Unit 4 Wood Frame Construction

In this Unit:

Hands-On Math Project Preview

Construction Calculations

After completing this unit, you will use trigonometry to calculate the rafter lengths for various design options and create a table to present the options. You will also calculate the total rise of specific roof angles and spans.

Project Checklist

As you read the chapters in this unit, use this checklist to prepare for the unit project:

- ✓ List the materials used in roof framing.
- ✓ Describe the different styles of roof design.
- ✓ Identify how to calculate rafter length and rise.

Go to glencoe.com for this book's OLC. Find the WebQuest activity for Unit 4 called "Planning for Construction."

Construction Careers Framing Carpenter

Profile A framing carpenter is a type of structural worker. Framing carpenters assemble the basic structural features that are later finished by other specialty carpenters.

Academic Skills and Abilities

- mathematics
- blueprint reading
- geometry
- interpersonal skills
- mechanical drawing

Career Path

- on-the-job training
- apprenticeship programs
- trade and technical school courses
- certification

Go to **glencoe.com** for this book's OLC to find more information about carpentry and construction careers.

Explore the Photo

Wood Frame Construction Framing carpenters construct the frame of the building. *Why do you think teamwork and communication are an important to a framing carpenter?*

CHAPTER 12

Wood as a Building Material

Chapter Objectives

After completing this chapter, you will be able to:

- **List** the advantages of wood as a building material.
- **Define** hardwoods and softwoods.
- **Describe** flat-sawn and quarter-sawn boards.
- **Explain** how the moisture content of wood is controlled.
- **Identify** common defects in lumber.
- **Summarize** conditions and factors that lead to wood damage.

Discuss the Photo

Natural Resources Wood is a renewable resource. This means that wood that has been consumed or used can be replaced by reproduction. *Why should human beings help renew natural resources such as forests?*

Writing Activity: Collaborative Writing

Team up with two other classmates. Brainstorm a list of ideas about how lumber is used in structures. Then, work with your team to write one or two paragraphs summarizing your ideas.

Wood Wheatcroft/Getty

Chapter 12 Reading Guide

Before You Read Preview

Wood is used more than any other material in the construction of a house. It is easy to work with and extremely versatile. 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

- cambium
- deciduous tree
- coniferous tree
- lumber
- moisture content (MC)
- fiber-saturation point
- seasoning
- kiln
- grade
- grade stamp
- warp
- nominal dimension
- dry rot
- wood preservative

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.

- species
- ecosystems
- photosynthesis
- equilibrium

Graphic Organizer

As you read, use a two-column chart like the one shown to organize types of trees.

Hardwood	Softwood

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

Academic Standards

Science

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

Physical Science: Chemical reactions (NSES)

Life Science: Matter, energy, and organization in living systems (NSES)

Life Science: Behavior of organisms (NSES)

Science in Personal and Social Perspectives: Natural resources

Science in Personal and Social Perspectives: Environmental quality

Mathematics

Measurement: Understand measurable attributes of objects and the units, systems, and processes of measurements (NCTM)

Problem Solving: Solve problems that arise in mathematics and other contexts (NCTM)

English Language Arts

Use written language to communicate effectively (NCTE 4)

Industry Standards

Wood and Lumber Building Materials

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

Section 12.1

Wood Basics

The Value of Wood

Why must we take care of our forests?

For all-around utility, wood has no equal as a building material. It can be used to form most of the house's frame and many interior and exterior surfaces. It is also a key element in the construction of doors, windows, cabinetry, stairs, and other features. Wood is versatile and readily available. It can be cut to different sizes and formed into many different shapes.

Because wood has been used for thousands of years, carpenters, builders, architects, and others know a great deal about how it performs. Even so, new types of wood and wood-based materials are being developed all the time. For more on these materials, see Chapter 13. This chapter will focus on solid wood.

Solid wood is used for many types of construction for several reasons:

- Wood is strong. Certain common framing woods are as strong and rigid as some types of steel.
- Wood is easily fastened with nails, staples, bolts, connectors, screws, or glue.
- Wooden buildings are easily altered or repaired. Openings can be cut and additions made without difficulty.
- Wood has low heat conductivity, which helps to reduce heat loss.
- Wood accepts decorative coatings such as paint and stains.
- Wood resists acids, saltwater, and other corrosive agents better than many other structural materials.
- Wood is a renewable resource.

Our Forest Resources

Most of the wood used in the United States is harvested from millions of acres of forestland spread across North America. Many years ago, trees were cut without regard for the effect cutting would have on the forest itself and the surrounding areas. However, many people now understand that we must take greater care of forests across the globe. The benefits include:

- Continued ability to harvest lumber
- Protection of important water resources
- Soil conservation
- Production of oxygen and absorption of carbon dioxide
- Preservation of wildlife and plant habitats (environments) and endangered **species** (types of organisms)
- Maintenance of scenic areas

Build It Green If forests are managed properly, there will be no shortage of wood. Individual trees may grow back, but forest **ecosystems** are fragile and may require thousands of years to reach a mature stage.

How Trees Grow

The growing, "working" parts of a tree are shown in **Figure 12-1**. They include the tips of its roots, the buds, the leaves, and a thin layer of cells just inside the bark called the cambium. The **cambium** is a layer of living tissue that produces new wood, called *sapwood,* along its inner surface. New bark is created along the cambium's outer surface. Sapwood enables water and nutrients from the tree's roots to reach its leaves. As successive layers of sapwood build up around the tree, the layers nearest the center gradually turn into

a nonliving material called *heartwood*. Heartwood does not contribute to growth, but it gives strength and rigidity to the tree.

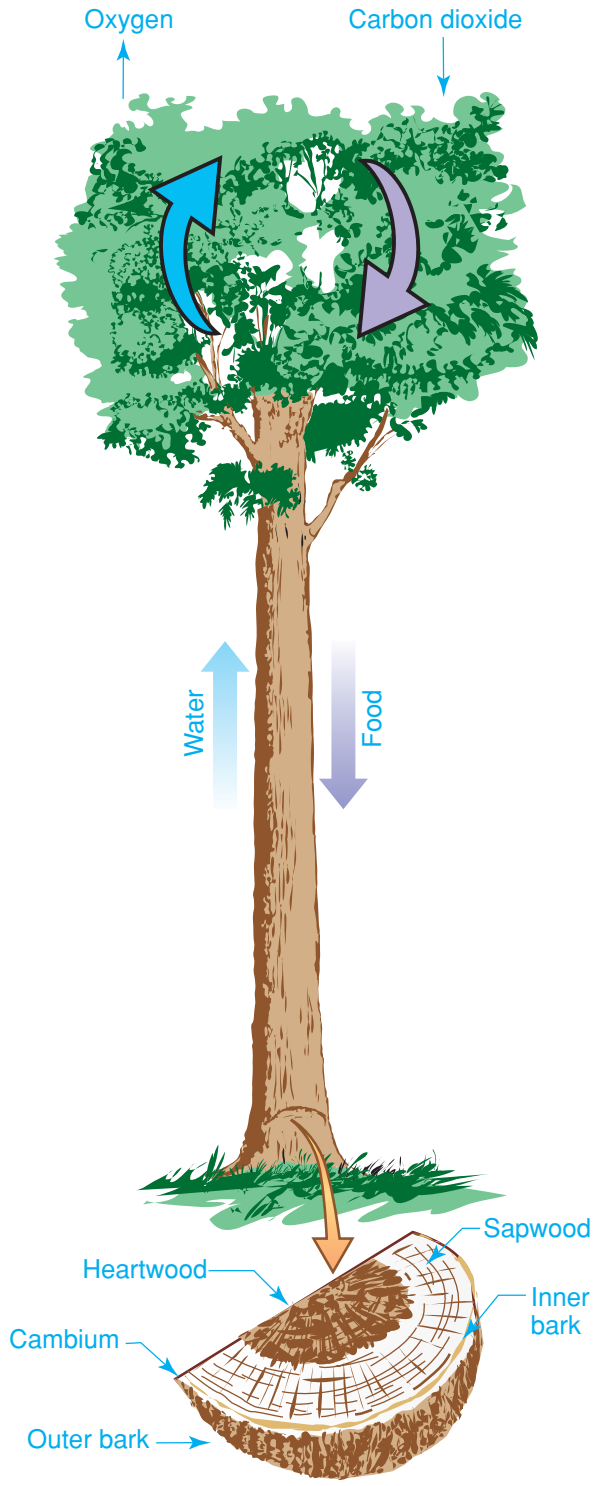


Figure 12-1 How a Tree Grows
A Growth System A tree depends on all its elements in order to grow.

Water from the soil enters a tree through its roots. The water travels upward through the sapwood into the leaves. Through the process of **photosynthesis**, carbon dioxide in the atmosphere and water are combined in the presence of chlorophyll and sunlight. This provides food to nourish the whole tree. This food is carried from the leaves to the rest of the tree through the inner bark. Oxygen is released through the leaves as a byproduct of photosynthesis.

After a tree has been harvested, its life story can be read in the *annual rings* (growth rings) of the stump. In temperate climates, the tree adds one annual ring during each year of growth. Most annual rings consist of a light band formed in the spring (early wood) and a dark band formed in the summer (late wood). When growth conditions are good and food and water abundant, the rings are wide. When long dry spells or other adverse conditions occur, growth slows and the rings are narrow. Annual rings are visible in the end grain of lumber, as shown in **Figure 12-2**. Experienced builders sometimes study these rings to determine the suitability of the lumber for various uses.

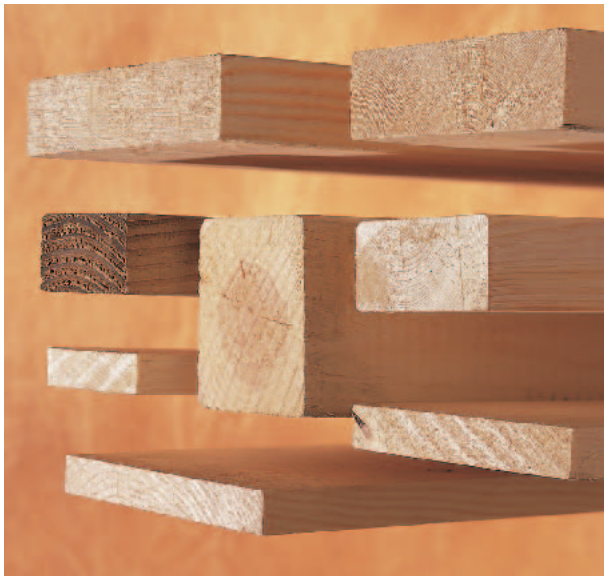


Figure 12-2 Growth Rings
History Growth rings are visible on the ends of boards. *When are growth rings narrow?*

Hardwoods and Softwoods

The terms *hardwood* and *softwood* identify woods based on the two main types of trees. The terms do not indicate actual softness or hardness of the wood. In fact, some hardwoods, such as balsa wood, are softer and less dense than many softwoods. Some softwoods, such as yew, are harder than some hardwoods. Hardwoods are cut from broad-leaved, deciduous trees. A **deciduous tree** is a tree that sheds its leaves annually, during cold or very dry seasons. In the United States and other countries with temperate climates, most broad-leaved trees are deciduous and lose their leaves in the fall. Some common hardwoods are walnut, mahogany, maple, birch, cherry, oak, and ash. Softwoods are those that come from coniferous trees. A **coniferous tree** is a tree that produces seeds in cones and has needle-like or scalelike leaves. Common examples of coniferous trees are pine, hemlock, fir, cedar, and redwood trees.

Wood for construction has traditionally been used in the general region in which the logs were harvested. **Table 12-1** lists the North American softwoods that are used most for wood products. However, the global economy and improvements in shipping have made wood products from one region available in other regions. For example, tropical hardwoods from Central and South America are found increasingly in North American markets. Only those tropical woods purposely grown on tree plantations (farms) can be considered renewable resources.

Recall *How long might it take to replace a forest ecosystem?*

Processing Lumber

What is a nominal dimension?

When a tree has been cut down and its limbs have been removed, the result is called

Table 12-1: Principal Commercial Softwoods

Common Commercial Names	Alternate Names
Cedar	
Alaska cedar Eastern red cedar Incense cedar Northern white cedar Port Orford cedar Southern white cedar Western red cedar	Southern red cedar Atlantic white cedar
Cypress	
Cypress	Bald cypress Pond cypress
Fir	
Balsam fir Douglas fir Noble fir White fir	Fraser fir Subalpine fir California red fir Grand fir Pacific silver fir
Hemlock	
Eastern hemlock Mountain hemlock West Coast hemlock	Carolina hemlock Western hemlock
Juniper	
Western juniper	Alligator juniper Rocky Mountain juniper Utah juniper
Larch	
Western larch	None
Pine	
Jack pine Lodgepole pine Norway pine Ponderosa pine Sugar pine Idaho white pine Northern white pine Longleaf yellow pine Southern yellow pine	Red pine Western white pine Eastern white pine Longleaf pine Slash pine Loblolly pine Longleaf pine Pitch pine Shortleaf pine
Redwood	
Spruce	
Eastern spruce Engelmann spruce Sitka spruce	Black spruce Red spruce White spruce Blue spruce
Tamarack	
Yew	
Pacific yew	None

a log. Logs are sawn lengthwise into smaller pieces at a mill. These pieces of wood have a uniform thickness and width and are referred to as **lumber**.

Cutting Boards From Logs

The way in which a board is cut from the log can affect its appearance and performance. Two methods are commonly used: flat-sawing and quarter-sawing.

Flat-Sawn Lumber Most construction lumber is *flat-sawn* lumber, as shown in **Figure 12-3** on page 322. At the mill, a log is squared up lengthwise, and then sawn into boards. As you look at the end grain of a flat-sawn board, you can see that the growth rings run across the board's width. As you look at the face, you can see a distinctive archlike pattern. Flat-sawn lumber is relatively inexpensive. Flat sawing produces boards of greater width than other cutting methods. However, such boards are more likely to shrink and warp.

Quarter-Sawn Lumber *Quarter-sawn* lumber is a premium wood. At the mill, a log is first sawn lengthwise into quarters. Boards are then cut from the faces of each quarter, as shown in **Figure 12-4** on page 322. Looking at the end grain of a quarter-sawn board, you can see that the growth rings run across the thickness of the board. These growth rings generally form angles of 60° to 90° to the board's surface. Quarter-sawn boards with end grain at angles between 30° and 60° are referred to as rift-sawn boards.

Quarter-sawn boards have a low tendency to warp, shrink, or swell. They also provide a more durable surface than flat-sawn lumber. They do not tend to twist or cup. They hold paints and finishes better. However, quarter-sawn lumber is more expensive and less plentiful than flat-sawn lumber and is not generally carried by home centers. In addition, it is generally not carried by do-it-yourself building supply outlets.

Controlling Moisture Content

The amount of water wood contains is referred to as its **moisture content (MC)**. It is expressed as a percentage of what the wood would weigh if it were completely dry. For example, assume that a block of wood that has just been cut from a tree weighs 60 lbs. After being dried in an oven, it weighs only 50 lbs. Thus the original piece contained 10 lbs. of water. That is 20 percent of the wood's dry weight (10 ÷ 50 = .20). The lower the percentage, the drier the wood.

Fiber-Saturation Point A living tree takes in a lot of water. The tree stores water first in the cell walls. When a tree's cell walls have absorbed all the water they can hold, the wood is at the **fiber-saturation point**. For most woods, the fiber-saturation point occurs when the wood contains about 28 percent moisture, though this number can vary. If the tree takes in additional water, it stores that water in the cambium cell cavities.

Removal of water from the cell cavities of harvested wood has no apparent effect upon its properties except to reduce its weight. For this reason, drying the wood until its moisture content is roughly 28 percent does not result in shrinkage. However, reducing moisture to less than 28 percent will remove water from the cell walls, causing the wood to shrink in all directions.

Seasoning The process of drying wood is called **seasoning**. There are two methods of seasoning wood: air drying and kiln drying.

In *air drying*, the rough lumber is stacked outdoors in layers separated by thin wooden cross-pieces called *stickers*. The lumber remains stacked from one to three months or longer. After air drying, the lumber has an average moisture content of 19 percent or less.

In *kiln drying*, the lumber is also stacked in layers with stickers between. It is then placed in a kiln. A **kiln** is an oven in which moisture, airflow, and temperature are carefully controlled. Properly kiln-dried (KD) lumber has less than 10 percent moisture content. In a kiln, drying may take less than four days.

Even though lumber is dried to a certain moisture content, it continues to absorb or give off water, depending on the humidity

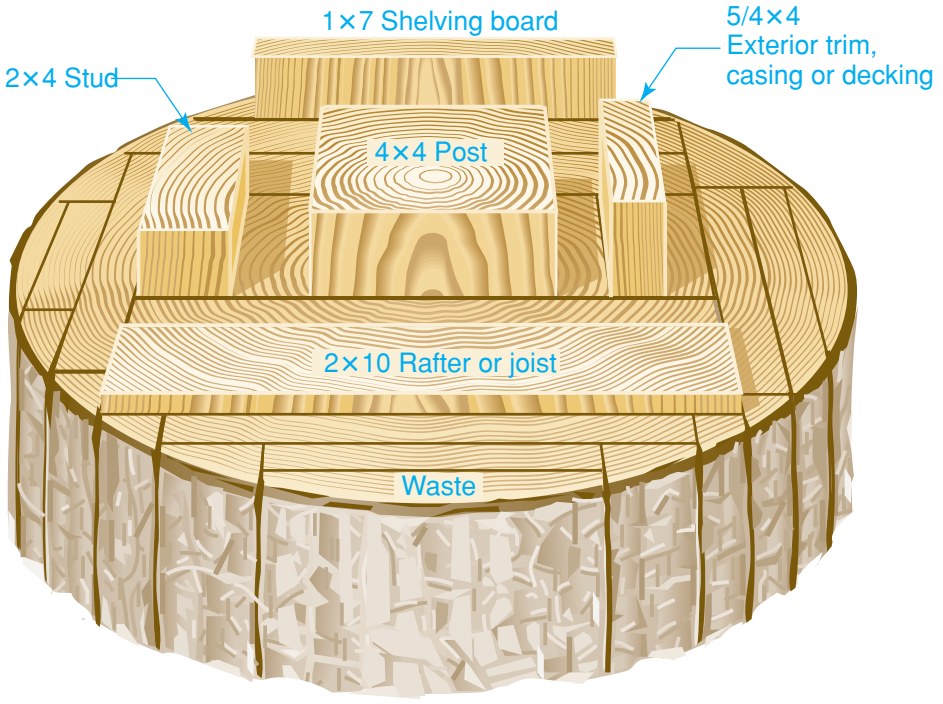


Figure 12-3 Flat-Sawn Lumber
Rings across the Width Notice the orientation of growth rings on the ends.

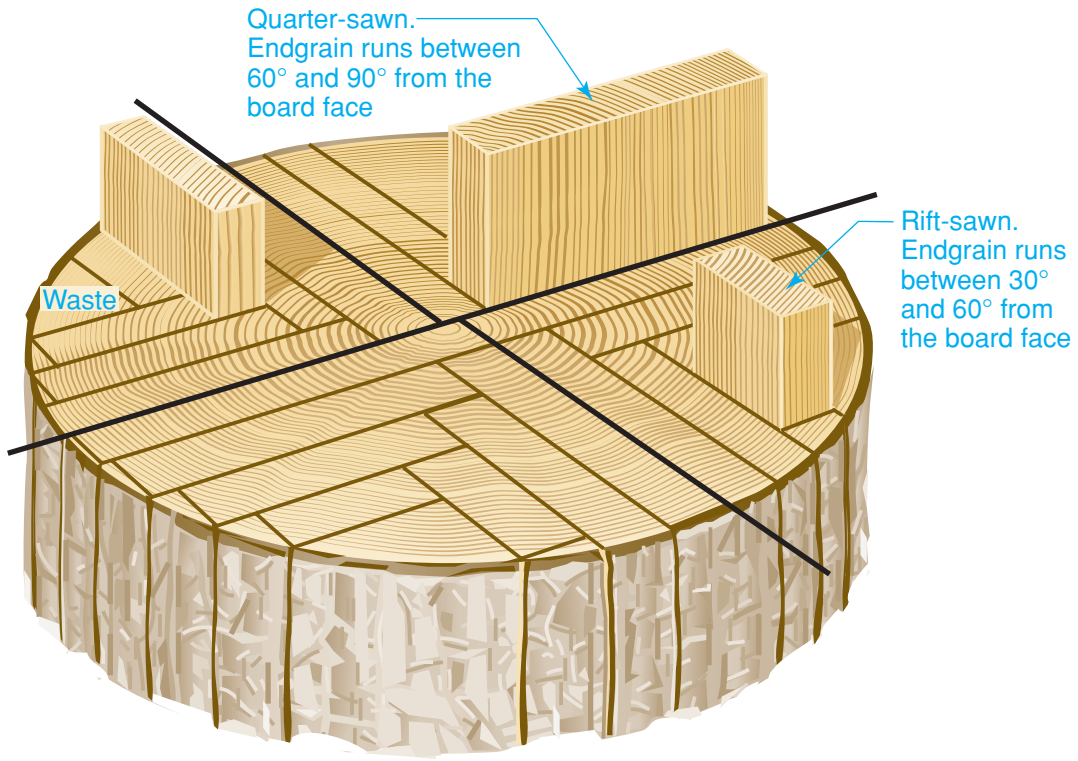


Figure 12-4 Quarter-Sawn Lumber
Rings across the Thickness Compare the direction of grain on the ends of these boards with the directions on those in **Figure 12-3**.

of the surrounding air. If the air is damp, dry wood absorbs moisture and swells. If the air is very dry, the wood shrinks. If the air alternates between moist in the summer and dry in the winter, as it does in many parts of North America, wood expands and contracts. This is sometimes referred to as *seasonal expansion*.

Lumber shrinks in both width and length. Shrinkage in length is usually so small that it is not considered a problem. Shrinkage across the width of the board, however, can be more troublesome. The shrinkage of studs, for example, can cause drywall nails to pop. The shrinkage of floorboards can cause gaps to appear in the flooring, as shown in **Figure 12-5**. In wood maintained at a consistent moisture content, swelling and shrinkage are kept to a minimum. This may require the builder to temporarily condition a home once it has been dried-in to reduce the cracking and shrinking of any installed finished millwork.

The size of a board will vary about 1 percent for each 4 percent change in moisture content. When the moisture content of the wood is in balance with the humidity of the surrounding air, it neither gains nor loses moisture. At that point, the moisture content is said to have reached **equilibrium**. A portable moisture meter, shown in **Figure 12-6**, is the most common instrument for checking the moisture content of wood.

On-Site Storage Lumber kept outside at the job site should be supported off the ground and stacked with stickers (thin pieces of wood) between layers. It should be covered loosely with waterproof material.

Lumber kept indoors will absorb or lose moisture until it reaches a balance with the moisture of the air in the room. Flooring and wood paneling should be delivered at least several days in advance of installation to allow the wood to reach equilibrium. Storing the materials in the room prior to installation is called *conditioning*.

Grading Lumber

Lumber is graded according to various characteristics of the wood. **Grade** is a general indication of the quality and strength of a piece of lumber. Being able to identify grades is an important skill for carpenters and other building professionals.

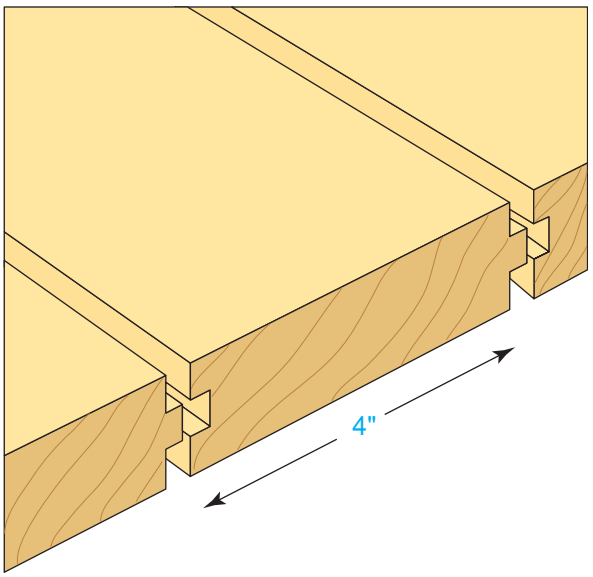


Figure 12-5 Wood Shrinkage
The Cause of Gaps If the moisture content is excessive in floor boards, gaps will appear between the boards as the wood dries.

Figure 12-6 A Moisture Meter
Checking Moisture An electronic moisture meter can be used to check the moisture content of wood.

Hardwood Grades Hardwood is used where beauty or durability is important, such as for door and window casings, stair treads, balusters, handrails, and cabinetry. Hardwoods are available in three common grades, *firsts and seconds (FAS)*, *select*, and *No. 1 common*. Each kind of hardwood lumber is graded by a slightly different standard. Generally, firsts and seconds are used for built-ins, fine casework, and paneling.

Softwood Grades Grading standards for softwoods have been developed by governmental agencies in cooperation with producers, distributors, and users of softwoods. According to these standards, softwood lumber is divided into two basic groups:

- Green (unseasoned) lumber with a moisture content of more than 19 percent.
- Dry (seasoned) lumber with a moisture content of 19 percent or less.

Each major lumber trade association has developed a complete set of grading standards. These rules are extensive and vary somewhat with each association. The builder who uses lumber primarily from one section of the country should understand the grading used in that area. For example, if most of the lumber used comes from the western states, then the standards published by the Western Wood Products Association would apply. If the lumber comes from southern states, standards set by the Southern Forest Products Association would apply. Familiarity with common lumber abbreviations will simplify the selection and specifications of softwood lumber. For information, refer to the **Ready Reference Appendix** table "Lumber Abbreviations" on the OLC.

After a softwood board has been graded, it is marked with a grade stamp, as shown in **Figure 12-7**. A **grade stamp** is a permanent

(A) WWPA Certification Mark: Certifies Association quality supervision. ⓦⓦ is a registered trademark.

(B) Grade Designation: Grade name, number, or abbreviation.

(C) Species Identification: Indicates species by individual species or species combination.

(D) Mill Identification: Firm name, brand, or assigned mill number. WWPA can be contacted to identify an individual mill whenever necessary.

(E) Condition of Seasoning: Indicates condition of seasoning at the time of surfacing.
S-GRN. Over 19 percent moisture content (unseasoned).
MC15 or KD15. 15 percent maximum moisture content.
S-DRY or KD. 19 percent maximum moisture content.

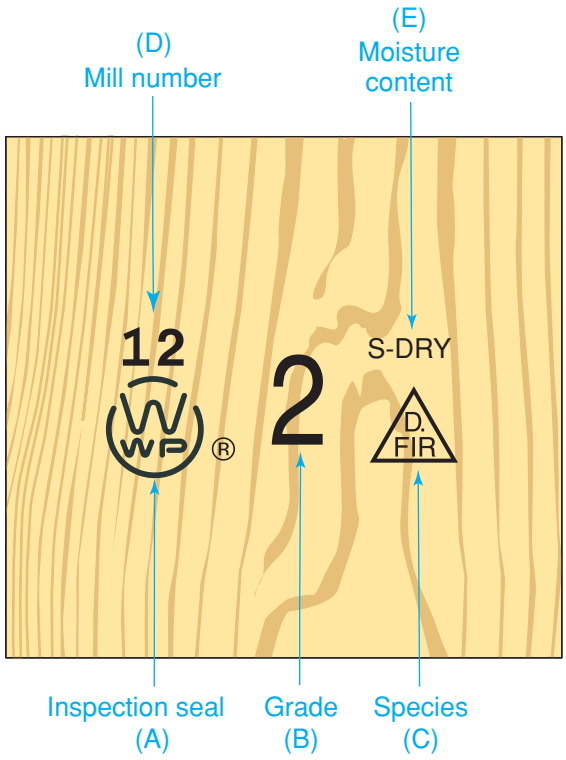


Figure 12-7 A Grade Stamp
Knowing the Board Most grade stamps contain information similar to the information in this stamp from the Western Wood Products Association.

mark that identifies the board's species, quality, mill source, and gives a general indication of strength. Grade stamps let building inspectors know if a house is being built with lumber of suitable quality. Information on the specific grades of framing lumber used in residential construction can be found in Chapter 14.

Lumber Defects

A lumber defect is a flaw that detracts from the quality of the wood in either appearance or usefulness. About 25 characteristics and conditions are considered when wood is graded. They are described in any set of grading rules. Some of the more common defects are shown and described in **Figure 12-8** on pages 326–327. The term **warp** is a general description of any variation from a flat surface. It includes *bow, crook,* and *cup,* or any combination of these.

When selecting lumber, the carpenter must examine each board for defects. However, boards do not always have to be perfect to be useable. It is important to consider the exact use required of the wood. For example, a minor defect along one edge of a board would not be a problem if the board was to be ripped to a slightly narrower width. Likewise, a large knot near the end of a 12' board would not be a problem unless the carpenter needed the full length of the board. Sometimes a flawed board can be set aside for cutting into shorter lengths. For example, carpenters often cut flawed 2×4 stock into blocking.

Standard Sizes of Lumber

The width and thickness of lumber are given by two types of measurements: *nominal dimensions* and *actual dimensions*. The **nominal dimension**, such as 2" by 4" (2×4), is the size of the board, in inches, as originally cut. Nominal dimensions, or nominal sizes, refer to the width and thickness of rough-sawn lumber (not its length).

After the board has been surfaced and seasoned at the mill, its *actual dimension* becomes less than its nominal dimension. Building codes use actual dimensions when they address maximum allowable sizes for drilling holes and notching. *Dressed sizes* apply after the wood has shrunk and been surfaced with a planing machine. The width and thickness of dressed lumber are less than its nominal width and thickness. For example, a 2×4 stud actually measures about 1½ × 3½. For the differences between nominal and actual sizes, see the **Ready Reference Appendix** table "Standard Sizes for Framing Lumber, Nominal and Dressed" on the OLC.

Sizes of lumber used in building construction have been standardized for convenience in ordering and handling. Softwood lumber is readily available in actual lengths of 8', 10', 12', 14', and 16'. Common nominal dimensions are 2", 4", 6", 8", 10", and 12" in width; and 1", 2", 4", and 6" in thickness.

Hardwoods are not standardized for length or width. They run ¼", ½", 1", 1¼", 1½", 2", 2½", 3", and 4" in thickness.

Metric Sizes The United States is the only major lumber-producing country that does not exclusively use the metric system of measurement. However, wood intended for export to other countries may be sized to metric measurements. In addition, wood produced in other countries and imported to the United States for certain uses may be sized to metric measurements. Thickness and width are given in millimeters (mm), length is given in meters (m).

Science: Life Science

Photosynthesis Green plants make their own food. Through photosynthesis, glucose, a form of sugar, is formed. Oxygen is released into the atmosphere as a byproduct. Where does the glucose go?

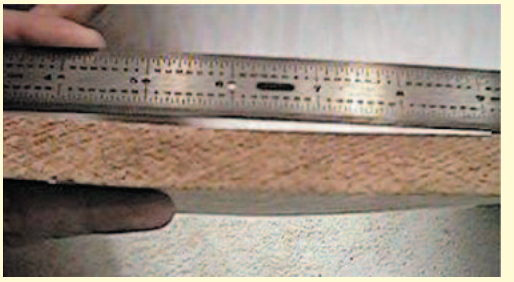
Starting Hint Sugar is food.

Figure 12-8 Lumber Defects

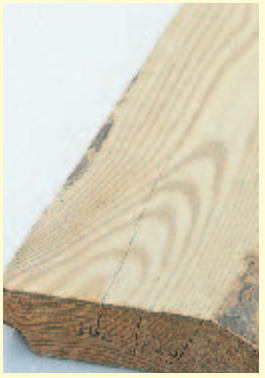
Looking for Trouble A piece of lumber could have one or more of these defects.

Bow A flatwise deviation (bend) along the grain from a straight, true surface. Bow is measured at the point of greatest deviation.

Crook An edgewise deviation (bend) from a straight, true surface. Crook is measured at the point of greatest deviation.



Cup A flatwise deviation (bend) across the grain from a straight, true surface. Cup is measured at the point of greatest deviation.



Check A small crack that runs across the growth rings, parallel with the grain. Check usually occurs as a result of seasoning.

Shake A lengthwise grain separation between or through the growth rings. It may be further classified as *ring shake* or *pitch shake*.

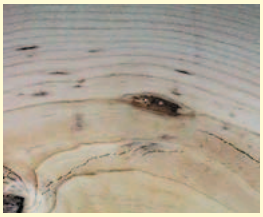
Split A lengthwise separation extending from one surface through the piece of lumber to the opposite side or an adjoining surface.

Decay Disintegration of wood due to the action of wood-destroying fungi. It also may be called *dote*, *rot*, or *unsound wood*.

Knot Place where a branch once grew. Knots are classified according to size, quality, and occurrence. To determine the size of a knot, average the maximum length and maximum width, unless otherwise specified. A sound encased knot and a sound intergrown knot are shown above.

Jon P. Muzzarelli

Knothole Hole left by the removal of an embedded knot.



Pitch Accumulation of resin in the wood cells in a more or less irregular patch.

Pitch-pocket An opening between growth rings that usually contains or has contained resin, bark, or both.

Stain Discoloration on or in lumber other than its natural color.

Torn grain Torn spot created as the board is machined to size.

Wane Presence of bark or lack of wood on the edge or corner.

Section 12.1 Assessment

After You Read: Self-Check

1. What is the difference between hardwoods and softwoods?
2. Compare the advantages of quarter-sawn lumber with those of flat-sawn lumber.
3. What is KD lumber?
4. What causes the moisture content of lumber to reach a point of equilibrium?

Academic Integration: Science

5. **Measurement Systems** Common lumber sizes are almost identical in both the customary and metric systems. For example, the basic thicknesses are 25 mm and 1" (25.4 mm), and the basic widths are 100 mm and 4". Metric lengths range from 1.8 m (about 6') to 6.3 m in increments of 300 mm. Note that 300 mm is close to, but slightly shorter than, 1'. Estimate the nominal dimensions in millimeters of a 2" × 2" piece of softwood lumber.

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

Jon P. Muzzarelli

Section 12.2

Protecting Wood

Causes of Wood Damage

Which insects damage wood?

Wood must be protected from decay and from being damaged by certain insects. Both problems are more likely to occur when wood becomes wet.

Rain is the most obvious source for the introduction of water. A house must be designed to encourage rainwater to drain freely away. Water vapor is a less obvious source. Water vapor is given off during cooking, washing, and other household activities. This vapor can pass through walls and ceilings. When it reaches a cold surface, such as sheathing or studs in the winter, it condenses into water droplets. Leaking pipes are a third source of moisture. They should be fixed immediately to prevent damage to the house. Gaps around exterior wood trim or between a chimney and the siding can allow water to seep into walls. Such problems should be eliminated with regular maintenance, such as caulking all gaps.

Wood Decay

Wood used where it will always be dry, or even where it may be wetted briefly and promptly dried, will not decay. However, wood will decay if kept wet for long periods at temperatures favorable to the growth of decay organisms. Wood decay, or rot, is caused by *fungi* (such as mildew and mold) that use wood for food. These fungi require air, warmth, food, and moisture for growth. Damp wood provides an ideal environment for them.

In early stages, decay caused by fungi may show up as a discoloration of the wood. Paint also may become discolored where the underlying wood is rotting. Advanced surface decay is more easily recognized. Generally, the affected wood is brown and crumbly. Brown, crumbly decay is sometimes called **dry rot**. This is a misnomer because wood must be damp for rotting to occur. At other times the wood may be rather white and spongy. Decay inside the wood is often indicated by sunken areas on the surface or by a hollow sound when the wood is tapped with a hammer. Where the surrounding air is very damp, the decay fungus may grow out on the surface, appearing as white or brownish growths in patches or strands, as shown in **Figure 12-9**. In some cases, decay fungus has a vinelike structure. The presence of fungus stains or mold is a warning that conditions are or have been suitable for decay. Affected lumber should always be examined for decay damage before installation.

Preventing Decay Fungi grow most rapidly at temperatures between 70°F and 85°F (21°C and 29°C). High temperatures, such as those used in kiln-drying of lumber, kill fungi. Low temperatures, even far below 0°F (-18°C), merely cause them to become dormant. The best way to prevent fungi attack is to keep wood dry. Wood-destroying fungi cannot grow in dry wood. A moisture

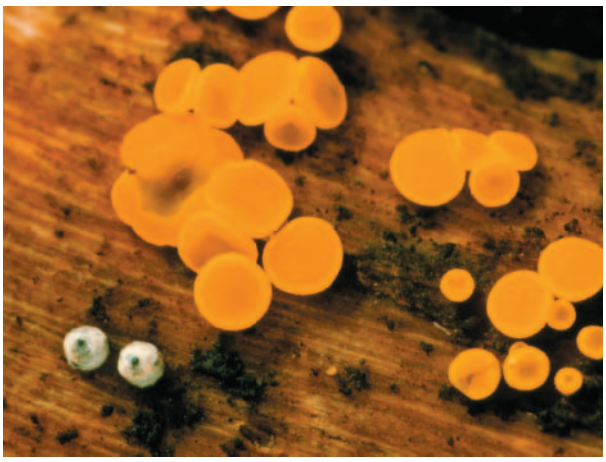


Figure 12-9 Decay Fungus
Damp Wood Damp conditions are essential for the growth of fungi on wood.

content of 20 percent or less is generally dry enough to prevent or stop growth.

Construction lumber that is improperly seasoned may be infected with one or more fungi and should be avoided. Such wood may contribute to serious decay in both the structure and exterior parts of buildings. You may see signs of infection in wood that is improperly seasoned. You can also determine the moisture content of such wood with an electronic moisture meter.

Decay-Resistant Woods When untreated, the sapwood of all common native woods has low resistance to decay. This gives it a short life under decay-producing conditions. The natural decay resistance of native woods lies in the heartwood. Of the species commonly used in house construction, the heartwood of bald cypress, redwood, and various cedars is highest in decay resistance. However, lumber made entirely from heartwood is becoming more and more difficult to obtain. This is because increasing amounts of timber are cut from the smaller trees of second-growth stands in which little heartwood has developed. In general, when decay resistance is needed in load-bearing members that would be difficult or expensive to replace, preservative-treated wood is used (see Chapter 35 for more information).

Recall *Which wood species resist decay?*

Insects

Under certain conditions, wood can be damaged by insects such as termites, carpenter ants, and beetles. Some of the conditions that encourage fungi, such as too much moisture, can also encourage wood-infesting insects.

Termites *Termites,* shown in **Figure 12-10**, are the most destructive of the insects that infest wood. The best time to protect against them is during the planning and construction of the building. Remove all woody debris, such as stumps and lumber scraps, from the soil at the building site before and after construction. No wood member of the structure should be in contact with the soil. Forms of protection include chemical termiticide (termite-killing) treatments, physical barriers, natural termite resistant woods, or pressure-preservative treated wood.

Figure 12-10 Termites
A Hazard to Wood Termites are the most destructive insect that affects wood.

Termites can be grouped into two main classes: subterranean and dry-wood termites. *Subterranean termites* account for about 95 percent of all termite damage. They eat the interior of the wood and can cause much damage before they are discovered. They honeycomb the wood with tunnels separated by thin layers of sound wood. They are common throughout Hawaii and the southern two-thirds of the United States, except in mountainous and extremely dry areas. **Figure 12-11** on page 330 shows termite infestation probability for the contiguous United States.

Subterranean termites thrive in moist, warm soil containing a large supply of food in the form of wood or other material containing cellulose (plant fibers). In their search for additional food, they build shelter tubes over foundation walls, in cracks, or on pipes or supports leading from the soil into the house. These flattened tubes, from ¼" to ½" or more in width, protect the termites in their travels. Metal or masonry barriers such as those shown in **Figure 12-12** on page 330 should be installed in areas where these termites are common.

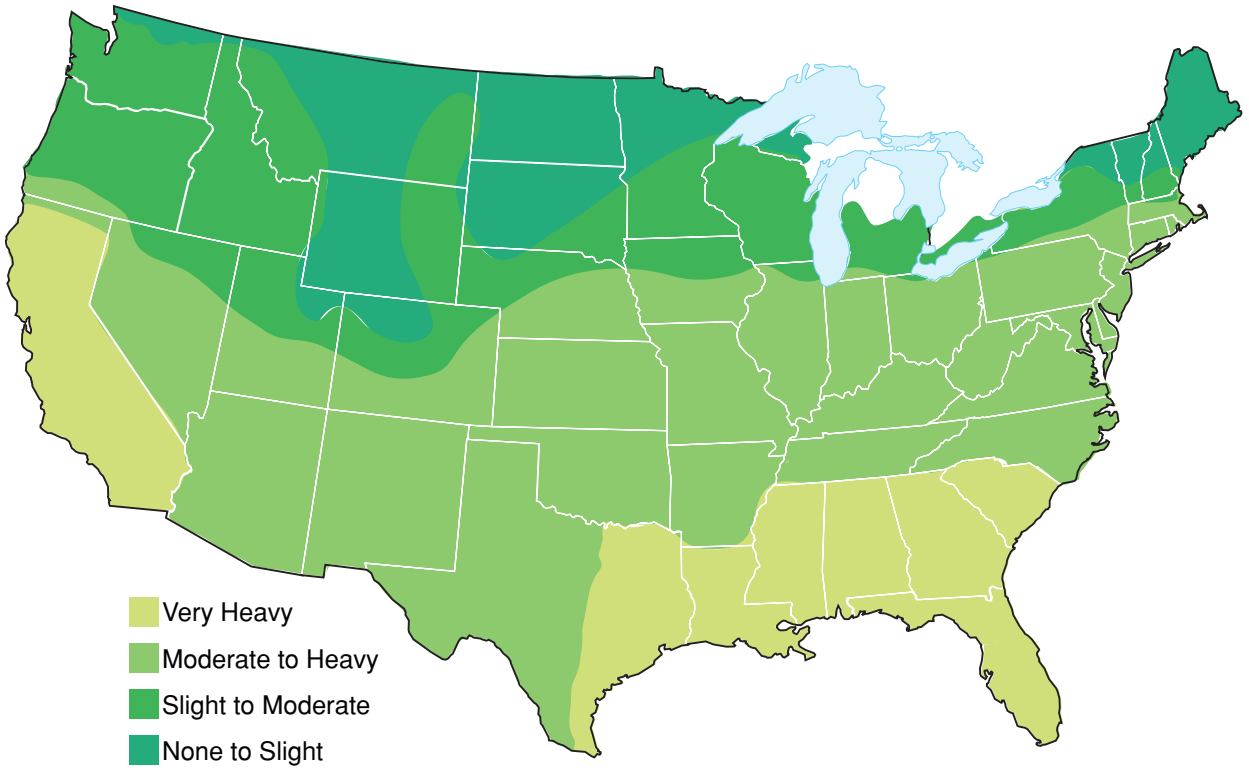


Figure 12-11 Termite Probability Map

Areas of Greatest Hazard Lines separating areas are approximate. Local conditions may be more severe than shown here.

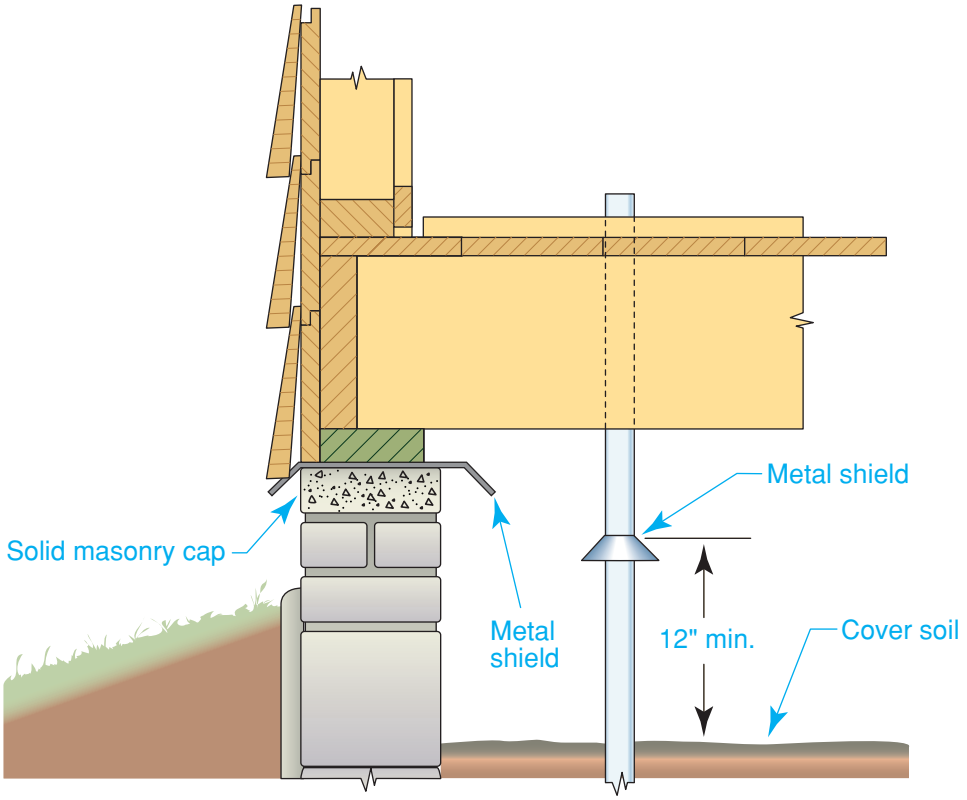


Figure 12-12 Termite Shields

Metal Blockers Two types of shields used to block termite access to wood.

An especially destructive type of subterranean termite is the *Formosan termite.* This termite was introduced into the United States after World War II, and it is now found in most of the southern states as well as California and Hawaii. Native species feed on dead trees and processed wood. Formosan termites will eat these plus anything else that contains wood fiber, including live trees and many plants. Because they are aggressive, live in very large colonies, and can survive on many different food sources, Formosan termites are more destructive than native species.

Dry-wood termites fly directly to the wood instead of building tunnels from the ground. They chew across the grain of the wood, creating broad pockets, or chambers. These chambers are connected by narrow tunnels. The termites remain hidden in the wood and are seldom seen, except when they take flight. They are more difficult to control, but they cause less serious damage than subterranean termites. Dry-wood termites are common in the tropics. They have also been found in the United States along the Atlantic Coast from Virginia to the Florida Keys, westward along the coast of the Gulf of Mexico, and up the Pacific Coast as far as northern California.

Other Insects The insects shown in **Figure 12-13** can also cause wood damage.

Carpenter Ants *Carpenter ants* are a problem primarily in the Northeast, Midwest, and Northwest, though they can be found throughout the country. They nest in the ground as well as in dead trees, firewood, and houses. Carpenter ants do not eat wood.

Figure 12-13 Other Destructive Insects

Wood Insects These insects can cause wood damage.

Carpenter Ants Destructive tunnelers that burrow into wood to create nests.

Carpenter Bee Expert drillers that commonly infest fascia boards and window trim.

Beetles The powderpost beetle, shown at left, and the deathwatch beetle, shown at right.

They eat plant juices, insects, honey, and food particles found inside a house. The damage they cause comes from the irregular tunnels they create in wood for their nests. Small sawdust piles may indicate their presence. Controlling carpenter ants can be difficult. To be most effective, chemical treatments must be applied to the nest itself.

Beetles Two types of beetles commonly infest wood: the powderpost beetle and the deathwatch beetle. The *powderpost beetle* is more common. It is second only to the termite in the amount of damage it causes. These beetles commonly enter the house via already-infested wood such as firewood, rough-sawn timbers, and barn wood. They attack hardwoods only, preferring ash, oak, mahogany, hickory, maple, and walnut. Most of the infestation occurs in sapwood that has a moisture content between 10 and 20 percent.

One common sign of a powderpost beetle infestation is a tiny pile of fine, flourlike powder. This material is pushed out of the wood as the beetles emerge. Infested wood should either be removed or professionally treated. Treating only the surface of the infested wood with an insecticide will not kill beetles deep within the wood.

Deathwatch beetles are larger beetles. They infest the sapwood of both hardwoods and softwoods. They are most likely to be found in wood with a high moisture content, such as wood used in unheated housing and damp crawl spaces. Treatment is similar to that required for powderpost beetles. In addition, it is very important to cut off the supply of moisture.

Carpenter Bees *Carpenter bees* resemble bumblebees in shape. The bee has a metallic blue-black body covered with yellow or orange hairs. They cut a ½" diameter hole in bare or untreated wood. They then build their nests by boring a tunnel parallel to the surface of the wood. Sawdust seen around a small, symmetrical hole indicates their presence. New generations of bees will return to the nest annually. Carpenter bees can be controlled with insecticides. However, one of the best ways to prevent infestation is to paint the wood.

Preservative Treatments

Lumber can be treated with liquid wood preservatives soon after being milled. This can increase the lumber's resistance to decay, insects, and fire. A **wood preservative** is a chemical that protects wood.

Decay-Resistant and Insect-Resistant Wood Various woods can be successfully treated, but fir, spruce, and pine are the most common. Preservative-treated wood is generally used outdoors or where it is in contact with concrete or masonry. In one treatment process, the wood is dipped into chemicals and then air-dried. In another process, the chemicals are forced deep into the wood under pressure. In a third process, the chemicals are injected into the wood. Depending on the process and the chemicals used, treated wood will be various shades of green or brown. Some treated wood can be painted or stained.

The amount of preservative used can be adjusted to provide different levels of protection. Wood that is in direct contact with the ground (such as fence posts) should have the

JOB SAFETY

TREATED WOOD The chemicals in treated wood can be toxic. Wear gloves to protect your hands when you are handling the material frequently. When sawing or machining, wear a dust mask to prevent nose, throat, and lung irritation. Cut treated lumber outdoors to avoid indoor accumulations of airborne sawdust. Wear eye protection. After handling, wash your hands thoroughly, particularly before eating. Do not burn scraps, as this may result in toxic fumes. Always dispose of treated wood according to local regulations.

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

highest level available. Preservative-treated lumber is graded and stamped to indicate its suitability for various uses. Special fasteners may be required when assembling pressure-treated wood products because of the tendency of preservatives to accelerate metal corrosion. Check with the manufacturer for installation instructions. For more on this topic, see Chapter 35.

Fire Retardant Treated Wood Another type of preservative is used to make FRT (fire retardant treated) wood. FRT wood is important in wildfire-prone areas and areas where there are limited firefighting services or water supplies. The preservatives do not prevent wood from burning, but they can significantly reduce the ability of flames to spread. This can give firefighters more time to put out a fire that has started.

Fire retardant chemicals are forced into the lumber under pressure, then the wood is re-dried to a moisture content of 19 percent or less. Plywood can also be treated. It is dried after treatment to a moisture content of 15 percent or less.

FRT lumber can be cut to length, drilled, and lightly sanded without affecting its performance. You do not have to apply additional preservative to the cut ends of boards. However, ripping, surfacing, and milling operations are only permitted in certain cases. Always check manufacturer's installation requirements when working with FRT lumber. It should be used only in interior applications protected from the weather. It is not intended for exterior use. Check local building codes for any other restrictions on the use of FRT wood products. Though FRT chemicals are less toxic than other preservatives, you should follow the same precautions for handling and cutting FRT wood.

Section 12.2 Assessment

After You Read: Self-Check

1. Decay fungi grow best within what temperature range?
2. What condition creates the best environment for decay?
3. Wood from what part of the tree is most decay-resistant?
4. Explain the differences between the two basic types of termites.

Academic Integration: Science

5. **Local Ecosystem** Find your state in Figure 12-11 if possible. Research which types of termites, if any, are in your state using your local Cooperative Extension office. Locate information about safe ways to prevent local termite damage. For example, are any special building materials recommended? Are there any non-toxic ways to destroy termites that are offered in your state? Report your findings in a one-page summary.

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

CHAPTER 12

Review and Assessment

Chapter Summary

Section 12.1

The suitability of lumber for construction depends on the species of wood, how the lumber is manufactured, and on various measurements of its strength and stiffness. Wood may be either hardwood or softwood. Softwoods are more common in construction. Defects can reduce the utility of lumber. Grading standards take defects and other characteristics of wood into account.

Section 12.2

Wood can be damaged by decay and by wood-infesting insects, such as termites and beetles. This damage can be prevented by reducing the moisture content of lumber and ensuring that wood is not allowed to remain wet. Decay-resistant or preservative-treated woods can prevent problems.

Review Content Vocabulary and Academic Vocabulary

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

Content Vocabulary

- cambium (p. 318)
- deciduous tree (p. 320)
- coniferous tree (p. 320)
- lumber (p. 321)
- moisture content (MC) (p. 321)
- fiber-saturation point (p. 321)
- seasoning (p. 321)
- kiln (p. 321)
- grade (p. 323)
- grade stamp (p. 324)
- warp (p. 325)
- nominal dimension (p. 325)
- dry rot (p. 328)
- wood preservative (p. 332)

Academic Vocabulary

- species (p. 318)
- ecosystems (p. 318)
- photosynthesis (p. 319)
- equilibrium (p. 323)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *sapwood* (p. 318), *heartwood* (p. 319), *annual rings* (p. 319), *flat-sawn* (p. 321), *quarter-sawn* (p. 321), *air drying* (p. 321), *stickers* (p. 321), *kiln drying* (p. 321), *seasonal expansion* (p. 323), *conditioning* (p. 323), *firsts and seconds (FAS)* (p. 324), *select* (p. 324), *No. 1 common* (p. 324), *actual dimension* (p. 325), *dressed sizes* (p. 325), *termites* (p. 329), *carpenter ants* (p. 331), *powderpost beetle* (p. 332), *deathwatch beetle* (p. 332), *carpenter bees* (p. 332).

Review Key Concepts

3. Classify two advantages and disadvantages of using wood for building.

4. Give an example of a hardwood and a softwood.

5. Explain the difference between a flat-sawn board and a quarter-sawn board.

6. Summarize how to calculate the fiber-saturation point of lumber.

7. Describe these three closely related lumber defects: bow, crook, and cup.

8. Identify two ways to prevent wood damage.

Critical Thinking

9. **Synthesize** Why is it important to maintain forests responsibly?

Academic and Workplace Applications

STEM Mathematics

10. **Percentages** Moisture content is the weight of water held in the wood expressed as a percentage of the weight of the oven-dry wood. It can be calculated using the following formula:

$$\frac{\text{initial (wet) weight} - \text{oven-dry weight}}{\text{oven-dry weight} \times 100\%}$$

Calculate the moisture content of a piece of wood that weighs 56 grams wet and 48 grams when oven-dry. Then state whether the MC is above or below the fiber-saturation point.

Math Concept Percentage is a proportion that means *per hundred*. For example, 37% means 37 out of 100.

Step 1: Subtract the oven-dry weight from the initial wet weight (56g − 46g).

Step 2: Multiply the oven-dry weight by 100% (48g × 100%).

Step 3: Divide the first number by the percentage to determine the moisture content and compare it to the fiber-saturation point percentage.

STEM Science

11. **Metric Conversions** You can convert feet to meters using the following conversion formula:

1 foot = 0.3048 meters

You are a U.S. lumber exporter and you are sending a shipment to a country which uses the IS (the metric system). Your customer has asked you to convert the total lineal footage of their order from feet to meters on the invoice. The total lineal footage is 244. How many meters is this? Round up to the nearest tenth.

21st Century Skills

12. **Communication Skills** A brochure is a printed document containing both text and visual information. For example, various organizations publish brochures about design values, spans, standard sizes, grades, and the properties of wood. Examples of organizations might include the American Wood Council, American Forest and Paper Association, the Canadian Wood Council, the Southern Forest Products Association, and Western Wood Products Association. With a partner, create a brochure for either the organization or for one aspect of wood that you learned in this chapter, such as a brochure about sustainable forest products.

- Use software or art materials to design your brochure.
- Choose art and text to identify the main details about the organization on the interior panels.

Standardized TEST Practice

CERTIFICATION PREP

Multiple Choice

Directions Choose the word or phrase that best completes the following statements.

13. The process of drying wood is called _____.

a. saturation
b. controlling moisture
c. seasoning
d. expansion

14. The insect that represents the greatest risk to wood is the _____.

a. carpenter bee
b. termite
c. beetle
d. moth

15. The average moisture content of kiln-dried lumber is _____.

a. 19% or less
b. 19% or more
c. 10% or less
d. 10% or more

TEST-TAKING TIP

Pay attention to key words in the question and in each answer choice. For example, in question 14, the key words are greatest risk. *The word* greatest *helps you know that the question is a comparison.*

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