CHAPTER 2

Building Codes & Planning

Chapter Objectives

After completing this chapter, you will be able to:

- **List** the steps in planning to build a house.
- **Name** three sources of house plans.
- **Explain** how to obtain financing for construction.
- **Identify** several elements used in architectural drawings and architectural plans.
- **Summarize** the advantages of computer-aided drafting and design.
- **Describe** the three basic types of cost estimates and give an example of a direct cost and an indirect cost.

Discuss the Photo

Plans Builders should consult an accurate set of plans frequently during every phase of construction. *What components might be found in a standard set of building plans?*

Writing Activity: Business Letter

Write a brief letter or an e-mail to your local building department asking them which general building code is used in your area. Use correct spelling and include your contact information so that you will receive a response. Share the response you received with the class.

Getty Images

Chapter 2 Reading Guide

Before You Read Preview

Building codes and architectural plans guide the construction of a new house. Choose a content vocabulary or academic vocabulary word that is new to you. When you find it in the text, write down the definition.

Content Vocabulary

- building code
- building permit
- stock plan
- floor plan
- mortgage
- architect's scale
- plan view
- elevation
- schedule
- specifications
- bid
- quantity takeoff
- board foot
- indirect cost

Academic Vocabulary

You will find these words in your reading and on your tests. Use the academic vocabulary glossary to look up their definitions if necessary.

- exceeds
- scale
- derived
- allocation

Graphic Organizer

As you read, use a chart like the one shown to organize information about content vocabulary words and their definitions, adding rows as needed.

Content Vocabulary	Definition
building code	Standard set of regulations that govern the procedures and details of construction

Go to glencoe.com for this book's OLC for a downloadable version of this graphic organizer.

Academic Standards

English Language Arts

Use different writing process elements to communicate effectively (NCTE 5)

Mathematics

Number and Operations: Compute fluently and make reasonable estimates (NCTM)

Measurement: Apply appropriate techniques, tools, and formulas to determine measurements (NCTM)

Geometry: Use visualization, spatial reasoning, and geometric modeling to solve problems (NCTM)

Science

Unifying Concepts and Processes: Constancy, change, and measurement (NSES)

Science in Personal and Social Perspectives: Environmental quality (NSES)

Industry Standards

Reading Plans and Blueprints

NCTE National Council of Teachers of English
NCTM National Council of Teachers of Mathematics
NSES National Science Education Standards

Section 2.1

Codes & Zoning

Building Codes

What are building codes?

A house is a complex structure. It is made up of many materials and parts that must fit together with precision. Unless construction is planned carefully, the house will not be safe, durable, functional, or comfortable. A **building code** is a standard set of regulations that govern the procedures and details of construction. Its purpose is to ensure that buildings are structurally sound and safe from fire and other hazards. Most communities follow one or more building codes.

Building codes establish minimum standards of quality and safety. A builder can construct a house that **exceeds** code requirements. Many builders who have a reputation for high-quality work do this. However, by law, a builder must not construct a house that does not meet the code requirements. During construction, a building inspector visits the project at various times to ensure that the building codes are being followed.

Model Building Codes

Local building codes are usually based on model building codes. A *model building code* is a set of regulations developed by an independent organization on which local governments can base their own building codes. For many years, all U.S. construction was guided by one of three major model U.S. building codes. They set minimum standards for residential construction. The *National Building Code* was used primarily by a narrow band of states ranging from Missouri to Pennsylvania, and in New England. The *Standard Building Code* was used primarily in southern states. The *Uniform Building Code* was used primarily in western and upper midwestern states. Canada relies on the *National Building Code of Canada*.

Other factors beyond regional concerns may determine the information in model building codes. For example, the Americans with Disabilities Act (ADA) and the Fair Housing Act (FHA) contain provisions regarding new construction. Public buildings and certain multi-family dwellings must comply with these provisions to ensure that the building is accessible to individuals who have disabilities. The most recent model building codes include standards for meeting these provisions.

Model building codes also cover work related to installing such utilities as electricity and plumbing. The *National Electrical Code* and the *Uniform Plumbing Code* are two examples.

Building codes cover standard types of construction. However, an architect or builder may decide to use unusual materials and techniques. For example, it is possible to build a house entirely out of concrete, as shown in **Figure 2-1**. The designer must then prove to local officials that the house would meet or exceed standard requirements and that it would be safe.

Figure 2-1 Alternative Construction
Something Unusual This concrete home is an example of an alternate construction method.

Courtesy of Poghand Assoc.

Modifying Codes The building department, which is a part of town, city, county, or state government, may adopt all the provisions of a model code. If so, the department does not need to develop its own code. However, sometimes it will adopt only those parts of the model code that fit local conditions. Throughout each unit of this book, *Regional Concerns* have been highlighted for this reason.

The International Residential Code To help make building codes more uniform, several of the organizations that develop the codes jointly produced the *International Residential Code for One- and Two-Family Dwellings.* The International Residential Code (IRC) is a standardized building code that is designed to account for regional variations. The map in **Figure 2-2** shows one example of a regional variation. The IRC covers detached one- and two-family dwellings and townhouses that are no more than three stories high. It is updated every three years and has been adopted by all 50 states. However, most building departments review and update their codes every three to five years. Many have decided to follow the IRC, but some may still choose to use one of the older model codes. Because the IRC provides minimum standards that are widely recognized, this code is referred to throughout this book. *For your own work, always follow the codes that have been adopted in your local area.*

Permits and Inspections

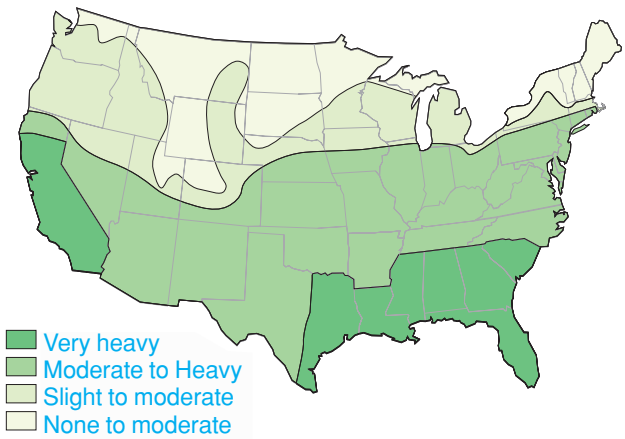
In areas covered by building codes, the builder must obtain a building permit before beginning construction of a house. A **building permit** is a formal, printed authorization for the builder to begin construction. To obtain a permit, the builder must submit a full set of working drawings, called plans, to the local building department. Plans show exactly how a house will be built. Builders must check with the local building department for permit requirements. There can be financial penalties for building without a building permit. In some cases, work not covered under a permit must be demolished.

REGIONAL CONCERNS

Local Climate U.S. building codes vary by climate. Codes in coastal areas exposed to hurricanes include regulations aimed at reducing damage caused by high winds and flooding. Structures in earthquake-prone areas must withstand earthquakes, while those in "Tornado Alley," an area in the Great Plains where tornadoes frequently occur, must be built to reduce damage caused by high winds and debris. The northernmost states in the United States have detailed energy conservation regulations, while some western states have water conservation regulations.

Because codes are modified to suit local conditions, a house in South Carolina might be built to a different code than a house in Minnesota. This is generally not a problem for local carpenters and builders. They learn what is required during their training. However, if a carpenter or builder moves to another region, he or she must learn how the codes differ.

Go to **glencoe.com** for this book's OLC for more information about regional concerns.



Note: Lines defining area are approximate only. Local conditions may be more or less severe than indicated by the region classification.

Figure 2-2 Termite Infestation Probability
Regional Hazards The IRC addresses regional variations in hazards. This IRC code shows that the risk of termite damage varies from region to region. Codes in high-risk areas are stricter than codes in low-risk areas.

The building department examines the plans to make that they meet local codes. If they do, the builder is issued a permit, which must be posted on the building site throughout construction. The cost of a building permit is usually based on the estimated cost of construction.

At key points during construction, a city or county building inspector will visit the job site to examine the work. The inspections vary but often include an examination of footing trenches and foundation formwork, framing, wiring, plumbing, and insulation. The builder must contact the building department to schedule an inspection when each part of the job is complete, but before it is covered by other work. The inspector can require that work be done over if it does not meet building codes. If the work has passed inspection, the inspector will initial or sign off on the paperwork.

When the house is complete, one last inspection is made. If there are no problems, a *certificate of occupancy* (CO) is issued. This document states that the house is ready to live in.

Reading Check

Analyze *Why would a carpenter be familiar with multiple codes?*

Before Construction Starts

What is a floor plan?

A lot of planning occurs before a house can be built. This process involves more than just figuring out what the building codes are. The home has to fit the needs of the occupants, both at the present time and in the future. How construction will be paid for must also be determined. Sometimes a builder constructs a house before there is a buyer. This kind of house is called a speculative house, or spec house. A house built for a particular client is called a custom house. With a custom house, the builder and the future homeowners continue to communicate while the house is in the process of being built. **Figure 2-3** shows a homeowner and a builder discussing a custom house.

Figure 2-3 Good Communication
Planning Frequent discussions with homeowners can ensure that the house is completed on time and on budget.

Lot or House Selection

When it comes to choosing a lot to build on, the following factors are important to consider.

Cost It is recommended that a homeowner spend not more than 25 percent of gross monthly income for housing. This amount of money includes mortgage payments, insurance, property taxes, utilities, and repairs.

Location How close is the property to jobs, schools, community services, and recreational facilities? Is the neighborhood likely to remain fairly stable, or will it change as the surrounding area grows? Are utilities such as water, sewer service, and electricity available?

Lot Shape and Contour Is the lot wide enough and deep enough for the desired house? Does it have unusual contours or other features that would make construction difficult or expensive? Will neighboring houses be so close that privacy will be a problem?

Special Conditions Examples may include: Is the lot on a flood plain? Are there underground springs in the area? Is there industrial contamination to consider?

Keith Wood/Corbis

Zoning Restrictions Most communities are divided into zones in which certain types of buildings are encouraged or restricted. Common zones are those for single-family dwellings, apartments and condominiums, commercial buildings, and industrial buildings. Many people prefer to reside (live) in a neighborhood that does not include commercial or industrial buildings.

Deed Restrictions Within any zone there may be deed restrictions on an individual lot. Deed restrictions might specify such things as the minimum-size house that can be built on the lot, requirements for certain architectural features, or setback distances. A setback distance is the minimum distance allowed from the house to adjacent features, such as other houses or the street. For example, a house near a stream might have to be located a certain distance above predicted flood levels. Additionally, a house built in a historic area might be limited to the use of certain exterior colors or roofing materials.

Legal Documents

Once the lot has been selected and the builder has been contracted, there are certain legal documents that must be processed. At least four legal documents are involved with the purchase of a house:

- The official survey, which shows the boundaries of the property.
- The deed, which is evidence of ownership.
- The abstract of title, which is a history of the deeds and other papers affecting the ownership of the property.
- The contract of sale (sometimes called a *sales contract*), which describes all the details relating to the purchase.

Before buying property, the purchaser should have the property surveyed to confirm that its dimensions match the dimensions noted on the sales contract. After the property is purchased, the buyer should retain a copy of the official survey, the deed, and the abstract of title. These are needed to secure financing and permits for new construction.

The contract of sale is required when a house or land is purchased. For an existing house, the contract contains such information as its exact location, the sales price, and a listing of anything inside the house that was not part of the sale. For example, the current owner might want to take the laundry appliances to another house. If a builder is hired to build a new house, the contract specifies such things as when the work will begin and when it will end. It also includes a great deal of detail regarding the house. For example, it might specify the level of quality the construction must reach. You can read more about specifications in Section 2.2.

To be valid, a contract of sale must have these features:

- It must be written (not verbal).
- It must clearly state the terms of the agreement, so there will be no disagreement about what is being purchased.
- It must include the price and the terms of payment.
- It must be dated.
- It must be signed by both the buyer and the seller. Both parties must be competent and old enough to sign legal documents.

House Plans

Every type of house, whether it is a spec house or a custom house, needs to have a house plan. House plans can be obtained in several ways. The buyer can purchase a stock plan. A **stock plan** is a standard house plan that can be adapted to fit many different lots. Companies that sell stock plans usually provide floor plans and other drawings to show what the finished house will look like. A **floor plan** is a scale drawing showing the size and location of rooms on a given floor. Once a suitable house plan has been chosen, complete working drawings and materials lists can be purchased. Stock plans are also available on the Internet, from plan books, and from some magazines.

House plans can also be obtained from local builders. Often, a builder specializes in a certain type of house, as shown in **Figure 2-4**. The builder develops one or two basic plans and then adapts them as needed to suit various buyers. This is why houses in a neighborhood often have similar features.

A third way to obtain house plans is to hire an architect or building designer to develop them to the buyer's specifications. A design fee may be based on a percentage of construction costs or it may be a flat fee. A percentage fee can range from five percent to ten percent. Some people prefer to use an architect or designer because the design can be tailored exactly to their needs. The architect may be hired to design the house as well as supervise its construction.

Financing

After a builder has been chosen, financing must be obtained from a lender, usually from a bank or a savings and loan company. The loan is for a certain percentage of the total cost. This percentage varies, but 80 percent is common. The borrower provides the balance as a down payment.

Typically, a borrower starts with a construction loan. A construction loan is a short-term loan used during construction. The lender provides money periodically as the work progresses. These sums of money are called draws, or advances.

After construction is finished, the construction loan is converted to a mortgage. A **mortgage** is a long-term (15 to 30 years) loan that is secured by the property. It allows the lender to claim the property if the borrower does not make the mortgage payments. The borrower pays interest and principal over the life of the loan.

Loan providers, as well as some federal agencies, may establish certain requirements for home construction. These requirements are not the same as building codes. They are

REGIONAL CONCERNS

Climate and Design The design of a house is often influenced by climate, available materials, and local traditions. For example, houses in New England must withstand heavy snowfalls, so eaves (roof overhangs) are short or nonexistent. In the Northwest, however, houses often have deep eaves to shield walls and windows from frequent rains. In the Southwest, houses are often built of dense materials, such as adobe and masonry (bricks or stone), which keep house interiors cool.

Go to **glencoe.com** for this book's OLC for more information about regional concerns.

A

B

Figure 2-4 Regional Styles

Weather Resistant The roofing materials shown here are appropriate to the different climates in which these houses are found. **A.** Clay-tile roof on a Spanish-style house in the Southwest. **B.** Cedar roof shingles on a log house in the Northwest.

David R. Frazier Photolibrary, Inc.

Estimating and Planning

Construction Costs

CERTIFICATION PREP

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Average Cost per Square Foot

To determine house construction costs, builders and designers often start with the average cost per square foot for residential buildings in their area. They multiply this figure by the number of square feet in the plans to estimate total costs.

It is important to understand that actual costs can be higher because of special features, unusual materials, custom products, or special building requirements. For example, kiln-dried lumber is more expensive than air-dried lumber. Housing standards for areas that have high risk of earthquakes or flooding may have different code requirements.

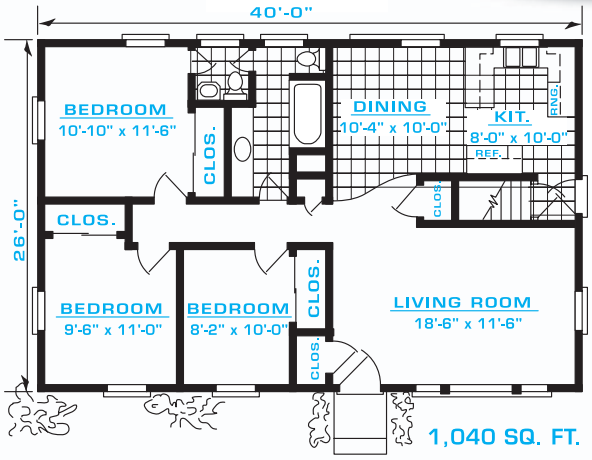
The best way to get an accurate price estimate is to ask subcontractors to bid on the project. They will study the plans to calculate exact costs. It is important to get several written bids and to talk to subcontractors in detail about what their bid includes.

The table below shows sample costs for a 1,040 ft² house in different geographic areas.

Calculating Average Cost

To calculate average cost by square foot, first determine the square footage of the house. This information is often available on architectural plans and drawings. A simple house plan is shown at the top of the next column. If the information is not available, you can use the measurements on plans to determine the number of square feet in the house.

1. Say that a two-story house has 1,040 square feet on the first floor and



900 square feet on the second floor. Add the two floors together to get the total size of the house.

$$1{,}040\ ft^2 + 900\ ft^2 = 1{,}940\ ft^2$$

2. Multiply the total square footage of the house by the cost of construction per square foot. You can determine this number by averaging the total costs of all the materials and labor. It is good to use a calculator when you are using large numbers. Using the costs provided in the table, you can calculate that the cost for a 1,940 ft² house in Charleston, SC would be $97,000.

$$1{,}940\ ft^2 \times \$50/ft^2 = \$97{,}000$$

Estimating on the Job

A contractor has given you the average cost of constructing a house in Euless, TX at $38 per square foot. Estimate the cost of building three houses with the following square footages: 1,500 ft², 3,422 ft², and 4,689 ft².

Sample Location	House Size	Cost of Construction per sq. ft.	Total Estimated Cost
New Orleans, LA	1,040 ft²	$65	$67,600
Charleston, SC	1,040 ft²	$50	$52,000
Chino, CA	1,040 ft²	$120	$124,800
Minnville, KY	1,040 ft²	$27	$28,080

standards that a builder must meet to obtain a certain type of mortgage. Builders must be aware of these additional requirements before construction begins.

Once financing has been arranged, contracts are signed for the construction. From then on, it is the responsibility of the builder and/or architect to make sure that the building goes as planned. A loan officer at the bank may also require progress reports to ensure that money loaned by the bank is being used properly.

Builders are usually paid a certain portion of the construction costs before work is started. They are then paid additional amounts at certain stages, such as after the roof is installed. Again, these are the draws from the construction loan. Final payment is made after the client and lender have inspected and approved the work.

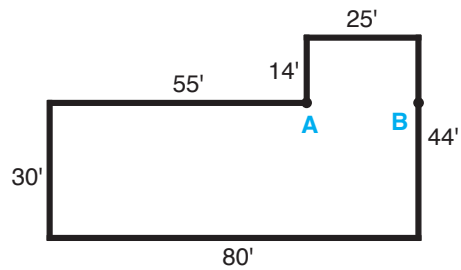
Section 2.1 Assessment

After You Read: Self-Check

1. What is a building code? What is its purpose?
2. What is a building permit, and what must you provide to apply for one?
3. Describe the document that indicates that a house is ready to live in.
4. What is a mortgage?

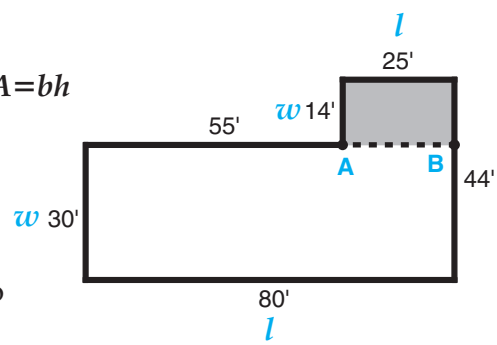
Academic Integration: Mathematics

5. **Calculate Area** You have been given the following plan for the foundation of a one-story rectangular house. Calculate the surface area of the floor.



Math Concept Surface area is the sum of all of the areas of the shapes that cover the surface of the object. The area of a flat rectangular surface can be calculated using the following formula: **area = length × width**, or $A=lw$

Area can also be calculated as **area = base × height**, or $A=bh$



Step 1: The foundation is made up of two rectangles. A rectangle is a four-sided figure in which all four of its angles are right angles. This means that the sides opposite one another are of equal length. Draw a dotted line between point A and point B to help you see the two rectangles more clearly.

Step 2: Multiply length by width to calculate the areas of the larger rectangle (80' × 30') and the smaller rectangle (25' × 14'). Add both areas to find the total area of the foundation.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 2.2

Architectural Drawing

Drawing & Measurement

Why are plans important?

The ability to read and understand a set of construction plans is an essential skill. Plans tell you everything you need to know about how to build something. The use of lines, symbols, and words make the ideas of the designer or architect clear to those individuals who must work on a construction project. These individuals include carpenters and other tradespeople, materials suppliers, and building inspectors. To be successful in most construction-related jobs, you must be able to interpret the plans correctly. You must also be able to measure accurately and read a tape measure.

Types of Drawings

Construction plans consist of drawings of the structure that show how it should be assembled. A *sketch* of something is a quick and informal drawing. An architect might make a sketch to capture an original idea. He or she might also sketch a house to show clients how it would look. A master carpenter might sketch a framing connection as a way of showing an apprentice how to make it.

Builder's Tip

TRACKING CHANGES Various versions of the plans are produced during the design development of a house. Before construction begins, make sure you have reviewed the latest set of the plans. If you have any questions, contact the project manager or designer. Make sure any subcontractors that will be working for you also have the most recent set of plans.

Architectural plans, sometimes called construction drawings or working drawings, are a set of more formal drawings. They provide an organized and precise way of showing how an entire structure should be built and can be consulted at any time, as shown in **Figure 2-5**. Copies of original plans are called prints. Many people refer to prints as *blueprints*. This is because plans used to be printed as white lines on a dark blue background. Modern plans typically have blue lines on a white background. An architect, an architectural designer, or a drafter usually creates the original drawing from which prints are made.

Figure 2-5 Reading Plans
Understanding Details Plans function as a universal language that even those who do not speak the same language can understand.

Measuring Systems

Two basic systems of measurement are used worldwide. The United States currently uses the customary system (Standard system) of measurement. Most other nations use the metric system. Some industries in the United States have changed over to the metric system. In construction, however, the customary system is still used. Some products, such as paint, are often labeled using both systems of measurement.

In the customary system, lengths are given in inches, feet, yards, and miles. In the metric system, lengths are given in millimeters, centimeters, meters, and kilometers. Compare the systems in **Figure 2-6**. A meter, which is the basic metric unit of length, is slightly longer than a yard (39.37"). One inch is equal to 25.4 millimeters. The metric system is based on units of ten. The millimeter is equal to 1/1000 of a meter, and a centimeter is 1/100 of a meter. A kilometer consists of 1,000 meters.

The two most common length measures in the customary system used for residential construction are the inch and the foot. In the metric system, the two length measurements most commonly used in construction are the millimeter and the meter. A customary/metric conversion table titled "Metric Conversion Factors" can be found in the **Ready Reference Appendix** in the back of this book.

In the customary system, liquids are measured in quarts and gallons. In the metric system, they are measured in liters. A liter is about 5 percent larger than a quart. Liquid finishing materials, including paints, are normally given in liters, half-liters, and quarter-liters. Weight in the customary system is given in pounds. In the metric system it is given in kilograms. A kilogram is approximately 2.2 pounds.

In some parts of the world that use metric measures, particularly Great Britain, a standard unit of measurement is 300 millimeters—which is very close to one foot.

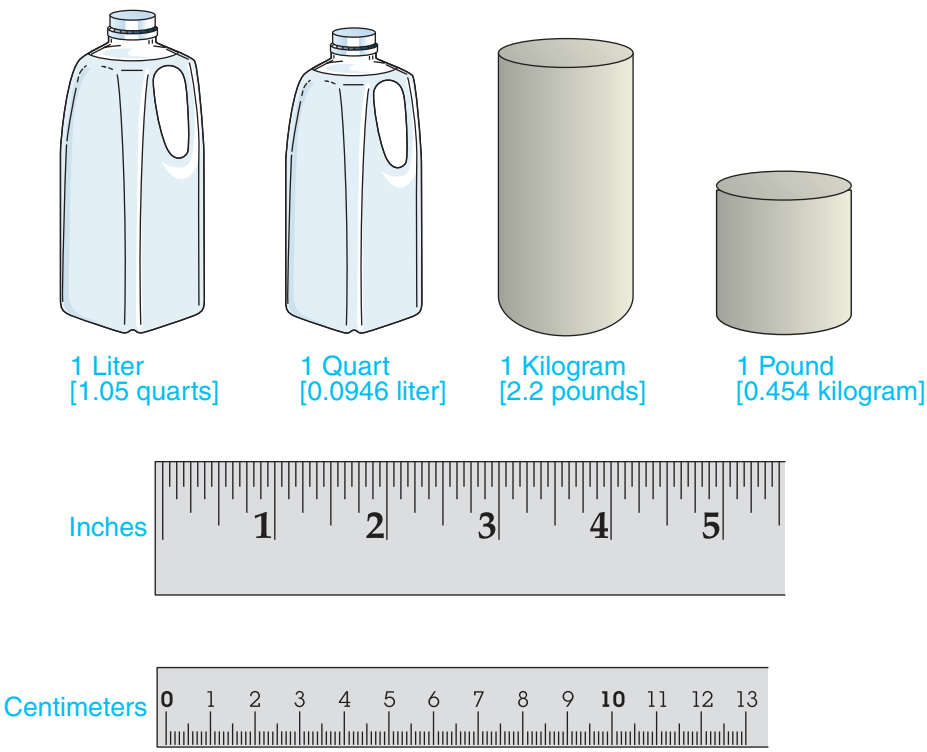


Figure 2-6 Two Systems
Volume, Weight, Length The metric system compared with the customary system.

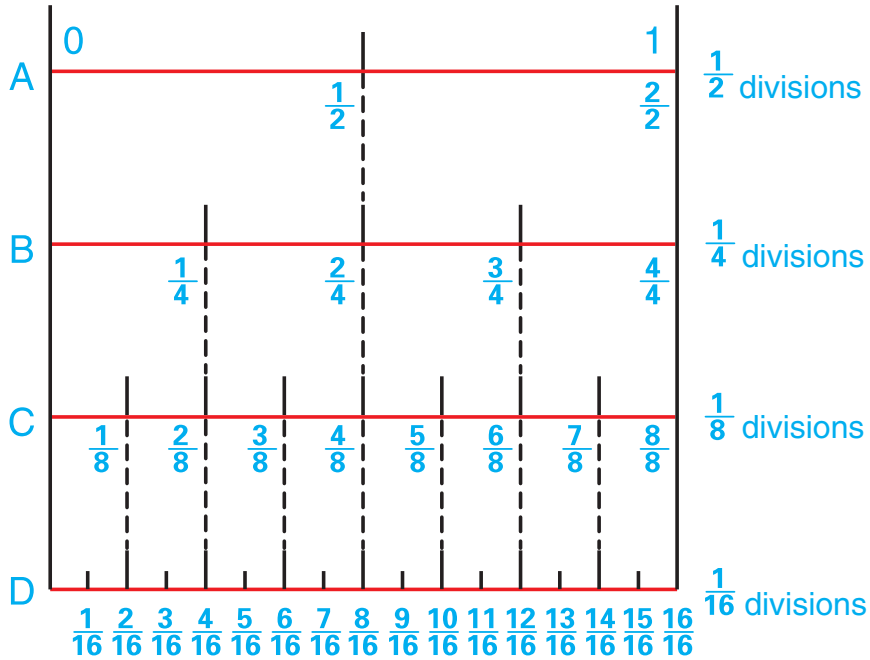


Figure 2-7 Divisions of an Inch

Common Fractions Carpenters rarely need to measure in increments smaller than 1/16 inch. For ease in reading, this drawing shows an inch larger than it really is.

On architectural plans, all building dimensions are given in millimeters. All site measurements appear in meters and millimeters. In the United States, building dimensions are given in feet, inches, and fractions of an inch. All site dimensions are given in feet and inches.

Reading a Customary Rule Measuring devices used in construction are based on multiples of 12 inches (one foot). The skills for measuring are the same, whether using a 1' rule or a 100' layout tape measure:

Take a look at the drawing shown in **Figure 2-7**. The distance between 0 and 1 represents 1". At *A*, the inch is divided into two equal parts. Each half represents ½". At *B*, the inch is divided into four equal parts. The first marker indicates ¼", the second marker 2/4" (½"), and the third marker ¾". At *C*, the inch is divided into eight equal parts; each small division is ⅛". Two of these divisions make 2/8" (¼"). Four make 4/8" (½"). At *D*, the inch is divided into 16 parts. Notice that 4/16" is equal to ¼". One mark past ¼" indicates 5/16". Notice on your own rule that between one inch mark and the next, the ½" mark is the longest. The ¼" mark is the next longest, then the ⅛" mark. The 1/16" mark is the shortest.

To read a fraction of an inch, count the number of small divisions beyond the inch mark. For example, when measuring the object in **Figure 2-8**, you will find that it is 2" plus four 1/16" segments. This is 2 4/16", which is the same as 2¼".

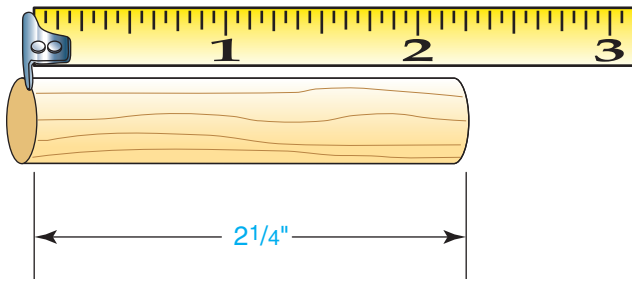


Figure 2-8 Measuring an Object

Using a Tape Measure Note how the end of the tape measure is hooked on the object being measured. Use a rule to measure the distance indicated by the arrows.

Table 2-1: Customary Scales Used for Drawings		
Measurements based on ...	Scale of drawing	Scale as ratio
1' = 1'	full size	1:1
6" = 1'	half size	1:2
3" = 1'	one-forth size	1:4
1½" = 1'	one-eighth size	1:8
1" = 1'	one-twelth size	1:12
¾" = 1'	one-sixteenth size	1:16
½" = 1'	one-twenty-fourth size	1:24
⅜" = 1'	one-thirty-second size	1:32
¼" = 1'	one-forty-eighth size	1:48
3/16" = 1'	one-sixty-forth size	1:64
⅛" = 1'	one-ninety-sixth size	1:96

Understanding Scale

In order to represent large objects on small sheets of paper or computer screens, architectural plans are drawn to scale. **Scale** is the ratio between the size of the object as it is represented and the actual size of the object. Drawings that are done to scale are drawn with the same proportions as the objects they represent, but at a different size. In the case of architectural plans, the drawings are much smaller than the actual buildings and other objects they represent.

An architect can represent a building of any size on a small piece of paper by drawing it to a certain scale. However, it is important to understand that scale is not a unit of measurement. If the drawn object is exactly the same size as the real object, it is called a full-size or full-scale drawing. If the object is reduced, it will probably be drawn to one of the common scales shown in **Table 2-1**. Look at the scale in which 3" = 1'. It is called one-fourth size because there are four sets of 3" lengths in 1'. What size is a drawing in which ½" = 1'?

Many architects use computers to draw plans, but others use traditional tools. The tool that architects use when making scale drawings is called an **architect's scale**. It allows the measurements in reduced-scale drawings to be measured as if they were in actual feet and inches. A traditional architect's scale is shown in **Figure 2-9**. Several sets of markings representing various scales can be displayed on its triangular shape. Some of these markings read left to right, while others read right to left. Architect's scales are also available in other shapes, including a flat scale that resembles a ruler, as shown in **Figure 2-10**.

A scale of ¼" = 1' 0" is most often used for drawing houses. A distance of ¼" on the drawing represents a distance of 1' 0" on the actual house. For example, if you used a tape measure to measure a window on a house, it might be 4' high and 3' wide. If you drew that window to a scale of ¼" = 1' 0", its size on the paper would be 1" high and ¾" wide. If you wrote its

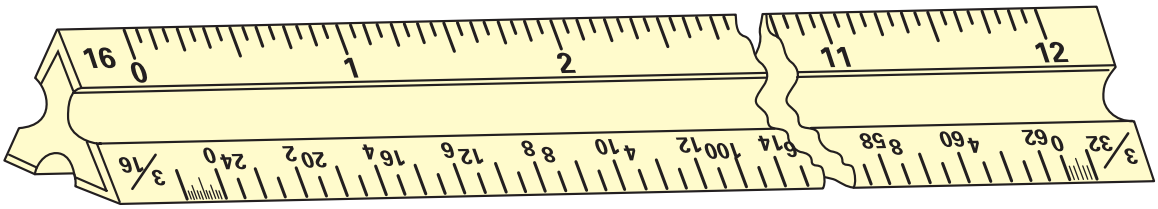


Figure 2-9 An Architect's Scale
Many Scales on One Tool The architect's scale is often used when making scale drawings. It is also useful for taking measurements from drawings that were made using a computer.

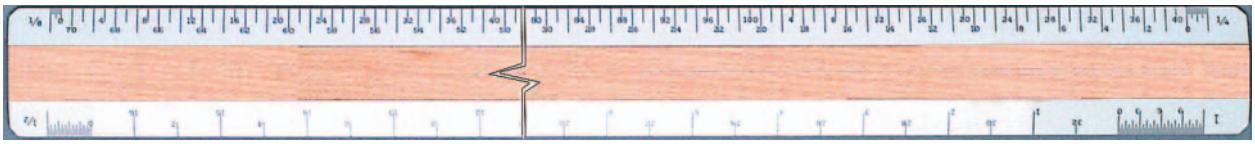


Figure 2-10 A Flat Scale
Another Shape This flat scale is easier for beginners to use than ones with a triangular shape.

dimensions next to the window on the drawing, however, you would write the size of the real window.

Using an Architect's Scale An architect's scale can be confusing for a beginner to use. Look at the flat architect's scale shown in Figure 2-10. Its left end is labeled ⅛, meaning that a ⅛" = 1' 0" scale starts at this end. This scale reads from left to right beginning at the zero mark. The other end of the instrument is labeled ¼, meaning that a ¼" = 1' 0" scale starts from that end. It reads from right to left beginning at the zero mark.

In Figure 2-10, a distance of 8' 6" is shown on the ¼" = 1' 0" scale. A distance of 14' 0" is shown on the ⅛" = 1' 0" scale. Can you see how these distances were determined? With practice, you will be able to draw lines of any distance using a scale.

Reading Check

Explain *What is an architect's scale used for?*

Making an Architectural Drawing

What are the elements of an architectural drawing?

Architectural drawings have traditionally been done by hand, and many are still done this way. However, computers are becoming the primary method for creating drawings. This is partly because relatively inexpensive computers are now powerful enough to run sophisticated software for drawing and design. The same basic elements are used whether drawings are made by hand or computer.

Elements of a Drawing

An architectural drawing consists of lines, dimensions, symbols, and notes. All four of these elements are very important to understanding, or reading, the drawing.

Lines Lines show the shape of an object and are used for many other purposes as well. The lines described in **Figure 2-11** on page 46 are commonly used for all drawings.

- *Centerlines* are used to indicate the center of an object. They are composed of long and short dashes, alternately and evenly spaced. At intersections, the short dashes cross. Very short centerlines may be broken if they will not be confused with other lines.
- *Dimension lines* indicate the start and end point of a particular dimension. They have arrowheads at each end. The dimension is written as a break in the middle of the line.
- *Leader lines* connect a note or a reference to part of the drawing. They usually end in an arrowhead or a large, circular dot. Arrowheads should always end at a line. Dots should be within the outline of an object. Leaders should end at any suitable portion of the note, reference, or dimension.

Science: Measurement

Metric Conversions What are the dimensions of a 12" × 2" × 1" plank in millimeters?

Starting Hint One inch = 25.4 mm.

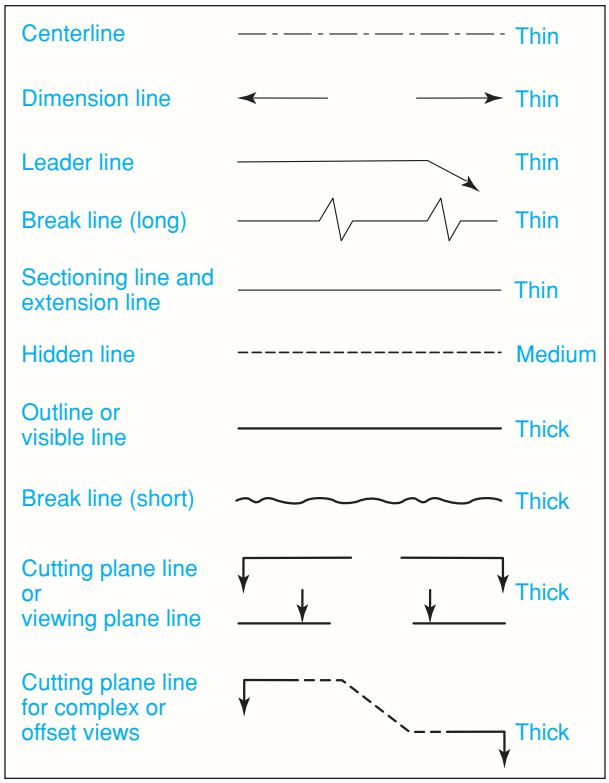


Figure 2-11 Line Meanings
Common Lines These are the lines most commonly found on architectural plans. The thickness, length, and shape of a line help to convey its meaning.

- *Break lines* may be solid, freehand lines that indicate short breaks. Full, ruled lines with freehand zigzags are used for long breaks.
- *Sectioning lines* indicate the exposed surfaces of an object in a sectional view. They are generally full, thin lines, but they may vary with the kind of material shown.
- *Extension lines* mark the end points of a dimension and should not touch the outline of the object.
- *Hidden lines* are short, evenly spaced dashes that show the hidden features of a part of the drawing. They always begin with a dash in contact with the line from which they start. However, a space is added when such a dash would form the continuation of a full line. Dashes touch at corners.
- *Visible lines* represent those edges of the object that can actually be seen.
- *Cutting plane lines* or viewing plane lines show sections that would otherwise be hidden. A section is a view that shows an object as if part of it were cut away to expose the inside.

Dimensions Dimensions are numbers that tell the size of something. The dimension of a particular feature on a plan can be determined by using an architect's scale. However, some dimensions are also written on plans. Carpenters and other tradespeople must follow the written dimensions when laying out the framing of a structure.

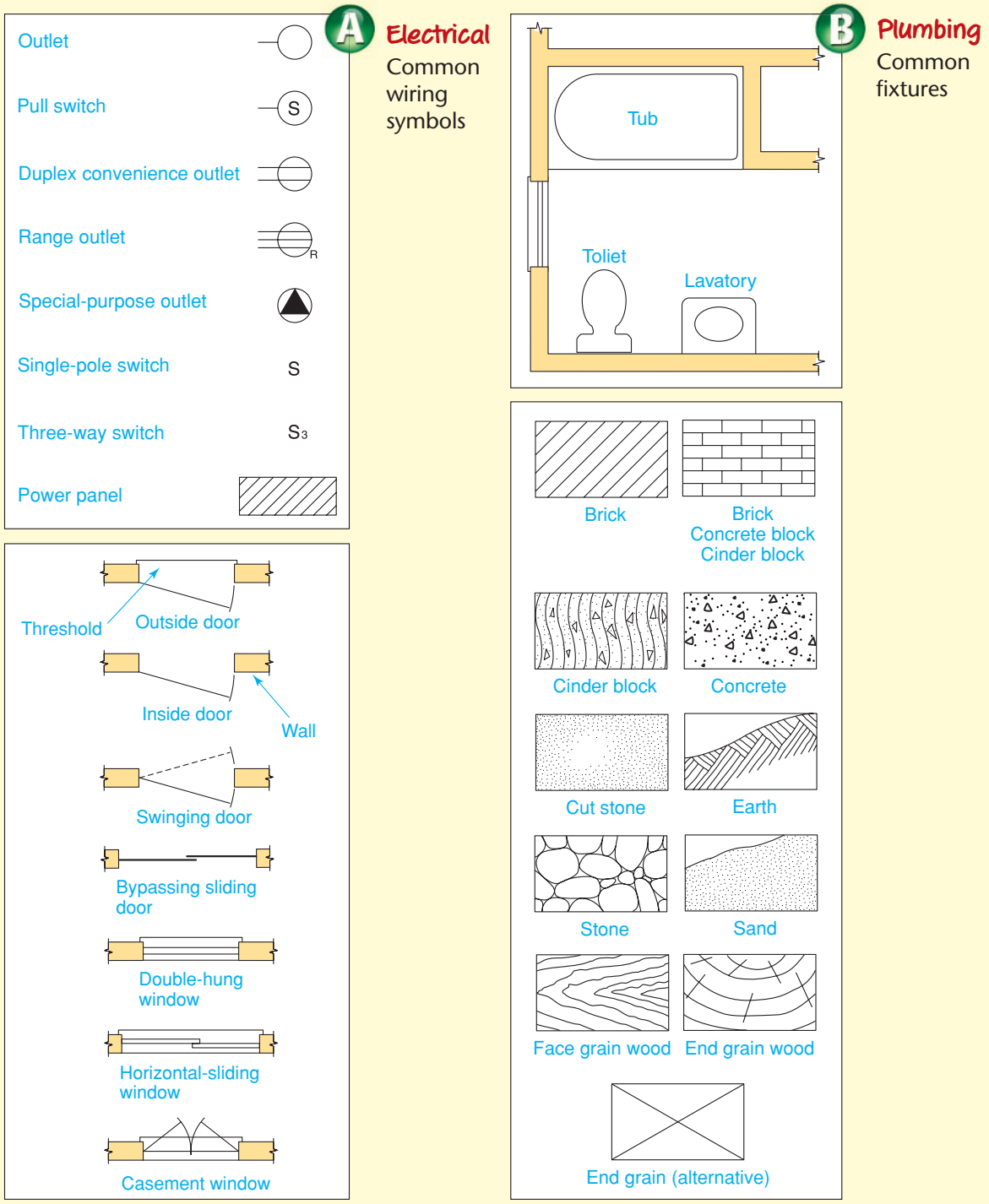
Plans are dimensioned both outside and inside the building lines. Outside dimensions describe openings and other changes in the exterior wall in addition to its overall dimension. Inside dimensions locate walls relative to each other and to exterior walls. All horizontal dimensions are shown in the plan (top) view. All vertical dimensions are shown in elevation (side) view. Some dimensions may not be shown. These can be **derived** by adding or subtracting other dimensions in the drawing.

Symbols Symbols are used to represent things that would be impractical to show in some types of drawings. For example, they are often used to represent doors, windows, electrical receptacles, plumbing fixtures, and heating equipment.

Many symbols appear on plans. Some of them are easy to interpret, such as plumbing symbols. Symbol keys are sometimes found on the plans to explain less obvious symbols. Just as a written language is composed of letters grouped into words, symbols are grouped in various ways to make them easier to interpret. Many electrical symbols have similar shapes. Some symbols are used to indicate objects, while others are used to indicate materials. You can see examples of these types of symbols in **Figure 2-12**.

Figure 2-12 Different Symbols

Symbol Keys Symbols can help workers understand the components of a building. *Why might symbols be useful for workers who might not speak the same language?*



A Electrical
Common wiring symbols

B Plumbing
Common fixtures

C Doors and Windows
Note that the symbols show the direction of door swings and the way windows open.

D Building Materials
The way building materials are depicted on plans often represents what the actual material looks like.

Notes Notes are short, written explanations of some feature that might not be clear from the drawing or that requires extra emphasis. Notes give information about such matters as materials, construction, and finish. They are included wherever necessary. There are two kinds of notes: specific and general.

Specific Notes Specific notes might clarify dimensions or suggest a construction technique. For example, a note might be included telling the carpenters to be sure to check the dimensions of an unusually shaped bathtub before framing the bathroom walls.

General Notes General notes can be added that refer to many or all drawings in a set of plans. An example of a general note might be: "All dimensions are given from stud face to stud face." General notes may be underlined to attract attention.

To save space in notes, abbreviations are often used. Standard abbreviations for use on construction drawings can be found in the **Ready Reference Appendix** table called "Architectural Abbreviations," which is located in the back of this book.

Computer-Aided Drafting and Design

Architectural plans are often drawn by hand using pencil or ink. Plastic templates speed up the drawing of elements that are used over and over again, such as circles and arcs or symbols for plumbing fixtures and electrical components. However, computers are increasingly used for drawing architectural plans. Drawing on a computer is much faster than drawing by hand.

Computer-aided drafting and design (CADD or CAD) software programs can be used to create site plans, floor plans, elevation drawings, and even perspective (realistic) drawings of a structure. One advantage of using CADD software to prepare architectural plans is that details can be drawn once and reused on subsequent projects. However, software incompatibilities may prevent these drawings from being widely shared.

JOB SAFETY

AVOIDING STRESS HAZARDS AND EYESTRAIN

Anyone who prepares architectural plans may spend many hours in front of a computer. Be sure to arrange the monitor, keyboard, and electronic drawing tablets to minimize the risk of repetitive stress hazards. Eyestrain is another risk with computer use. Adjust lighting conditions accordingly, particularly to reduce glare.

Go to **glencoe.com** for this book's OLC for more on job safety.

The future establishment of uniform CADD standards will reduce or eliminate the problem of these incompatibilities. In the meantime, you can verify that details are compatible with your software when you receive files from outside sources.

Electronic drawing files can be printed out in the architect's office. They can also be given to a local printing company by uploading the files over the Internet or by giving them a CD-ROM. Printing companies have high-quality, high-volume color printers that can process many drawings quickly. Drawings can also be sent as digital files attached to e-mail.

Using a computer offers many advantages. The drawings can be revised with ease. Estimating software can be combined with CADD software to produce a list of materials directly from the drawings. With a computer, symbols are easy to add, delete, or move. Symbol libraries that can be stored in the computer are also available. When an architect wants to use a particular type of window in a house, its symbol can be obtained and inserted into the drawing with the click of a mouse. Manufacturers often provide symbol libraries that include specifications for their products.

Section 2.2 Assessment

After You Read: Self-Check

1. What does a centerline look like, and what does it represent?
2. What are extension lines?
3. Name two elements in plans that are commonly represented by symbols.
4. What does CADD software do, and how is it used in the construction industry?

Academic Integration: Mathematics

5. **Drawing to Scale** Create a scale drawing to represent a rectangular flat surface that is eighteen feet long and 1.5 feet wide. Use a scale of 1 yard = 1 inch. Label the dimensions of your drawing.

   Math Concept Scale is the ratio between the size of a representation of an object and the size of the actual object. A ratio is a comparison of two numbers. Ratios can be expressed with colons (1:1) or as fractions ($\frac{1}{1}$).

   Step 1: Convert the length from feet to yards. There are 3 ft in 1 yard. (18 feet ÷ 3 ft/yd = 6 yards). Convert the width from feet to yards (1.5 ft ÷ 3 ft/yd = 0.5 yards).

   Step 2: Use the scale of 1 yard = 1 inch to convert yards to inches.

   Step 3: Use a ruler to create your drawing. Label the length and the width of the rectangle.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 2.3 Reading Architectural Plans

Using Plans

What information is on a typical foundation plan?

A complete set of architectural plans consists of various views of the site and the building. Taken together, these views provide the information a carpenter, subcontractor, or builder would need in order to do their work. Knowing which view is likely to contain certain information is an important part of using plans.

The views of a building include general drawings and detail drawings. General drawings consist of plan views and elevations. Their purpose is to show large portions of the building. Details are shown with section views and detail drawings. They provide information about how parts fit together. Additional information is often given in the form of schedules and specifications. Other workers, such as estimators, depend on them.

Figure 2-13 Two-Story House with Triple Garage
House on Flat Lot Building plans for the house shown here appear in the following pages.

Figure 2-13 is a photograph of a house. Many of the architectural plans shown in the rest of this chapter are for this house.

Plan Views

A **plan view** is a top view. It is also known as a bird's-eye view. It allows you to see the width, length, and location of objects as if you were standing on a platform high above them and looking down. It is not possible to see the height of objects in a plan view. Several types of plan views are commonly used.

A *site plan*, or *plot plan*, shows the building lot with boundaries, contours, existing roads, utilities, and other details such as existing trees and nearby buildings. The basic elements of a site plan, such as the one shown in **Figure 2-14**, are drawn from notes and sketches based upon a survey. This plan shows where the driveway will be located. The outline of the building is often superimposed on the site plan, and corners are located by reference to natural objects, other buildings, and/or survey markers. The excavation contractor relies on this plan.

A *foundation plan* is a top view of the footings and foundation walls. A foundation plan is shown in **Figure 2-15**. It also shows the location of posts and other elements,

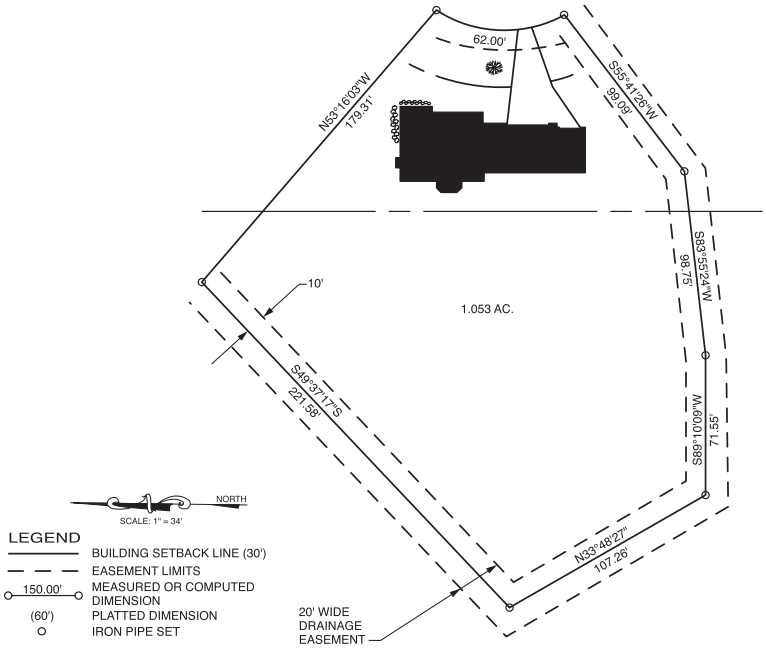


Figure 2-14 A Site Plan
House and Lot A typical site plan shows where the building will be placed on the lot.

such as pads needed to support an exterior deck. All openings in foundation walls are labeled and dimensioned. The type and location of foundation anchor bolts are identified. This plan is used by foundation contractors.

Floor plans such as those shown in **Figure 2-16** on page 52 are included for each level of the building. They are drawn as if the house were sliced horizontally at a level that would include all doors and window openings. This imaginary slicing is referred to as a *cutting plane*. A floor plan shows the outside shape of the building; the arrangement, size, and shape of rooms; the types of materials used; the thickness of walls; and the types, sizes, and locations of doors and windows. A floor plan may also include details of the structure, although these are usually shown on separate drawings called framing plans. Many tradespeople rely on floor plans.

Reflected ceiling plans are drawn as the ceiling would appear in a mirror placed on the floor below it. Reflected plans are used to show complex designs, such as tray ceilings (a type of decorative ceiling construction), or to show the locations of multiple lighting fixtures. They are not always included in a set of plans.

Framing plans show the size, number, and spacing of structural elements. Separate framing plans may be drawn for the floors and the roof. The floor framing plan must specify

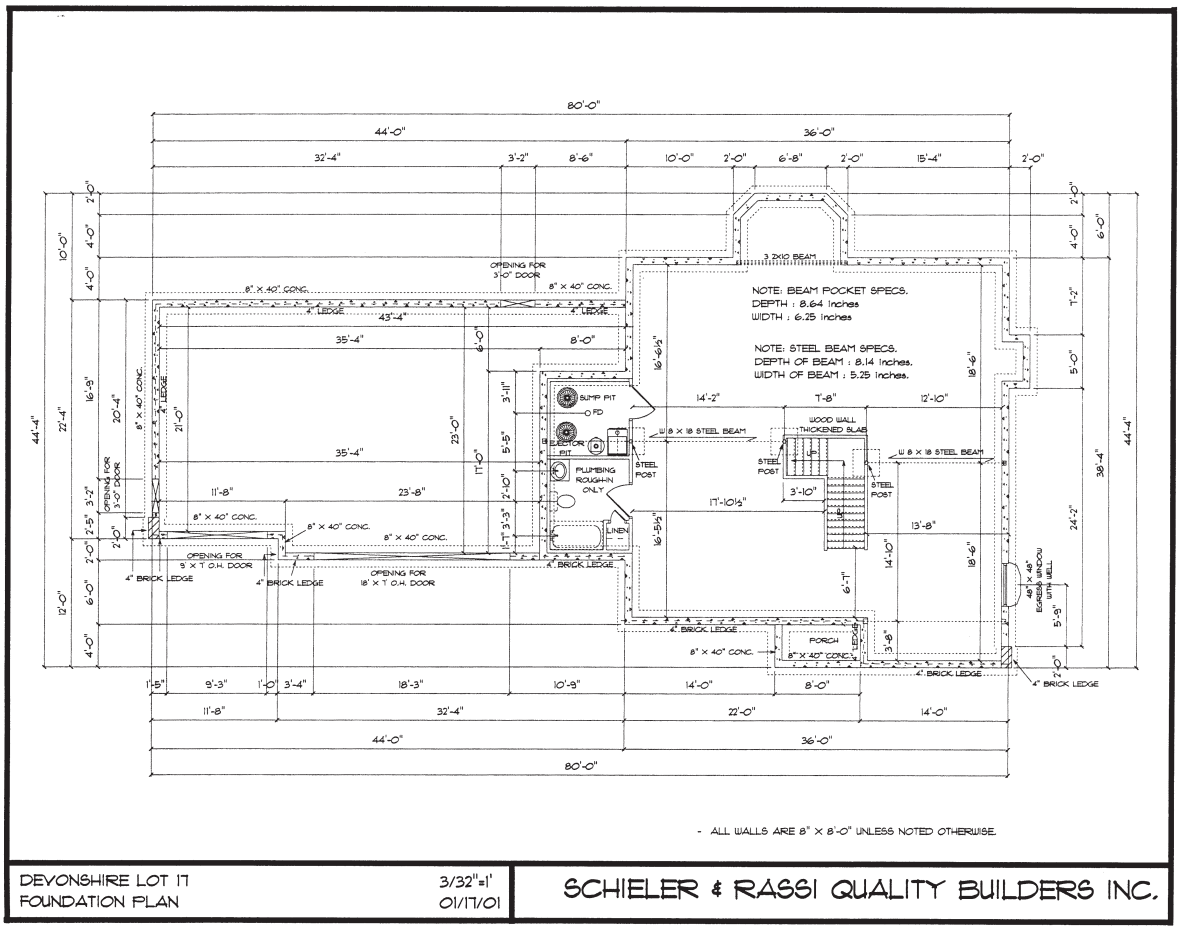


Figure 2-15 Site Plan

The Foundation Mistakes made in reading the foundation plan can translate to mistakes in the layout of the slab, footings, or basement. This will have an impact on the wall framing, and the wall dimensions will need to be modified. Changing wall dimensions will affect doors, windows, and electrical systems.

Builder's Tip

VERIFY DIMENSIONS When building from architectural plans, always verify that the door and window schedules match dimensions given on the floor plans. It is far easier to correct mistakes before framing begins than after the house has been framed and sheathed.

the sizes and spacing of joists, girders, and columns used to support the floor. Doubled framing around openings and beneath bathroom fixtures is also shown. Detail drawings are added, if necessary, to show the methods of anchoring joists and girders to the foundation walls. Roof framing plans show the size and spacing of rafters, as well as information about the roof slope and sheathing. Carpenters rely on these plans.

The *electrical plan,* which is drawn like a simplified floor plan, shows the location and type of every electrical feature of the building. These features include switches, ceiling lights, receptacles, and the service panel. The plan also indicates a schematic view of the electrical wiring that connects individual features to each other. The electrician relies on this plan.

The *mechanical plan* shows the arrangement and location of plumbing and heating features. Plumbers and mechanical contractors rely on this plan. A carpenter should also consult it to see if any special framing details might be required for these systems.

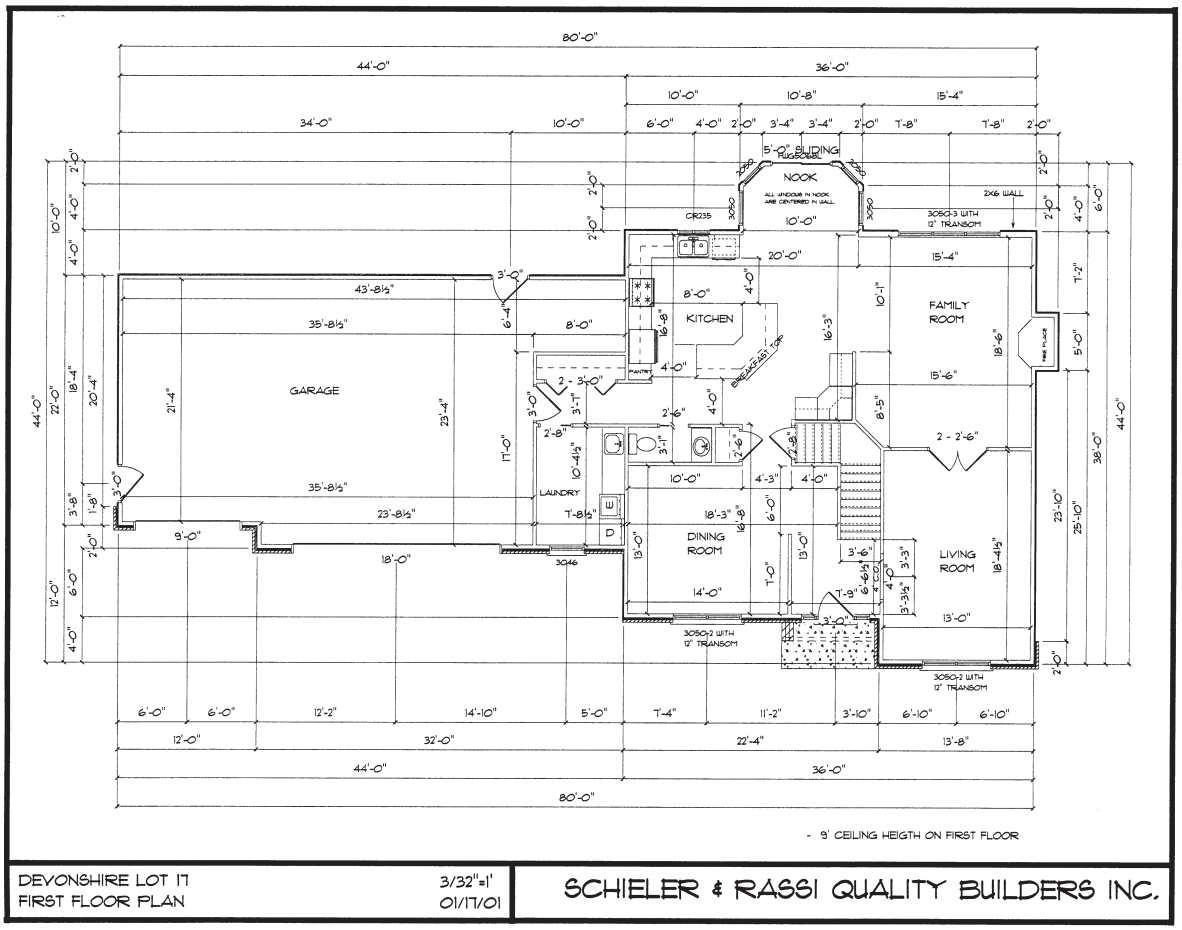


Figure 2-16 Floor Plan
First Floor This plan shows the first floor of the house and is similar to the foundation plan in overall shape.

This is an example of how various types of plans often can be useful to more than one trade.

A *landscaping plan* shows the location of existing features such as trees and streams and provides information about new landscaping features that will be added later. These features include plants, trees, walkways, and irrigation systems. Decks are also included on landscaping plans (see Chapter 36). A landscaping plan is often developed by a landscape designer after the house is complete. Plants are represented by drawings that indicate the mature size of each one.

Elevations

An **elevation** is a side view that allows you to see the height and width of objects. An interior elevation shows a wall inside the building, as if you were in the room looking straight at it. This view shows information such as ceiling heights and the layout of interior trim and cabinets.

An exterior elevation shows one side of the building's exterior, as shown in **Figure 2-17**. Four elevation views are usually enough to show all sides of a house. However, if some of the walls do not meet at 90°, additional elevation views will be necessary to show them. Exterior materials (such as siding) are shown on all elevations. The size of windows and doors is sometimes given.

Reading Check

Contrast *What is the difference between a plan view and an elevation view?*

Figure 2-17 Elevation Views

Exterior Elevations These views show the front, back, right side, and left side of the house. A complicated house may require additional elevation views.

Section Views

Section views provide important information about materials, fastening and support systems, and concealed features. They show how an object looks when "cut" vertically by an imaginary cutting plane, as shown in **Figure 2-18**. The cut is not necessarily continuous but may be staggered to include as much construction information as possible. Section views are similar to elevation views because they allow you to see the actual shape of objects as shown from one side. They are extremely useful to many trades. For example, all the details of wall framing cannot be shown in a framing plan so they are usually shown in an elevation. A wall-framing elevation would show the locations of studs, plates, sills, and bracing in a particular wall.

Where a section view is used to give more information about a larger drawing, the cutting plane is shown on the larger drawing by thick lines (see the cutting plane line in Figure 2-11 on page 46). These cutting plane lines, which sometimes have an arrow at each end, are identified with letters, numbers, or both. These labels help the reader understand exactly what portion of the house the section view represents. For example, a cutting plane line labeled "B-4" might be drawn on a floor plan or foundation plan. The section view that relates to this

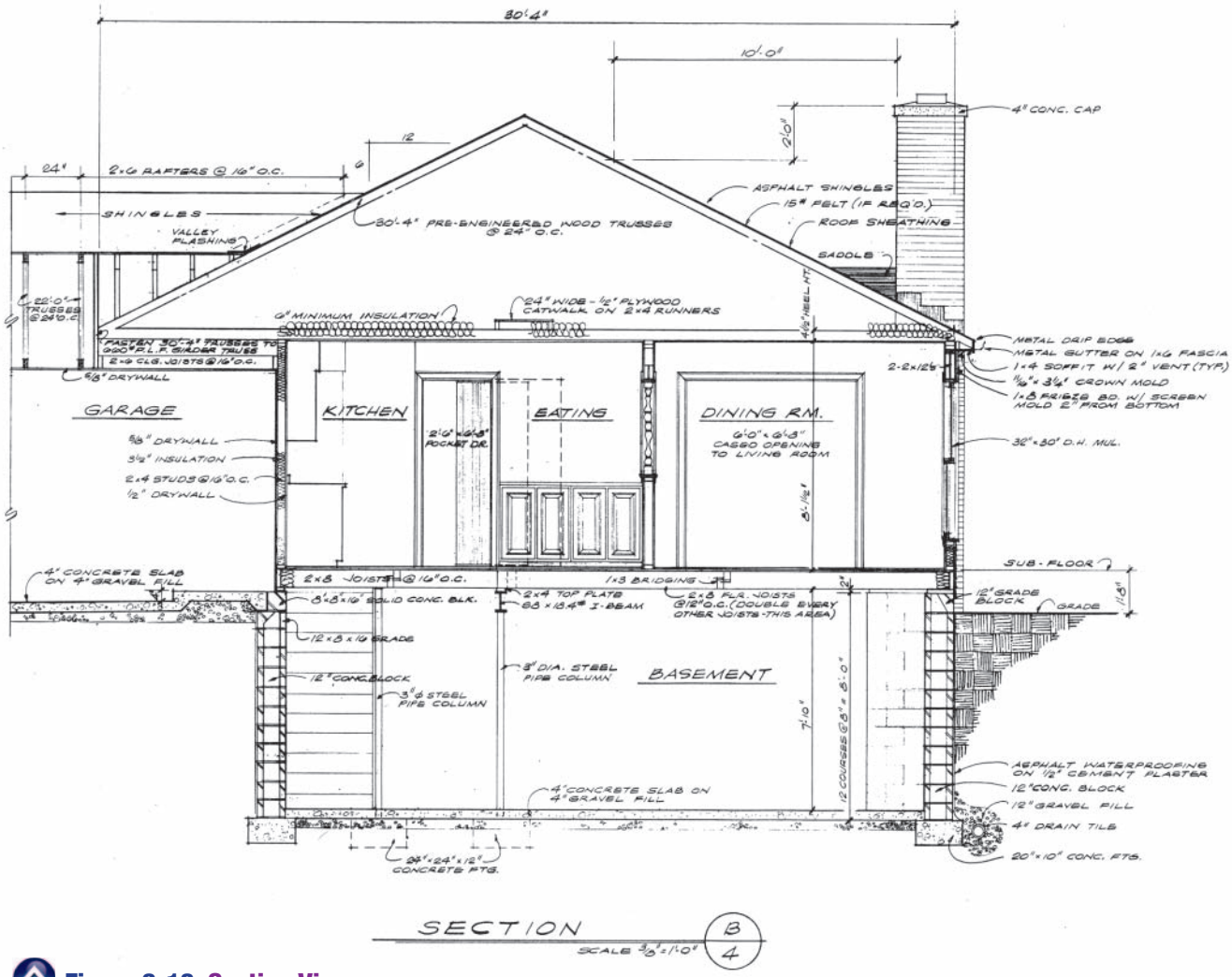


Figure 2-18 Section View

A Horizontal Slice A section view shows the relationship of many details of the house. A complex house often requires several section views.

slice through the house would be labeled "Section B-4."

Sections may be classified as typical or specific. *Typical sections* show construction features that are repeated many times throughout a structure. They are labeled "TYP," which is an abbreviation (shortened form) of "Typical."

When a feature occurs only once and is not shown clearly elsewhere, it is called a *specific section.* These features are generally not labeled.

Detail Drawings

When precise information is needed about a small or complex portion of the building, a *detail drawing* is made. The window detail shown in **Figure 2-19** is a simple example of a detail drawing. Such drawings are used whenever the information given in elevations, plans, and sections is not clear enough. The construction at doors, windows, and eaves is often shown in detail drawings. Details are drawn at larger scales than plan views, such as ½" = 1' 0", ¾" = 1' 0", 1" = 1' 0", or ¼" = 1' 0". Some detail drawings may even be drawn at full size. Detail drawings are usually grouped so that references may be made easily from other drawings. They are often located on or near section drawings because they show a particular part of the section.

Detail drawings are sometimes made as isometric drawings. *Isometric drawings* are constructed around three basic lines that form 120° angles to one another. They sometimes illustrate an assembly detail, such as an interlocking joint in a timber-framed house. The isometric technique gives the detail a three-dimensional look.

Engineering Drawings

Many parts of a house are built using components that are manufactured elsewhere and then delivered to the job site. When these components are part of the house structure, *engineering drawings* may be required.

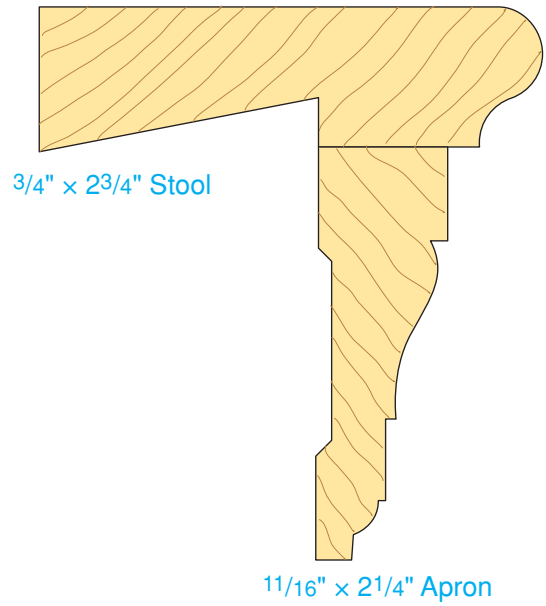


Figure 2-19 Trim Detail

Up Close This simple detail drawing shows how the window trim parts fit together and gives their exact dimensions.

Engineering drawings are sometimes prepared by a civil or structural engineer hired specifically to solve a particular problem related to the house or its site. For example, an engineer might provide the design for an unusually tall retaining wall. In other cases, the drawings are made by engineers who work for the manufacturer of a product. For example, a roof truss manufacturer would employ engineers to design the trusses.

Engineering drawings show that each component has been evaluated by an engineer and is safe for its intended use. One way to recognize engineering drawings is to look for the engineer's official stamp. This stamp identifies the engineer who did the design and shows that engineer's license number for the state in which he or she is authorized to practice.

It is important to understand that a product or connection shown in engineering drawings must not be altered (changed) in any way without written approval of the engineer. For example, if the drawings show a connection held together with six bolts, all six bolts must be installed using the exact size

and type of bolt called for in the drawings. Floor and roof trusses are always covered by engineering drawings. Any alteration, even a small notch, might cause the truss to fail.

Renderings

A *rendering* is sometimes called a presentation drawing. It is more like a picture of the structure than any other type of architectural drawing, as shown in **Figure 2-20**. Its purpose is most often to show the exterior of a house as it would look when completed. A rendering often includes such elements as plants, shadowing, and other features that add to a sense of reality.

Renderings are sometimes created for clients to help them visualize what the house would look like after all the landscaping has been done. Renderings are often in color. Computer software makes it easy to change colors and other details shown in renderings. In some cases, an architect might even start the design process with a computer-rendered drawing and then develop other drawings based on the original drawing.

Reading Check

Summarize *What is the purpose of a rendering?*

Schedules & Specifications

What type of information is in a schedule?

A set of architectural plans consists of many drawings. This is their most obvious feature. However, plans also include additional elements that help the builder to understand exactly what to build. These elements relate directly to the drawings, but are presented as charts, lists, or text.

Schedules

A **schedule** is a list or a chart. For example, the window schedule shown in **Figure 2-21** lists all the windows that will be used in the building. It contains information about the sizes of rough openings, glazing, finish, trim, manufacturer's name, and window type and size, among other things. It is information that would not necessarily appear in the drawings. Each window on the list is keyed to the floor plans with a letter or number. This ensures that windows will be put in the proper locations. A door schedule contains similar information.

Figure 2-20 Architectural Rendering
Finished View This is a rendering of the house shown in the preceding drawings.

SCHEDULES							
Windows				Doors			
Mark	Size	Type	Remarks	Mark	Size	Type	Remarks
W1	14-3'-4" × 5'-5"	D.H. VINYL		A	9'-0" × 6'-8"	OVERHEAD	GARAGE
W2	3-3'-4" × 4'-9"	D.H. VINYL		B	18'-0" × 6'-8"	OVERHEAD	GARAGE
W3	1-3'-4" × 4'-6"	D.H. VINYL		C	5'-0" × 6'-8"	FWD GLD PAT	NOOK
W4	2-2'-0" × 5'-5"	D.H. VINYL		D	3'-0" × 6'-8"	1/2 LIGHT	MN ENTR
W5	1-3'-4" × 2'-9"	D.H. VINYL		E	2-1'-0" × 6'-8"	1/2 LT SIDE LT	
W6	1-3'-0" × 3'-0"	D.H. VINYL		F	3-3'-0" × 6'-8"	6 PANEL	
W7	8-3'-0" × 1'-0"	D.H. VINYL	TRANSOMS	G	2-6'-0" × 6'-8"	BYPASS	
W8	2-4'-0" × 4'-0"	D.H. VINYL	FIXED PICT.	H	2-2'-6" × 6'-8"	BIFOLD	
W9	1-2'-2" × 1'-3"	D.H. VINYL	CIRCLE TOP	I	2-3'-0" × 6'-8"	BIFOLD	
W10	5'-0" × 1'-0"	D.H. VINYL	TRANSOM	J	2'-6" × 6'-8"	SGL POCKET	
				K	2'-4" × 6'-8"	SGL POCKET	
				L	2'-8" × 6'-8"	SGL POCKET	
				M	2-2'-6" × 6'-8"	FRENCH	
				N	2-2'-8" × 6'-8"	FRENCH	
				O	1'-8" × 6'-8"	ST 4 PANEL	
				P	2-2'-6" × 6'-8"	ST 4 PANEL	
				Q	4-2'-8" × 6'-8"	ST 4 PANEL	

Figure 2-21 Window and Door Schedule

A List of Sizes This schedule lists all the doors and windows for a house. It indicates their size and includes identification marks that identify the products on other drawings.

A *room-finish schedule* identifies the materials and finishes to be used for floors, walls, and ceilings for each room, including hallways. For example, a living room on the schedule might have strip-oak flooring, pine baseboard and window trim, painted drywall wall/ceiling surfaces, and wood paneling on two walls. In some cases, finish details may be included such as the color of the paint.

Specifications

Specifications are written notes that may be arranged in list form. They give instructions about materials and methods of work, especially those having to do with quality standards. Specifications such as those shown in **Figure 2-22** on page 58 may explain the level of quality expected of tradespeople and give the minimum quality for materials and finishes. In commercial construction, complex projects often require full-time specification writers. In residential construction, the specifications are often provided by the architect. Whether they are written by a specification writer or an architect, specifications should always be clear and brief.

Fire Ratings In many communities, fire hazards are a particular concern. In such cases the specifications for a house might include requirements for fire-resistant materials. Ratings of fire-resistant materials are often based on standardized tests that determine *flame-spread* ratings. Flame spread refers to how quickly flames will engulf the surface of a material. Materials are rated Class A (most resistant), Class B (less resistant) or Class C (least resistant). Another important rating is called *smoke density.* Smoke density is a measure of smoke created when a material is burning. For example, some foam plastics create dense, choking smoke when they burn and must be covered by nonflammable

SPECIFICATIONS

The house is to be built for_____ Owner,

residing at (Number)_____(Street)_____

(City or Town) (County) (State)

and is to be built upon the Owner's property located as described below:

LOCATION OF HOUSE ON LOT - The location of the house shall be as shown and dimensioned on the Plot Plan included in the Working Drawings.

GENERAL CONDITIONS OF THE SPECIFICATIONS

GENERAL DESCRIPTION OF THE WORK -The Contractor shall supply all labor, material, transportation, temporary heat, fuel, light, equipment, scaffolding, tools and services required for the complete and proper shaping of the work in strict conformity with the Drawings and Specifications. All work of all trades included in the Specifications shall be Performed in a neat and workmanlike manner equal to the best in current shop and field practice.

BIDS-in receiving bids for the work specified herein, the Owner incurs no obligations to any bidder and reserves the right to reject any and all bids.

CONTRACT DOCUMENTS-The Contract Documents consist of the Drawings, Specifications, Plot Plan and the Agreement. The Contract Documents are complementary and what is called for by one shall be as binding as if called for by all. The intent and purpose of the Contract Documents is to include all labor, material, equipment, transportation and handling neccesary for the complete and proper execution of the work.

CLEANING-The Contractor shall at all times keep the premises free from accumulations of waste materials and rubbish, and at the completion of the work all rooms and spaces shall be left broom clean.

WORK NOT INCLUDED-The following items of work are excluded from the Contract, however, may be included if noted under "Special Items Included."

Blasting
Sub-soil Drain
Waterproofing
Driveways and Walks
Finished Grading, Planting and Landscaping
Fences
Furniture and Furnishings
Venetian Blinds
Window Shades
Refrigerator
Cooking Range
Bathroom Accessories
Weatherstripping

EXCAVATION AND GRADING

Figure 2-22 Specifications

Detailed Instructions Specifications for a large house may be several pages long. This image shows only a portion of a specification sheet.

materials when used in a house. Building codes also include restrictions on some construction materials based on their flame spread and smoke density performance.

Codes also include another type of fire rating called fire resistance. A fire-resistance rating is based on standardized tests of how long an assembly or product will withstand a fire on one side without letting it pass through to the other side. For example, a wall with a 1-hour rating will prevent flames from burning through the assembly for at least one hour. The wall's fire rating might be improved in various ways. For example, one side could be covered with materials that had a higher fire rating. Products such as exterior doors are often required to have a minimum fire-resistance rating.

Section 2.3 Assessment

After You Read: Self-Check

1. Name the six types of views commonly included in a set of architectural plans.
2. What is a typical section and how is it often identified?
3. Give three pieces of information that you would expect to find on a window schedule.
4. What is found on a room-finish schedule?

Academic Integration: English Language Arts

5. **Architectural Abbreviations** An abbreviation is a shortened form of a written word or phrase. Abbreviations are used to save space on architectural drawings. For example, the architectural abbreviation for "Typical" is TYP. Go to the **Ready Reference Appendix** in the back of this book and find the section titled "Architectural Abbreviations". Read the information at the top of the page. Then, find the following abbreviations and list the words that they stand for: **OC**, **BF**, **FDN**, and **H**.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 2.4

Estimating & Scheduling

Estimating

Why is it important to make accurate estimates?

General contractors and subcontractors alike regularly make estimates. *Estimating* determines the costs of building a house, particularly the costs of labor and materials. This information is important because it relates directly to how profitable the contractor's business is. If construction costs are underestimated all the time, a contractor may not be able to make a profit. If estimates are overestimated too often, the contractor may lose jobs to contractors with lower, more accurate bids. A **bid** is a signed proposal to do work and/or supply a material for a specified price. The ability to make accurate estimates for bids is one of the most important skills any builder or contractor can develop.

When creating estimates, a builder often contacts suppliers of materials and labor and asks them to bid on the project. This process is called competitive bidding. The builder often requests bids from several sources for each portion of the project, such as excavation, framing, and roofing. After receiving all of the bids, the builder chooses one. For example, the goal might be to complete the house quickly. In this case, the builder might choose the company that promises the earliest start date. If the goal is to keep costs as low as possible, the builder might choose the company that submitted the lowest bid price.

Large construction companies employ workers who specialize in preparing quantity and cost estimates. Many building material retailers also have at least one estimator on staff. In a small construction company, however, it is the owner who generally prepares the estimates. Anyone who prepares estimates must:

- Be able to read and measure building plans accurately.
- Have an excellent understanding of the materials and techniques used to build houses.
- Have an excellent understanding of local building codes.
- Be precise in assembling and computing numerical data.

To prepare an accurate estimate, a builder or contractor needs only a pencil, paper, and a calculator. However, computers and estimating software, as shown in **Figure 2-23**, make the estimating process much faster. This is especially true for large and complicated projects. The Internet is another aspect of technology that is rapidly changing the process of estimating. For example, it is now possible for an estimator to check a manufacturer's actual inventory to determine if there is enough material in stock to complete a project. Some manufacturers and suppliers even feature online estimating features on their Web sites.

Figure 2-23 Estimating Materials
Checking the Plans Estimators rely on accurate plans to help them determine the quantity of materials.

Tony West/Alamy

Types of Estimates

Estimates are used at many different times during the construction process. Some are informal and approximate while others are detailed and precise. The earliest estimates are often the least accurate. Accuracy increases as estimates are refined to reflect new information. Three types of estimates are pre-design estimate, quantity takeoff, and unit-cost feature.

Pre-Design Estimate During the early stages of working with a client, a builder is often asked how much a new house will cost. Providing an accurate answer is impossible without spending many hours studying a set of plans. Instead, the builder may multiply the square footage of the house by the approximate construction costs per square foot in that community. This type of estimate is called a *pre-design estimate.* It may also be called a preliminary estimate, ballpark estimate, or conceptual estimate. It is an estimate made before the exact features of the house are known.

Costs for materials and labor vary considerably in different parts of the country. An experienced builder usually knows the range of overall construction costs in his or her area. For example, a house built with modest materials might cost $100 per square foot in one area or $110 per square foot in another. A more complex house in which high-quality materials are used might run $135 per square foot. Therefore, the pre-design estimate for an 1,800-square-foot house could range from $180,000 to $243,000. The cost of land is added to determine a pre-design total cost for the project. This figure would enable the client to determine whether or not new construction was affordable.

An architect may use pre-design estimates to figure his or her design fee. Insurance companies also use pre-design estimates to establish what the approximate replacement costs would be if damage occurred.

Quantity Takeoff For a detailed understanding of costs, a builder or contractor develops a quantity takeoff. A **quantity takeoff**, shown in **Figure 2-24**, is a cost estimate in which every piece of material required to build the house is counted and priced. It is also sometimes called a complete construction cost estimate or a quantity survey. A quantity takeoff is time consuming to create, but, once complete, it has other uses. For example, the builder may refer to the quantity takeoff when ordering materials.

Basement Stair

Part	Unit	Material	Length	Unit Cost	Total Cost
Stringer	LF	2×12 pine	12'		
Treads	PC				
Risers	PC				
Handrail	LF				
Balusters	PC				
Brackets	PC				
Other					

Figure 2-24 A Simple Quantity Takeoff

Tracking Costs In this example, the unit cost for the stringer (a length of lumber that supports steps) would be the cost per lineal foot. The total cost in this case would be the unit cost times 12, as the stringer is 12 feet long.

Special computer software can also be used to prepare quantity takeoffs. Some are linked to databases that can track fluctuations in the costs of materials. In some cases, an estimator may use a digitizing pen in order to measure and record dimensions directly from the plans and then store the information in a computer.

A complete set of building plans is necessary to prepare a quantity takeoff. The estimator must also review the project specifications carefully. There can be a big difference in cost between one grade of material and another, even though the number of pieces does not change. If a quantity takeoff is precise, there will be little or no difference between the estimate and actual construction costs.

Estimators must use the proper measure of quantity when preparing a quantity takeoff. For example, concrete is generally measured by the cubic yard. Framing lumber is measured by the lineal foot, by the piece, or by thousand-board-foot quantities. Carpeting is measured by the square yard and, increasingly, by the square foot. **Table 2-2** shows common abbreviations used in estimating.

Unit-Cost Estimate Another detailed estimate of construction costs is a *unit-cost estimate* or *component-cost estimate*. In making a unit-cost estimate the estimator divides the house into components, such as walls or roof. Estimates are made of the cost for each component. This is faster than the quantity takeoff method.

The "unit" of a unit-cost estimate depends on the component. The unit for walls is typically lineal feet (LF). Lineal feet is a measurement of length. The unit for floors and roofs is square feet (SF). For example, the 8' high interior partition shown in **Figure 2-25** on page 62 would be measured in lineal feet. The cost of the wall would include the costs of every part, including the following:

- plates
- studs and 16d nails
- drywall on both sides of the wall
- drywall screws
- joint tape and compound
- drywall primer
- interior paint (two coats)
- baseboard trim.

Table 2-2: Common Abbreviations Used in Estimating

APPR (approximate)	LBS/HR (pounds per hour)	OZ (ounce)
BDL (bundle)	LF (lineal foot))	PC (piece)
BF (board foot)	LH (left hand)	PR (pair)
CF (cubic foot)	M2 (square meter)	QT (quart)
CY (cubic yard)	M3 (cubic meter)	R/L (random lengths)
EA (each)	MH (man-hour)	RH (right hand)
GA (gauge)	MISC (miscellaneous)	SF (square foot)
GAL (gallon)	NA (not applicable)	SQ (square)
HR (hour)	NAT (natural)	UNF (unfinished)
LB (pound)	OA (overall)	YD (yard)

Note: These abbreviations are usually capitalized but may also be seen in other forms. For example, "each" may be written **Ea**. Some of these abbreviations may also be followed by periods. Some of these abbreviations differ from those used in this text.

If the wall were 12' long, then the total cost for the wall would be divided by 12 to determine the unit cost (the cost per lineal foot).

After a unit cost for this partition is figured, the estimator can quickly determine the total lineal footage of all partition walls in the whole house by measuring the plans. This figure is then multiplied by the unit cost to determine total costs for all the partition walls. It is important to note that this cost estimate would *not* cover exterior walls.

Depending upon the estimator's needs, the unit cost may be for materials only, or it may also include the cost of labor. A unit cost for labor for this particular project would include the labor of a carpenter, a drywall installer, and a painter.

Reading Check

Recall *What is a quantity takeoff?*

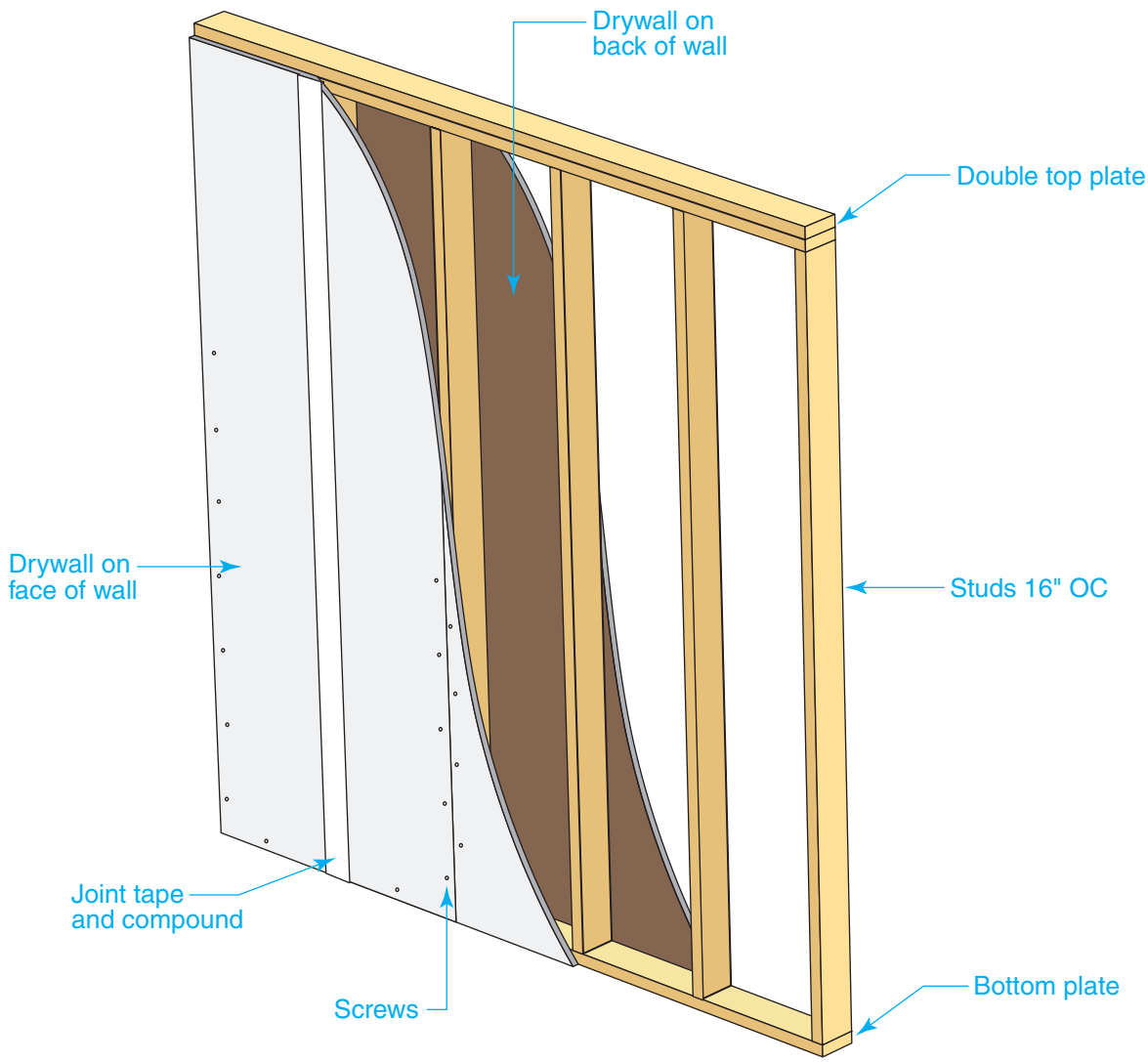


Figure 2-25 A Completed Partition Wall

All Parts Considered The unit measurement of this wall would be in lineal feet (LF). The unit cost would include every component of the wall from framing to finish work, including painting.

Calculating Board Feet

A **board foot** is a unit of measure that represents a piece of lumber having a flat surface area of 1 sq. ft. and a thickness of 1" nominal size, as shown in **Figure 2-26**. The number of board feet can be found by using simple arithmetic or by referring to **Table 2-3**.

To determine the number of board feet in one or more pieces of lumber, use the following formula:

$$\frac{\text{Number of Pieces} \times \text{Thickness (in.)} \times \text{Width (in.)} \times \text{Length (ft.)}}{12}$$

Example 1: Find the number of board feet in a piece of lumber 2" thick, 10" wide, and 6' long. See **Figure 2-27**.

$$\frac{2 \times 10 \times 6}{12} = 10 \text{ bd. ft.}$$

Example 2: Find the number of board feet in 10 pieces of lumber 2" thick, 10" wide, and 6' long.

$$\frac{10 \times 2 \times 10 \times 6}{2} = 100 \text{ bd. ft.}$$

Table 2-3: Rules for Estimating Board Feet

Width (in.)	Thickness (in.)	Board Feet
3	1 or less	¼ of the length
4	1 or less	⅓ of the length
6	1 or less	½ of the length
9	1 or less	¾ of the length
12	1 or less	Same as the length
15	1 or less	1¼ of the length

If all three dimensions are expressed in inches, the same formula applies. However, the divisor is changed to 144 (12^3).

Example 3: Find the number of board feet in one piece of lumber 2" thick, 10" wide, and 18" long.

$$\frac{1 \times 2 \times 10 \times 18}{144} = 2\tfrac{1}{2} \text{ bd. ft.}$$

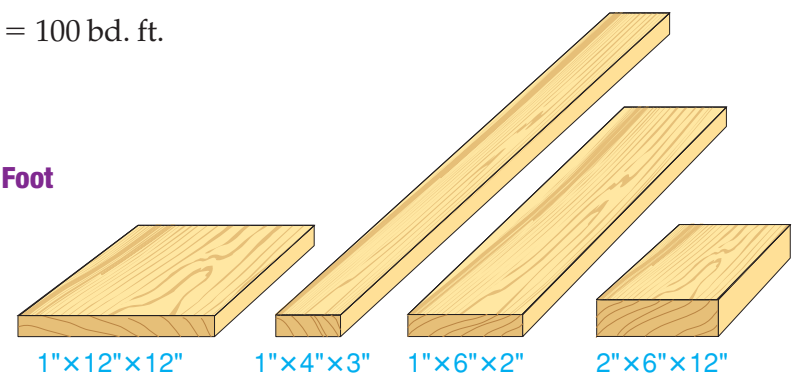
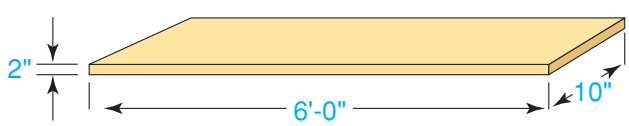


Figure 2-26 A Board Foot
Different Shapes, Same Measure
Each of these pieces contains one board foot of lumber.



$$\frac{\text{Pieces} \times \text{thickness (inches)} \times \text{width (inches)} \times \text{length (feet)}}{12} = \frac{1 \times 2 \times 10 \times 6}{12}$$

Figure 2-27 Figuring Board Feet
Calculation Number of pieces × thickness (in.) × width (in.) × length (ft.) ÷ 12 = bd. ft.

Allowances

When an estimate is being prepared for a custom house, some costs may not be known until late in the building process. These costs are usually related to products that the client must choose, such as lighting fixtures, floor coverings, and cabinetry. To account for these items, the estimator includes an *allowance* in the estimate. An allowance is a dollar figure representing the cost of products that have not yet been chosen when a detailed estimate is made. For example, $3,500 might be the builder's allowance for interior and exterior lighting fixtures. If the client later chooses fixtures that cost more, the client must pay the difference.

The advantage of allowances is that the builder can provide an early cost estimate without forcing the client to make difficult product choices. The hazard of allowances is that they can be unrealistically low. The client might be surprised by large expenses late in the process.

Money is usually set aside in a builder's construction budget to cover the costs of unforeseen situations. One example would be an unexpected stretch of wet weather. Such weather might require the builder to use pumps to keep the excavation dry. This **allocation** of money is called a *contingency allowance.* If the money is not required, the builder either adds it to the profit or refunds it to the client.

Builder's Tip

CHANGE ORDERS A client may wish to change some aspect of the house after construction has begun. In such a case, the builder and client sign a document that describes the changes and then estimates the cost for the extra work. This document is called a change order. A change order helps the builder keep track of extra costs. It also reduces the chances for misunderstandings between builder and client.

Types of Costs

A builder must account for two types of expenses in order to turn a profit. Direct costs, or project costs, are related to a certain house. They include such costs as labor, materials, building permits, temporary power hookups, and some types of insurance. Most direct costs can be determined based on a review of the building plans. The estimating techniques noted throughout this book are those that determine direct costs.

Indirect costs, or overhead, are not related to a particular house. These costs relate to the organization and supervision of the project. They include the cost of office equipment and supplies, construction tools and equipment, office payroll, and taxes.

Some charges may include both direct and indirect costs. For example, the monthly access charge for the phone in a builder's truck would be an indirect cost. The costs of both framing lumber and long-distance calls made to a supplier for lumber used on a project are examples of direct costs.

A percentage for profit must be added to every estimate. This percentage may range from 10 to 40 percent, depending on the job size and the amount and type of work.

Checklists

The heart of an estimate is a checklist that identifies every piece of material used at each stage of construction. The purpose of a checklist is to ensure that nothing is left out of the estimate.

The builder or estimator reviews each item on the checklist and determines which ones apply to the project. For each item, the estimator calculates the dimensions and quantity of each item needed as well as the cost.

Construction-Order Checklist Many builders prefer items on a checklist to be in the same order as the building tasks that need to be done. Thus, the first items on a construction-order checklist relate to excavation, the next

items relate to building the foundation, and so on. One advantage of this approach is that it encourages the estimator and the builder to think logically about how the house will be built.

CSI MasterFormat Checklist The Construction Specifications Institute (CSI) is a professional association that develops standards for writing specifications. CSI has developed a system of organizing specifications for various aspects of commercial construction. This system is called *MasterFormat*. The MasterFormat system organizes all aspects of construction into 16 main categories. Each category consists of many subcategories. Although the system was developed for commercial construction, some residential builders have adapted it for use in developing residential estimating checklists. You can see an example of a MasterFormat checklist on this book's OLC through **glencoe.com**.

Sources for Cost Information

Gathering information about the exact cost of materials and labor can be time-consuming. The estimator must check various sources.

Material Suppliers The estimator can contact local material suppliers to get the cost of materials. Generally this is done after the quantity is determined. This is because a large quantity of flooring, for example, generally costs less per square foot than a small quantity. Several suppliers may then make bids. For example, several suppliers may bid on supplying all the lumber and sheathing for a project. A builder generally accepts the lowest bid for a given quality and quantity.

Prior Bids If the builder has recently completed another house in a similar area using similar materials, some of the cost information can be obtained from the previous estimate.

Pricing Guides Books are available that contain detailed listings of the prices of materials and of the labor to supply them. These books are published annually or semi-annually.

Builder's Tip

TIME-SENSITIVE BIDS When obtaining bids from materials suppliers, note that such bids may be valid for only a certain period of time. After that time expires, the bid price is likely to change. An estimate must take this into account.

Online Databases Increasingly, estimators use the Internet to check current prices. Manufacturers and distributors of materials and products will post prices on their Web sites. This information is usually more current than information in printed pricing guides.

Reading Check

Explain *What is the difference between direct costs and indirect costs?*

Scheduling

What two elements are scheduled during the building of a home?

Estimating and scheduling are two separate tasks. However, these tasks are often linked because both organize the materials and labor needed to build a house. Scheduling organizes the construction process so the contractor can make the most efficient use of resources. It also enables the builder to determine when the project is ahead of or behind schedule.

Two elements must be scheduled when building a home: materials and activities. It is the responsibility of the general contractor to set up and monitor these schedules. Naturally, the size of the building project affects the complexity of the scheduling.

A contractor who is building only a few houses each year with a small crew often works part-time as part of the crew on the job site. The rest of the contractor's time is

spent coordinating the delivery of materials and the work of the subcontractors. Contractors with many projects may spend all their time on these matters or may hire supervisors to do it.

In residential construction, builders may use several different employment strategies. A builder may do any of the following:

- Build entirely with his or her own employees
- Build with a team composed of employees and subcontractors
- Build entirely with subcontractors.

It is important that all work be completed on time so as not to delay overall progress. Especially important is coordinating the work of subcontractors, because they work on different projects and for various builders.

Material Scheduling

Proper scheduling of material deliveries can have a major impact on the efficiency and quality of construction. The builder is responsible for ensuring access to the site. The builder must also make sure that delivered materials can be properly stored. For example, if a large load of oak flooring is delivered before the house is enclosed, it has to be stored outdoors. There, it is exposed to possible weather damage. In addition, the bundles of oak are in the way of workers, which may reduce worker efficiency.

Material scheduling must be coordinated by builders or general contractors. They work with suppliers to ensure that materials will be available for delivery when needed. Materials that are normally kept in stock, such as framing lumber, can usually be ordered on short notice. A non-stock item, such as a custom cabinet or Italian granite of an unusual color, may require a lead time of weeks or months.

Deliveries vary depending on the type and size of the project. They also depend on the number of people working on it and the time set for completion. Generally, material deliveries are made in the following order:

- *First Load:* all items needed to complete the house up to and including the subfloor.
- *Second Load:* wall framing and ceiling joists.
- *Third Load:* roof framing materials and roof coverings. If roof trusses are used, these will be shipped to the site on a special truck. This truck sometimes has a crane to lift trusses into position.
- *Fourth Load:* exterior doors, windows, exterior trim, and siding, as needed. After the house has been enclosed with doors and windows and can be locked up, the interior wall finish is applied. If the walls are plastered, adequate drying time must be allowed before additional material shipments are made.
- *Fifth Load:* hardwood flooring and underlayment materials.
- *Sixth Load:* interior doors, trim, and built-in cabinet materials.

Materials that are to be delivered to the job site are placed in the truck in the sequence in which they are to be used. When the materials are unloaded and stacked at the site, those materials that are needed first will be on top of the pile.

It is the general contractor's responsibility to check the delivered materials against the original order. If materials are damaged or missing, the supplier should be contacted immediately. If this is not done, construction may be delayed. If materials are left over, the supplier may accept them back for credit but may charge a restocking fee.

The supplier keeps a running tally of the materials shipped to the job site, as well as any credits for returns. The general contractor is expected to pay for materials on a certain time schedule, such as every week or month. In the case of special orders, full or partial payment may be required when the order is placed.

Activity Scheduling

The general contractor is responsible for scheduling subcontractors and other labor and keeps things moving smoothly. Careful scheduling can limit delays caused by subcontractors whose work needs to be done before other subcontractors can begin. For example, if a builder does not arrange for foundation subcontractors far enough in advance, the entire project may be delayed until a foundation subcontractor can fit the project into his or her schedule.

Following is a list of general steps in house construction. It is the general contractor's responsibility to see that these steps are carried out. However, sometimes jobs must be started ahead of schedule or delayed. Therefore, the steps may not always occur in this order. Note that required inspections must be scheduled at the appropriate time.

1. *Survey.* The job site is surveyed and the abstract of title (a record of ownership of the property) is brought up-to-date so that application for title insurance can be made. The abstract of title is the history of the ownership of a property.
2. *Permit.* A building permit is obtained from proper authorities so that work can begin.

JOB SAFETY

CALL BEFORE YOU DIG Before any excavation or trenching is done, the local gas, electric, water, and phone utility companies must be contacted. They then mark the location of utility lines. This "call before you dig" precaution helps to prevent the accidental cutting of buried lines that cross the property. Cutting into a power line is a serious safety hazard! Be sure you know where utilities are located before you begin an excavation.

Go to **glencoe.com** for this book's OLC for more on job safety.

Builder's Tip

SOIL TREATMENTS In areas of the country where termites are a particular problem (see Figure 2-2 on page 35), the soil is sometimes treated with chemicals to prevent infestations. A termite control specialist is sometimes called to treat the soil before the foundation slab is poured. Be sure to coordinate this process with the concrete delivery company.

3. *Excavation.* The excavator brings in power equipment and strips the topsoil away, piling it in one corner of the lot for future use. If the building will have a basement, it is excavated at this time.
4. *Temporary Power.* The electric company must be contacted to set up a temporary power pole on the building site and hook it up. The electricity is needed for operating power tools.
5. *Temporary Water.* On some job sites, the plumber makes the temporary water hookup, which must be coordinated with the city utilities. In existing neighborhoods, water can sometimes be obtained from a neighbor. In this case, the permanent hookup for water to the building is not made until the foundation walls have been installed.
6. *Foundation.* Footings and foundation walls are installed by the foundation subcontractor.
7. *Plumbing.* Pipelines for the water supply are installed in trenches by the plumbing contractor. If the house will be served by a well, it may be drilled at this time.
8. *Slabs.* If the house has a basement, the concrete floor is poured after the rough plumbing is installed and before the interior finish work. The concrete must cure thoroughly. The garage floor is put in anytime after the backfill is completed.

Often this is done at the same time as the basement floor. The concrete is delivered to the site.

9. *Framing.* The carpenters can now frame and sheathe the floors, walls, and roof.
10. *Backfilling.* At some point after the foundation formwork has been removed, the excavation area must be filled in with dirt. This is called backfilling. Before any backfilling can be completed, the exterior walls of the foundation must be moisture-proofed and foundation drainage must be in place. In addition, backfilling should not be done until the floor system is framed or the foundation walls are otherwise braced. This allows time for the concrete to gain strength and reduces the chance that the pressure of backfill will damage the walls.
11. *Mechanicals.* At this point, a number of activities may be carried out at the same time, or at least in rapid succession. These include plumbing, heating, and electrical work. All mechanical subcontractors must work in two stages: rough-in work and finish work. For example, when the framing is complete, the electrician begins to do the rough wiring. This includes installing the main circuit panel and outlet boxes and feeding all the wires through the framing. This is the rough-in portion of the work. Later, after the interior walls are completed, the electrician comes back to install the switches, receptacles, and light fixtures. A plumber installs bathtubs during the rough-in phase, because tubs are a built-in feature of the house.
12. *Windows and Doors.* While the mechanical subcontractors are doing the rough-in work, the carpenters install exterior doors and windows and complete any remaining details of the framing.

Builder's Tip

REDUCING DAMAGE Windows and doors should be installed as soon as possible after they are delivered to the site. This reduces the chance of damage to glass or frames. It also minimizes the number of times doors and windows must be handled. Early installation also keeps these materials out of the way of workers.

13. *Roofing and Siding.* To weatherize and protect the house, contractors install roofing and siding. Generally the roofing is installed first.
14. *Insulation.* After all rough-in work is done, insulation is installed in the walls and, as needed, in the ceiling.
15. *Interior and Exterior Finishes.* Most interiors are finished with drywall or plaster. Plastering must be done immediately. At the same time, carpenters can work on the exterior of the building installing siding, exterior trim, and the garage door. Normally, plaster is applied in two stages. Often a week or ten days must be allowed for drying after each stage before proceeding with other interior work. With drywall, the drying period is much shorter since the only wet application is taping the joints and covering nail heads.

JOB SAFETY

BACKFILL TIMING If backfilling is delayed until framing is completed, workers have to work around a large excavation. This can be unsafe because the workers must carry materials on planks over the excavation. However, if backfilling is done *before* framing begins, the foundation walls must be braced from the inside to prevent them from being caved-in by backfill.

Go to **glencoe.com** for this book's OLC for more on job safety.

16. *Finish Carpentry.* At this stage the carpenters are ready to do the interior finishing, provided the plaster and concrete are thoroughly dry. Be careful not to store interior trim in a house with high humidity due to wet plaster and concrete, as the wood will absorb the moisture and swell. Later it will dry out and crack. Wood floors may be installed at this stage but are usually finished later. Built-in shelves, interior doors, and cabinets come next. Finally, the interior moldings are applied, including base, shoe, ceiling, window, and door trim.
17. *Exterior Painting.* While carpenters are working on the inside of the house, painters can be finishing the exterior. The ideal arrangement is for the painters to work closely behind the carpenters so that the wood is properly sealed. If exterior trim has been pre-primed at the factory, timing is not as important.
18. *Finish Grading.* While the carpenters are completing the interior of the house, the exterior finish grading is done. This includes preparation work for sidewalks and driveways.
19. *Concrete Driveways and Sidewalks.* After finish grading, at the very last stages of construction, concrete driveways and sidewalks are installed.
20. *Landscaping.* Landscaping is the final step in completing the exterior of the house.
21. *Interior Painting.* After the carpenters have completed the interior of the house, the painting is done.
22. *Floor Coverings.* After the paint is dry, floor tile and resilient flooring are installed.
23. *Finish Electrical.* At this point the electricians can return to add switches, outlets, and light fixtures.
24. *Finish Plumbing.* The plumbing fixtures are now installed by the plumbing contractor.
25. *Wood Flooring.* One of the last jobs on the interior of the house is to finish the wood flooring. Many homes are completely covered by carpeting and require no floor finishing. However, if hardwood floors are used, sanding should be done after the interior painting to remove any paint drops or spillage. The actual finishing is done as one of the last jobs so that traffic does not raise dust while the finish dries. Hardwood flooring can also be purchased prefinished, which greatly simplifies this part of the job.
26. *Carpeting.* After the wood floors are finished, carpeting is laid.
27. *Cleanup.* The general contractor is responsible for the final cleanup. A responsible contractor will make sure that the windows are washed and all waste materials are removed.
28. *Punch List.* After the entire house has been completed, the general contractor or builder walks through the house with the new owner. This is a chance for the owner to make sure everything has been done to his or her satisfaction. Often, the owner will spot such things as scuffed paint, cracked woodwork, or light fixtures that do not work properly. The contractor then makes a punch list. This list identifies all the repairs that must be completed before the house is acceptable to the owner.

Builder's Tip

MAINTAIN GOOD COMMUNICATION General contractors must stay in contact with subcontractors as they work on the house. However, it is also important to maintain contact with subcontractors well ahead of the time when their work is to begin. This will often give the general contractor advance warning of any delays that could affect the building schedule.

Staying on Schedule

A complex project may involve hundreds of individual tasks. Keeping track of scheduled jobs is the key to successful construction management. Many builders use graphic methods to do this, including bar charts and diagrams. Computer software makes it fairly easy to set these up and revise them as needed.

Bar Charts A bar chart is an easy way to keep track of a project. It shows how long each task will take and when each task will start and end. A calendar format displays the entire job over time. A simple bar chart such as the one in **Figure 2-28** can be used to track small jobs, such as the addition of a bedroom to a house. Expanded versions of this type of bar chart can track the construction of an entire house.

The value of a bar chart is in its ability to show an overview of the entire project. It also shows how various tasks overlap. However, its simplicity limits its usefulness. A bar chart cannot show every complex relationship between various parts of the project, as shown in the construction sequence of **Figure 2-29**. That is why it is used primarily as a general planning tool.

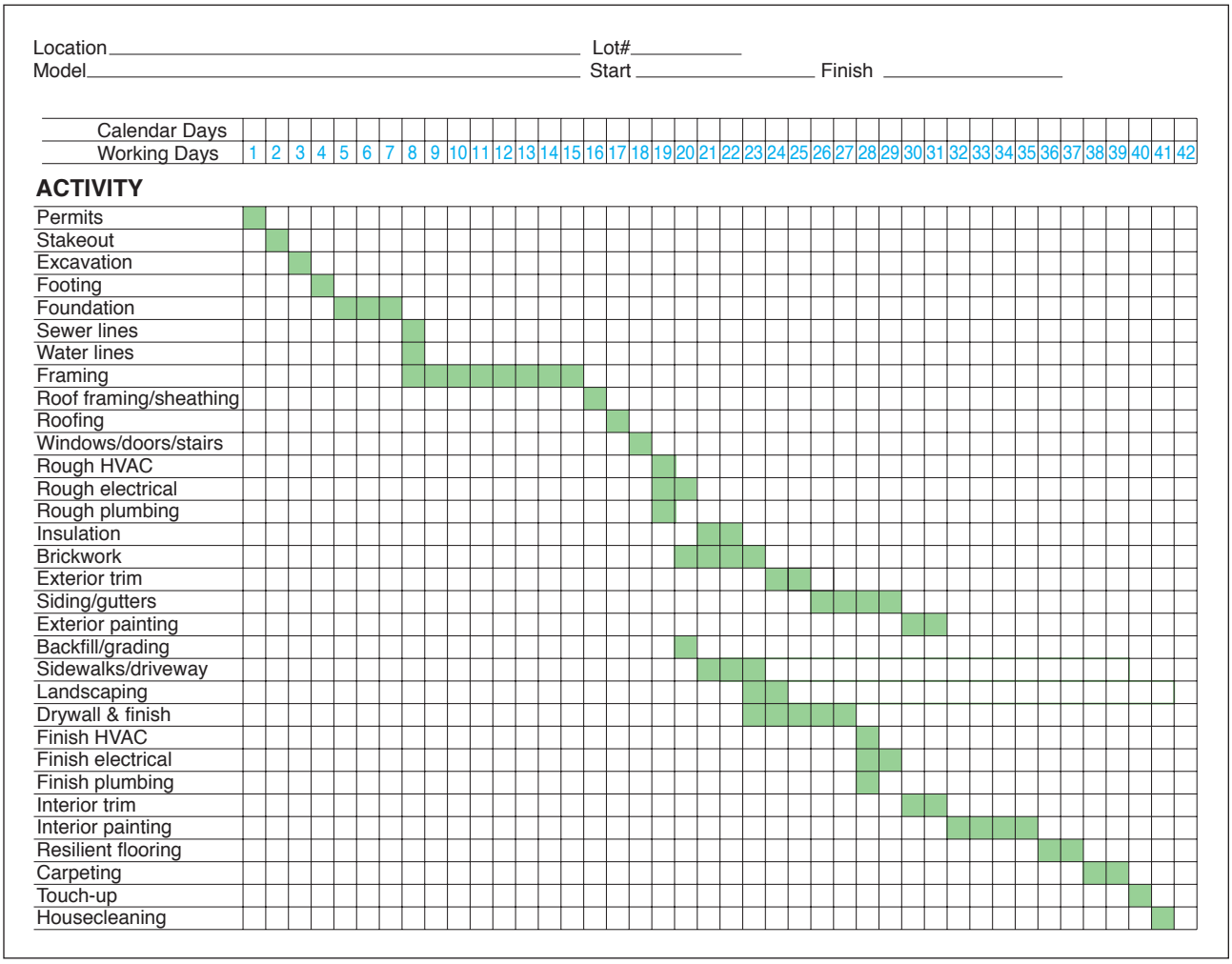


Figure 2-28 A Bar Chart

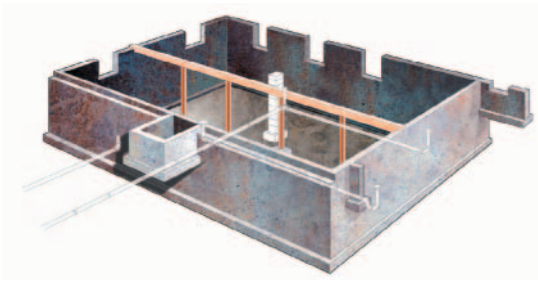
Keeping Track of Many Tasks A bar chart shows how long tasks take and presents them in chronological order.

Figure 2-29 Building a House

From Start to Finish A construction sequence shows how the various aspects of a project occur in relation to each other.

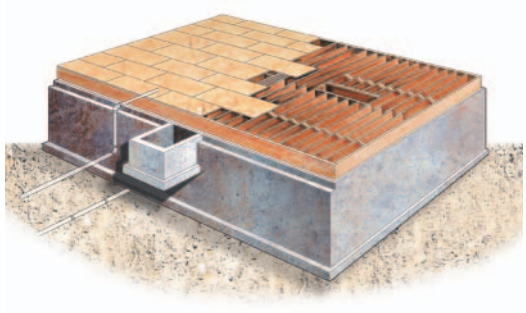
A Footings and Basement Walls

- The basement is excavated and then the footings are placed.
- The foundation walls are either poured or constructed of concrete block. The fill around the basement is omitted here to show footings and walls.
- The supporting columns and the center beam are installed.
- The exterior surface of the walls is moisture-proofed up to the finish grade level.
- The front porch excavation may be filled with sand and is ready for the porch and basement floors to be placed.



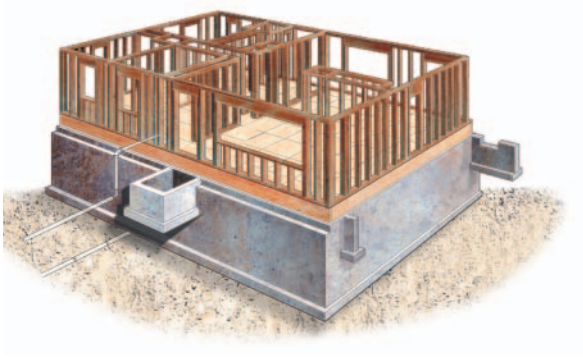
B First Floor Construction

- The rough grading is shown leveled off four inches below the finished grade line.
- The joists are installed. There are double joists at the stairwell and under inside partition walls.
- The double joists are separated with solid bridging. Metal or wood bridging is installed midway between the ends of other joists and the supporting beam.
- The plywood subfloor is laid.



C Wall Framing

Wall framing is completed. If the house has a second story, floor joists and additional wall framing will be added on top of the walls of the first story.



D Complete Framing

Cutaway view of the house showing some finished plumbing and heating. The actual placement of the fixtures and appliances would not be done until the house has been closed in.

E Rendering of Finished Home

The exterior of the home as it will look when it is completed.

Critical Path Method Diagrams The *Critical Path Method (CPM)* of scheduling shows the relationships among tasks as well as how long they take. It is the most common type of scheduling used in residential construction. The relationships are shown in a CPM diagram.

A CPM diagram's value is in identifying the tasks that are most important to the success of the project. Taken together, these tasks indicate the minimum amount of time needed. In other words, critical path tasks such as those shown in **Figure 2-30** are those in which any delay will automatically delay completion of the entire project.

The CPM diagram was originally developed to keep track of maintenance work in an oil and chemical refinery. A similar diagram, called Program Evaluation and Review Technique (PERT), was developed about the same time to track the construction of nuclear submarines and is used by some builders.

To develop a CPM schedule, list all the work that has to be done. The list of tasks under "Activity Scheduling" in this chapter is an example of a list of all of the work that must be done to complete a project. The following three questions should be answered for each task:

1. What tasks come before this one? All tasks have a logical order in which they are performed. For example, the drywall must be taped before it can be painted.
2. What tasks cannot start until this one is complete? For example, rough plumbing cannot be installed until the framing is in place. Wall framing for a second story cannot be built until the first floor walls are in place.
3. What tasks can be worked on at the same time? Building jobs move more quickly when various tradespeople are working at the same time. For example, electricians can be working inside the house while other tasks are taking place outside the house.

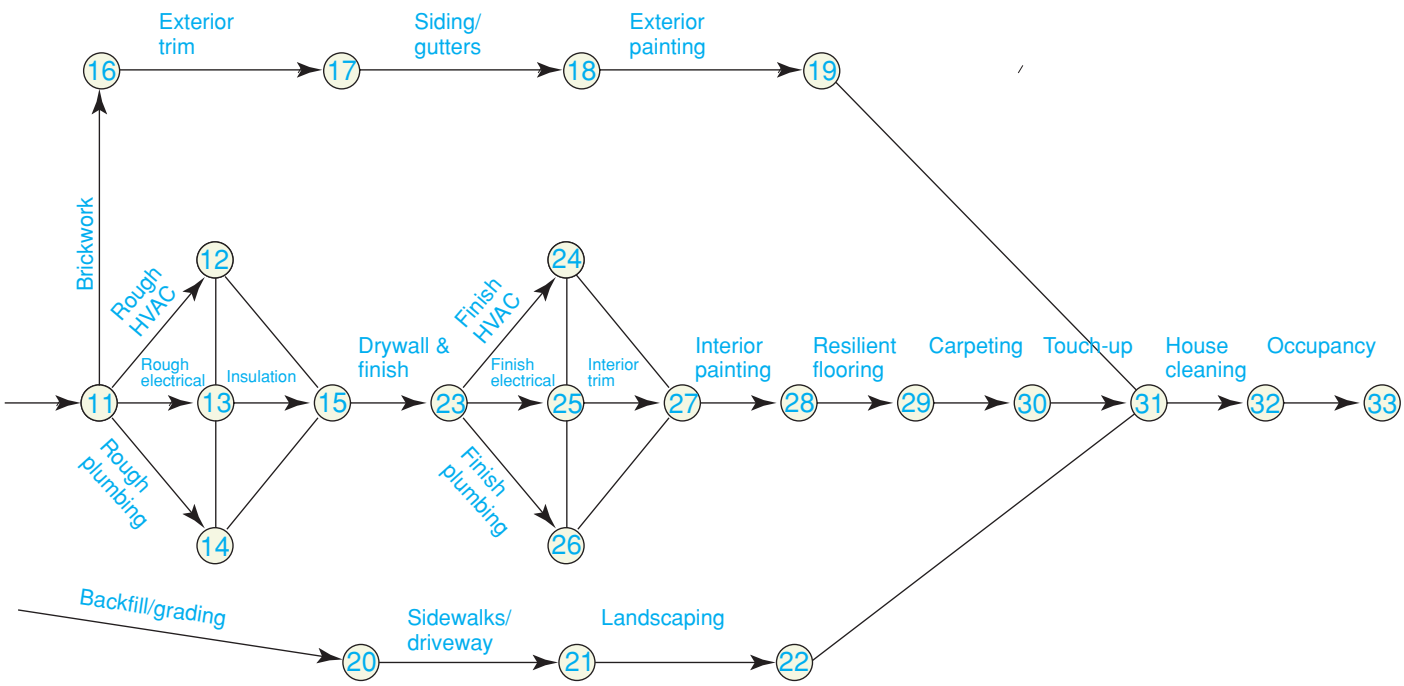


Figure 2-30 A CPM Diagram

Making Connections Obvious A CPM diagram arranges tasks based on their relationship to one another. The timeline would be placed at the bottom of the diagram and would depend on the schedule for the project.

After these questions have been answered, the tasks can be plotted on a CPM diagram. The arrows on the diagram indicate tasks. The tail of the arrow represents the start of a task, and the head represents the end. Boxes or circles, called *nodes,* represent events that can are key achievements in the project, such as "Roof trusses plumbed and braced." Arrows that follow one another along the same path indicate tasks that must end before the next task can begin. Parallel arrows represent tasks that go on at the same time. Arrows can be straight or curved.

Builder's Tip

PROJECT MANAGEMENT Project management software, which includes scheduling functions, makes schedule updates easy. If computers are *networked,* or linked together, workers can update their part of the project and inform others of changes simultaneously. Programs include graphic functions that can create charts and schedules that display the information visually.

Section 2.4 Assessment

After You Read: Self-Check

1. Why is it important that cost estimates be as accurate as possible?
2. Name two sources of information that can help a builder develop an estimating checklist.
3. Arrange the following tasks in chronological order, starting with the task that occurs first:
   - **A.** Interior Painting
   - **B.** Temporary Power
   - **C.** Floor Coverings
   - **D.** Insulation
   - **E.** Finish Carpentry
   - **F.** Floor Framing
   - **G.** Backfilling
4. What do arrows and nodes represent on a CPM diagram?

Academic Integration: English Language Arts

5. **Manage Information** Create a Critical Path Method (CPM) diagram for the first 25 steps noted under "Activity Scheduling" on pages 67–69. Assume that each of the steps listed takes three days to complete.

   Step 1: Begin by identifying the steps that form the critical path.

   Step 2: Next, identify the steps that may proceed at the same time as the critical tasks.

   Step 3: Use a ruler or computer software to create your graph. Use arrows to indicate tasks and circles to indicate nodes.

   When you complete your CPM diagram, compare it with another student's CPM diagram and discuss the differences in class.

Go to glencoe.com for this book's OLC to check your answers.

CHAPTER 2

Review and Assessment

Chapter Summary

Section 2.1

Building codes establish minimum standards of quality and safety in housing. A building department can develop its own codes or adopt model codes developed elsewhere. Financing can be obtained in the form of a construction loan and a mortgage.

Section 2.2

Construction plans consist of drawings of each part of the structure as well as its measurements. Objects on plans are generally drawn to scale with an architect's scale. The elements of a drawing include lines, dimensions, symbols, and notes. Computer-aided drafting and design enables architects to create plans and other drawings electronically.

Section 2.3

Plan views include site plans, foundation plans, floor plans, framing plans, electrical plans, and mechanical plans. Elevations, section views, schedules, engineering plans, and specifications give information that may not appear in plan views. Renderings show the finished building.

Section 2.4

Accurate estimates of materials and costs help builders ensure a profit. Types of estimates include the pre-design estimate, the quantity takeoff, and the unit-cost estimate. A schedule helps builders keep track of project materials and activities.

Review Content Vocabulary and Academic Vocabulary

1. Use each of these content vocabulary and academic vocabulary terms in a sentence or diagram.

Content Vocabulary

- building code (p. 34)
- building permit (p. 35)
- stock plan (p. 37)
- floor plan (p. 37)
- mortgage (p. 40)
- architect's scale (p. 44)
- plan view (p. 50)
- elevation (p. 53)
- schedule (p. 56)
- specifications (p. 57)
- bid (p. 59)
- quantity takeoff (p. 60)
- board foot (p. 63)
- indirect cost (p. 64)

Academic Vocabulary

- exceeds (p. 34)
- scale (p. 44)
- derived (p. 46)
- allocation (p. 64)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *model building code* (p. 34), *blueprints* (p. 41), *cutting plane* (p. 51), *detail drawing* (p. 55), *rendering* (p. 56), *change order* (p. 64), *punch list* (p. 69), *Critical Path Method (CPM)* (p. 72), *nodes* (p. 73).

Review Key Concepts

3. Identify the steps of planning to build a house.

4. Compare three sources of house plans.

5. Summarize how to obtain financing for construction.

6. Describe three elements used in architectural drawings and plans.

7. Restate the advantages of computer-aided drafting and design.

8. Define direct cost and indirect cost.

Critical Thinking

9. **Analyze** Describe the different types of cost estimates and how they differ from one another.

Academic and Workplace Applications

STEM Mathematics

10. **Finding Volume** A set of architectural plans shows an enclosed storage room. It will be 9' long × 9' wide × 8' high. The builders need to know the volume of the room so that they can install a dehumidifier to keep it dry. What is the volume of the storage room?

Math Concept The formula for finding the volume of a regular rectangular prism (a three-dimensional shape) is

$$V = lwh$$

where V stands for volume, l for length, w for width, and h for height. To solve this problem, insert the given length, width, and height into the formula. Solve for V. Use cubic units to express the volume of the room.

21st Century Skills

11. **Economic Literacy: Purchasing Property** The process for purchasing property differs from region to region. In some states, the attorney for the seller develops a contract of sale, and the attorney for the buyer does a title search through local records to make sure the title is free of any other claims on it. In other states, a realtor draws up a standardized contract and the title search is done by a title company.

A title company specializes in tracing the ownership of property through legal documents. Investigate the purchasing property process in your state. Summarize your findings in a two-paragraph report.

21st Century Skills

12. **Financial Literacy** The total cost of a house is $450,000. The length of the mortgage is 30 years. What is the monthly payment?

Starting Hint This problem has many steps. First, multiply the number of years in the mortgage (30) by the number of months in a year (12) to calculate the total number of monthly payments needed. Then divide the total cost of the house ($450,000) by the total number of payments to calculate the average monthly payment.

Standardized TEST Practice CERTIFICATION PREP

Multiple Choice

Directions Read the following questions. Then read the answer choices and choose the best answer.

13. Which of the following is NOT a legal document that must be processed to purchase a house?

a. official survey
b. deed
c. elevation plan
d. abstract of title

14. What is the ratio between the size of the object as drawn and its actual size called?

a. customary rule
b. scale
c. dimension
d. elevation

15. What are the two elements that must be scheduled when building a home?

a. construction-order checklist and CSI MasterFormat checklist
b. estimating and scheduling
c. materials and activities
d. prior bids and pricing guides

TEST-TAKING TIP

If you have time at the end of the test, reread the questions to make sure you have understood them.

*These questions will help you practice for national certification assessment.