	328.0
	Kilometres (k)	Miles	0.6241
Area	Square millimetres (m^2)	Square inches	0.00155
	Square centimetres (cm^2)	Square inches	0.1550
	Square decimetres (dm^2)	Square inches	15.50
	Square decimetres (dm^2)	Square feet	0.1076
	Square metres (m^2)	Square inches	1550.0
	Square metres (m^2)	Square feet	10.76
	Square metres (m^2)	Square yards	1.196
Volume	Cubic centimetres (cm^3)	Cubic inches	0.06102
	Cubic decimetres (dm^3)	Cubic inches	61.023
	Cubic metres (m^3)	Cubic feet	35.315
	Cubic metres (m^3)	Cubic yards	1.308
Weight	Grams (g)	Ounces (avoir.)	0.03527
	Grams (g)	Pounds	0.002205
	Kilograms (kg)	Pounds	2.205
	Metric tons (MT)	Pounds	2205.0
Power	Kilowatts (kw)	Horsepower	1.34
	British thermal units (Btu)	Calories	252.0
Temperature	Centigrade (C)	Fahrenheit	Use the formula: $F^\circ = (C^\circ \times 9/5) + 32$

unit to its eqivalent decimal form. Then the given quantity of English units should be multiplied by the corresponding factor for that unit shown in Table 4-2 and the result rounded off to the precision required. In the conversion of 1,531¼ square feet to square metres, for example, the number of square feet should be restated with the common fraction expressed as a decimal (1,531¼ = 1,531.25). The number of square feet is then multiplied by 0.0929, the number of square feet in a square metre (1,531.25 × 0.0929 m^2 = 142.253125 m^2); and the product is rounded off to the desired number of decimal places (142.253125 m^2 = 142.25 m^2). *NOTE:* Relatively small measurements, such as 17.3 centimetres, are generally expressed in equivalent millimetre form (17.3 centimetres would be expressed as 173 millimetres).

The apprentice should be aware that the conversion of measurements from one system to the other will produce only semiaccurate equivalents. Complete accuracy cannot be attained, because the units of one system are not evenly divisible by the units of the other, as mentioned previously. However, increasing the number of decimal places to which the metric unit is carried out increases the accuracy of the conversion.

TABLE 4-2

Conversion Factors for English to Metric Units

Type of measure	To change from	To	Multiply by
Linear	Inches (in)	Millimetres	25.4
	Inches (in)	Centimetres	2.54
	Inches (in)	Decimetres	0.254
	Feet (ft)	Centimetres	30.48
	Feet (ft)	Decimetres	3.048
	Feet (ft)	Metres	0.3048
	Yards (yd)	Centimetres	91.44
	Yards (yd)	Metres	0.9144
	Miles (mi)	Kilometres	1.609
Area	Square inches (sq in)	Square centimetres	6.451
	Square inches (sq in)	Square decimetres	0.0645
	Square feet (sq ft)	Square centimetres	929.0
	Square feet (sq ft)	Square decimetres	9.29
	Square feet (sq ft)	Square metres	0.0929
	Square yards (sq yd)	Square metres	0.8361
	Square miles (sq mi)	Square kilometres	2.590
Volume	Cubic inches (cu in)	Cubic centimetres	16.387
	Cubic feet (cu ft)	Cubic metres	0.0283
	Cubic yards (cu yd)	Cubic metres	0.7646
Weight	Ounces-avoir. (oz)	Grams	28.35
	Pounds (lb)	Grams	453.6
	Pounds (lb)	Kilograms	0.454
Liquid	Ounces (oz)	Litres	0.02957
	Fluid ounces (fl oz)	Cubic centimetres	29.574
	Pints (pt)	Litres	0.473
	Quarts (qt)	Litres	0.9464
	Gallons (gal)	Litres	3.785
Power	Horsepower (hp)	Kilowatts	0.746
	Calories (cal)	British thermal units	0.003968
Temperature	Fahrenheit (F)	Centigrade	Use the formula: $C° = (F° - 32) \times \frac{5}{9}$

Study Assignment

Determine the correct answer for each of the following problems and enter the result in the corresponding blank at the right.

1. 16 + 4 + 15 + 3 = ______
2. 5 + 18 + 17 + 9 = ______
3. 107 + 7 + 21 + 30 = ______
4. 32 − 21 = ______
5. 921 − 32 = ______
6. 48 × 15 = ______
7. 236 × 47 = ______
8. 536 × 103 = ______
9. 185 ÷ 5 = ______
10. 7,686 ÷ 21 = ______
11. $\frac{1}{2} + \frac{1}{4}$ = ______
12. $\frac{1}{4} + \frac{9}{16}$ = ______
13. $2\frac{3}{8} + 3\frac{1}{4}$ = ______
14. $\frac{2}{3} - \frac{1}{3}$ = ______
15. $\frac{7}{8} - \frac{1}{2}$ = ______
16. $\frac{3}{4} - \frac{7}{12}$ = ______
17. $\frac{1}{2} \times \frac{1}{3}$ = ______
18. $3\frac{7}{8} \times 3\frac{3}{8}$ = ______
19. $\frac{4}{5} \div 2$ = ______
20. $4\frac{5}{8} \div \frac{1}{3}$ = ______
21. $2.53 + $5.36 + $0.29 + $23.58 = ______
22. 0.17 + 5.3 + 0.53 + 9.632 = ______
23. 3.7 − 0.24 = ______
24. 0.38 − 0.26 = ______
25. 1.3 × 0.2 = ______
26. 5.7 × 2.5 = ______
27. 36.36 ÷ 6 = ______
28. 3.636 ÷ 0.6 = ______
29. 0.13 to the nearest tenth = ______
30. 5.176 to the nearest hundredth = ______
31. As a decimal fraction, 25 percent = ______
32. As a decimal fraction, 2.5 percent = ______
33. As a decimal fraction, 0.25 percent = ______
34. As a percent, 0.75 = ______
35. As a percent, 0.11 = ______
36. As a percent, 0.111 = ______
37. As a percent, $\frac{1}{8}$ = ______
38. As a percent, $\frac{2}{3}$ = ______
39. As a common fraction, 25 percent = ______
40. As a common fraction, 5 percent = ______
41. 15 feet 4 inches + 12 feet 8 inches + 13 feet 9 inches + 20 feet 10 inches = ______
42. 5 yards 2 feet 8 inches + 7 yards 1 foot 6 inches + 12 yards 2 feet 0 inches = ______
43. 23 feet 10 inches − 21 feet 6 inches = ______
44. 13 feet 6 inches − 4 feet 9 inches = ______
45. 5 yards 2 feet 10 inches − 2 yards 1 foot 5 inches = ______
46. 3 feet 8 inches × 6 = ______
47. 17 feet 9 inches × 14 = ______
48. 11 feet 6 inches ÷ 3 = ______
49. 19 feet 3 inches ÷ 3 = ______
50. 50 feet 2 inches ÷ 14 = ______
51. 100 square feet = ______ square metres ______
52. 2½ feet = ______ centimetres ______
53. 55 pounds = ______ kilograms ______
54. 65 cubic metres = ______ cubic yards ______
55. 160 millimetres = ______ inches ______

TOPIC 5 — COMMON MEASUREMENT AND CALCULATION PROBLEMS IN ROOFING

This topic and the related instruction classes are designed to enable the apprentice to do the following:

- **Determine the number of inches of exposure required for multiple-ply roof systems.**
- **Determine the number of rolls of felt needed to complete a job.**
- **Describe linear measurements.**
- **Calculate the number of squares in a shed or gable roof.**
- **Calculate the number of squares in a hip roof.**
- **Determine the number of squares in a parapet wall.**
- **Describe the procedures for determining the number of squares contained in circular, dome, barrel, and triangular roofs.**

Roofers are often required to determine or estimate various types of measurements. Most of the measurements involve either the perimeter or area of a roof. In most cases such calculations must be made for purposes of estimating and ordering materials for the job. The ability to make certain calculations quickly and accurately can be instrumental in keeping the costs of a job to a minimum—and the profits, therefore, to a maximum. Every trip that must be made for additional materials, for example, adds to the cost of the job and delays its completion. In the same manner, purchasing too much material because of overestimating the need for it can result in lost dollars and wasted materials.

Determining Felt Exposures for Built-up Roofs

Often roofers must determine felt exposures on multiple-ply built-up roof systems. If 36-inch-wide (91.4-centimetre-wide)* felts are to be used, the felt exposure can be calculated by subtracting 2 inches (5.1 centimetres) from the width of the felt rolls and dividing the remainder by the number of plies. (*NOTE:* Two inches (5.1 centimetres) represents the width of the selvage edge, a strip that differs from the main part of a sheet of roofing material; for example, the granule-free edge on some types of mineral-surfaced roll roofing.) For example, if 36-inch-wide (91.4-centimetre-wide) felt is to be used, 2 inches (5.1 centimetres) is subtracted from the width of the felt, and the remainder (34 inches, or 86.4 centimetres) is divided by the number of plies to be applied. With a three-ply assembly, the exposure for each ply would be $11\frac{1}{3}$ inches (28.7 centimetres) (36 in. − 2 in. = 34 in., and 34 in. ÷ 3 = $11\frac{1}{3}$ in.). The exposure of a four-ply roof would be $8\frac{1}{2}$ inches (21.6 centimetres) (36 in. − 2 in. = 34 in., and 34 in. ÷ 4 = $8\frac{1}{2}$ in.) For a five-ply assembly, the exposure would be $6\frac{4}{5}$ inches (17.3 centimetres) (36 in. − 2 in. = 34 in., and 34 in. ÷ 5 = $6\frac{4}{5}$ in.).

Estimating Materials Needed to Finish a Job

Sometimes the materials on hand at the jobsite may be insufficient to finish the job, and additional materials must be brought from the yard or must be purchased. How much additional material to transport or order will depend on the size of the unfinished area of the roof. In determining the approximate quantities, the roofer must first calculate the number of squares (100 square feet, or 9.3 square metres) left to cover.

Once the number of squares has been determined, this number should be multiplied by the number of plies to be applied, and this product should be divided by the number of squares that a single roll of the material will cover. If 12 squares remain, for example, on a three-ply built-up roof and 4-square felt rolls (such as No. 15 felt) are being used, the calculation of the number of additional rolls needed would be as follows: 12 (squares) × 3 (plies) = 36, and 36 ÷ 4 = 9 (rolls). Thus, nine additional rolls would be needed to cover the remaining 12 squares.

Linear Measurements

Linear measurement is used in the roofing trade for determining the straight footage of edgings, hips, ridges, starter strip flashings, gutters, and so forth. When estimating amounts of material, the roofer must not only figure the exact linear measurement (in linear feet) but also make allowance for laps, corners, and waste. These considerations increase the total amount of material required.

*For purposes of clarity and simplification, metric equivalents are not included with all calculations in this topic.

The perimeter of a roof is the distance around the outside boundary of the roof in linear feet, regardless of the shape of the roof—square, triangular, round, or whatever. Such a measurement does not, of course, reflect the total amount of material needed, because other parts of the roof, requiring the same material, may have to be considered.

Procedures for Determining the Number of Squares in a Roof

A roof surface has two dimensions—length and width. This surface measure, or area measure, is expressed in square units, usually square feet. The width and the length of a surface must both be expressed in the same units before an area measurement can be determined, because area is calculated by multiplying length by width, and only like units can be multiplied. Thus, if the length is given in inches, the width must also be in inches, and the area will be expressed in square inches. Similarly, if the width is in feet, the length must be in feet, and the area will be expressed in square feet.

To determine the number of squares in a roof, the roofer must first determine the area of the roof. Described below are some procedures for calculating the areas of different types of roofs and the number of squares to plan for in covering such roofs. (See Appendix B for a list of formulas that can be used to determine the areas of various types of roofs.)

Shed Roof

The procedure for determining the area of a shed roof (see Fig. 5-1) and the number of squares in such a roof is as follows:

1. Measure the length of the roof from one end of the rake to the other. The length of the rake in Figure 5-1 is 22 feet (6.7 metres).
2. Measure the width of the roof at the eave. This distance in Figure 5-1 is 20 feet (6.1 metres).

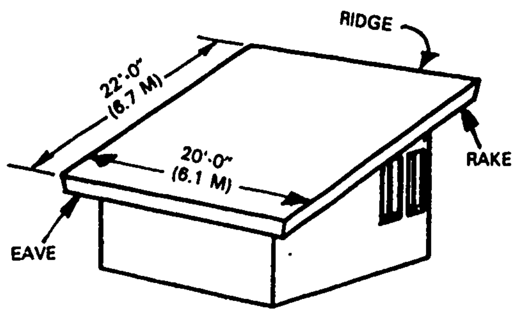


Fig. 5-1. A shed roof

3. Multiply the length by the width to determine the area in square feet. For Figure 5-1, 22 feet (6.7 metres) × 20 feet (6.1 metres) = 440 square feet (40.9 square metres).
4. Determine the number of squares in this product by dividing it by 100 square feet. For Figure 5-1, 440 square feet ÷ 100 square feet = 4.4 squares.
5. Round off the number of squares calculated in Step 4 to the next largest half square or full square: 4.4 squares = 4.5, or $4\frac{1}{2}$, squares.

Gable Roof

The area of a gable roof (see Fig. 5-2) and the number of squares included in a gable roof can be calculated as follows:

1. Multiply the sum of the lengths of the rakes by the length of the eave. For the roof shown in Figure 5-2, this calculation would be 20 feet (6.1 metres) × 20 feet (6.1 metres) = 400 square feet (37.2 square metres).
2. Divide the product determined in Step 1 by the number of square feet in a square: 400 square feet ÷ 100 square feet = 4 squares.

Plain Hip Roof

The procedure for finding the number of squares contained in a plain hip roof (see Fig. 5-3) is as follows:

1. Multiply the length of the main slope by 2. In Figure 5-3, the main slope is 10 feet (3 metres) long, and 2 × 10 feet (3 metres) = 20 feet (6.1 metres).
2. Multiply the product determined in Step 1 by the length of the roof at the eave. In Figure 5-3 the eave is 30 feet (9.1 metres) long, and 30 feet (9.1 metres) × 20 feet (6.1 metres) = 600 square feet (55.7 square metres).
3. Divide the product determined in Step 2 by the number of square feet in a square: 600 square feet ÷ 100 square feet = 6 squares.

Gable T Roof or Hip T Roof

The area of a gable T roof (see Fig. 5-4) or hip T roof and the number of squares contained in such a roof can be determined as follows:

1. Calculate the area of the main roof, disregarding the T. Use the method previously described for calculating the area of a gable roof. For the roof shown in Figure 5-4, 2 × 12 feet (3.7 metres) ×

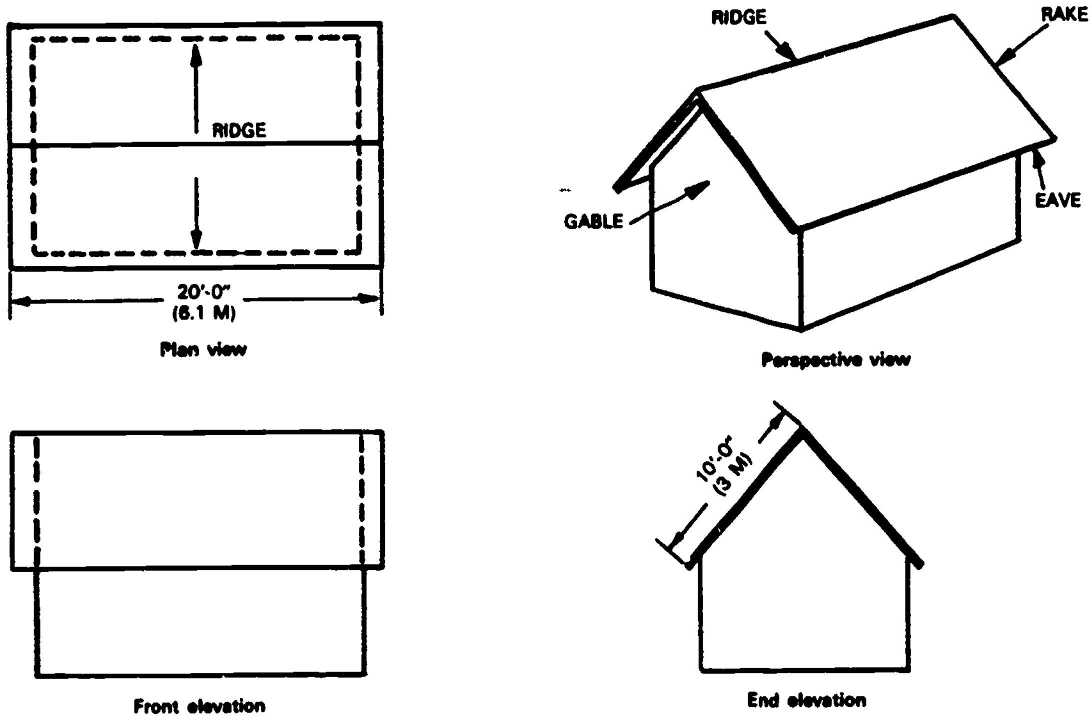


Fig. 5-2. Four views of a gable roof

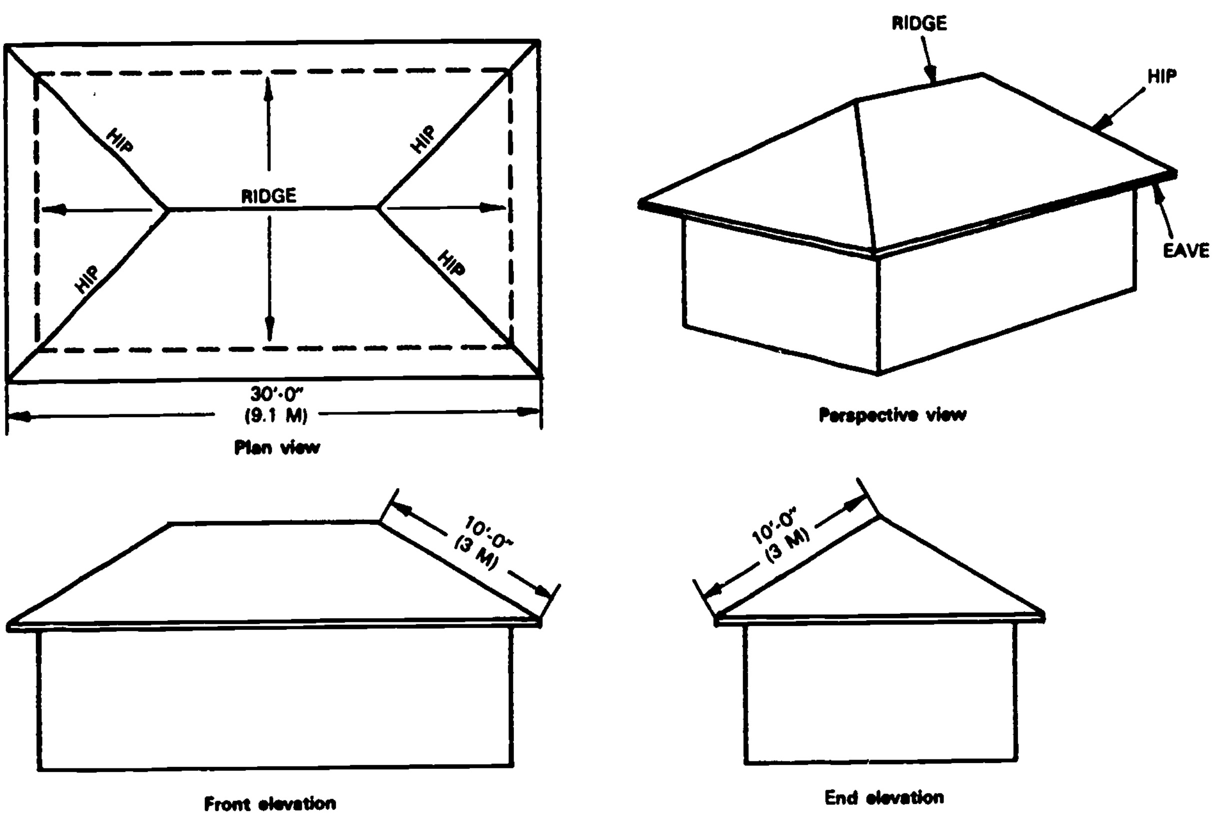


Fig. 5-3. Four views of a plain hip roof

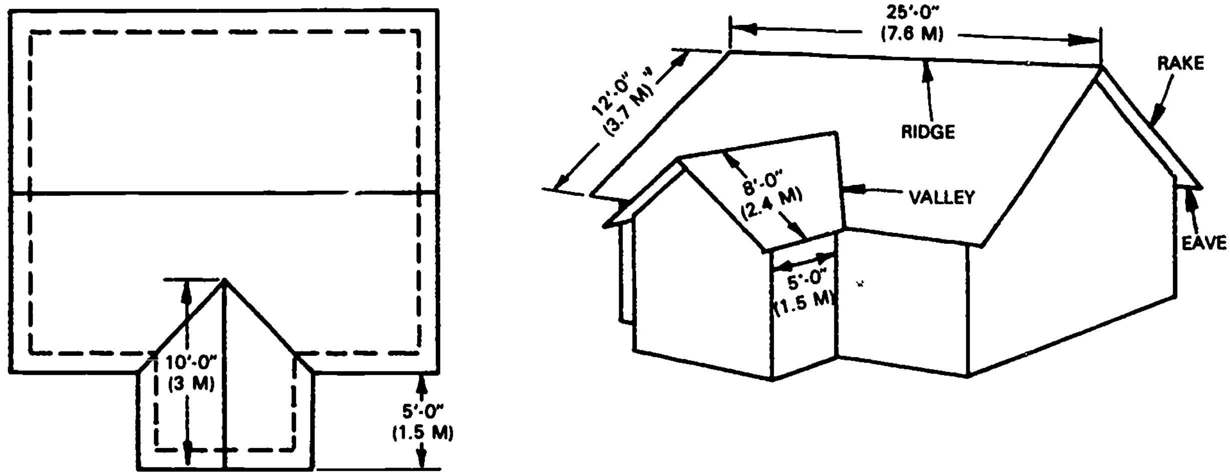


Fig. 5-4. An intersecting roof with a T gable

25 feet (7.6 metres) = 600 square feet (55.7 square metres).

2. Calculate the area of the T and add the square footage to the area of the main roof. For the T in Figure 5-4, 16 feet (4.8 metres) × 5 feet (1.5 metres) = 80 square feet (7.4 square metres), and 600 square feet (55.7 square metres) + 80 square feet (7.4 square metres) = 680 square feet (63.2 square metres). Note that the calculation is made to include only that part of the T that extends out past the eave line of the main roof.
3. Divide the total area by 100 square feet (9.3 square metres) to find the number of squares contained in the roof. For the roof in Figure 5-4, 680 square feet ÷ 100 square feet = 6.8 squares = 7 squares rounded off to the next largest square.

NOTE: When considering a hip roof, be sure to include the extra ridges and hips in the calculations.

Hip L Roof or Gable L Roof

A typical L gable roof is shown in Figure 5-5. Described below is the procedure for determining the area of such a roof and the number of squares included in it:

1. Add the lengths of the two ridges. For the roof in Figure 5-5, this calculation would be 30 feet (9.1 metres) + 20 feet (6.1 metres) = 50 feet (15.2 metres).
2. Multiply the sum from Step 1 by the sum of the lengths of the two rakes at one end of the roof. For Figure 5-5, 50 feet (15.2 metres) × 20 feet (6.1 metres) = 1,000 square feet (46.5 square metres).
3. Divide the product obtained in Step 2 by the number of square feet in a square: 1,000 square feet ÷ 100 square feet = 10 squares.

NOTE: Sometimes, it is easier to take measurements at the rakes and eaves and to treat the total area as being composed of two rectangles, as in the following calculations based on Figure 5-5:

1. 40 feet (12.2 metres) × 20 feet (6.1 metres) = 800 square feet (74.3 square metres)
2. 10 feet (3 metres) × 20 feet (6.1 metres) = 200 square feet (18.6 square metres)
3. 800 square feet (74.3 square metres) + 200 square feet (18.6 square metres) = 1,000 square feet (92.9 square metres)

Parapet Walls

Careful measurement of a parapet wall is essential for determining both the area of the wall and the amount of flashing required in constructing it.

Determining the number of squares in a parapet wall with one corner measuring zero. The area of a parapet wall with one corner that measures zero (see Fig. 5-6) and the number of squares contained in such a wall can be calculated as follows:

1. Determine the perimeter of the flat roof. The perimeter of the roof shown in Figure 5-6 is 100 feet (30.5 metres): 30 feet (9.1 metres) + 20 feet (6.1 metres) + 30 feet (9.1 metres) + 20 feet (6.1 metres) = 100 feet (30.5 metres).
2. Find the height of the parapet at the lowest point of the roof. In Figure 5-6 this height is 2 feet (91.4 centimetres).

3. Multiply the perimeter of the roof by the height determined in Step 2. For the roof in Figure 5-6, 100 feet (30.5 metres) × 2 feet (0.6 metre) = 200 square feet (18.6 square metres).
4. Divide the product obtained in Step 3 by 2. For Figure 5-6, 200 square feet (18.6 square metres) ÷ 2 = 100 square feet (9.3 square metres).
5. Divide the quotient obtained in Step 4 by the number of square feet in a square: 100 square feet ÷ 100 square feet = 1 square.

Determining the number of squares in a parapet wall with four corners having measurable heights. With a parapet wall that includes measurable heights at all four corners (see Fig. 5-7), one procedure for calculating the area of the wall and the number of squares contained in the wall is the following:

1. Determine the perimeter of the roof. The perimeter of the roof in Figure 5-7 is 100 feet (30.5 metres): 30 feet (9.1 metres) + 20 feet (6.1 metres) + 30 feet (9.1 metres) + 20 feet (6.1 metres) = 100 feet (30.5 metres).
2. Subtract the minimum height of the parapet from the maximum height and multiply the difference by half the perimeter: 30 inches (76.2 centimetres) − 6 inches (15.2 centimetres) = 24 inches (61 centimetres) = 2 feet; 2 feet (0.6 metre) × 50 feet (15.2 metres) (half the perimeter) = 100 square feet (9.3 square metres).
3. Multiply the minimum height of the parapet by the perimeter of the roof. For Figure 5-7, 0.5 feet (6 inches; 15.2 centimetres) × 100 feet (30.5 metres) = 50 square feet (4.6 square metres).
4. Add the figures obtained in steps 2 and 3 to determine the area of the inside verticle surfaces of the parapet. For Figure 5-7, 100 square feet (9.3 square metres) + 50 square feet (4.6 square metres) = 150 square feet (13.9 square metres).
5. Divide the area of the inside vertical surfaces of the parapet by the number of square feet in a square: 150 square feet ÷ 100 square feet = 1.5 squares.

Circular Roofs

The area of a circular roof (see Fig. 5-8) and the number of squares that such a roof comprises can be determined by following these steps:

1. Determine the diameter of the roof. (The diameter of a circle is a straight line that runs from a point on the outside of the circle through the center and on to another point on the outside of the circle.) The diameter of the circular roof in Figure 5-8 is 20 feet (6.1 metres).

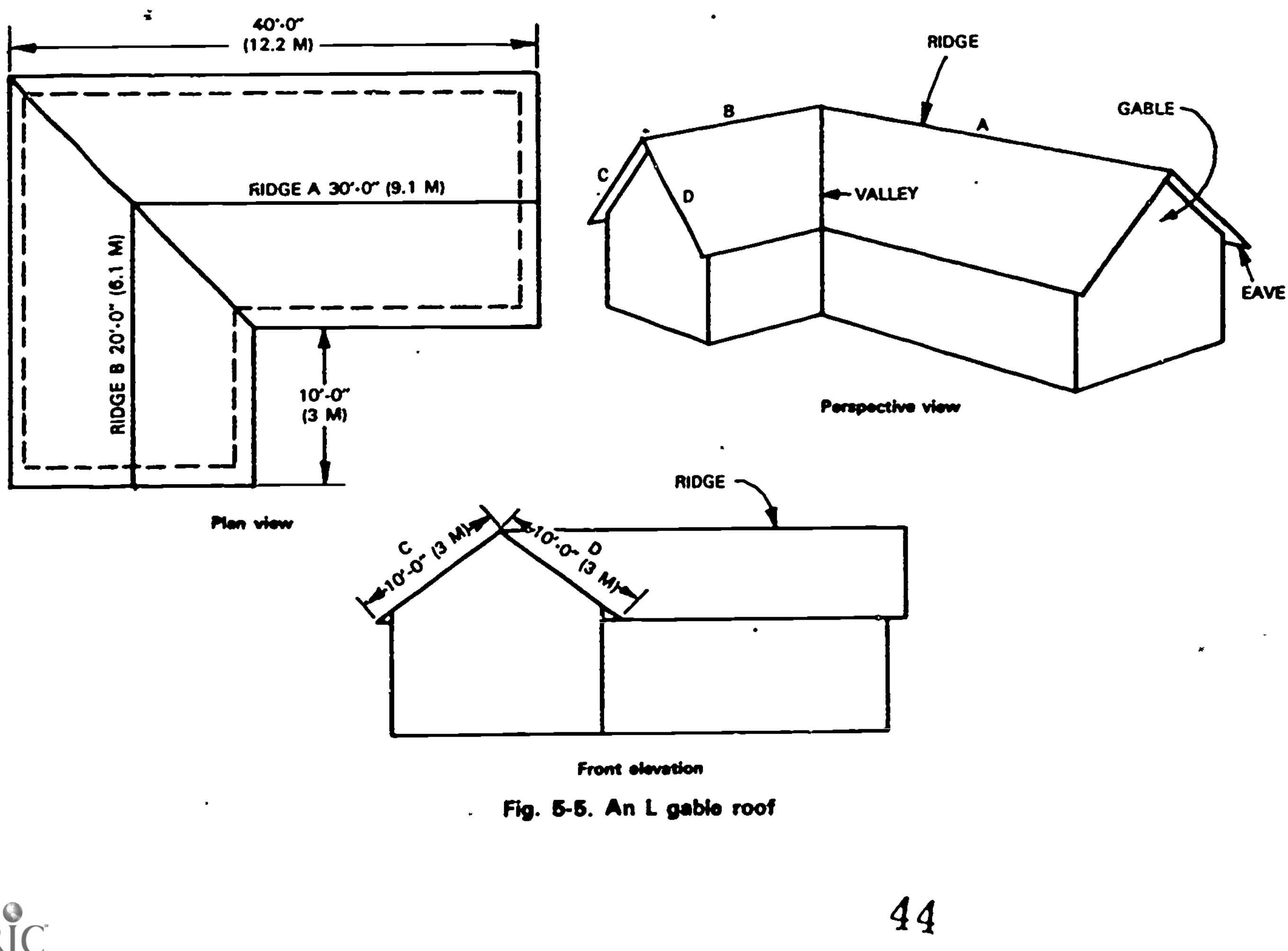


Fig. 5-5. An L gable roof

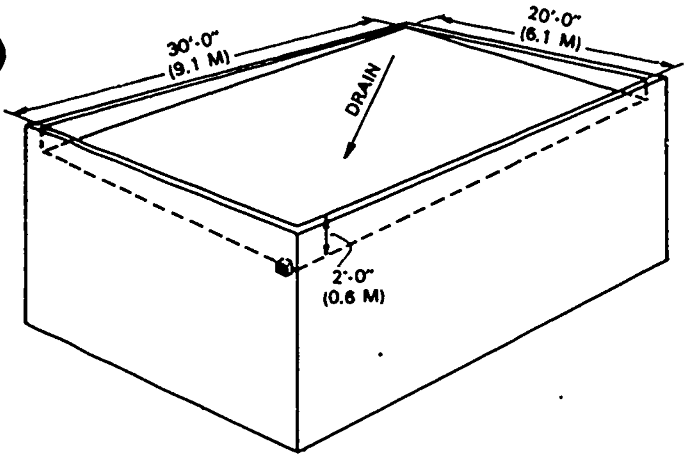


Fig. 5-6. Parapet wall with one corner measuring zero

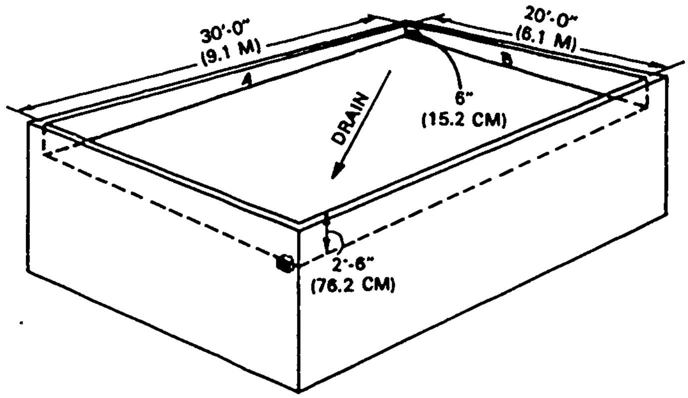


Fig. 5-7. Parapet wall with measurable heights at all four corners

2. Find the radius of the circle. (The radius of a circle is one-half the diameter.) The radius of the circular roof in Figure 5-8 is 10 feet (3 metres).
3. Square the radius (multiply the radius by itself). For Figure 5-8, 10 feet (3 metres) × 10 feet (3 metres) = 100 square feet (9.3 square metres).
4. Multiply the product obtained in Step 3 by 3.14 (3.14 is derived from π [the Greek letter pi], which stands for a constant value of 3.1416, or the number of times a circle will fit around its circumference). For Figure 5-8, 100 square feet (9.3 square metres) × 3.14 = 314 square feet (29.2 square metres).
5. Divide the area calculated in Step 4 by the number of square feet in a square: 314 square feet ÷ 100 square feet = 3.1 squares (3.5 squares rounded off).

Dome Roof

The area of a dome roof (see Fig. 5-9) and the number of squares to be covered in this type of roof can be determined as follows:

1. Determine the radius of the dome's base. The radius of the dome shown in Figure 5-9 is 50 feet (15.2 metres), since the radius equals one-half the diameter.
2. Square the radius of the dome. For Figure 5-9, 50 feet (15.2 metres) × 50 feet (15.2 metres) = 2,500 square feet (232.3 square metres).
3. Multiply π (3.14) by 4 (3.14 × 4 = 12.56).
4. Multiply the square of the radius calculated in Step 2 by 4 times π determined in Step 3: 2,500 square feet (232.3 square metres) × 12.56 = 31,400 square feet (2 917.1 square metres).
5. Divide the product obtained in Step 4 by 2: 31,400 square feet (2 917.1 square metres) ÷ 2 = 15,700 square feet (1 458.5 square metres).
6. Divide the number of square feet determined in Step 5 by 100 square feet to determine the number of squares contained in the roof: 15,700 square feet ÷ 100 square feet = 157 squares.

Barrel Roof

The procedure described below for figuring the area of a barrel roof (see Fig. 5-10) and the number of

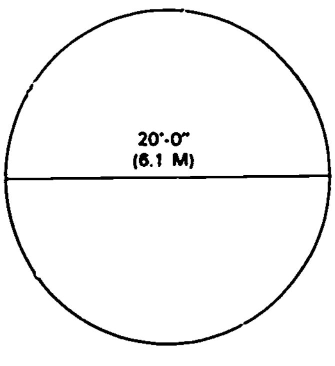


Fig. 5-8. A circular roof

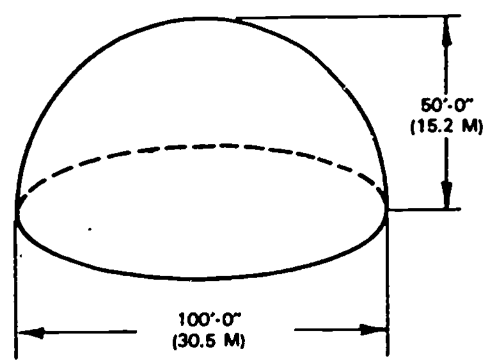


Fig. 5-9. A dome roof

squares included in this type of roof is not completely accurate, but it can generally be used for estimating the quantity of materials that will be needed:

1. Determine the span of the roof and add 14 percent to the span. In Figure 5-10 the span is 100 feet (30.5 metres), and 14 percent of the span is 14 feet (4.3 metres); thus, 100 feet (30.5 metres) + 14 feet (4.3 metres) = 114 feet (34.8 metres).
2. Multiply the sum determined in Step 1 by the width to determine the area of the roof. For Figure 5-10, 114 feet (34.8 metres) × 50 feet (15.2 metres) = 5,700 square feet (529.5 square metres).
3. Divide the area calculated in Step 2 by 100 square feet (9.3 square metres) to determine the number of squares contained in the roof: 5,700 square feet ÷ 100 square feet = 57 squares.

Triangular Roof

The area of a roof that is triangular in shape (see Fig. 5-11) can be calculated as follows:

1. Determine the length of the triangle's base. The base is the side upon which the triangle appears to rest. In the triangle in Figure 5-11, the base is 40 feet (12.2 metres).
2. Determine the height (or "altitude" as it is often called) of the triangle. The height of a triangle is the perpendicular line drawn to the base from the vertex (the point where two lines meet) opposite the base. The height (altitude) may also be determined by extending the base and altitude and connecting them, as shown in Figure 5-11. In Figure 5-11 the height of the triangle is 35 feet (10.7 metres).
3. Multiply the base by the height. For the triangular roof in Figure 5-11, 40 feet (12.2 metres) × 35 feet (10.7 metres) = 1,400 square feet (130.1 square metres).
4. Divide the product determined in Step 3 by 2 to determine the area of the triangle: 1,400 square feet (130.1 square metres) ÷ 2 = 700 square feet (65 square metres).
5. Divide the area of the triangle by 100 square feet (9.3 square metres) to determine the number of squares contained in the roof: 700 square feet ÷ 100 square feet = 7 squares.

NOTE: A simplified method of calculating the area of a triangle is to find half the base (or the altitude) and then multiply this figure by the altitude (or the base). With this procedure it is not necessary to divide by 2 after multiplying.

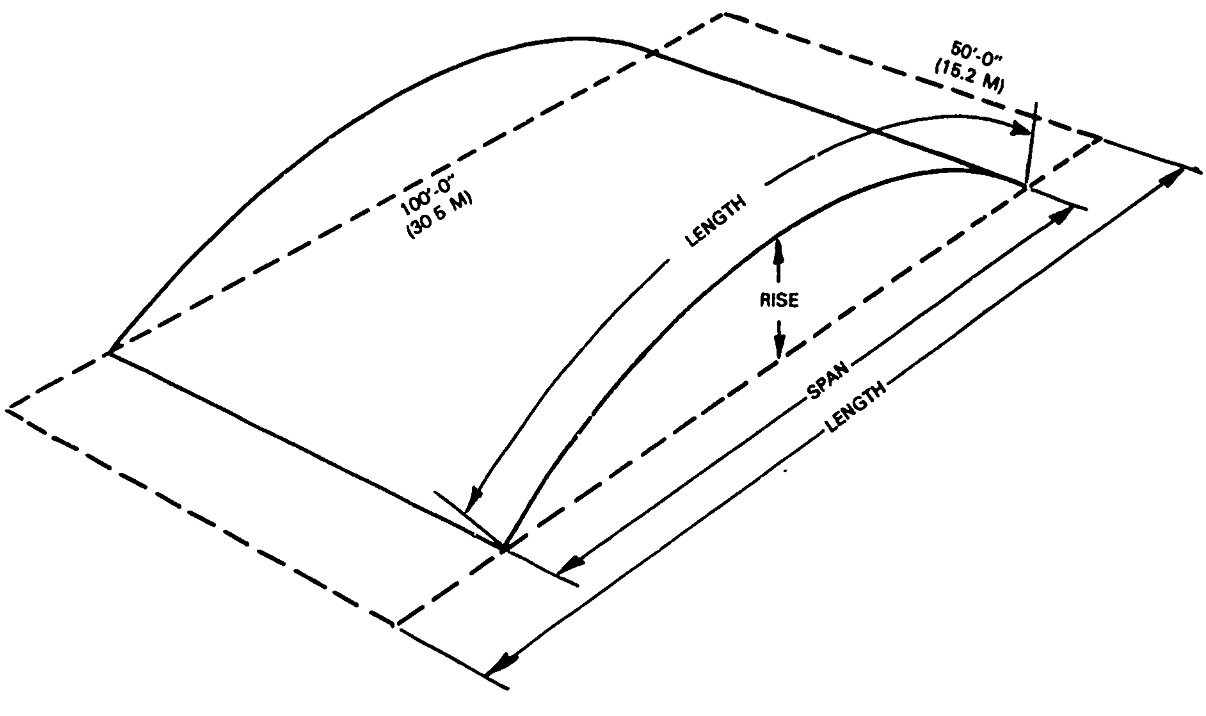
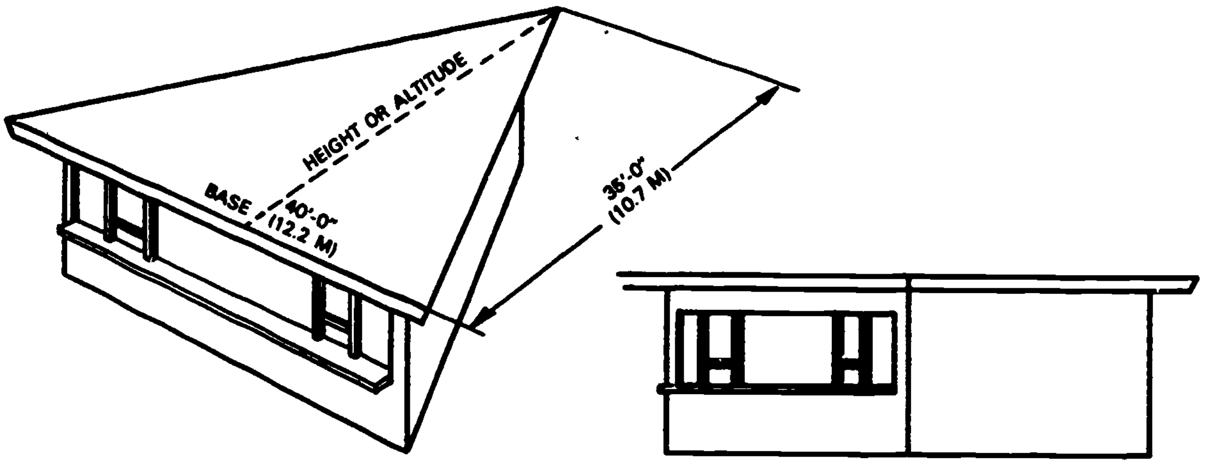


Fig. 5-10. A barrel roof



Perspective view

Elevation view

Fig. 5-11. A triangular roof

Instructional Materials

Materials Required for Each Apprentice

Built-up Roofing. Sacramento: California State Department of Education, 1981. (Orders to: California State Department of Education, Publications Sales, P.O. Box 271, Sacramento, CA 95802; $4, plus sales tax for California residents.)

Rigid Roofing. Sacramento: California State Department of Education, 1980. (Orders to: California State Department of Education, Publications Sales, P.O. Box 271, Sacramento, CA 95802; $4, plus sales tax for California residents.)

Materials Recommended for the Classroom

Dwelling Construction Under the Uniform Building Code (Latest edition). Whittier, Calif.: International Conference of Building Officials. (Orders to: International Conference of Building Officials, 5360 S. Workman Mill Road, Whittier, CA 90601.)

Uniform Building Code (Latest edition). Whittier, Calif.: International Conference of Building Officials. (Orders to: International Conference of Building Officials, 5360 S. Workman Mill Road, Whittier, CA 90601.)

APPENDIX A

Multiplication Tables

1 × 1 = 1	2 × 1 = 2	3 × 1 = 3	4 × 1 = 4
1 × 2 = 2	2 × 2 = 4	3 × 2 = 6	4 × 2 = 8
1 × 3 = 3	2 × 3 = 6	3 × 3 = 9	4 × 3 = 12
1 × 4 = 4	2 × 4 = 8	3 × 4 = 12	4 × 4 = 16
1 × 5 = 5	2 × 5 = 10	3 × 5 = 15	4 × 5 = 20
1 × 6 = 6	2 × 6 = 12	3 × 6 = 18	4 × 6 = 24
1 × 7 = 7	2 × 7 = 14	3 × 7 = 21	4 × 7 = 28
1 × 8 = 8	2 × 8 = 16	3 × 8 = 24	4 × 8 = 32
1 × 9 = 9	2 × 9 = 18	3 × 9 = 27	4 × 9 = 36
1 × 10 = 10	2 × 10 = 20	3 × 10 = 30	4 × 10 = 40
1 × 11 = 11	2 × 11 = 22	3 × 11 = 33	4 × 11 = 44
1 × 12 = 12	2 × 12 = 24	3 × 12 = 36	4 × 12 = 48

5 × 1 = 5	6 × 1 = 6	7 × 1 = 7	8 × 1 = 8
5 × 2 = 10	6 × 2 = 12	7 × 2 = 14	8 × 2 = 16
5 × 3 = 15	6 × 3 = 18	7 × 3 = 21	8 × 3 = 24
5 × 4 = 20	6 × 4 = 24	7 × 4 = 28	8 × 4 = 32
5 × 5 = 25	6 × 5 = 30	7 × 5 = 35	8 × 5 = 40
5 × 6 = 30	6 × 6 = 36	7 × 6 = 42	8 × 6 = 48
5 × 7 = 35	6 × 7 = 42	7 × 7 = 49	8 × 7 = 56
5 × 8 = 40	6 × 8 = 48	7 × 8 = 56	8 × 8 = 64
5 × 9 = 45	6 × 9 = 54	7 × 9 = 63	8 × 9 = 72
5 × 10 = 50	6 × 10 = 60	7 × 10 = 70	8 × 10 = 80
5 × 11 = 55	6 × 11 = 66	7 × 11 = 77	8 × 11 = 88
5 × 12 = 60	6 × 12 = 72	7 × 12 = 84	8 × 12 = 96

9 × 1 = 9	10 × 1 = 10	11 × 1 = 11	12 × 1 = 12
9 × 2 = 18	10 × 2 = 20	11 × 2 = 22	12 × 2 = 24
9 × 3 = 27	10 × 3 = 30	11 × 3 = 33	12 × 3 = 36
9 × 4 = 36	10 × 4 = 40	11 × 4 = 44	12 × 4 = 48
9 × 5 = 45	10 × 5 = 50	11 × 5 = 55	12 × 5 = 60
9 × 6 = 54	10 × 6 = 60	11 × 6 = 66	12 × 6 = 72
9 × 7 = 63	10 × 7 = 70	11 × 7 = 77	12 × 7 = 84
9 × 8 = 72	10 × 8 = 80	11 × 8 = 88	12 × 8 = 96
9 × 9 = 81	10 × 9 = 90	11 × 9 = 99	12 × 9 = 108
9 × 10 = 90	10 × 10 = 100	11 × 10 = 110	12 × 10 = 120
9 × 11 = 99	10 × 11 = 110	11 × 11 = 121	12 × 11 = 132
9 × 12 = 108	10 × 12 = 120	11 × 12 = 132	12 × 12 = 144

Zero × any number = zero

APPENDIX B

Formulas for Determining the Areas of Various Types of Roofs

Type of roof	*Formula*
Barrel roof	A = (span + 14% of span) × width
Circular roof	A = pi × radius squared, or $3.14 \times r^2$
Dome roof	A = square of the radius of the dome × 4 × pi, or $r^2 \times 4 \times 3.14$
Gable roof	$A = \left(\text{length at rake} + \text{length at rake}\right) \times \text{length at eave}$
Gable T roof or hip T roof	$A = \left(\text{area of main roof (large gable roof)} + \text{area of T roof (small gable roof)}\right)$
Hip L roof or gable L roof	A = sum of length of the two ridges × sum of the lengths of the two rakes at one end
Parapet wall with four corners having measurable heights	$A = \left(\text{half the perimeter} \times \text{difference between maximum and minimum heights of parapet}\right) + \left(\text{perimeter} \times \text{minimum height of parapet}\right)$
Parapet wall with one corner measuring zero	$A = \dfrac{\text{perimeter} \times \text{height of parapet at lowest point of roof}}{2}$
Plain hip roof	A = 2 × length of main slope × length at eave
Shed roof	A = length × height
Triangular roof	$A = \dfrac{\text{base} \times \text{height}}{2}$ or $\dfrac{b}{2} \times h$ or $\dfrac{h}{2} \times b$

50

Roofing

Plans and Specifications

Tests

The following section contains objective tests for each topic of the workbook. The value of the tests depends to a great extent on the care taken by instructors and school supervisors in keeping them confidential.

Supervisors and instructors should feel free to modify the application of the workbook material and the tests to satisfy local needs. Also, the instructors will probably supplement the information in the workbook with other material that they themselves have developed, and they will need to augment the tests with questions based on any supplementary material they may use.

Instructors and supervisors should be aware that the test pages are perforated to facilitate removal of the tests, either individually or as a complete set, at the discretion of the instructor or supervisor.

Plans and Specifications

TOPIC 1 — REGULATIONS GOVERNING THE ROOFING AND WATERPROOFING INDUSTRY

Decide which of the four answers is correct, or most correct; then write the corresponding number in the blank at the right.

1. In California the most widely used building code is the: 1. ____

   1. *National Building Code*
   2. *Uniform Construction Code*
   3. *Dwelling Construction Under the Uniform Building Code*
   4. *Uniform Building Code*

2. The two basic categories of roofs are fire-retardant and: 2. ____

   1. Flammable
   2. Nonflammable
   3. Ordinary
   4. None of the above

3. Which of the following classifications of roofs is (are) fire-retardant? 3. ____

   1. Class A only
   2. Class B only
   3. Class C only
   4. Classes A and B only

4. The average length of a guarantee on a guaranteed (bonded) roof is how many years? 4. ____

   1. Ten to 25
   2. Ten to 20
   3. Five to 20
   4. Five to 25

5. Roof damage to a bonded roof is generally not covered when the damage results from certain causes. Damage from which of the following would probably *not* be covered under the terms of the guarantee? 5. ____

   1. Wind
   2. Settlement
   3. Cracking of the roof deck
   4. All of the above

PLANS AND SPECIFICATIONS

TOPIC 2 — OVERVIEW OF BLUEPRINTS

Decide which of the four answers is correct, or most correct; then write the corresponding number in the blank at the right.

1. To be able to read blueprints accurately, a tradesperson must have knowledge of· 1. ____

    1. Mathematics
    2. Building materials
    3. Construction nomenclature
    4. All of the above

2. The scale used most commonly on residential plans and elevations is: 2. ____

    1. $\frac{1}{4}$" = 1'0" (0.6 centimetre = 30.5 centimetres)
    2. $\frac{3}{32}$" = 1'0" (0.2 centimetre = 30.5 centimetres)
    3. $\frac{3}{8}$" = 1'0" (1 centimetre = 30.5 centimetres)
    4. 3" = 1'0" (7.6 centimetres = 30.5 centimetres)

3. A major problem in "scaling" a drawing to determine an unknown dimension is that: 3. ____

    1. The scale indicated on the drawing may be incorrect.
    2. The scale indicated on the drawing may not be applicable to the dimension under consideration.
    3. Prints often shrink during processing, and, thus, the distances on the print may not be accurate.
    4. The edge of an architect's scale is not flat, and measurements taken with such an instrument will probably be inaccurate.

4. Which of the following tasks might a roofer be called on to perform? 4. ____

    1. Change the plans to conform to the local building code.
    2. Resolve a conflict between the architect and the engineer.
    3. Apply siding or floor membranes.
    4. None of the above.

5. A blueprint that shows an object from a vantage point directly above the object, that is, looking down on the object, is called a (an): 5. ____

    1. Elevation view
    2. Plan view
    3. Section view
    4. Detail view

6. In a complete set of blueprints, the sheet that contains the most information about a project is the: 6. ____

    1. Floor plan
    2. Framing plan
    3. Plot plan
    4. Electrical plan

7. Which of the following may require a detail drawing? 7. ____

    1. Doors
    2. Windows
    3. Arches
    4. All of the above

8. The symbol  on a roof plan indicates a: 8. ____

1. Skylight
2. Roof opening
3. Scupper
4. Roof drain

9. The symbol  indicates the presence of a: 9. ____

1. Floodlight
2. Skylight
3. Duct penetration
4. Roof vent

10. Which of the following symbols is used to indicate a pipe 2 inches (5.1 centimetres) or less in diameter? 10. ____

1. 
2. 
3. 
4. 

PLANS AND SPECIFICATIONS

TOPIC 3 — OVERVIEW OF SPECIFICATIONS

Decide which of the four answers is correct, or most correct; then write the corresponding number in the blank at the right.

1. The responsibility for the content of the specifications for a construction job rests with the: 1. ____

   1. Architect
   2. Contractor
   3. Local building department
   4. Subcontractors

2. No changes should be made in the plans and specifications for a project without the approval of the: 2. ____

   1. Owner
   2. Local building department
   3. Architect
   4. General contractor

3. Which of the following is (are) included in specifications? 3. ____

   1. The catalog numbers of appliances to be installed
   2. Designations of the quality of the materials to be used on the project
   3. Guarantees of performance by those working on the project
   4. All of the above

4. The specifications, sketches, working drawings, and written contract become the basis for agreement between the: 4. ____

   1. General contractor and subcontractors
   2. Architect and general contractor
   3. General contractor and owner
   4. All of the above

5. Which of the statements below is (are) true? 5. ____

   1. Every construction project should include a set of specifications.
   2. Specifications include detailed information that cannot be easily shown on a set of blueprints.
   3. Specificatons detail the grade of equipment to be used on the project.
   4. All of the above.

PLANS AND SPECIFICATIONS

TOPIC 4 — MATHEMATICS

Determine the correct answer for each of the problems below and enter the result in the corresponding blank at the right.

1.	$107 + 421 + 819 + 1{,}006 =$	1. ____
2.	8 feet 7 inches = ____ inches	2. ____
3.	$417 \times 207 =$	3. ____
4.	$622 \div 14 =$	4. ____
5.	$3\frac{1}{2} \div \frac{1}{2} =$	5. ____
6.	$32.8 - 12.9 =$	6. ____
7.	$\frac{7}{8} \times \frac{3}{4} =$	7. ____
8.	$0.62 + 1.23 + 32.16 + 0.41 =$	8. ____
9.	4.236 to the nearest tenth =	9. ____
10.	0.26 = ____ percent	10. ____
11.	7 feet 4 inches − 9 inches =	11. ____
12.	3 feet 6 inches × 6 =	12. ____
13.	5 feet 2 inches ÷ 2 =	13. ____
14.	$1.3 \times 0.22 =$	14. ____
15.	As a common fraction reduced to lowest terms, 44 percent =	15. ____
16.	12 feet 3 inches + 2 feet 11 inches =	16. ____
17.	As a decimal, $\frac{1}{8} =$	17. ____
18.	10 feet 6 inches ÷ 3 =	18. ____
19.	$43.719 - 0.01 =$	19. ____
20.	$6.009 \times 6.9 =$	20. ____

TOPIC 5 — COMMON MEASUREMENT AND CALCULATION PROBLEMS IN ROOFING

Decide which of the four answers is correct, or most correct; then write the corresponding number in the blank at the right.

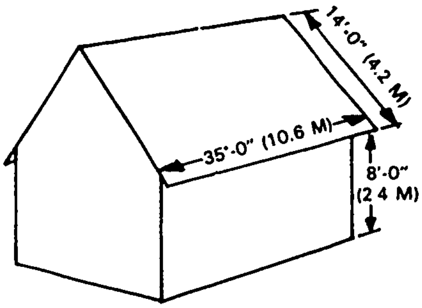
1. If 36-inch-wide (91.4-centimetre-wide) felt is to be used for a two-ply roof assembly, what will be the exposure of the felt? 1. ____

   1. 16 inches (40.6 centimetres)
   2. 17 inches (43.2 centimetres)
   3. 11⅓ inches (28.7 centimetres)
   4. None of the above

2. On a built-up roofing job, 8 squares remain to be roofed. The roof assembly is a three-ply assembly, and each roll of felt will cover 3 squares. How many more rolls of felt will be needed to complete the job? 2. ____

   1. 8
   2. 9
   3. 10
   4. 12

3. What is the perimeter of the roof shown below? 3. ____



   1. 126 feet (38.4 metres)
   2. 196 feet (59.7 metres)
   3. 490 square feet (45.5 square metres)
   4. 1,225 square feet (113.8 square metres)

4. What is the area of the roof shown in Question 3? 4. ____

   1. 280 square feet (26 square metres)
   2. 490 square feet (45.5 square metres)
   3. 980 square feet (91 square metres)
   4. 163 feet (49.6 metres)

5. Which of the formulas listed below can be used to determine the area of a barrel roof? 5. ____

   1. A = (span + 14% of span) × width
   2. $A = \pi \times r^2$
   3. $A = (b \times h) \div 2$
   4. $A = l \times h$

6. How many squares are contained in 725 square feet (67.3 square metres) of roofing? 6. ____

1. 725
2. 100
3. 72.5
4. None of the above

7. Multiplying the length of the rake of a roof by the sum of the length of the two rakes of the roof will give the area of which type of roof? 7. ____

1. Dome
2. Circular
3. Hip L
4. Shed

8. A 4-square roll of felt will cover: 8. ____

1. 4 square feet (0.3 square metre)
2. 44 square feet (4 square metres)
3. 100 square feet (9.3 square metres)
4. 400 square feet (37.1 square metres)

9. In figuring the number of linear feet of material to purchase for a job, the roofer must allow for waste, laps, and: 9. ____

1. The size of the materials truck
2. Corners
3. The owner's budget
4. FHA specifications

10. Which of the following must be known before the number of squares in a roof can be determined? 10. ____

1. The type of roofing material to be applied
2. The perimeter of the roof
3. The area of the roof
4. The circumference of the roof

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