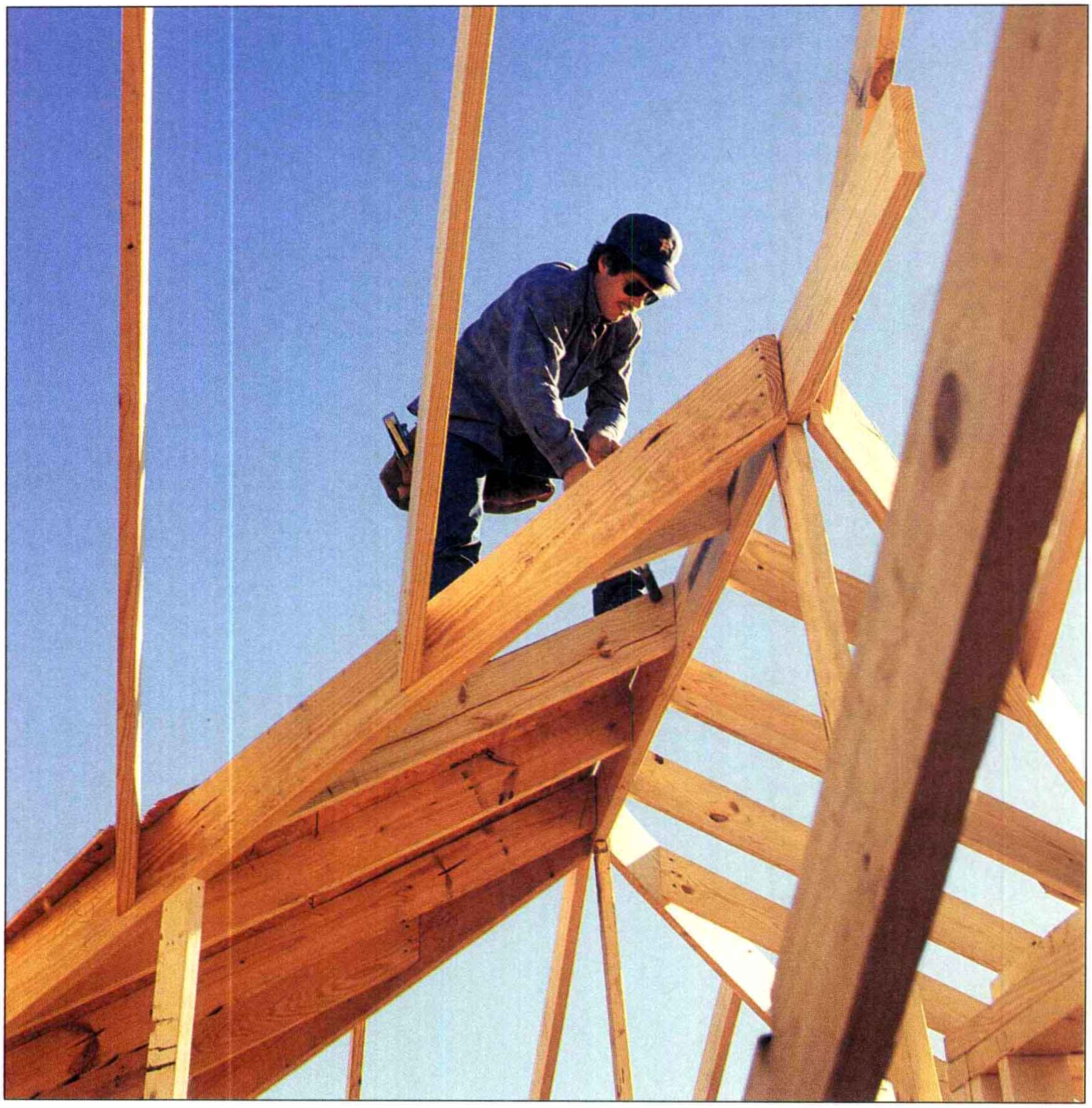
Basic Carpentry Techniques

ORTHO BOOKS

- Step-by-step instructions for building foundations, floors, walls, and roofs
- How to construct stairs, install windows and doors, and add interior trim
- A complete guide for selecting and working with hand tools and power tools
- Tips for estimating, selecting, and ordering materials

Basic Carpentry Techniques



Created and Designed by the Editorial Staff of Ortho Books

Project Editor
David W. Toht

Writer
Roger S. Grizzle

Illustrator
Mario Ferro

Ortho Books

Publisher
Robert B. Loperena

Editorial Director
Christine Jordan

Managing Editor
Sally W. Smith

Acquisitions Editors
Robert J. Beckstrom
Michael D. Smith

Prepress Supervisor
Linda M. Bouchard

Sales & Marketing Manager
David C. José

Publisher's Assistant
Joni Christiansen

Graphics Coordinator
Sally J. French

Address all inquiries to:
Ortho Books
Box 5006
San Ramon, CA 94583-0906

2 3 4 5 6 7 8 9
98 99 2000 01 02

ISBN 0-89721-319-X
Library of Congress Catalog Card Number 96-67948

THE SOLARIS GROUP
2527 Camino Ramon
San Ramon, CA 94583-0906

Editorial Coordinator
Cass Dempsey

Copyeditor
Judith Dunham

Proofreader
Alice Mace Nakanishi

Indexer
Frances Bowles

Separations by
Color Tech Corp.

Printed in the USA by
Banta Book Group

Thanks to
Deborah Cowder
Jef Flanders
Hank Hanson, Future Fence
Kaufman and Broad—South Bay, Inc.
David Van Ness

Builders
Names of builders are followed by the page numbers on which their work appears. L=left; C=center; R=right; T=top; B=bottom

Meadowcreek by Radisson Development Corp.: 24, 50–51, 90BL, 90BR
Silverhawk & Company, Inc.: 71, 90TR

Photographers
Names of photographers are followed by the page numbers on which their work appears. L=left; C=center; R=right; T=top; B=bottom

Michael Landis: 17, 24, 50–51, 90CL, 90CR, 91C, 91B
Fred Lyon: 3B, 7, 22–23
Geoff Nilsen: Front cover
Ortho Photo Library: 71, 90TL, 90TR, 90BL, 90BR, 91T
Chriss Poulsen: Back cover
Kenneth Rice: 49
Gary Russ: 1
Kevin Vandivier: 3T, 4–5

Front Cover
Today's carpenter relies on a broad range of tools, from simple hand tools that have not changed in their basic design for many generations to power and pneumatic tools with increasingly sophisticated designs. Whether you work with a treasured collection of hand-me-downs or the latest models from the showroom floor, you will want to organize them with a toolbox similar to the one shown here (for another view, see page 24; to build the box, see page 40). A detailed discussion of carpentry tools begins on page 23.

Title Page
This carpenter is toenailing a 2×8 valley jack rafter to the 2×10 ridge board. Building codes specifiy the number and size of nails required for such connections, and the maximum length that various sizes of lumber may span when used in specific applications, such as rafters. Framing a complex roof is beyond the scope of this book, but you will find techniques for framing a simple gable roof beginning on page 72.

Page 3
Top: Temporary diagonal braces hold these walls in place until permanent bracing or sheathing can be installed.

Bottom: Tools needed for measuring, marking, cutting, positioning, and fastening boards are all in this tool belt. Having them close at hand prevents wasted effort looking for them around the job site.

Back Cover
There is something very satisfying about standing back to view your project at the end of the day and seeing what you have accomplished.

Basic Carpentry Techniques

Getting Started

Planning 6
Materials 7
Fasteners 18

Tools

Beginning With the Basics 24
Tools for Cutting and Shaping 27
Assembly Tools 37
Woodworking Power Tools 41

Carpentry Techniques

Foundations 52
Rough Carpentry 62
Assembling the Roof 72
Finishing and Trim Carpentry 80
Reference Tables 92

Index 94
U.S./Metric Measure Conversion Chart 96

GETTING STARTED

Whether you are putting an extra shelf in a closet or building a house from the ground up, the success of any project depends on good planning. There is always the temptation to get out the tools and start making sawdust, but this often leads to mistakes that have to be undone later. The job will go more smoothly and the headaches will be fewer if you take the time to plot your course in advance by drawing plans and checking the requirements of local building codes. This chapter will help you get started.

Once your planning is done, you can begin to select materials. Wood will likely be chief among them. This chapter explains how wood is processed, how it behaves, and how to pick the right type for the job. You'll also be introduced to the many wood by-products and nonwood building materials currently available. Fasteners will have to be selected as well, and today that means more than just nails and screws. A section in this chapter discusses the many new options in fasteners and connectors.

Framing a roof is perhaps the most difficult, yet satisfying, basic carpentry skill. In some cultures the carpenters attach a flag, tree bough, or other traditional symbol to the highest point of the roof when they have completed framing it—and mark the occasion with a well-deserved celebration. As with any carpentry project, such success depends on plans that are made long before the first nail is driven.

PLANNING

The planning process involves evaluating your needs and then translating them into a comprehensive plan. This can be as simple as counting your books, measuring their overall dimensions, and drawing a plan for a bookshelf. For a major project, it's more extensive. You may need to enlist the help of design professionals.

Finding Ideas

If you have a general idea of a project you'd like to build but aren't quite sure what it should look like, you will first have to settle on a design. Spend some time on this phase, explore the possibilities, and allow the concept to incubate and mature before forging ahead. Poke through home-improvement books and magazines in local libraries and bookstores. Try to familiarize yourself with the different ways other people have solved problems similar to your own.

Working Drawings

Always try out ideas on paper before building anything. Even if you are working from a ready-made plan, chances are you will have to modify it to meet your particular needs. Drawing up the plan beforehand will help you visualize the construction process and anticipate any problems that might be encountered.

Make your drawings to scale on graph paper, with each square representing a certain number of inches or feet. Floor plans and elevations of buildings are usually drawn at a scale of ¼ inch to the foot. Construction details for foundations and framing connections are drawn at a larger scale, from ¾ inch to 1½ inches to the foot, depending on the level of detail required. Small woodworking projects are usually easier to draw full size.

Building Permits

If you are planning a substantial building project, you will need to take out a building permit. Any work that involves structural modifications to a house or changes to electrical, plumbing, or mechanical systems usually requires a permit—in fact, some municipalities require a permit for any job costing more than $100. Resist the temptation to go ahead without a permit. If you're discovered, the building inspector may require you to tear out all or part of what you've built and obtain a permit before you do it over again.

Make your first trip or a phone call to the building department before drawing the plans. Be sure to ask the following questions.

• What drawings are required? At the very least, you will need a site plan, a floor plan, and elevations. The site plan shows the property lines, the location of the house on the property, and the location of the planned improvements. A floor plan shows the location of walls, door and window openings, and plumbing and electrical fixtures. Elevations show side views of the outside of the building. In addition, you may need to provide details of foundations, framing connections, and major structural elements.

• What restrictions may apply to the project? Most jurisdictions have limitations on setbacks from property lines, overall building height, and lot coverage. In addition, some areas require new construction to meet specific architectural design criteria.

• What do permits cost? When you submit your plans, you must pay a fee based on the anticipated value of the improvements.

Budget and Schedule

Many home-improvement projects die an early death because the homeowners run out of time or money before they can finish. Don't rely on guesswork. Put together a budget and a schedule that are as realistic as possible.

Start with the materials list. Some lumberyards will figure the materials from your plans if the order is large enough. If you make your own list, try to think of everything you will need, from lumber to nails to hardware. Take your lists to potential suppliers for pricing.

Estimating labor is not so easy, especially if you're short on experience. The secret is to break the work down into manageable tasks and look at each one individually. Compile a list of everything you'll have to do, in as much detail as you can. Imagine yourself going through each phase of construction, one step at a time, and make an educated guess about the number of hours each step will take. Add up the total, and allow some extra time for setup, cleanup, problem solving and head scratching—and the inevitable run back to the lumberyard.

You can also arrive at a rough time estimate by applying this rule of thumb: On most construction projects, the cost of labor is approximately equal to the cost of materials. If you are a beginner, assume you will be working for minimum wage (pay yourself a little more if you have some carpentry experience). Divide the cost of materials by your hourly rate to figure the number of hours you can expect to spend with your tool belt on. If the result indicates that you will be giving up more of your spare time than you're willing to sacrifice, consider hiring professional help. You may want to subcontract any concrete work needed, for instance, and do the carpentry yourself.

Once you have a labor estimate, you can prepare a construction schedule. Making a schedule is helpful even for small projects because it provides clear-cut goals for each day's work and helps you avoid getting bogged down in small details. Remember, the object is to get from the beginning to the end of the project in the most direct way possible.

MATERIALS

Inevitably, material selection starts with wood. Frank Lloyd Wright summed up what so many feel. "Wood is universally beautiful to man," he said. "It is the most humanly intimate of all materials. Man loves his association with it, likes to feel it under his hand, sympathetic to his touch and his eye."

Wood is just about the nearest thing there is to the ideal building material. Pound for pound, it's nearly as strong as steel. It's easy to cut, shape, and fasten. It is warm to the touch—some kinds of wood even smell good. Its variations of color and grain are endlessly fascinating. All carpenters should be familiar with the properties of wood, what characteristics to look for when selecting lumber, and which products are appropriate for a given use.

From Trees to Lumber

It may be only a few hours from the moment a tree is felled until it arrives at the lumber mill for sawing. In less than five minutes, that tree can be converted into lumber ready for market.

Logs are first stripped of their bark, then are sent to the "head rig" to be sawed. The sawyer evaluates the log for quality and decides how it should be cut for the best yield. Then the log goes through a series of saws where it is sliced into slabs, rip-cut to width, and trimmed to length. Trimmings are fed into a chipper to be converted into raw material for paper, particleboard, and other wood products. In some modern mills, computers can analyze a log, plan the best cutting strategy, and set up the saws to make the cuts. The rough-sawed lumber is then smoothed, graded, and either stacked for shipment or set aside for kiln-drying and further processing.

The best cuts of wood come from the outside of old trees, near the bark. Knots are less numerous there, the grain rings closer together, and the wood more finely textured. These boards are graded for appearance and are cut into finish lumber and select lumber used for moldings and cabinet making.

Toward the center of the tree, where all branches originate, knots are more numerous. This part of the log yields the beams, timbers, and dimension lumber used for wood framing. This structural lumber is graded for strength rather than appearance.

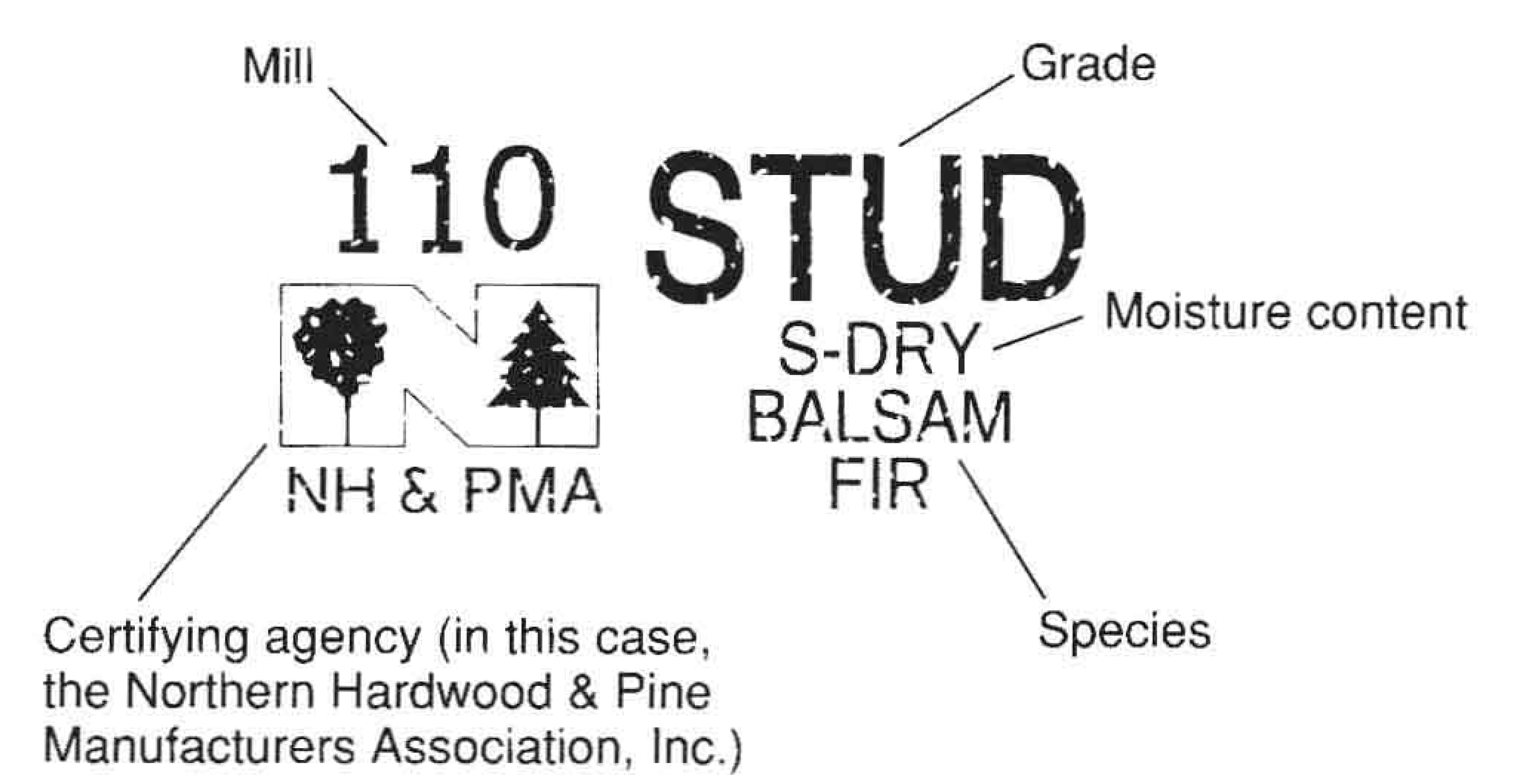
Sawing Styles

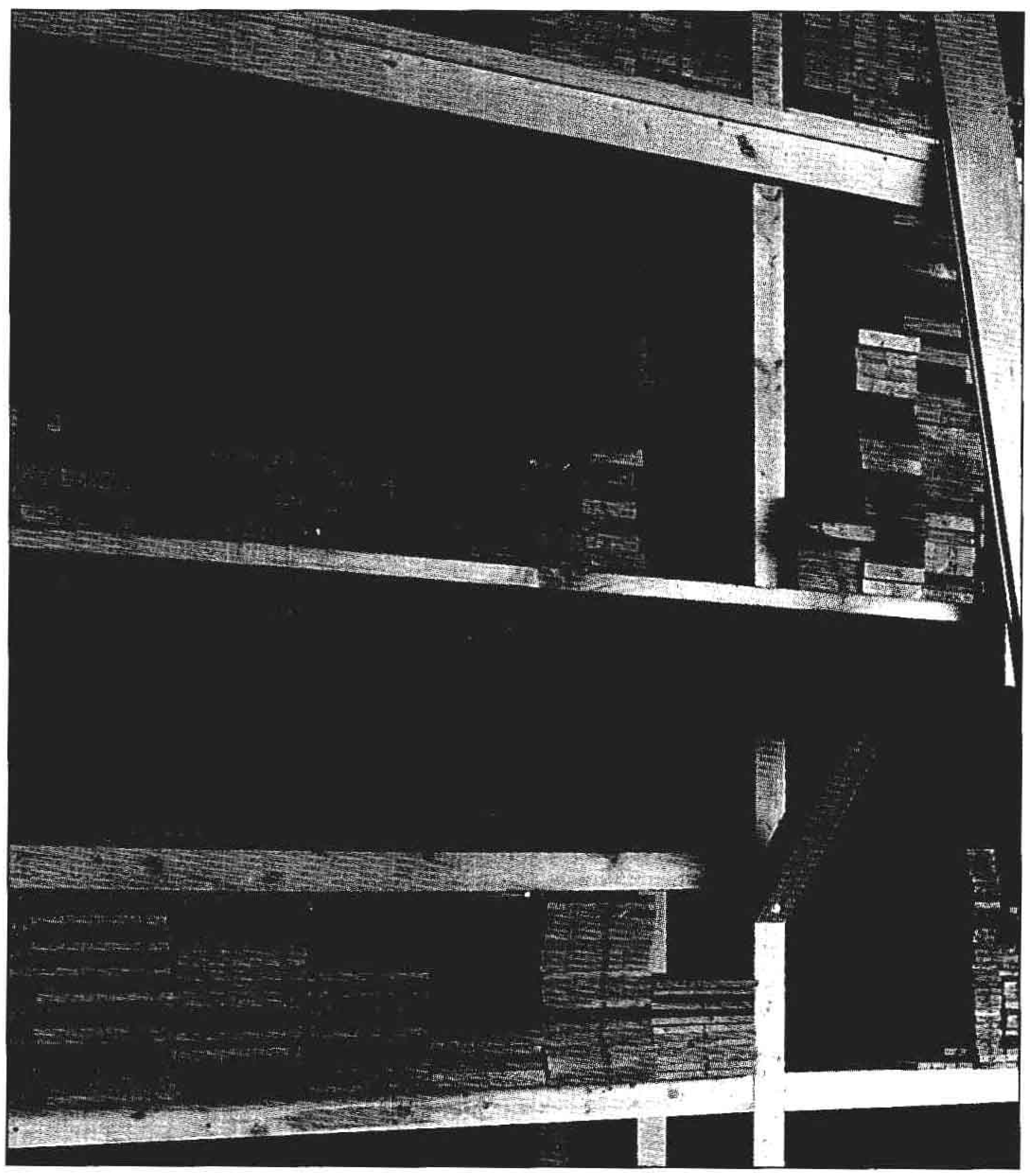
How a log is cut affects the properties of the lumber produced. There are two basic methods of cutting wood: plain sawing and quarter sawing.

Plain sawing is the least wasteful and fastest way to saw a log. Most construction-grade lumber is produced in this manner. Plain-sawed lumber is cut roughly parallel to the annual growth rings of the tree, producing boards with a grain pattern of wavy lines, V shapes, and ovals, with circular knots. Although this method yields strong lumber, plain-sawed boards can be prone to cupping and warping.

Quartersawed lumber, also called vertical-grain lumber, is cut perpendicular to the growth rings, resulting in boards with a grain pattern of parallel lines. As long as it is knot-free, quartersawed lumber is stronger and more stable than plain-sawed lumber, making it desirable for finish

Lumber Grading Stamp

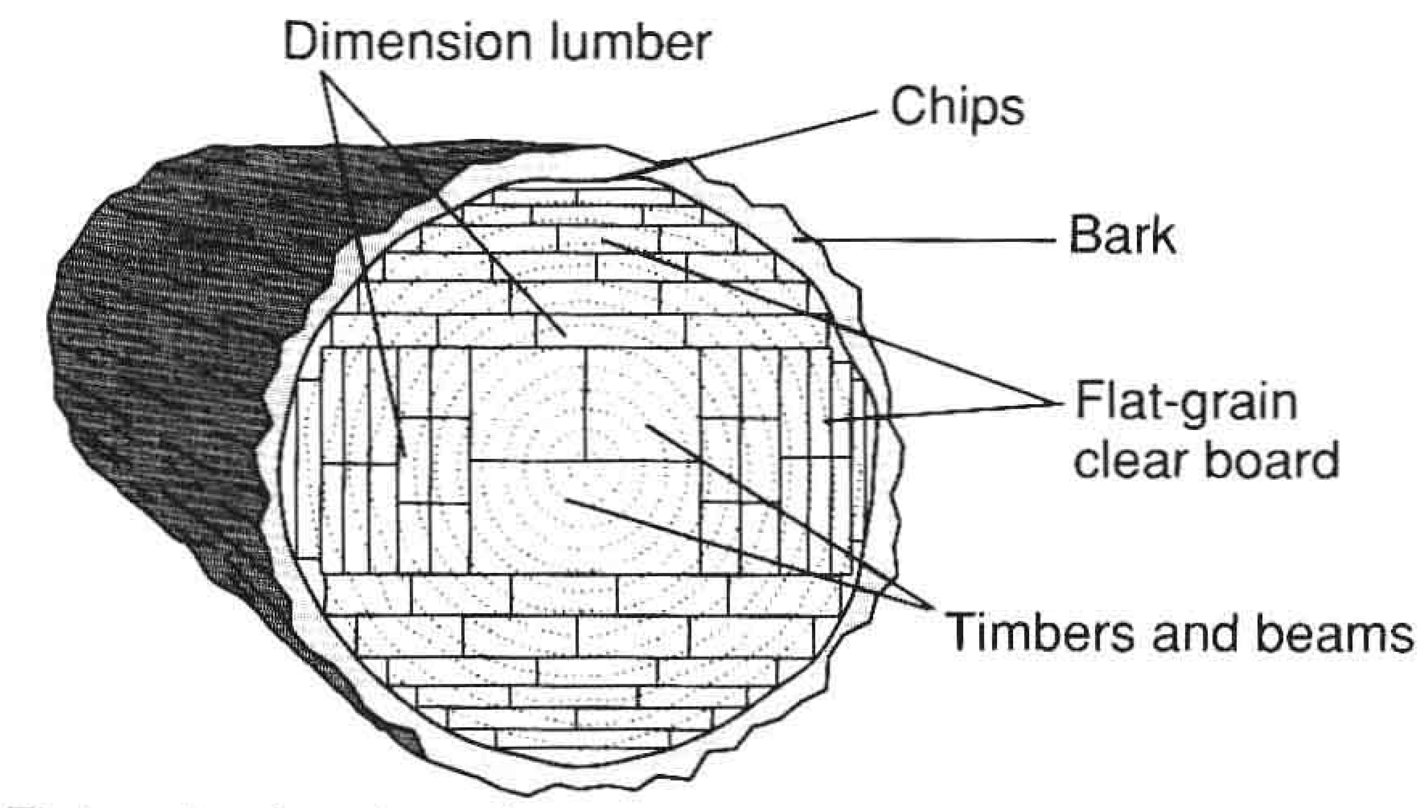


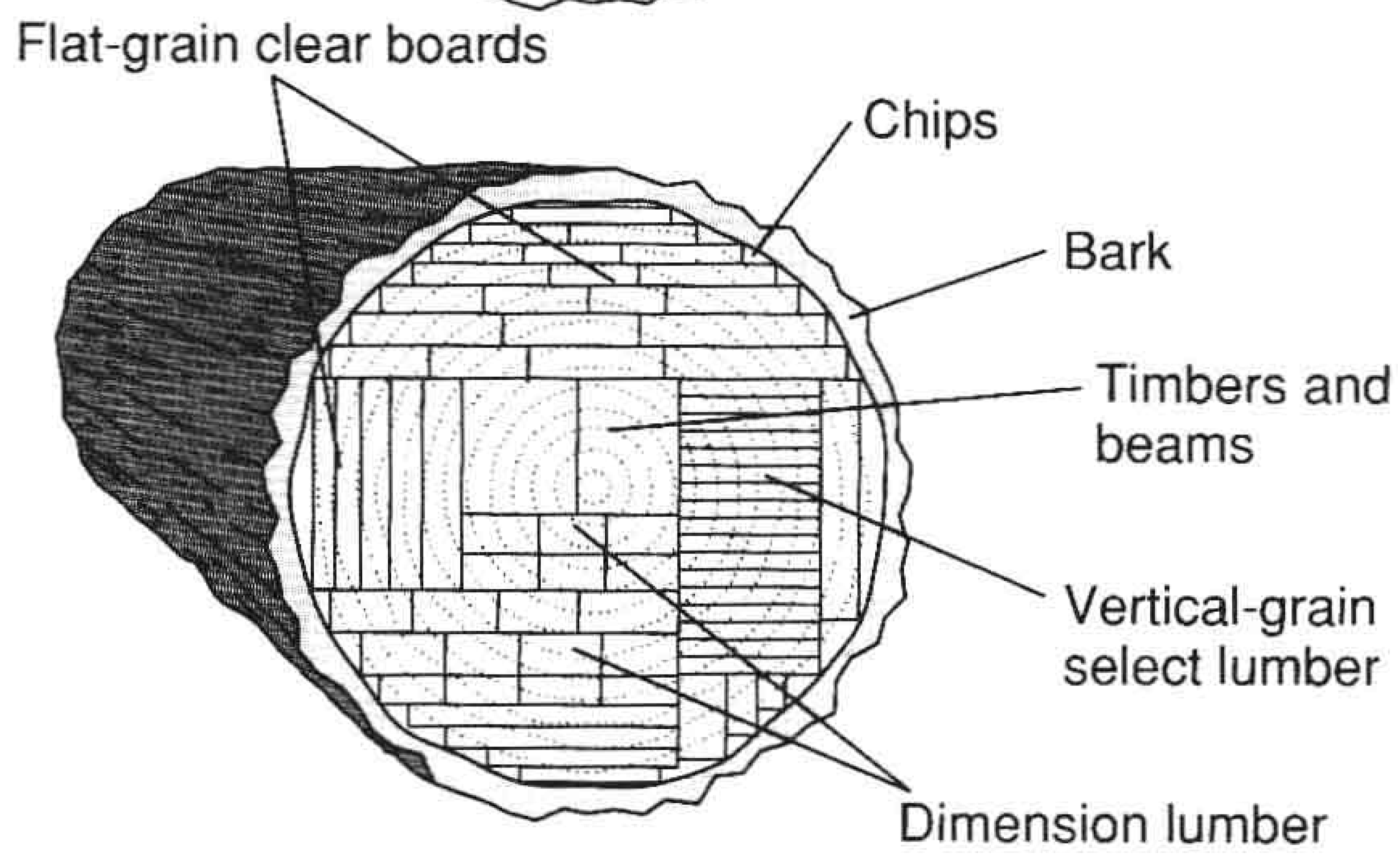


The boards in most lumber yards are sorted and stacked according to species, grade, and dimension. The numbers on the ends of these boards indicate length.

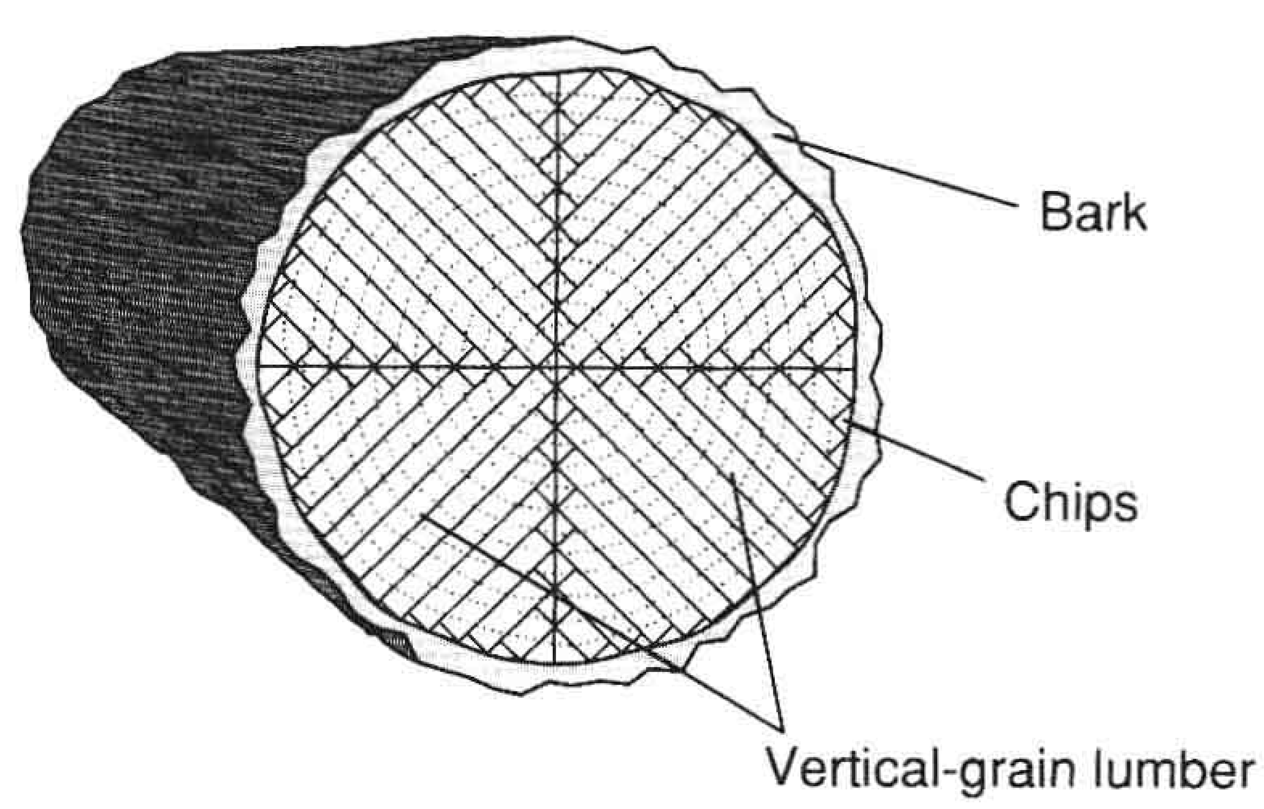
Wood-Cutting Methods

Plain-Sawed Lumber





Quartersawed Lumber



After debarking, a log is cut in either of two basic ways. The most common is called plain sawing. This process results in less waste, and therefore the wood is less expensive. The other process, called quarter sawing, results in lumber that is less likely to warp and is more beautifully grained in most species. There are further variations on these basic cutting methods, depending on the species, size of log, and kind of lumber ordered.

work. However, the knots in quartersawed lumber show up as long V-shaped spikes that may extend across the width of a board. A spike knot seriously weakens a board. Quarter sawing requires the kind of clear, defect-free logs that come mainly from old-growth forests. Because such forests are increasingly rare, and because so much of the log winds up as sawdust and waste wood, quartersawed lumber is fairly expensive.

Veneers are very thin sheets of wood that can be laminated to each other or to another substrate to produce panels. The resulting panels are strong and stable. Almost all veneers produced in the United States are made into plywood, although sheets of fine-wood veneers are available for furniture and cabinet making. Veneer is usually made by rotating a log against a fixed knife that peels off a continuous layer of wood the way paper toweling unspools from a roll. The grain pattern looks like a plain-sawed board that has been stretched out unnaturally wide. All structural plywood and the lower grades of finish plywood and paneling are made from rotary-cut veneers. For higher grades of finish plywood, the veneers are sliced off a fixed block of wood, resulting in natural-looking grain patterns that resemble plain-sawed or quartersawed lumber.

Wood Movement

Wood moves. It's an inescapable fact of nature, directly related to the amount of moisture in the wood. Freshly cut wood shrinks until it is dry and afterward expands and contracts with changes in humidity. To complicate things even more, wood changes its size significantly in width (across the grain), but hardly at all in length (along the grain).

In order to control shrinkage, the freshly cut, or green, lumber is either air-dried or kiln-dried. Initial air-drying brings the moisture content of the lumber down to about 20 percent when most of the free moisture in the pores of the wood has evaporated. Air-drying makes the wood stronger and only slightly shrinks it.

When the moisture content of lumber is taken below 20 percent, water trapped in the cell walls of the wood fibers begins to evaporate, the cells start to shrivel, and the wood shrinks. If the wood is being air-dried, this process can take a long time—about a year for each inch of thickness. In order to speed things up, mills dry lumber in kilns, where temperature and humidity are carefully controlled to prevent warping and cracking during drying. Kiln-dried lumber is much more stable than green lumber. It is also more expensive and therefore is usually reserved for high-quality cuts of wood used for furniture, cabinets, millwork, and floors.

In practical terms, the inherent tendency of wood to hold and relinquish moisture means that the header beams over doors and windows can shrink, cracking the wallboard in the corners. Doors and windows can get stuck in their frames. Plywood sheathing can swell and buckle. Board paneling and siding can shrink, causing unsightly gaps. Careful selection of lumber, storing lumber in a weatherproof location, and protecting bare lumber during the process of construction will keep moisture from being sealed into the job. In spite of these safeguards, permanent wood protection is often required.

Protecting Wood

Wood has two enemies: fungus and bugs. Several types of fungus attack wood. Fungal infestations are often referred to as dry rot. The name is something of a misnomer, because dry-rot fungi can survive only under damp conditions, when the moisture content of wood is over 20 percent. Therefore, it is important to keep wood buildings dry by providing air circulation around structural members (particularly under floors), sealing against the intrusion of water, and maintaining proper clearances from moist earth.

Insects can also cause serious damage to wood buildings. Of all the wood-eating bugs, subterranean termites (genus *Reticulitermes* sp.) do the most damage. These termites build their nests underground and travel back and forth to their feeding grounds through mud tunnels. You can often spot the source of an infestation by looking for tunnels along foundation walls and in crawl spaces. Termites are attracted to moist wood, so keeping wood dry is your best first line of defense. Treating serious infestations is a job best left to experienced professionals.

Because most dry-rot and termite problems start close to the ground, use pressure-treated wood, which is immune to both fungi and termites, in locations where wood is in contact with foundations, slabs, or bare earth.

Decay-Resistant Wood Species

Some types of trees have an inherent preservative (usually tannic acid) that protects them from decay. Only the darker heartwood, from the center of the tree, contains this preserving agent; the lighter colored sapwood, surrounding the heartwood, is not rot resistant. Redwood, cypress, and some (but not all) species of cedar are the most common examples of decay-resistant lumber.

Because of their beautiful coloration and excellent weathering properties, these woods are prized for exterior woodwork. They are also more expensive, and their use is usually restricted to siding, railings, trim, and other applications where appearance and durability are most important.

Pressure-Treated Wood

Wood species that would normally be subject to decay and insect attack can be treated by a process of injecting preservatives under pressure. These preservatives bind chemically to the wood tissue and won't leach out, making the wood nontoxic under normal use. Pressure-treated lumber is far superior to wood that has been merely sprayed or dipped in a preservative. In many cases, it will outlast naturally durable species. Pressure-treated lumber is necessary when wood will be subjected to ground contact or will be buried.

The most common types of chemicals used for pressure-treating lumber are water-borne salts such as chromated copper arsenate (CCA) and chemonite, or ammoniacal copper arsenate (ACA). These preservatives are appropriate where the wood will be used close to plants. They can be used safely around the home except for surfaces that will be in direct contact with food or serving utensils. Other preservatives used are pentachlorophenol and creosote, but they are so toxic that their use has been banned in many parts of the country. Lumber treated with these preservatives cannot be painted or stained as easily as lumber treated with CCA or ACA. Pentachlorophenol applied with liquid petroleum gas (LPG) is an exception.

Pressure-treated lumber has a green or beige tint and does not darken if left to weather. Depending on the amount of preservative used, pressure-treated wood is rated for ground contact (LP-22 rating, for direct burial uses, such as fence posts), or above-grade use (LP-2 rating, for sills, bottom plates of walls, and framing members within 6 inches of the ground). Sometimes pressure-treated wood is incised or punctured on the surface to facilitate the penetration of chemicals. For projects where a smooth, unblemished appearance is critical, ask for pressure-treated lumber without incisement. It's also worth the extra cost to buy lumber that is kiln-dried after treatment (KDAT) to avoid excessive warping in exposed outdoor applications.

Wear goggles and a dust mask when cutting pressure-treated lumber and gloves when handling it—especially if the lumber is damp. Do not burn scraps; dispose of them in an approved landfill. Coat the ends of cut boards with an approved preservative.

Lumber Grades

Virtually all the lumber produced in the United States is subject to grading systems that evaluate wood products for strength and appearance. Graders base their judgments on such factors as wood species, number and type of defects, grain patterns, and surface appearance. There are many grading associations across the country, each with its own set of rules, so you can't assume that a given lumber grade always means the same thing. With this in mind, consider the information below a *general* guide to lumber grading as practiced by most associations. Check with a local lumber supplier to verify that what you are buying is suitable for your needs.

For grading purposes, there are two broad categories of softwood lumber: structural lumber, which is graded primarily for strength, and finish lumber, which is graded for appearance.

Structural Lumber

This is the lumber used to construct wood-framed houses. Pieces of wood 2 to 4 inches thick are known as dimension lumber. The term *timber* includes anything 5 inches or thicker.

Smaller sizes of dimension lumber (2×4 and 4×4) are graded differently than the larger sizes. Utility grade is

Characteristics of Wood

These charts give detailed information on softwoods and hardwoods. The softwoods are used in rough carpentry; the hardwoods are used more often in fine woodworking. For the construction process described in this book, you will be concerned mainly with softwoods. You'll find the chart on hardwoods helpful for your other woodworking projects.

Softwood

Type	Sources	Uses	Characteristics
Cedar (Red)	East of Colorado and north of Florida	Mothproof chests, lining for linen closets, sills.	Very light, soft, weak, brittle. Natural color. Generally knotty, beautiful when finished in natural color, easily worked.
Cedar (Western Red, White)	Pacific Coast, Northwest, Lake States and Northeastern United States	Paneling, fence posts, siding, decks. Red cedar used for chests and closet lining.	Fine-grained, soft. Red: reddish brown with white sapwood. White: light with light brown heartwood. Brittle, light-weight; easily worked; low shrinkage; high resistance to decay. Strong, aromatic.
Cypress	Southeastern coast of the United States	Interior wall paneling and exterior construction, i.e., posts, fences, cooperage, docks, bridges, greenhouses, water towers, tanks, boats, river pilings.	Lightweight, soft, not strong, easy to work. Coarse texture. Durable against water decay. Light brown to nearly black.
Fir (Douglas)	Washington, Oregon, California	Construction flooring, doors, plywood, low-priced interior and exterior trim.	Light tan; moderately hard; close-grained. Most plentiful wood in the United States; used mostly for buildings and structural purposes; strong, moderately heavy.
Fir (White)	Idaho, California	Small home construction.	Soft; close, straight-grained; white with reddish tinge. Low strength; nonresinous; easily worked, low decay resistance.
Hemlock	Pacific Coast, western states	Construction lumber; pulpwood; containers; plywood core stock.	Lightweight; moderately hard; light reddish brown with a slight purple cast.
Larch	East Washington, Idaho, Oregon, Montana	Framing, shelving, fencing, shop projects, furniture.	Moderately strong and hard. Glossy russet-colored hardwood with straw-colored sapwood. If this wood is preservative treated, it can be used for decking.
Pine (Lodgepole)	West Coast from the Yukon to Mexico	Framing, shelving, fencing boards, small furniture, shop projects.	Hard, stiff, straight-grained. Mills smoothly, works easily, glues well, resists splintering, and holds nails well. Light brown heartwood, tinged with red with white sapwood.
Pine (Southern)	Southeastern United States	Floors, trusses, laminated beams, furniture frames, shelving.	Strongest of all softwoods with a pale yellow sapwood and reddish heartwood.
Pine (Sugar)	Western Oregon's Cascade mountains, Sierra Nevada of California	Shingles, interior finish, foundry patterns, models for metal castings, sash and door construction, quality millwork.	Lightweight, uniform texture, soft. Heartwood is light brown with tiny resin canals that appear as brown flecks. The sapwood is creamy white. Straight-grained and warp resistant.
Pine (White, Ponderosa)	United States	Solid construction in inexpensive furniture, sash, frames, knotty paneling.	Soft; pale yellow to white in color; fine-grained; darkens with age. Uniform texture and straight grain; lightweight, low strength, easily worked; has moderately small shrinkage, polishes well; warps or swells little.
Redwood	West Coast	Sash, doors, frames, siding, interior and exterior finish, paneling, decks.	Heartwood is cherry to dark brown; sapwood is almost white. Close, straight grain. Moderately lightweight, moderately strong; great resistance to decay; low shrinkage, easy to work, stays in place well; holds paint well.
Spruce	Various parts of the United States and Canada	Indoor work only. Pulpwood; light construction and carpentry work.	Soft, lightweight, pale with straight unpronounced grain and even texture.

Hardwood

Type	Sources	Uses	Characteristics
Ash (White)	United States	Upholstered furniture frames, interior trim.	Hard; prominent, coarse grain; light brown. Strong, straight grain; stiff, shock resistant; moderate weight; retains shape, wears well; easily worked.
Beech	Eastern United States	Flooring, chairs, drawer interiors.	Hard; fine grain; color varies from pale brown to deep reddish brown. Heavy, strong; has uniform texture; resists abrasion and shock; medium luster.
Birch (Yellow, Sweet)	Eastern and Northeastern United States and Lake States	Cabinet wood, flooring, plywood paneling, exposed parts and frames of furniture.	Hard, fine grain; light tan to reddish brown. Yellow is most abundant and important commercially; white sapwood and reddish brown heartwood. Heavy, stiff, strong; good shock resistance, uniform texture; takes natural finish well; satiny in appearance.
Cherry (Black, Wild)	Eastern and Northern United States	Paneling, furniture.	Moderately hard; light to dark reddish brown, fine grain; darkens with age. Strong, stiff, heavy; high resistance to shock and denting; not easily worked; high luster.
Gum (Red, Sap)	South	Plywood, interior trim, posts, stretchers, frames, supports—frequently used in combination with other woods.	Heartwood (red gum) is light to deep reddish brown; sapwood (sapgum) nearly white; moderately hard, fine grain. Moderately heavy, strong, uniform texture; takes finish well; frequently finished in imitation of other woods. In early 1900s, it was the most frequently used furniture wood in the U.S.
Hickory	Arkansas, Ohio, Tennessee, Kentucky	Tool handles, wagon stock, baskets, wagon spokes, pallets, ladders, athletic goods.	Very heavy, hard, stronger and tougher than other native woods; sapwood and heartwood of same weight. Difficult to work, subject to decay and insect attack.
Maple (Sugar, Black)	Great Lakes, Northeast, Appalachians	Interior trim, furniture, floors in homes, dance halls, bowling alleys.	One of the hardest woods in U.S.; heartwood is reddish brown; sapwood is white; usually fine, straight-grained; sometimes curly, wavy, or bird's-eye grain occurs. Strong, stiff; good shock resistance; great resistance to abrasive wear, one of the most substantial cabinet woods; curly maple prized for fiddlebacks.
Oak (Red, White)	Eastern United States, mainly Mississippi Valley and South	Flooring, interior trim, furniture, plywood for cabinetwork, paneling.	Hard, pronounced open grain; rich golden color to light reddish brown. Moderately heavy, stiff, strong, resilient, tough; comparatively easy to work with tools; takes many finishes.
Poplar (Yellow)	Eastern United States	Interior trim, siding, furniture, panels, plywood cores.	Sapwood is white; heartwood is yellowish brown tinged with green; soft; straight, fine grain. Lightweight, moderately weak, does not split readily when nailed; easily worked, easy to glue; stays in place well, holds paint and enamel well; finishes smoothly.
Sycamore	Eastern half of United States	Interior trim, fancy paneling, furniture.	Light to reddish brown; hard, close, interlocked grain. Moderately heavy, strong; rays are conspicuous when quartersawed; seasoning without warping is difficult.
Walnut (Black)	Central United States	Furniture, paneling, cabinetwork interior.	Light to dark chocolate brown; hard; moderately prominent, straight grain; sapwood is nearly white. Strong; resists shock and denting, easily worked; takes stain and finishes exceedingly well; heavy, stiff, is stable in use; one of the most beautiful native woods; has luminous finish.

the lowest grade suitable for construction. Its use is restricted to nonstructural building components such as interior partitions, blocking, and furring strips. The next rung up the quality ladder is standard grade, the most common grade used for light framing. Construction-grade lumber is stronger yet; it is straighter and contains fewer and smaller defects than the other grades. A fourth grade of small-size dimension lumber is called stud grade. Intended for wall framing, it has a strength rating that usually falls somewhere between standard and construction grade. Most stud-grade lumber comes precut to the exact length required for common sizes of stud walls.

In the larger sizes of dimension lumber and timbers (2×6 and up), there can be as many as 10 different grades to choose from. For residential construction, three grades are all you will ordinarily need. Grade 2 lumber is all-purpose lumber suitable for most structural purposes. It may contain heart center (the middle of the tree), which can cause warping, cracks, and twisting, but in applications that are concealed by the finished structure, this is not usually a serious problem. Grade 1 lumber is generally free of heart center. It also has straighter grain and smaller knots, and it's used where appearance or extra strength are important. At the top of the structural lumber heap is select structural grade. The strongest, stiffest, and most stable of all grades, it is used for heavily loaded beams and horizontal members that have to span long distances. It is also the most expensive grade, but is worth the extra money if you need good lumber for exposed structural framing.

Nominal and Actual Dimensions of Lumber

Nominal Size	Actual Size*
1 × 2"	¾ × 1½"
1 × 3"	¾ × 2½"
1 × 4"	¾ × 3½"
1 × 6"	¾ × 5½"
1 × 8"	¾ × 7¼"
1 × 10"	¾ × 9¼"
1 × 12"	¾ × 11¼"
5/4 × 6"	1¼ × 5½"
2 × 2"	1½ × 1½"
2 × 3"	1½ × 2½"
2 × 4"	1½ × 3½"
2 × 6"	1½ × 5½"
2 × 8"	1½ × 7¼"
2 × 10"	1½ × 9¼"
2 × 12"	1½ × 11¼"
4 × 4"	3½ × 3½"
4 × 6"	3½ × 5½"
4 × 8"	3½ × 7¼"
4 × 10"	3½ × 9¼"
4 × 12"	3½ × 11¼"
6 × 6"	5½ × 5½"
6 × 8"	5½ × 7¼"
8 × 8"	7¼ × 7¼"

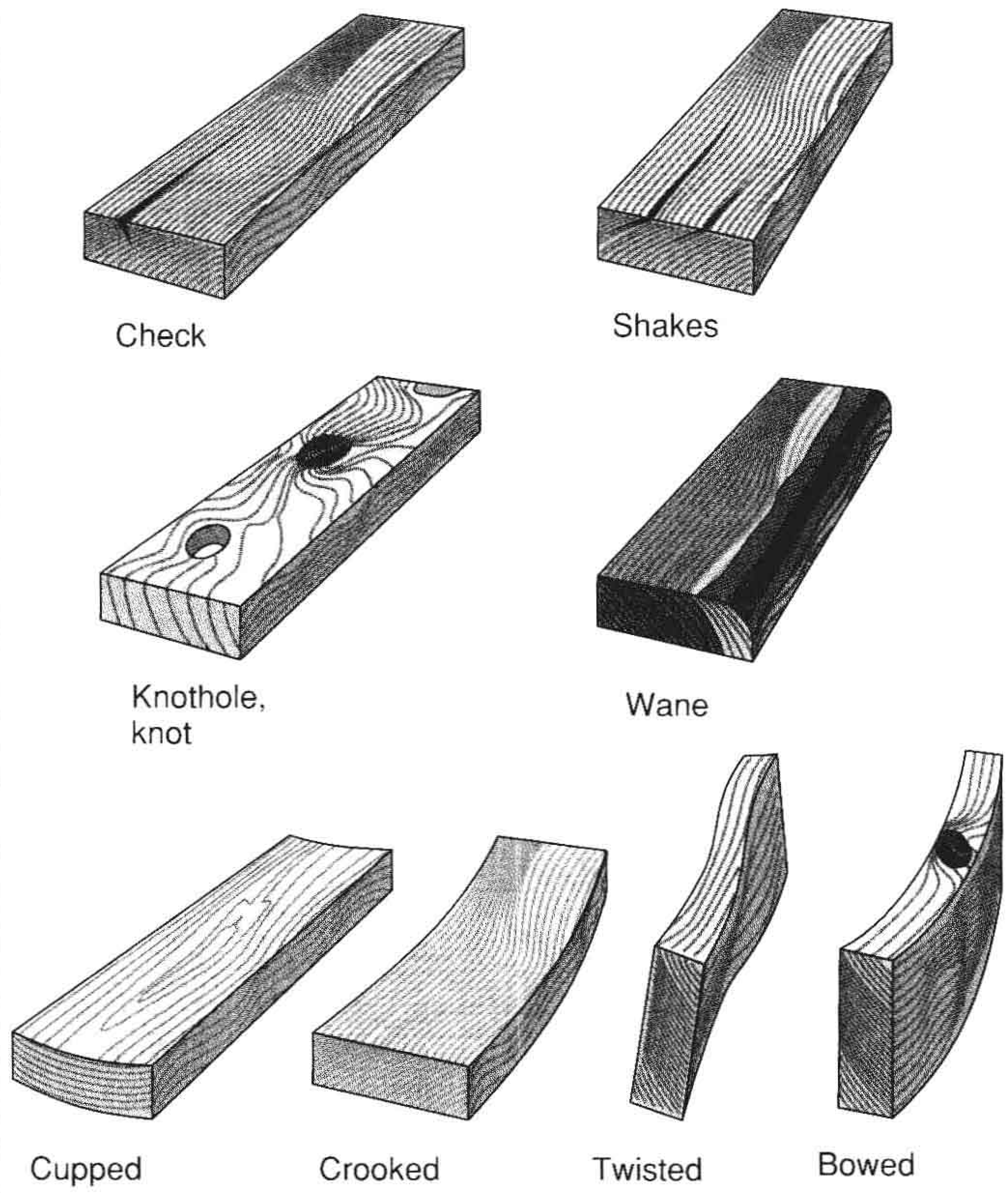
*Dimensions may vary. Always measure.

Finish Lumber

Grading systems for finish lumber are not standardized and vary according to wood species and the various grading associations involved. Some use a letter system, with grade A being the best grade and grade D the lowest; others use numbers, beginning with grade 1. The part of the tree the wood was cut from also comes into play, because the heartwood of some species is more valuable than the sapwood. Quarter sawing, moisture content, and other factors also affect how finish lumber is graded.

Remember that finish lumber is graded for appearance. Select your own finish lumber whenever possible. If it looks good to you, and the price is right, it will probably do the job.

Problem Boards



Selecting Lumber

Wood comes from living trees and is bound to contain some defects. A perfect board is rare indeed. Nevertheless, if you understand the nature of common wood defects and how they affect wood performance, you can make informed decisions when the time comes to pick out the lumber for your project.

- Knots are not necessarily defects. In fact, a tight knot in the center of a board may actually make it stronger, because the wood tissue around the knot is denser than the rest of the board. A board with an edge knot, on the other hand, will eventually develop a kink at the knot, even if the board looks straight when you buy it. Loose knots—the kind that fall out and leave an open hole—are acceptable as long as they are small, but large ones should be considered serious defects. Spike knots, sometimes found in quarter-sawed lumber, cause problems if their diameter is more than one fourth of the thickness of the board. Set aside lumber with unacceptable knots and cut for blocking, cripple studs, and other short pieces.

• Cupped structural lumber is usually not a problem. All plain-sawed lumber cups to some extent, especially if it is milled while still green.

Cupping can be a problem with finish lumber, though, especially if it's used outside, where it will be exposed to the weather. Your best insurance against cupping is to buy lumber that has been kiln-dried before surfacing. An even better solution, if your budget permits, is to buy quarter-sawed lumber—it's least likely to have cupping problems.

• Twisted lumber causes the most problems when used for header beams over door and window openings. No matter how you install a twisted header, one or more corners will stick out and cause lumps in the wall finishes. For studs, joists, and rafters, twist can usually be eliminated by blocking and strategic nailing. There's not much you can do about twisted beams and timbers, though, so avoid them unless you can use them where they won't show.

• Bowed lumber is nothing to worry about unless the bow is really pronounced. Bowed studs can be straightened by nailing a piece of scrap to adjacent studs until the wall finishes are in place, or by adding extra blocking. Since finish lumber is usually nailed to the framing, nails will hold bowed pieces flat.

• Crooked lumber is not uncommon and is hard to avoid. You just have to make allowances for it when you use it. You can spot even a very slight crook by picking up one end of a board and sighting down it with one eye. The convex edge of the board is called the crown side. If you're framing a wall, arrange all the studs so the crowns face the outside of the building. For roofs and floors, place the crowns up so that they will straighten out when the building is loaded. Badly crooked lumber should be rejected or cut into shorter pieces.

• Checks are splits that run perpendicular to the growth rings of a piece of lumber. These cracks that result from shrinkage usually show up near the ends of boards, where the wood dries out fastest. Lumber that contains boxed heart, or the center of the tree, checks more than other cuts, and unseasoned lumber checks more than kiln-dried wood. Still, checking is more of a cosmetic than structural defect, so don't hesitate to use checked lumber if appearance is not the primary consideration.

• Shakes, which are splits that follow the grain rings, are more serious. They are caused by extreme bending stresses in the tree before it is cut, usually from wind or snow loads. Do not use lumber with shakes that extend more than halfway through the board.

• Wane is the natural outer surface of the tree, just under the bark, that is found in some lumber. Because boards with wanes at the edges are cut from the outside of the log, they are likely to be of high quality, except for the bad edge. As long as there is enough of a flat surface on this edge to hold a nail, lumber with wane is acceptable for most uses.

Storing Lumber

Even if you are able to purchase the best-quality lumber, it's important to store it properly until it can be used. Lumber that's piled up willy-nilly will turn into worthless wood spaghetti in very short order. Stack lumber off the ground on pieces of scrap wood, called stickers, with all pieces butted tightly together. Cover the stack with plywood or a weighted tarp.

If you won't be using the lumber for a period of weeks or months, it's a good idea to store the whole pile with stickers. This promotes uniform seasoning by allowing air to circulate around every piece in the stack. Place strips of lath, spaced about 4 feet apart, between each layer of lumber. Make sure each sticker is directly above the one below it, or the weight of the pile will put a permanent bow in the boards at the bottom.

Manufactured Wood Products

Manufactured wood products are produced by taking wood apart and reassembling it into new forms with high-strength adhesives. Manufacturers of these products can use marginal lumber and milling waste to make building materials that in many ways are superior to their solid-wood counterparts.

You are probably familiar with some of these materials—plywood, particleboard, and hardboard have been around for many years. Others, such as oriented-strand board (OSB) and laminated-veneer lumber (LVL), are less familiar but are becoming more common.

Some manufactured wood products are bonded with urea-formaldehyde or phenol-formaldehyde glues. These resins emit gases for a significant period of time. People who are sensitive to urea-formaldehyde—used in particleboard and some types of medium-density fiberboard (MDF)—should choose a product made with less noxious phenolformaldehyde, and test their reaction to it before building an addition or a home. When buying particleboard or MDF, check for the mark HUD 24 CFR PART 3280. This indicates that the product complies with federal standards on emissions of formaldehyde gas.

Sheet Products

Plywood

This familiar material has long been widely used in the building trades. Layers of veneers are glued up into sheets, with the grain direction of the veneers alternating between layers. These sheets are stable, split resistant, and big enough to cover large areas quickly.

Plywood Veneer Grades

This chart with its description of the six different levels of veneer grades on plywood, listed in descending order of quality, was made available by the American Plywood Association.

N	Smooth-surface "natural finish" veneer. Made of select-grade wood that is either all heartwood or all sapwood. Free of open defects. No more than 6 repairs permitted in each 4 × 8 panel; each must be made of wood, must be parallel to the grain, and must be matched to the grain and color of the panel. This is top-quality grade.
A	Smooth and paintable with no more than 18 neatly made repairs; each must be made parallel to the grain. Can be used for natural finish in applications that are not too demanding.
B	Solid surface with circular repair plugs, shims, and tight knots up to 1 inch across the grain allowed. Some minor splits permitted.
C plugged	Improved C veneer. Splits limited to ⅛-inch width with knotholes and borer (insect) holes limited to ¼–½ inch. Some synthetic repair and broken grain permitted.
C	Tight knots to 1½ inches allowed. Knotholes permitted up to 1 inch across the grain and some to 1½ inches if the total width of the knots and knotholes is within specific limits. Permissible to have synthetic or wood repairs, discoloration, and sanding defects if they do not impair the strength. Limited splits are allowed. Stitching—the process of sewing random-sized pieces of plywood together—is permitted.
D	Knots and knotholes across the grain and up to 2½ inches wide are allowed. Within specified limits they can be up to 3 inches wide. Stitching is permitted as is a limited number of splits. This level is limited to interior grades of plywood.

Plywood manufacturers have developed dozens of different grades and types of plywood for specific uses, but there are basically two general categories: structural plywood and finish plywood.

Structural plywood is usually made of softwood species and always carries a grade stamp that gives the structural grade, allowable rafter and floor-joist spacing, and other important information. It's most often used for sheathing floors, roofs, and walls.

Finish plywood has face veneers of hardwood or softwood, and is designed to be used for finished products such as cabinets, wall paneling, and door skins.

Oriented-Strand Board and Waferboard

These products are made from large wood chips fused together with phenolformaldehyde adhesives. Oriented-strand board (OSB) consists of layers of chips laid so the fibers in one layer run at more or less right angles to those in the next, similar to the way plywood is made. The chips used in waferboard are randomly oriented in the sheet. OSB is stronger than waferboard for a given thickness, so it is the type most often found on building sites.

OSB panels are structurally as strong as plywood and are usually used for roof sheathing, wall sheathing, and subfloors. The panels have a smooth side and a textured side. The textured side should be installed up if you use OSB for roof sheathing, because the smooth face can be dangerously slippery.

Because OSB expands more than plywood with changes in moisture, the installed panels should be spaced ⅛ inch apart on the edges and ¼ inch at the ends. OSB is not as good as plywood at holding nails, especially near the edges. Therefore, it's important to maintain the proper distance from the edges of the sheet when nailing. OSB also tends to swell around the edges when it gets wet and therefore may not be the best choice for underlayment beneath thin floor coverings.

Particleboard and Medium-Density Fiberboard

These two products are made from wood chips, sawdust, and small fibers, bonded with urea-formaldehyde or phenolformaldehyde adhesives, and compressed into sheets under heat and pressure.

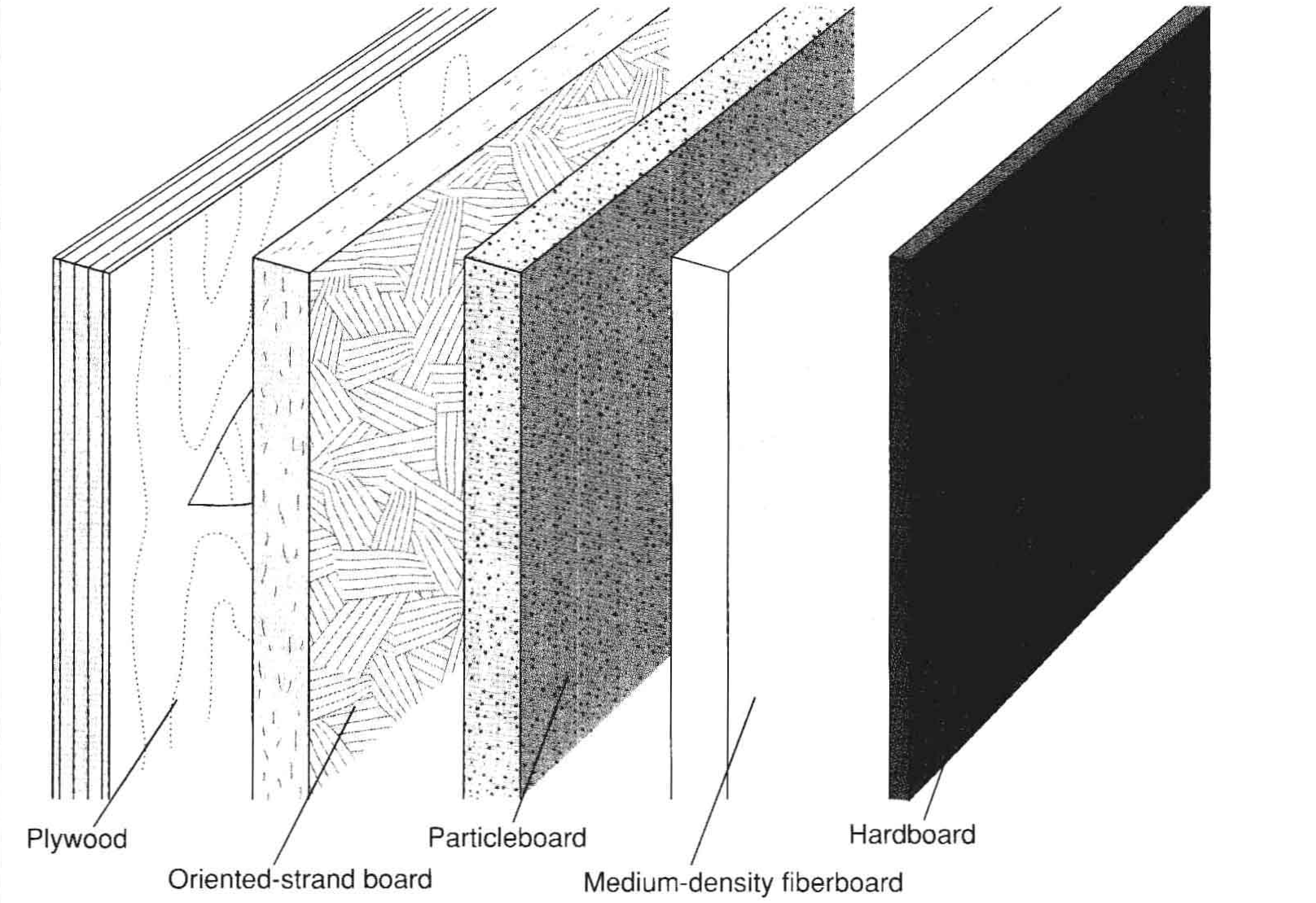
Particleboard, composed of small chips and sawdust, is an inexpensive alternative to plywood for many applications. It is dense, heavy, and impact resistant, making it a good choice for underlayment beneath sheet flooring, for concealed portions of cabinets, and as the substrate for plastic-laminate countertops.

Medium-density fiberboard (MDF) is made from individual wood fibers bonded with phenolformaldehyde adhesives. It is very finely textured and even denser than particleboard. MDF has excellent machining properties and is used to make paint-grade moldings, door panels, and furniture parts.

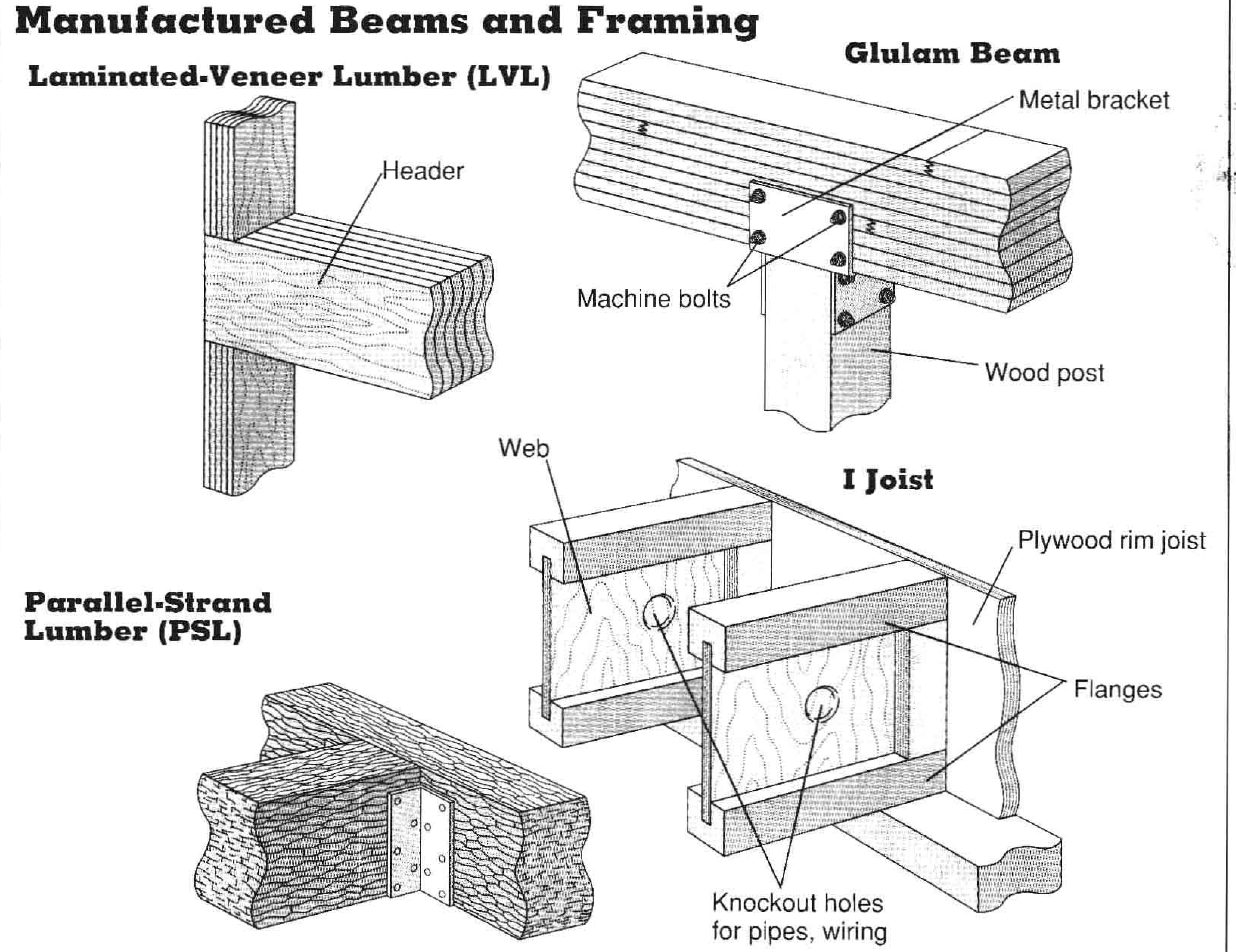
The edges of particleboard and MDF sheets are poor at holding nails and screws; you must use specialized fasteners or pieces of solid wood when joining pieces of particleboard or MDF.

One useful particleboard variant is known as melamine board. This is a particleboard sheet that has been coated with a layer of tough, lightly textured plastic. The primary advantage of this material is that it can be made into cabinets that don't require further finishing. Another plus is that the melamine coating seals the particleboard surface, virtually eliminating any off-gassing of formaldehyde vapors. Exposed edges of melamine boards are usually covered with wood or plastic veneers or with strips of solid wood. White, cream, and gray are stock colors, but melamine can be ordered in dozens of other colors.

Composition Panels



Manufactured Beams and Framing



Hardboard

Hardboard, which is actually a high-density fiberboard, is used for cabinet backs, drawer bottoms, siding, perforated board, and doors. It comes tempered and untempered. The tempered variety is water resistant and is used to make siding.

Unlike solid wood, hardboard siding moves in length as well as width, so special installation procedures must be followed to allow for expansion and contraction. Follow the manufacturer's instructions carefully to protect the warranty when installing hardboard siding.

Manufactured Beams and Framing Lumber

Wood I Joists

I joists are made of a plywood or OSB web glued to two solid-wood or LVL flanges in the shape of an I beam. They are primarily used for floor joists, although they can also be used for rafters, ceiling joists, and headers.

Wood I joists offer many advantages over solid-wood framing materials. They are lighter, straighter, and more dimensionally stable than comparable sawed lumber. Floors framed with I joists are flatter than conventionally framed floors and are not subject to shrinkage that can cause settling and annoying floor squeaks. I joists are capable of very long spans—up to 25 feet or more—and can eliminate the need for intermediate beams and bearing walls.

Framing With Steel

As the available supply of quality timber dwindles and prices rise, builders have been exploring alternatives to traditional wood framing. One such option that has seen rapid growth in recent years is the steel-stud framed building.

Steel framing has several advantages over wood. Steel studs are lightweight and strong. They won't burn (although they can lose their strength in a very hot fire). They won't shrink, warp, or rot, and termites hate them. Steel studs can be made from recycled scrap metal and can be recycled again once their useful life is over. And every house framed in steel saves the lives of several trees.

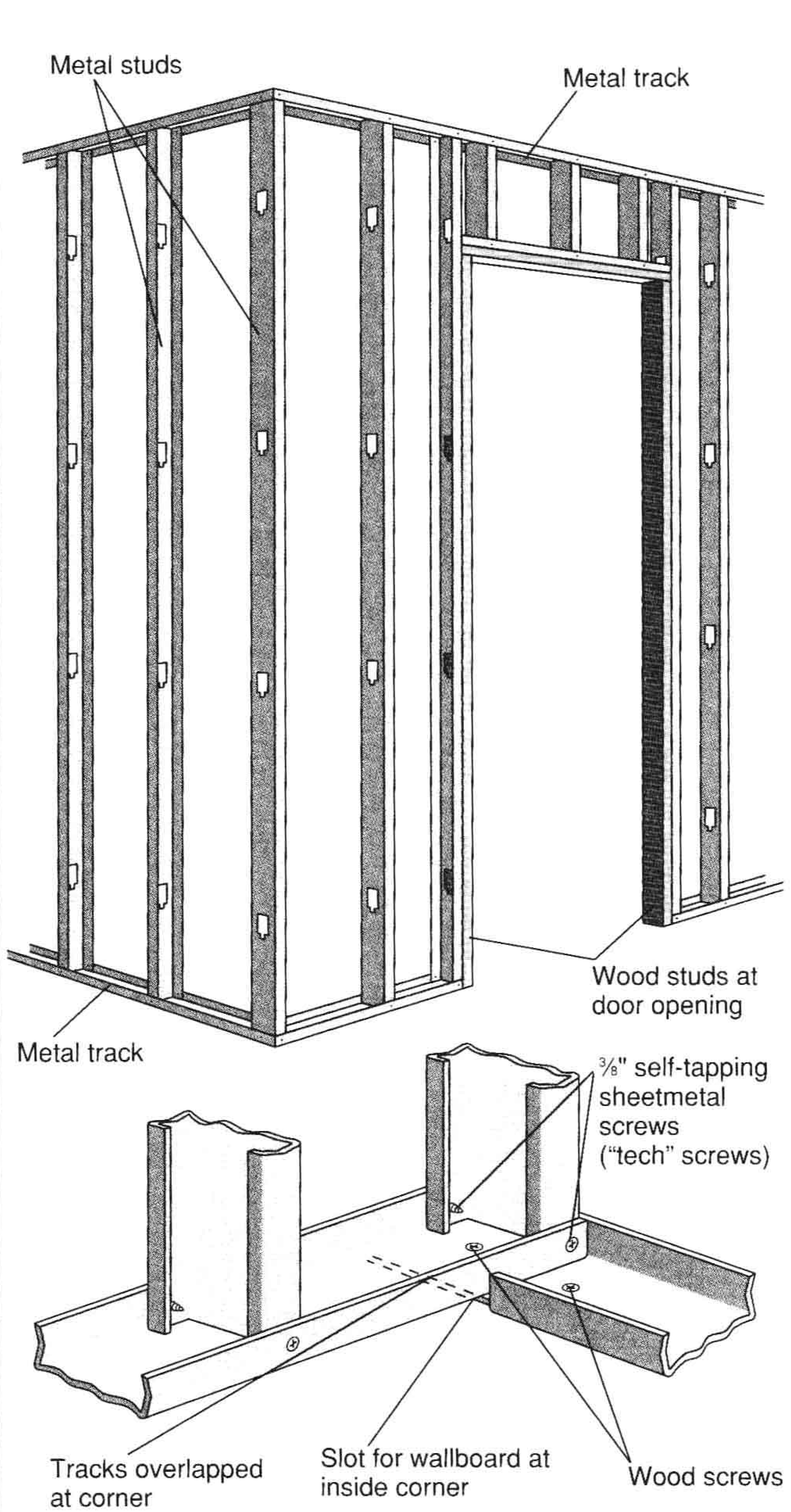
The basic structural components of steel-framed buildings are similar to their wood counterparts, with studs, joists, rafters, and roof trusses, but the techniques used to assemble them are different. Hammers and nails give way to electric screw guns and drill-point screws, and toothed saw blades are replaced by abrasive metal-cutting blades and tin snips.

Steel studs are made of C-shaped sheet-metal channels. They come with prepunched holes for running electrical wiring and plumbing through the walls. Steel studs are available in several different sizes and weights, depending on load-bearing requirements.

Virtually all connections in steel framing are made with specially designed screws. For light-duty work, a sharp-pointed screw that punches through the sheet metal is used; for heavy-gauge studs, a drill-point screw, with a tip that looks just like a small drill bit, is the fastener of choice. Other specialized screws are used to fasten the wallboard, siding, floors, and trim to the framing. Given the great number of screws in a metal-stud job, the only practical way to drive them is with a power screw gun.

Although sizable load-bearing structures require specialized building techniques, nonbearing interior walls built of light-gauge studs are easy to construct with just a screw gun and metal snips (use a felt-tip pen for layout work). Metal studs can be a good choice for remodeling jobs, with the added bonus of not having to sweep up a pile of sawdust at the end of the day. If you are thinking of framing a project in steel, obtain a copy of the manufacturer's recommended framing practices and study it carefully. Consult an architect or engineer for any job with significant structural loads.

Metal Framing



Holes can be cut in the webs to route plumbing, wiring, and duct work through the floor. When properly placed, these holes can be nearly the full depth of the joist.

If you are thinking of using I joists, bear in mind that it's crucial to follow proper framing procedures. Most manufacturers provide detailed drawings of typical framing conditions and span charts for normal uses. The supplier will put together a complete materials package from your drawings and specify which framing details are appropriate for your installation.