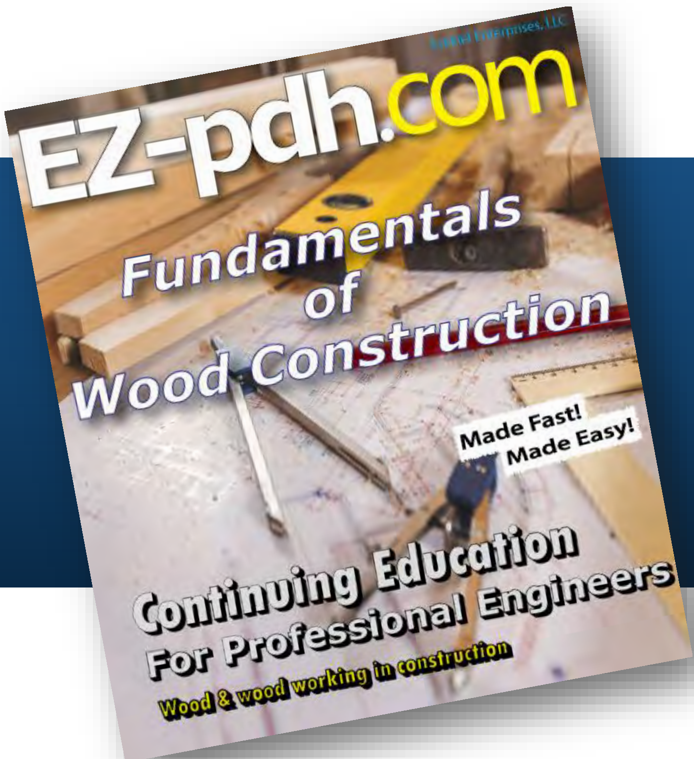

Fundamentals of Wood Construction

Three (3) Continuing Education Hours

Course #CV1220

Approved Continuing Education for Licensed Professional Engineers

EZ-pdh.com
Ezekiel Enterprises, LLC
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New Smyrna Beach, FL 32170
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Course Description:

The Fundamentals of Wood Construction course satisfies three (3) hours of professional development.

The course is designed as a distance learning course that overviews the basics of wood construction and woodworking techniques.

Objectives:

The primary objective of this course is to enable the student to understand the basics of wood in construction including common woodworking techniques for construction.

Grading:

Students must achieve a minimum score of 70% on the online quiz to pass this course. The quiz may be taken as many times as necessary to successful pass and complete the course.

A copy of the quiz questions are attached to last pages of this document.

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Fundamentals of Wood Construction

1.0.0 TYPES of WOOD and USES

Of all construction materials, wood is probably the most often used and perhaps the most important. The variety of uses of wood is practically unlimited. Building professionals accomplish few construction projects without using some type of wood. It is used for permanent structures as well as concrete forms, scaffolding, shoring, and bracing. The wood from these temporary structures is reusable again and again. The types, sources, uses, and characteristics of common woods are given in *Table 1*. The types of classifications of wood for a large project are usually designated in the project specifications and included in the project drawings.

Table 1 – Common Woods

TYPES	SOURCES	USES	CHARACTERISTICS
ASH	East of Rockies	Oars, boat thwarts, benches, gratings, hammer handles, cabinets, ball bats, wagon construction, farm implements	Strong, heavy, hard, tough, elastic, close straight grain, shrinks very little, takes excellent finish, lasts well
BEECH	East of Mississippi and Southeastern Canada	Cabinetwork, imitation mahogany furniture, wood dowels, capping, boat trim, interior finish, tool handles, turnery, shoe lasts, carving, flooring	Similar to birch but not so durable when exposed to weather, shrinks and checks considerably, close grain, light or dark red color
BIRCH	East of Mississippi River and North of Gulf Coast states, Southeast Canada, and Newfoundland	Cabinetwork, imitation mahogany furniture , wood dowels, capping, boat trim, interior finish, tool handles, turnery, carving	Hard, durable, fine grain, even texture, heavy, stiff, strong, tough, takes high polish, works easily, forms excellent base for white enamel finish, but not durable when exposed. Heartwood is light to dark reddish brown in color
BUTTERNUT	Southern Canada, Minnesota, Eastern U.S. as far South as Alabama and Florida	Toys, altars, woodenware, millwork, interior trim, furniture, boats, scientific instruments	Very much like walnut in color but softer, not as soft as white pine and basswood, easy to work, coarse grained, fairly strong
DOUGLAS FIR	Pacific Coast and British Columbia	Deck planking on large ships, shores, strongbacks, plugs, filling pieces and bulkheads of small boats, building construction, dimension timber, ***plywood***	Excellent lumber, strong, easy to work. Clear straight grained, soft but brittle. Heartwood is durable in contact with ground, best structural timber of northwest.
ELM	States East of Colorado	Agricultural implements, wheel-stock, boats, furniture, crossties, posts, poles	Slippery, heavy, hard, tough, durable, difficult to split, not resistant to decay
HICKORY	Arkansas, Tennessee, Ohio, and Kentucky	Tools, handles, wagon stock, hoops, baskets, vehicles, wagon spokes	Very heavy, hard, stronger and tougher than other native woods, but checks, shrinks, difficult to work, subject to

Table 1 – Common Woods

TYPES	SOURCES	USES	CHARACTERISTICS
			decay and insect attack
LIVE OAK	Southern Atlantic and Gulf Coasts of U.S., Oregon, and California	Implements, wagons, ship-building	Very heavy, hard, tough, strong, durable, difficult to work. Heartwood is light brown or yellow, sap wood is nearly white
MAHOGANY	Honduras, Mexico, Central America, Florida, West Indies, Central Africa, and other tropical sections	Furniture, boats, decks, fixtures, interior trim in expensive homes, musical instruments	Brown to red color, one of most useful of cabinet woods, hard, durable, does not split badly, open grained, takes beautiful finish when grain is filled but checks, swells, shrinks, warps slightly
MAPLE	All states East of Colorado and Southern Canada	Excellent furniture, high-grade floors, tool handles, ship construction, crossties, counter tops, bowling pins	Fine grained, grain often curly or “Birds’ Eyes,” heavy, tough, hard, strong, rather easy to work, but not durable. Heartwood is light brown, sap wood is nearly white
NORWAY PINE	States bordering Great Lakes	Dimension timber, masts, spars, piling, interior trim	Light, fairly hard, strong, not durable in contact with ground
PHILIPPINE MAHOGANY	Philippine Islands	Pleasure boats, medium-grade furniture, interior trim	Not a true mahogany, shrinks, expands, splits, warps, but available in long, wide, clear boards
POPLAR	Virginias, Tennessee, Kentucky, and Mississippi Valley	Low-grade furniture, cheaply constructed buildings, interior finish, shelving, drawers, boxes	Soft, cheap, obtainable in wide boards, warps, shrinks, rots easily, light, brittle, weak, but works easily and holds nails well, fine-textured
RED CEDAR	East of Colorado and North of Florida	Mothproof closets, lining for linen closets, sills, and other uses similar to white cedar	Very light, soft, weak, brittle, low shrinkage, great durability, fragrant scent, generally knotty, beautiful when finished in natural color, easily worked
RED OAK	Virginias, Tennessee, Arkansas, Kentucky, Ohio, Missouri, Maryland	Interior finish, furniture, cabinets, millwork, crossties when preserved	Tends to warp, coarse grain, does not last well when exposed to weather, porous, easily impregnated with preservative, heavy, tough, strong
REDWOOD	California	General construction, tanks, paneling	Inferior to yellow pine and fir in strength, shrinks and splits little, extremely soft, light, straight grained, very durable, exceptionally resistant to decay
SPRUCE	New York, New England, West Virginia, Central	Railway ties, resonance wood, piles, airplanes, oars, masts, spars, baskets	Light, soft, low strength, fair durability, close grain, yellowish, sap wood indistinct

Table 1 – Common Woods

TYPES	SOURCES	USES	CHARACTERISTICS
	Canada, Great Lakes states, Idaho, Washington, Oregon		
SUGAR PINE	California and Oregon	Same as white pine	Very light, soft, resembles white pine
TEAK	India, Burma, Thailand, and Java	Deck planking, shaft legs for small boats	Light brown color, strong, easily worked, durable, resistant to moisture damage
WALNUT	Eastern half of U.S. except Southern Atlantic and Gulf Coasts, some in New Mexico, Arizona, California	Expensive furniture, cabinets, interior woodwork, gun stocks, tool handles, airplane propellers, fine boats, musical instruments	Fine cabinet wood, coarse grained but takes beautiful finish when pores closed with wood filler, medium weight, hard, strong, easily worked, dark chocolate color, does not warp or check, brittle
WHITE CEDAR	Eastern coast of U.S., around Great Lakes	Boat planking, railroad ties, shingles, siding, posts, poles	Soft, lightweight, close grained, exceptionally durable when exposed to water, not strong enough for building construction, brittle, low shrinkage, fragment, generally knotty
WHITE OAK	Virginias, Tennessee, Arkansas, Kentucky, Ohio, Missouri, Maryland, and Indiana	Boat and ship stems, stern-posts, knees, sheer strakes, fenders, capping, transoms, shaft logs, framing for buildings, strong furniture, tool handles, crossties, agricultural implements, fence posts	Heavy, hard, strong, medium coarse grain, tough, dense, most durable of ***hardwoods***, elastic, rather easy to work, but shrinks and likely to check. Light brownish grey in color with reddish tinge, medullary rays are large and outstanding and present beautiful figures when quarter sawed, receives high polish
WHITE PINE	Minnesota, Wisconsin, Main, Michigan, Idaho, Montana, Washington, Oregon, California	Patterns, any interior job or exterior job that doesn't require maximum strength, window sash, interior trim, millwork, cabinets, cornices	Easy to work, fine grain, free of knots, takes excellent finish, durable when exposed to water, expands when wet, shrinks when dry, soft, white, nails without splitting, not very strong, straight grained
YELLOW PINE	Virginia to Texas	Most important lumber for heavy construction and exterior work, keelsons, risings, filling pieces, clamps, floors, bulkheads of small boats, shores, wedges, plugs, strongbacks, staging, joists, posts, piling, ties, paving blocks	Hard, strong, heartwood is durable in the ground, grain varies, heavy, tough, reddish brown in color, resinous, medullary rays well marked

1.1.0 Lumber

The terms wood, lumber, and timber are often spoken or written as if their meanings are alike or nearly so. In the Builder's language, the terms have distinct, separate meanings. Wood is the hard, fibrous substance that forms the major part of the trunk and branches of a tree. Lumber is wood that has been cut and surfaced for use in construction work. Timber is lumber that is 5 inches or more in both thickness and width.

1.2.0 Seasoning of Lumber

Seasoning lumber is removing moisture from the small and large cells of wood, or drying. The advantages of seasoning lumber are reducing its weight, increasing its strength and resistance to decay, and decreasing shrinkage, which helps to avoid checking and warping after placing the lumber. A seldom used and rather slow method of seasoning lumber is air drying in a shed or stacking in the open until dry. A faster method, known as kiln drying, has lumber placed in a large oven or kiln and dried with heat supplied by gas or oil fired burners. Lumber is dry enough for most uses when its moisture content has been reduced to about 12 to 15 percent. As a Builder, you will learn to judge the dryness of lumber by its color, weight, smell, and feel. After the lumber is cut, you will be able to judge the moisture content by looking at the shavings and chips.

1.3.0 Defects and Blemishes

A defect in lumber is any flaw that tends to affect the strength, durability, or utility value of the lumber. A blemish is a flaw that mars only the appearance of lumber. A blemish that affects the utility value of lumber, such as a tight knot that mars the appearance of lumber intended for fine cabinet work, is also considered a defect. Various flaws apparent in lumber are listed in *Table 2*.

Table 2 – Wood Defects & Blemishes

Common Name	Description
Bark Pocket	Patch of bark over which the tree has grown, and which it has entirely or almost entirely enclosed
Check	Separation along the lengthwise grain, caused by too rapid or nonuniform drying
Cross Grain	Grain does not run parallel to or spiral around the lengthwise
Decay	Deterioration caused by various fungi
Knot	Root section of a branch that may appear on a surface in cross section or lengthwise. A cross-sectional knot may become may be loose or tight. A lengthwise knot is called a spike knot.
Pitch Pocket	Deposit of solid or liquid pitch enclosed in the wood
Shake	Separation along the lengthwise grain that exists before the tree is cut. A heart shake moves outward from the center of the tree and is caused by decay at the center of the trunk. A wind shake follows the circular lines of the annual rings; its cause is not definitely known.
Wane	Flaw in an edge or corner of a board or timber. It is caused by the presence of bark

Table 2 – Wood Defects & Blemishes

Common Name	Description
	or lack of wood in that part.
Warp	Twist or curve caused by shrinkage that develops in a once flat or straight board.
Blue Stain	A blemish caused by a mold fungus; it does not weaken the wood.

1.4.0 Classification of Lumber

Trees are classified as either ***softwood*** or hardwood, as shown in *Table 3*. All lumber is therefore classified in the same way. The terms “softwood” and “hardwood” can be confusing since some softwood lumber is harder than some hardwood lumber. Generally, hardwoods are more dense and harder than softwoods. Lumber can be further classified by the name of the tree from which it comes. For example, Douglas fir lumber comes from a Douglas fir tree; walnut lumber comes from a walnut tree, and so forth.

Table 3 – Different Types of Softwoods and Hardwoods

Softwoods	Hardwoods
Douglas fir Southern pine Western larch	Basswood Willow American Elm
Hemlock White fir Spruce	Mahogany* Sweet gum White ash*
Ponderosa Pine Western red cedar Redwood	Beech Birch Cherry
Cypress White pine Sugar pine	Maple Oak* Walnut*

*Open-grained wood

The quality of softwood lumber is classified, according to its intended use, as being yard, structural, factory, or shop lumber. Yard lumber consists of those grades, sizes, and patterns generally intended for ordinary building purposes. Structural lumber is 2 or more inches in ***nominal*** thickness and width and is used where strength is required. Factory and shop lumber are used primarily for building cabinets and interior finish work.

Lumber manufacturing classifications consist of rough dressed (surfaced) and worked lumber. Rough lumber has not been dressed but has been sawed, edged, and trimmed. Dressed lumber is rough lumber that has been planed on one or more sides to attain smoothness and uniformity. Worked lumber, in addition to being dressed, has also been matched, shiplapped, or patterned. Matched lumber is tongue and groove, either sides or ends or both. Shiplapped lumber has been rabbeted on both edges to provide a close lapped joint. Patterned lumber is designed to a pattern or molded form.

1.4.1 Softwood Grading

The grade of a piece of lumber is based on its strength, stiffness, and appearance. A high grade of lumber has very few knots or other blemishes. A low grade of lumber may have ***knotholes*** and many loose knots. The lowest grades are apt to have splits, checks, honeycombs, and some warpage. The grade of lumber to be used on any construction job is usually stated in the specifications for a set of blueprints. Basic classifications of softwood grading include boards, dimension, and timbers. The grades within these classifications are shown in *Table 4*.

Table 4 – Softwood Lumber Grades

	BOARDS			
APPEARANCE: **SELECTS**	B & Better C Select D Select		(IWP – Supreme) (IWP – Choice) (IWP – Quality)	
APPEARANCE: **FINISH**	Superior Prime E			
APPEARANCE: **PANELING**	Clear (Any Select or Finish Grade) No. 2, 3 Common selected for knotty paneling			
APPEARANCE: **SIDING (Bevel, Bungalow)**	Superior Prime		**Alternate Board Grades**	
BOARDS SHEATHING	No. 1 Common (IWP – Colonial) No. 2 Common (IWP – Sterling) No. 3 Common (IWP – Standard) No. 4 Common (IWP – Utility)		Select Merchantable Construction Standard Utility	
	DIMENSION			
LIGHT FRAMING 2 in. to 4 in. Thick 2 in. to 4 in. Wide	Construction Standard Utility Economy	This category is for use where high strength values are NOT required, such as studs, plates, sills, cripples, blocking, etc.		
	Stud Economy Stud	An optional all-purpose grade limited to 10 feet and shorter. Characteristics affecting strength and stiffness values are limited so that the Stud grade is suitable for all stud uses, including load bearing walls.		
STRUCTURAL LIGHT FRAMING 2 in. to 4 in. Thick 2 in. to 4 in. Wide	Select Structural No. 1 No. 2 No. 3 Economy	These grades are designed to fit those engineering applications where higher bending strength ratios require light framing sizes. Typical uses would be for trusses, concrete pier wall forms, etc.		
STRUCTURAL JOISTS & PLANKS 2 in. to 4 in. Thick 6 in. and Wider	Select Structural No. 1 No. 2 No. 3 Economy	These grades are designed especially to fit in engineering applications for lumber 6 inches and wider, such as joists, rafters, and general framing uses.		
	TIMBERS			
BEAMS & STRINGERS	Select Structural No. 1 No. 2 (No. 1 Mining) No. 3 (No. 2 Mining)	**POSTS & TIMBERS**	Select Structural No. 1 No. 2 (No. 1 Mining) No. 3 (No. 2 Mining)	

Lumber is graded for quality in accordance with American Lumber Standards set by the National Bureau of Standards for the U.S. Department of Commerce. The major quality grades, in descending order of quality, are select lumber and common lumber. *Table 5* lists the subdivisions for each grade in descending order of quality.

Table 5 – Grades and Subdivisions of Lumber

SELECT LUMBER	
Grade A	This lumber is practically free of defects and blemishes.
Grade B	This lumber contains a few minor blemishes.
Grade C	This lumber contains more numerous and more significant blemishes than grade B. Those blemishes must be capable of being easily and thoroughly concealed with paint.
Grade D	This lumber contains more numerous and more significant blemishes than grade C, but it is still capable of presenting a satisfactory appearance when painted.
COMMON LUMBER	
No. 1	Sound, tight-knotted stock containing only a few minor defects. Must be suitable for use as watertight lumber.
No. 2	Contains a limited number of significant defects but no knotholes or other serious defects. Must be suitable for use as grain-tight lumber.
No. 3	Contains a few defects that are larger and coarser than those in No. 2 common; for example, occasional knotholes.
No. 4	Low-quality material containing serious defects like knotholes, checks, shakes, and decay.
No. 5	Capable only of holding together under ordinary handling.

1.4.2 Hardwood Grades

Grades of hardwood lumber are established by the National Hardwood Lumber Association. Firsts and Seconds (FAS) is the best grade. It specifies that pieces be no less than 6 inches wide by 8 feet long and yield at least 83 1/3 percent clear cuttings. The next lower grade is selects, which permits pieces 4 inches wide by 6 feet long. A still lower grade is No. 1 common. Lumber in this group is expected to yield 66 2/3 percent clear cuttings.

1.4.3 Lumber Sizes

Standard lumber sizes have been established in the United States for uniformity in planning structures and in ordering materials. Lumber is identified by nominal sizes. The nominal size of a piece of lumber is larger than the actual dressed dimensions.

Referring to *Table 6*, you can determine the common widths and thicknesses of lumber in their nominal and dressed dimensions.

Table 6 – Nominal and Dressed Sizes of Lumber

Nominal Size (Inches)	Dressed Size (Inches)
1 x 3	3/4 x 2 1/2
1 x 4	3/4 x 3 1/2
1 x 6	3/4 x 5 1/2
1 x 8	3/4 x 7 1/4
1 x 10	3/4 x 9 1/4
1 x 12	3/4 x 11 1/4
2 x 4	1 1/2 x 3 1/2
2 x 6	1 1/2 x 5 1/2
2 x 8	1 1/2 x 7 1/4
2 x 10	1 1/2 x 9 1/4
2 x 12	1 1/2 x 11 1/4
3 x 8	2 1/2 x 7 1/4
3 x 12	2 1/2 x 11 1/4
4 x 12	3 1/2 x 11 1/4
4 x 16	3 1/2 x 15 1/4
6 x 12	5 1/2 x 11 1/2
6 x 16	5 1/2 x 15 1/2
6 x 18	5 1/2 x 17 1/2
8 x 16	7 1/2 x 15 1/2
8 x 20	7 1/2 x 19 1/2
8 x 24	7 1/2 x 23 1/2

You can see in *Table 6* that nominal lumber sizes are a little larger than dressed lumber sizes. For softwood boards, there is a general rule to figure the dressed size of a piece of lumber, based on the nominal size. For boards with a nominal width up to and including one inch, the dressed size will be 1/4 inch smaller. For boards with a nominal width of two to six inches, the dressed size will be 1/2 inch smaller. For boards with a width larger than six inches, the dressed size will be 3/4 inch smaller. This rule may not be accurate in every case, so if there is any doubt about the size of a dressed piece of lumber, measure the piece.

1.4.4 Locally Procured Materials (Foreign Lumber)

You will have the opportunity to work on construction projects overseas. Be aware that the quantity and sizes of material, including lumber, will be different than what you work with in the United States. The Naval Facilities Engineering Command (NAVFAC offices take this into account when they solicit project plans from the local engineering firms. The local Resident Officer in Charge of Construction (RIOCC is well aware of the various products available in the project area and their intended use. The local Public Works Department or Supply Department is available for ensuring locally purchased material meets the specifications outlined for the project.

1.5.0 Engineered Wood Products

In the early part of the twentieth century there were more abundant old-growth forests, which provided structural beams, timbers, joists, and other weight-bearing lumber. These old-growth forests have been reduced, driving up the cost of construction material and increasing conflict with forest conservation groups.

Lumber producers have developed laminating techniques that allow the use of younger trees to create a variety of building products. These products, called Engineered Wood Products, have a number of benefits over products fomr old-growth forests.

- They are made from more abundant young trees.
- The yield from a tree increases 30 to 50 percent.
- The engineered products are stronger than the natural products. A piece of engineered lumber the same size can bear more weight than its natural counterpart. Better yet, a smaller piece of engineered lumber can bear the same weight as a larger natural piece of lumber.
- Engineered lumber, with its greater strength, can span a greater distance than natural lumber.
- A length of engineered lumber is lighter than than the same length of natural lumber, which makes it easier to handle.
- Engineered lumber does not warp, crown, or twist, which helps it retain accurate dimensions.

There are five main categories of engineered wood products. These include ***laminated*** veneer lumber, parallel strand lumber, laminated strand lumber, wood I-beams, and glue-***laminated lumber,*** also known as glue-lam.

1.5.1 Laminated Veneer Lumber (LVL)

LVL is similar to plywood because it is made from multiple layers of laminated thin wood veneer. Unlike plywood, the layers in LVL run in the same direction, parallel to the long direction, and do not have crossbands. The layers are glued with exterior grade adhesive, then pressed together and heated under pressure.

You can use LVL for permanent application in floor and roof beams, as well as door and window headers, or for temporary applications like scaffolding and concrete forms.

1.5.2 Parallel Strand Lumber (PSL

PSL is made from long veneer strands. These strands are laid parallel to each other and bonded together with an adhesive in a specialized heating process.

You can use PSL as beams, posts, and columns. It is good for use in load-bearing applications.

1.5.3 Laminated Strand Lumber (LSL

LSL is made from small logs that can’t be used for standard lumber. The bark is removed from the logs, and then the logs are cut into short strands. The strands are dried, coated with resin, and pressed into long blocks called billets by a process that includes steam injection.

You can use LSL for millwork such as doors and windows, or other applications that require high-grade lumber. LSL does not have the load bearing capacity of PSL.

1.5.4 Wood I-Beams

The wood I-beam shown in *Figure 1* is a composite structural member made up of a web with flanges bonded to it with exterior type adhesives. The web is made of oriented strand board or plywood; the flanges are made of dimension lumber or laminated veneer lumber with grooves that fit over the web.

Like the steel I-beam that it resembles, the wood I-beam is exceptionally strong. You can use it for floor joists, rafters, and headers.

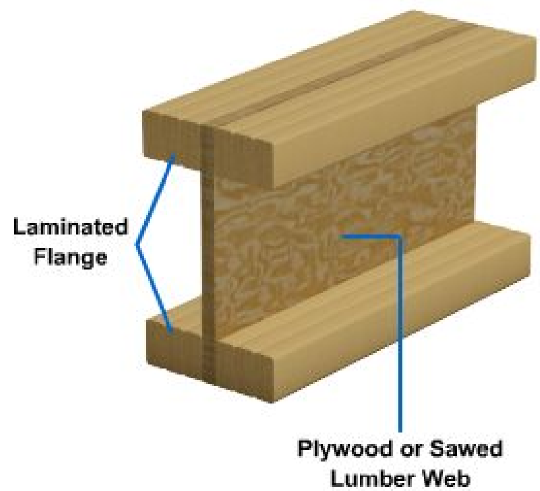


Figure 1 –Wood I-beam.

1.5.5 Glue-Laminated Lumber (Glulam)

The laminated lumber shown in *Figure 2* is made of several pieces of kiln-dried lumber held together as a single unit, a process called lamination. The pieces are nailed, bolted, or glued together with the grain of all pieces running parallel.

Figure 2 – Laminated lumber.

Glulam is very versatile; it can be shaped into forms from straight beams to complex curved members. You can use it for headers, floor girders, ridge beams, stair treads and stringers, purlins, cantilever beam systems, and arches.

Laminating greatly increases the load carrying capacity and rigidity of the wood. When extra length is needed, the pieces are spliced with the splices staggered so that no two adjacent laminations are spliced at the same point. Built up beams and girders are examples. They are built as shown in *Figure 3*, usually nailed or bolted together and spliced.

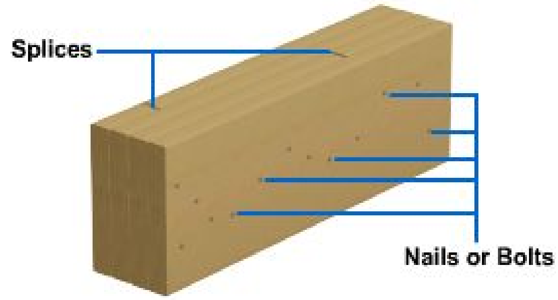


Figure 3 – Built up beam.

Lamination can be used independently or with other materials in the construction of a structural unit. Trusses can be made with lamination for the chords and sawed lumber for the web members as shown in *Figure 4*.

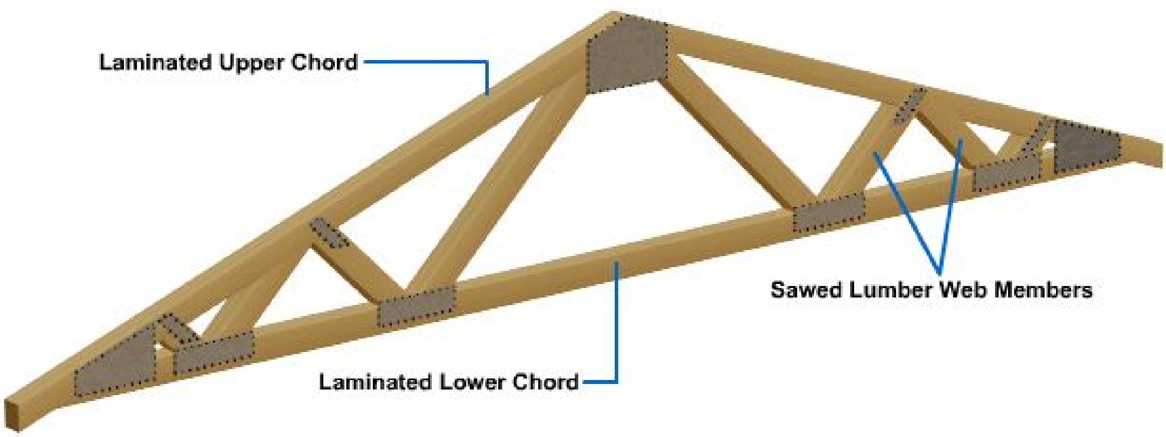


Figure 4 – Truss using laminated and sawed lumber.

Units such as plywood box beams and stressed skin panels can contain both plywood and lamination, as shown in Figure 5.

Probably the most common use of lamination is in the fabrication of large beams and arches. Beams with spans in excess of 100 feet and depths of 8 1/2 feet have been constructed using 2-inch boards. Laminations this large are factory produced. They are glued together under pressure. Most laminations are spliced using scarf joints as shown in Figure 6, and the entire piece is dressed to ensure uniform thickness and width.

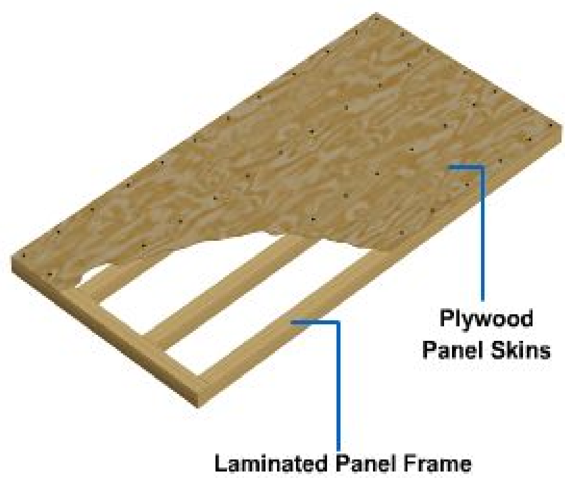


Figure 5 – Stressed skin panel.

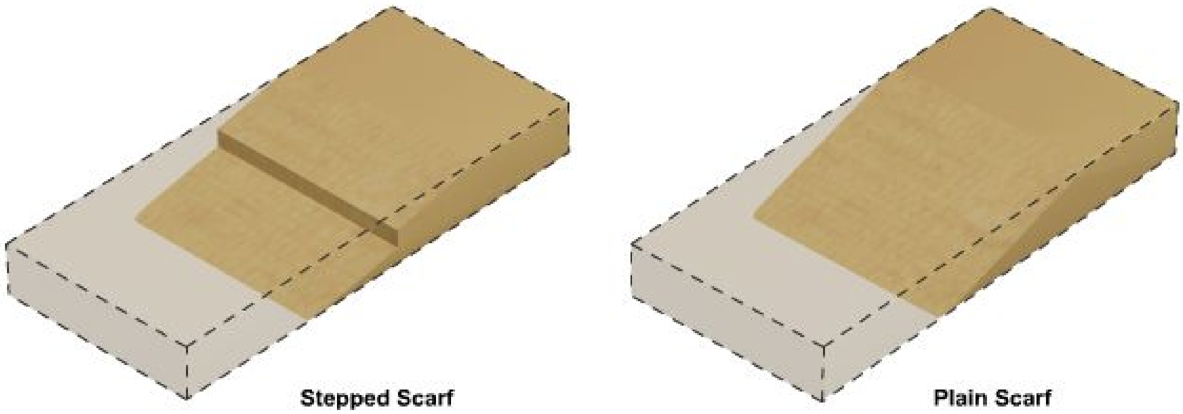


Figure 6 – Scarf joints.

The depth of the lamination is placed in a horizontal position and is usually the full width of the beam, as shown in *Figure 7*.

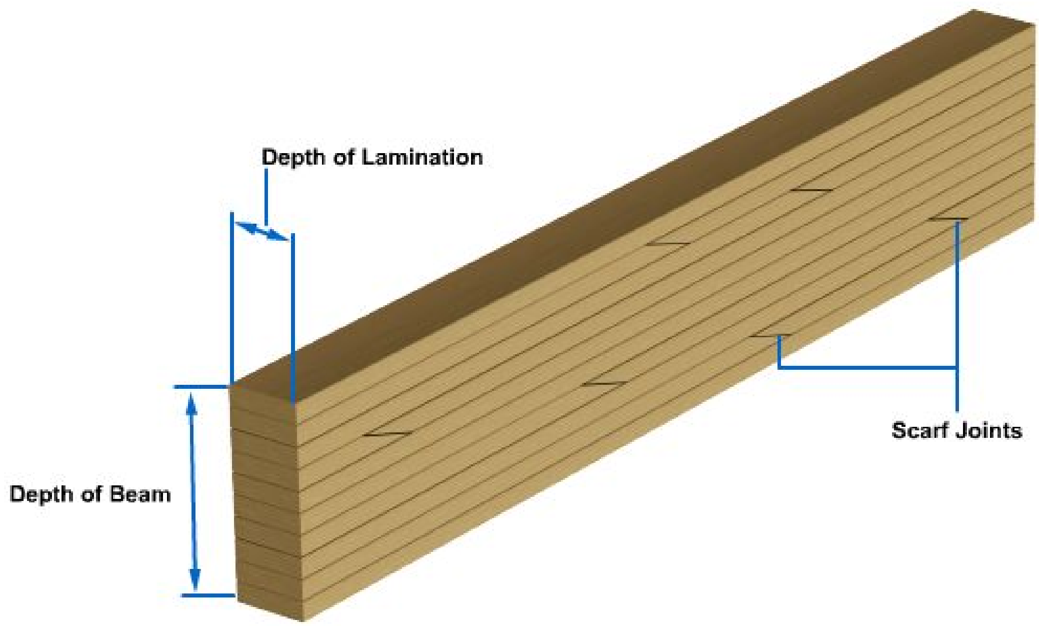


Figure 7 – Laminated beam.

1.6.0 Plywood

Plywood is constructed by gluing together a number of layers (plies of wood with the grain direction turned at right angles in each successive layer. This design feature makes plywood highly resistant to splitting. It is one of the strongest building materials available to Seabees. An odd number (3, 5, or 7 of plies is used so that they will be balanced on either side of a center core and so that the grain of the outside layers runs in the same direction.

The outer plies are called faces or face and back. The next layers under these are called crossbands, and the other inside layer or layers are called the core, as shown in *Figure 8*. A plywood panel made of three layers would consist of two faces and a core.

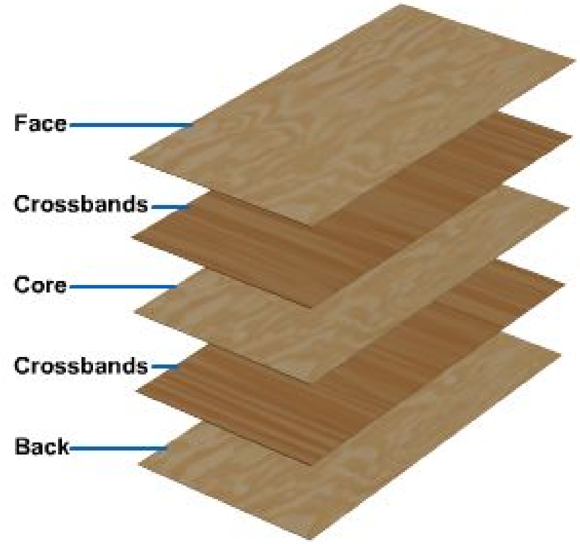


Figure 8 – Grain directions in a sheet of plywood.

There are two basic types of plywood, exterior and interior. Exterior plywood is bonded with waterproof glues. It can be used for siding, concrete forms, and other constructions where it will be exposed to the weather or excessive moisture. Interior plywood is bonded with glues that are not waterproof. It is used for cabinets and other inside construction where the moisture content of the panels will not exceed 20 percent.

Plywood is made in thicknesses of 1/8 inch to more than 1 inch, with the common sizes being 1/4, 3/8, 1/2, 5/8, and 3/4 inch. A standard panel size is 4 feet wide by 8 feet long. Smaller size panels are available in the hardwoods.

Plywood can be worked quickly and easily with common carpentry tools. It holds nails well and normally does not split when nails are driven close to the edges. Finishing plywood presents no unusual problems; it can be sanded, texture coated with a permanent finish, or left to weather naturally.

There is probably no other building material as versatile as plywood. It is used for concrete forms, wall and roof sheathing, flooring, box beams, soffits, stressed skin panels, paneling, shelving, doors, furniture, cabinets, crates, signs, and many other items.

1.6.1 Softwood Plywood Grades

All plywood panels are quality graded based on products standards (currently PS 1/74. The grade of each type of plywood is determined by the kind of veneer (N, A, B, C, or D) used for the face and back of the panel and by the type of glue used in construction. The plywood veneer grades are shown in *Table 7*.

Table 7 – Plywood Veneer Grades

DESCRIPTION	
N	Special order "natural-finish" veneer. Select all heartwood or all sapwood. Free of open defects. Allows some repairs.
A	Smooth and paintable. Neatly made repairs permissible. Also used for natural finish in less demanding applications.
B	Solid surface veneer. Circular repair plugs and tight knots permitted.
C	Knotholes to 1 inch. Occasional knotholes 1/2 inch larger permitted providing

	total width of all knots and knotholes within a specified section does not exceed certain limits. Limited splits permitted. Minimum veneer permitted in exterior-type plywood.
C Plgd	Improved C veneer with splits limited to 1/8 inch in width and knotholes and borer holes limited to 1/4 inch by 1/2 inch.
D	Permits knots and knotholes to 2 1/2 inches in width and 1/2 inch larger under certain specified limits. Limited splits permitted.

Many species of softwood are used in making plywood. There are five separate plywood groups based on stiffness and strength. Group 1 includes the stiffest and strongest and group 5 the weakest woods. A list of groupings and associated woods is shown in *Table 8*.

Table 8 – Classification of Softwood Plywood Rates Species for Strength and Stiffness

GROUP 1	GROUP 2		GROUP 3	GROUP 4	GROUP 5
Apitong	Cedar,	Maple,	Alder,	Aspen,	Basswood
Beech,	Port	Black	Port	Bigtooth	Fir,
American	Orford	Mengkulang	Birch,	Quaking	Balsam
Birch,	Cypress	Meranti,	Paper	Cativo	Poplar,
Sweet	Douglas fir	Red	Cedar,	Cedar,	Balsam
Yellow	Fir,	Mersawa	Alaska	Incense	
Douglas fir	California	Pine,	Fir,	Western	
Kapur	Red	Pond	Subalpine	Red	
Keruing	Grand	Red	Hemlock,	Cottonwood,	
Larch,	Noble	Virginia	Eastern	Eastern	
Western	Pacific	Western	Maple,	Black	
Maple,	Silver	White	Bigleaf	Western poplar	
Sugar	Hemlock,	Spruce,	Pine,	Pine,	
Pine,	White	Red	Jack	Eastern	
Caribbean	Western	Sitka	Lodgepole	White	
Ocote	Lauan,	Sweetgum	Ponderosa	Sugar	
Pine,	Almon	Tamarack	Spruce		
South	Bagtikan	Yellow poplar	Redwood		
Loblolly	Mayapis		Spruce,		
Longleaf	Red Lauan		Black		
Shortleaf	Tangile		Engelmann		
Slash	White lauan		White		

1.6.2 Grade/Trademark Stamp

Construction and industrial plywood panels are marked with different stamps.

Construction Panels - Grading identification stamps, as shown in *Figure 9*, indicate the kind and type of plywood. The stamps are placed on the back and sometimes on the edges of each sheet of plywood.

For example, a sheet of plywood having the designation “A-C” would have A grade veneer on the face and C grade veneer on the back. Grading is also based on the number of defects, such as knotholes, pitch pockets, splits, discolorations, and patches in the face of each panel. Each panel or sheet of plywood has a stamp on the back that gives all the information you need. *Table 9* lists some uses for construction grade plywood.

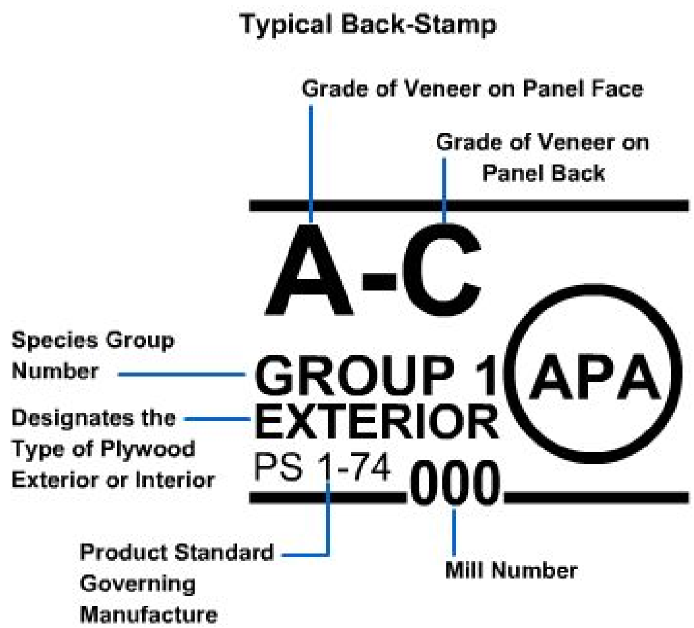


Figure 9 – Standard plywood identification symbols.

Table 9 – Plywood Uses

SOFTWOOD PLYWOOD GRADES FOR EXTERIOR USES				
Grade (Exterior)	**Face**	**Back**	**Inner Plies**	**Uses**
A-A	A	A	C	Outdoor where appearance of both sides is important.
A-B	A	B	C	Alternate for A-A where appearance of one side is less important.
A-C	A	C	C	Siding, soffits, fences. Face is finish grade.
B-C	B	C	C	For utility uses, such as farm buildings, some kinds of fences, etc.
C-C (Plugged)	C (Plugged)	C	C	Excellent base fir tile and linoleum, backing for wall coverings.
C-C	C	C	C	Unsanded, for backing and rough construction exposed to weather.
B-B Concrete Forms	B	B	C	Concrete forms. Reuse until wood literally wears out.
MDO	B	B or C	C or C-Plugged	Medium density overlay. Ideal base for paint; for siding, built-ins, signs, displays.
HDO	A or B	A or B	C- Plugged	High density overlay. Hard surface, no paint needed. For concrete forms, cabinets, counter tops, tanks.

SOFTWOOD PLYWOOD GRADES FOR INTERIOR USES				
Grade (Interior)	**Face**	**Back**	**Inner Plies**	**Uses**
A-A	A	A	D	Cabinet doors, built-ins, furniture where both sides will show.
A-B	A	B	D	Alternate of A-A. Face is finish grade, back is solid and smooth.
A-D	A	D	D	Finish grade face for paneling, built-ins, backing.
B-D	B	D	D	Utility grade. One paintable side. For backing, cabinet sides, etc.
Standard	C	D	D	Sheathing and structural uses such as temporary enclosures, subfloor. Unsanded.

Industrial Panels - Structural and sheeting panels have a stamp found on the back. A typical example for an industrial panel grade of plywood is shown in *Figure 10*.

The span rating shows a pair of numbers separated by a slash mark (/. The number on the left indicates the maximum recommended span in inches when the plywood is used as roof decking (sheeting. The right hand number applies to span when the plywood is used as subflooring. The rating applies only when the sheet is placed the long dimension across three or more supports. Generally, the larger the span rating, the greater the stiffness of the panel.

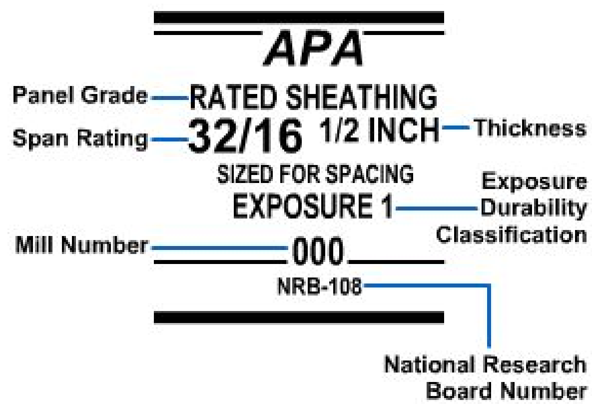
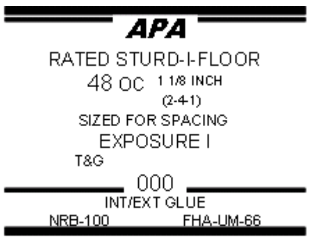


Figure 10 – Structural stamp.

Figure 11 lists some typical engineered grades of plywood. Included are descriptions and most common uses.

Typical Trademarks	Description and Common Uses	Grade Designations	
APA RATED SHEATHING 48/24 3/4 INCH SIZED FOR SPACING EXTERIOR 000 NRB-196	Exterior sheathing panel for subflooring and wall and roof sheathing, siding on service and farm buildings, crating, pallets, pallet bins, cable reels, etc. Manufactured as conventional veneered plywood. Common thicknesses: 5/16, 3/8, 1/2, 5/8, 3/4.	APA Rated Sheathing Ext	**EXTERIOR USE**
APA RATED SHEATHING STRUCTURAL I 42/20 5/8 INCH SIZED FOR SPACING EXTERIOR 000 PS1-74C-C NRB-168	For engineered applications in construction and industry where resistance to permanent exposure to weather or moisture is required. Manufactured only as conventional veneered PS 1 plywood. Unsanded. STRUCTURAL 1 more commonly available. Common thicknesses: 5/16, 3/8, 1/2, 5/8, 3/4. (3)	APA Structural I & II Rated Sheathing Ext	
APA RATED STURD-I-FLOOR 20 OC 19/32 INCH SIZED FOR SPACING EXTERIOR 000 NRB-100	For combination subfloor-underlayment under resilient floor coverings where severe moisture problems may be present , as in balcony decks. Possesses high concentrated and impact load resistance. Manufactured only as conventional veneered plywood. Available square edge or tongue and groove. Common thicknesses: 5/8 (19/32), 3/4 (23/32).	APA Rated Sturd-I-Floor Ext	
APA RATED SHEATHING 32/16 1/2 INCH SIZED FOR SPACING EXPOSURE I 000 NRB-106	Specially designed for subflooring and wall and roof sheathing, but can also be used for a broad range of other construction and industrial applications. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Special engineered applications, including high load requirements and certain industrial uses, may require veneered panels conforming to PS 1. Specify Exposure 1 when long construction delays are anticipated. Common thicknesses: 5/16, 3/8, 7/16, 1/2, 5/8, 3/4.	APA Rated Sheathing Exp 1 or 2	**PROTECTED OR INTERIOR USE**
APA RATED SHEATHING STRUCTURAL I 24/0 3/8 INCH SIZED FOR SPACING EXPOSURE I 000 PS1-74 C-D INT/EXT GLUE NRB-106	Unsanded all-veneer PS 1 plywood grades for use where strength properties are of maximum importance: structural diaphragms, box beams, gusset plates, stressed-skin panels, containers, pallet bins. Made only with exterior glue (Exposure 1). Structural 1 more commonly available. Common thicknesses: 5/16, 3/8, 1/2, 5/8,3/4. (3)	APA Structural I & II Rated Sheathing Exp 1	
APA RATED STURD-I-FLOOR STRUCTURAL I 24 OC 23/32 INCH SIZED FOR SPACING T&G NET WIDTH47 1/2 EXPOSURE I 000 NRB-106	For combination subfloor-underlayment. Provides smooth surface for application of resilient floor covering and possesses high concentrated and impact load resistance. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Available square edge or tongue and groove. Specify Exposure 1 when long construction delays are anticipated.	APA Rated Sturd-I-Floor Exp 1 or 2	

	Common thicknesses: 5/8 (19/32, 3/4 (23/32).		
	For combination subfloor-underlayment on 32- and 48-inch spans and for heavy timber roof construction. Provides smooth surface for application of resilient floor coverings and possesses high concentrated and impact load resistance. Manufactured only as conventional veneered plywood and only with exterior glue (Exposure 1). Available in square edge or tongue and groove. Thickness: 1 1/8.	APA Rated Sturd-I-Floor 48 oc (2-4-1) Exp 1	

(1) Specific grades, thicknesses, constructions, and exposure durability classifications may be limited in supply in some areas.
(2) Specify Performance-Rated Panels by thickness and Span Rating.
(3) All plies in Structural I panels are special improved grades and limited to Group 1 species. All plies in Structural II panels are special improved grades and limited to Group 1, 2, or 3 species.

Figure 11 – List of engineered grade of softwood plywood.

Exposure Ratings - The grade/trademark stamp lists the exposure durability classification for plywood. There are two basic types or ratings, exterior and interior. The exterior type has a 100 percent waterproof glue line, and the interior type has a highly moisture resistant glue line. Panels can be manufactured in three exposure durability classifications; Exterior, Exposure 1, and Exposure 2.

Panels marked Exterior can be used where there is continual exposure to weather and moisture. Panels marked Exposure 1 can withstand moisture during extended periods, but they should be used only indoors. Panels marked Exposure 2 can be used in protected locations. They may be subjected to some water leakage or high humidity but generally should be protected from weather.

Most plywood is made with waterproof exterior glue. Interior panels may be made with intermediate or interior glue.

1.6.3 Hardwood Plywood Grades

Hardwood plywood panels are primarily used for door skins, cabinets, and wall paneling. The Hardwood Plywood Manufacturers' Association has established a grading system with the following grades: premium (A, good grade (1, sound grade (2, utility grade (3, and backing grade (4. For example, A-3 grade hardwood plywood has a premium face and a utility back. 1-1 grade has a good face and a good back.

2.0.0 WOODWORKING METHODS

This section covers some of the methods Builders use to join wood.

2.1.0 Planing and Squaring to Dimensions

Planing and squaring a small piece of board to dimensions is what you might call the first lesson in woodworking. Like many other things you may have tried to do, it looks easy until you try it. The six major steps in this process are illustrated and described in *Figures 12* through *17*. You should practice these steps until you can get a smooth, square board with a minimum of planing.

1. Work the First Face - Plane one broad surface smooth and straight. Test it crosswise, lengthwise, and from corner to corner. Mark the work face x.

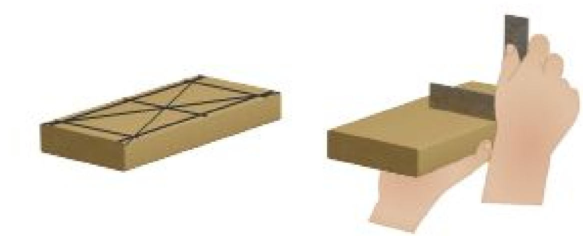


Figure 12 – Working the face.

2. Work the First Edge - Plane one edge smooth, straight and square to the work face. Test it from the work face. Mark the work edge x.

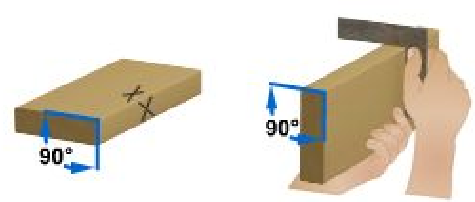


Figure 13 – Working the edge.

3. Work the First End - Plane one end smooth and square. Test it from the work face and work edge. Mark the work face x.

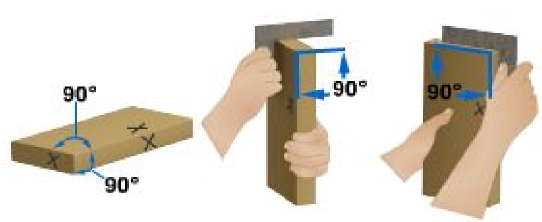


Figure 14 – Working the first end.

4. Work the Second End - Measure length and scribe around the stock. Align square to the work edge and work face. Saw off excess stock near the line and plane smooth to the scribed line. Test the second edge from both the work face and the work edge.

Figure 15 – Working the second end.

5. Work the Second Edge - From the work edge, gauge a line for width on both faces. Plane smooth, straight, square, and to the gauge line. Test the second edge from the work face.

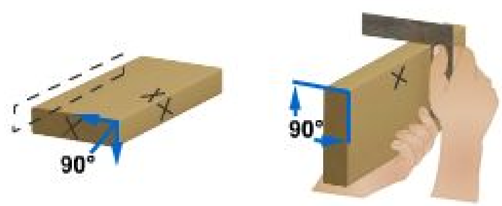


Figure 16 – Working the second edge.

6. Work the Second Face - From the work face, gauge a line for thickness around the stock. Plane the stock to the gauge line. Test the second face as the work face is tested.

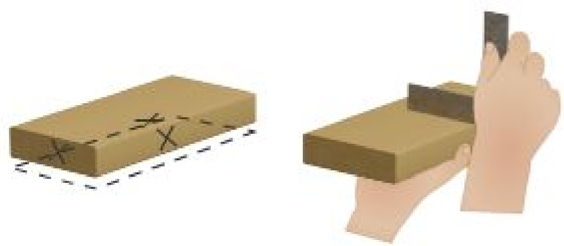


Figure 17 – Working the second face.

2.2.0 Joints and Joining

One basic skill of woodworking is the art of joining pieces of wood to form tight, strong, well made joints. The two pieces that are to be joined together are called members. The two major steps in making joints are (1) laying out the joint on the ends, edges, or faces and (2) cutting the members to the required shapes for joining.

The instruments normally used for laying out joints are as follows:

- Try square
- Miter square
- Combination square
- Sliding T bevel
- Marking or mortising gauge
- Scratch awl
- Sharp pencil or knife for scoring lines

For cutting the more complex joints by hand, the hacksaw, dovetail saw, and various chisels are essential. The rabbet and fillister plane for ***rabbet joints*** and the router plane for smoothing the bottoms of dadoes and ***gains*** are also helpful.

Simple joints are used mostly in rough or finish carpentry. They may be used occasionally in millwork and furniture making. They include:

- Butt joints
- ***Lap joints***
- ***Miter joints***

More complex joints are used mostly in making furniture and cabinets and in millwork. They include:

- Rabbet joints
- Dado and gain joints
- Blind ***mortise and tenon joints***
- Slip tenon joints
- Box corner joints
- ***Dovetail joints***

Edge joints are used mainly in furniture and cabinet work. They include:

- Dowel joints
- Spline joints

Plain butt joints and tongue and groove joints are used in practically all types of woodworking.

The joints used in rough and finished carpentry are, for the most part, simply nailed together. Nails in a 90° plain butt joint can be driven through the member abutted against and into the end of the abutting member. The joints can also be ***toenailed*** at an angle through the faces of the abutting member into the face of the member abutted against, as shown in *Figure 18*. Studs and joists are usually toenailed to soleplates and sills.

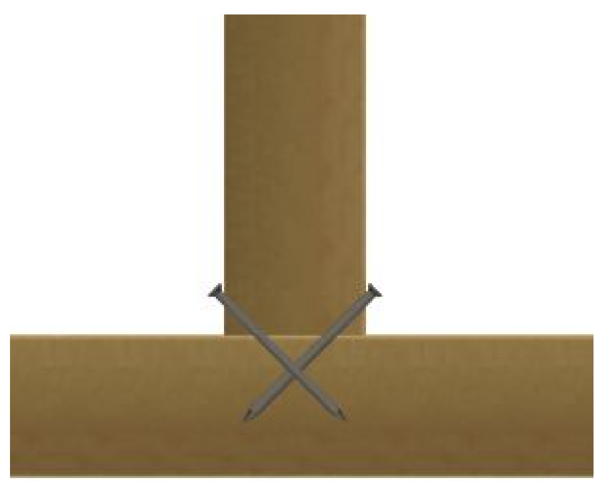
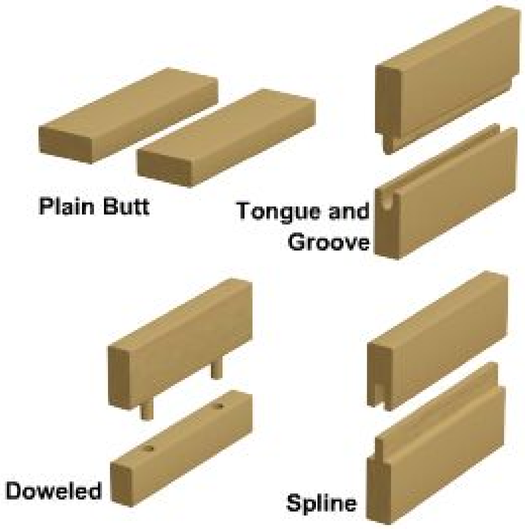


Figure 18 – Toenailing.



The more complex furniture and cabinet making joints are usually fastened with glue. Dowels, splines, ***corrugated fasteners***, keys, and other types of joint fasteners can provide additional strength. In the ***dado joint***, the gain joint, the mortise and tenon joint, the box corner joint, and the dovetail joint, the interlocking character of the joint is an additional factor in fastening.

All the joints we have mentioned can be cut either by hand or by machine, and are shown in *Figure 19*.

Figure 19 – Edge joints.

Whatever the method used and whatever the type of joint, remember, to ensure a tight joint, always cut on the waste side of the line, never on the line itself. Preliminary grooving on the waste side of the line with a knife or chisel will help a backsaw start smoothly.

2.2.1 Butt Joints

A 90° plain butt joint is two boards glued edge to edge or face to edge without overlapping as shown in *Figure 20*. It is mostly used for thin wood, under 1 inch thick.

A butt joint can have a wood or plywood piece called a fishplate used to fasten the ends of two members together with nails or bolts, shown in *Figure 21*. These are sometimes used at the junction of opposite rafters near the ridge line.

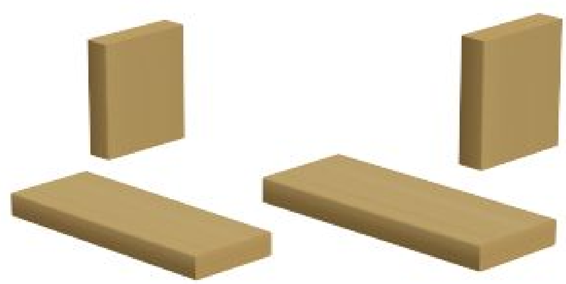


Figure 20 - 90° plain butt joints.

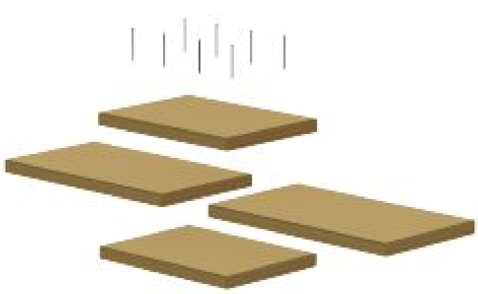


Figure 21 – End butt joints with fishplates.

2.2.2 Half Lap Joints

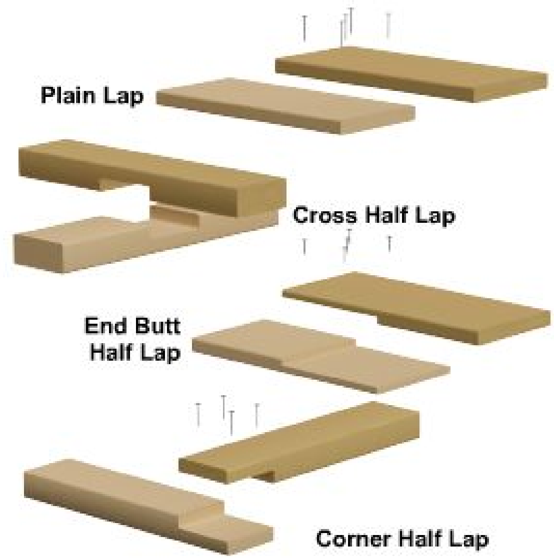


Figure 22 – Lap joints.

For half lap joints, the members to be jointed are usually of the same thickness, as shown in *Figure 22*.

The method of laying out and cutting an end butt half lap as shown in *Figure 22* is as follows:

1. Measure off the desired amount of lap from each end of each member and square a line all the way around at this point. For a corner half lap, as in *Figure 22*, measure off the width of the member from the end of each member and square a line all the way around. These are called shoulder lines.
2. Select the best surface for the face and set a marking gauge to one-half the thickness. Score a line, called the cheek line, on the edges and end of each member from the shoulder line on one edge to the shoulder line on the other edge. Gauge the cheek line from the face of each member to ensure the faces of each member will be flush after the joints are cut.
3. Make the shoulder cuts by cutting along the waste side of the shoulder lines down to the waste side of the cheek line.
4. Make the cheek cuts along the waste side of the cheek lines. When all cuts have been made, the members should fit together with faces, ends, and edges flush or near enough to be made flush with the slight paring of a wood chisel.

Other half lap joints are laid out in a similar manner; the main difference is in the cutting method. A cross half lap joint is best cut with a dado head or wood chisel rather than a handsaw. Others may easily be cut on a bandsaw. When you cut a half lap joint this way, be certain to cut on the waste side of the lines and make all lines from the face of the material.

2.2.3 Miter Joints

A miter joint is made by ***mitering*** the ends or edges of the members to be joined together as shown in *Figure 23*. The angle of the miter cut is one half of the angle formed by the joined members. In rectangular mirror frames, windows, and door casing boxes, adjacent members form a 90° angle, so the correct angle for mitering is one half of 90°, or 45°. For members forming an equal sided figure with other than four sides, such as an octagon or a pentagon, find the correct mitering angle by dividing the number of sides the figure will have into 180° and subtracting the result from 90°.

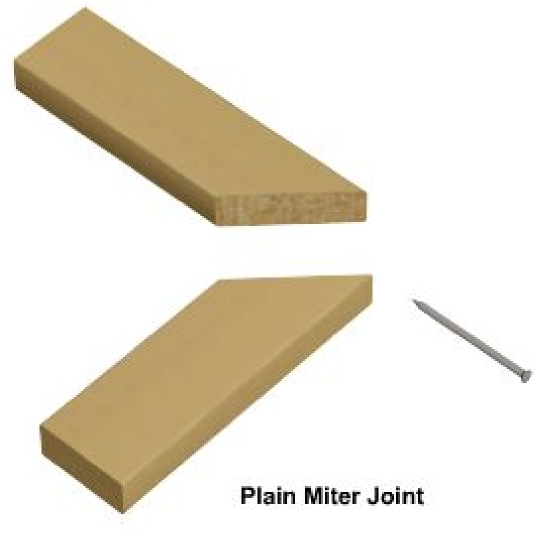


Figure 23 – Miter joint.

For an octagon, a figure with eight sides, determine the mitering angle by subtracting 180° divided by 8 from 90°. This is shown by the following formula:

90° - (180° ÷8)
or
90° - 22.5° = 67.5°

For a pentagon, a figure with five sides, the angle is:

90° - (180° ÷ 5)
or
90° - 36° = 54°

End miter members to 45° in the wooden miter box and to any angle in the steel miter box by setting the saw to the desired angle, or on the ***circular saw*** by setting the miter gauge to the desired angle. Edge miter members to any angle on the circular saw by tilting the saw to the required angle.

Sawed edges are sometimes unsuitable for gluing. If the joint is to be glued, the edges can be mitered on a ***jointer,*** as shown in *Figure 24*. Please note that the saw guard does not appear in this figure to better show the relationship of the blade to the stock.

Figure 24 – Beveling on a jointer for a mitered edge joint.

CAUTION

This is a dangerous operation and caution should be taken.

Since abutting surfaces of end mitered members do not hold well when they are merely glued, they should be reinforced. One type of reinforcement is the corrugated fastener. This is a corrugated strip of metal with one edge sharpened for driving into the joint. Place the fastener at a right angle to the line between the members, half on one member and half on the other, and drive it down flush with the member. The corrugated fastener mars the appearance of the surface into which it is driven, so use it only on the backs of picture frames and the like.

A more satisfactory type of fastener for a joint between end mitered members is the biscuit. This is a thin piece of wood or veneer that is glued into a kerf cut in the thickest dimension of the joint. Use the biscuit in the following manner:

1. Saw about halfway through the wood from the outer to the inner corner.
2. Apply glue to both sides of the biscuit, pushing the biscuit into the kerf.
3. Clamp it tightly and allow the glue to dry.
4. After it has dried, remove the clamp and chisel off the protruding portion of the biscuit.

A joint between edge mitered members can also be reinforced with a spline. This is a thick piece of wood that extends across the joint into grooves cut in the abutting surfaces. A spline for a plain miter joint is shown in *Figure 25*. Cut the groove for a spline either by hand or with a circular saw.

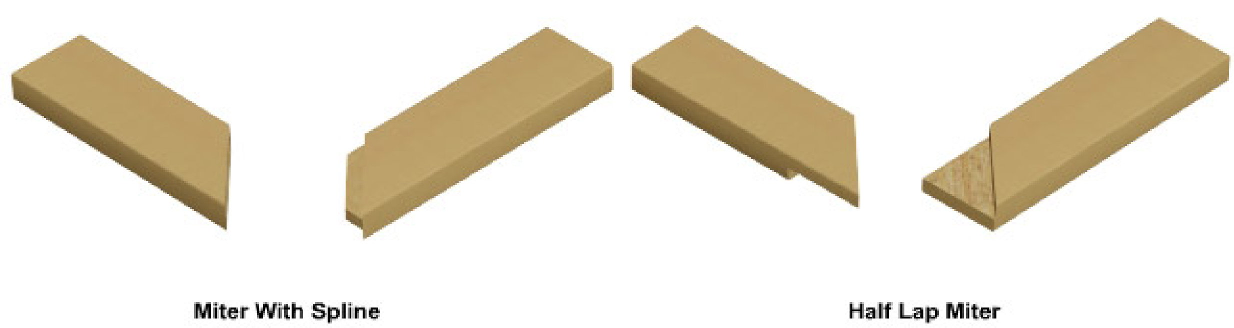


Figure 25 – Plain miter joint.

2.2.4 Grooved Joints

A three-sided recess running with the grain is called a groove, and a recess running across the grain is called a dado. A groove or dado that does not extend all the way across the wood is called a stopped groove or stopped dado. A stopped dado, also known as a gain, is shown in *Figure 26*.

A two-sided recess running along an edge, as shown in *Figure 27*, is called a rabbet T. Dadoes, gains, and rabbets are not, strictly speaking, grooves; but joints that include them are generally called grooved joints.

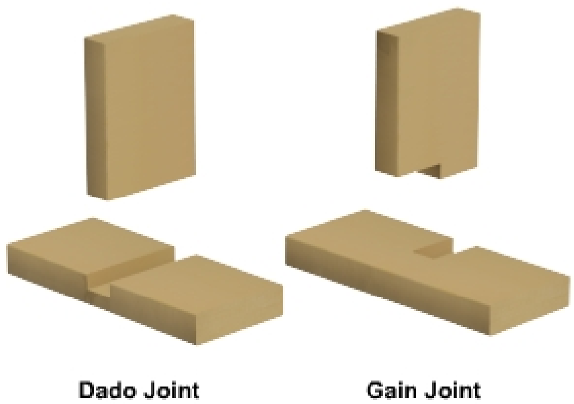


Figure 26 – Dado and gain joints.

Figure 27 – Rabbet joints.

Cut a groove or dado with a circular saw as follows:

1. Lay out the groove or dado on the end wood (for a groove) or edge wood (for a dado) that will first come in contact with the saw.
2. Set the saw to the desired depth of the groove above the table, and set the fence at a distance from the saw that will cause the first cut to run on the waste side of the line that indicates the left side of the groove.
3. Start the saw and bring the wood into light contact with it; then stop the saw and examine the layout to ensure the cut will be on the waste side of the line.
4. Readjust the fence, if necessary. When the position of the fence is right, make the cut.
5. Reverse the wood and proceed to set and test as before for the cut on the opposite side of the groove. Make as many recuts as necessary to remove the waste stock between the side kerfs.

The procedure for grooving or dadoing with the dado head is about the same, except that in many cases you can build up the dado head to take out all the waste in a single cut. The two outside cutters alone will cut a groove 1/4 inch wide. Inside cutters vary in thickness from 1/16 to 1/4 inch.

Cut a stopped groove or stopped dado on the circular saw, using either a saw blade or a dado head, as follows:

1. If the groove or dado is stopped at only one end, clamp a stop block to the rear of the table in a position to stop the wood from being fed any farther when the saw has reached the place where the groove or dado is supposed to stop.
2. If the groove or dado is stopped at both ends, clamp a stop block to the rear of the table and a starting block to the front. Place the starting block so the saw will

contact the place where the groove is supposed to start when the infeed end of the piece is against the block.

3. Start the cut by holding the wood above the saw with the infeed end against the starting block and the edge against the fence.

4. Lower the wood gradually onto the saw and feed it through to the stop block.

A rabbet joint requires two cuts; the cut into the face of the wood is called the shoulder cut, and the cut into the edge or end is called the cheek cut. A rabbet can be cut on the circular saw. Make the shoulder cut first, as follows:

1. Set the saw to extend above the table to the desired depth of the cheek.

2. Be sure to measure this distance from a sawtooth set to the left, or away from the ripping fence. If you measure it from a tooth set to the right or toward the fence, the cheek will be too deep by an amount equal to the width of the saw kerf.

By using the dado head, you can cut most ordinary rabbets in a single cut.

1. Build up a dado head equal in thickness to the desired width of the cheek.

2. Set the head to protrude above the table to the desired depth of the shoulder.

3. Clamp a 1-inch board to the fence to serve as a guide for the piece, and set the fence so the edge of the board barely contacts the right side of the dado head.

4. Set the miter gauge at 90°. Set the piece against the miter gauge, hold the edge or end to be rabbeted against the 1-inch board and make the cut.

On some jointers, a rabbeting ledge attached to the outer edge of the infeed table can be depressed for rabbeting, as shown in *Figure 28*. Please note that the saw guard does not appear in this figure to better show the relationship of the blade to the stock.

The ledge is located on the outer end of the cutterhead. To rabbet on a jointer of this type, depress the infeed table and the rabbeting ledge the depth of the rabbet below the outfeed table, and set the fence the width of the rabbet away from the outer end of the cutterhead. When the piece is fed through, the unrabbeted part feeds onto the rabbeting ledge. The rabbeted portion feeds onto the outfeed table.

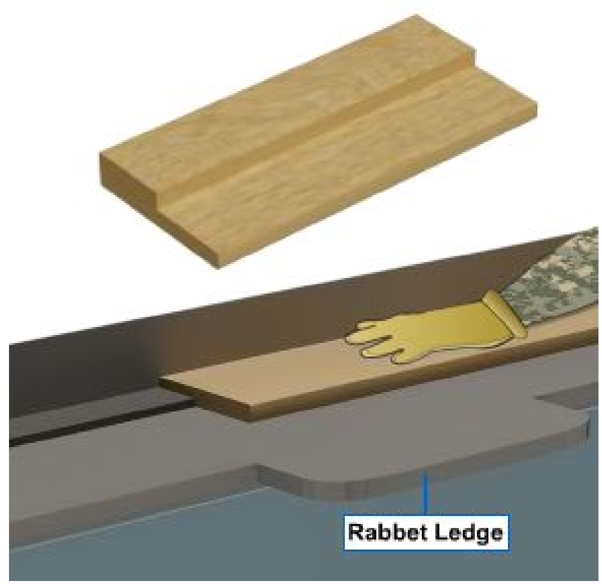


Figure 28 – Rabbeting on a jointer with a rabbeting ledge.

Various combinations of the grooved joints are used in woodworking. The tongue and groove joint is a combination of the groove and the rabbet, with the tongued member rabbeted on both faces. In some types of paneling, the tongue is made by rabbeting only one face. A tongue of this kind is called a barefaced tongue. A joint often used in making boxes, drawers, and cabinets is the dado and rabbet joint, shown in *Figure 29*. As you can see, one of the members is rabbeted on one face to form a barefaced tongue.

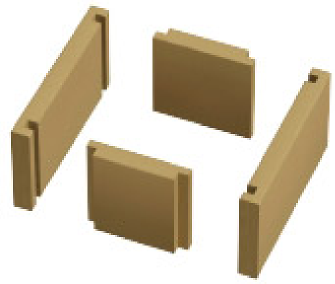


Figure 29 – Dado and rabbet joint.

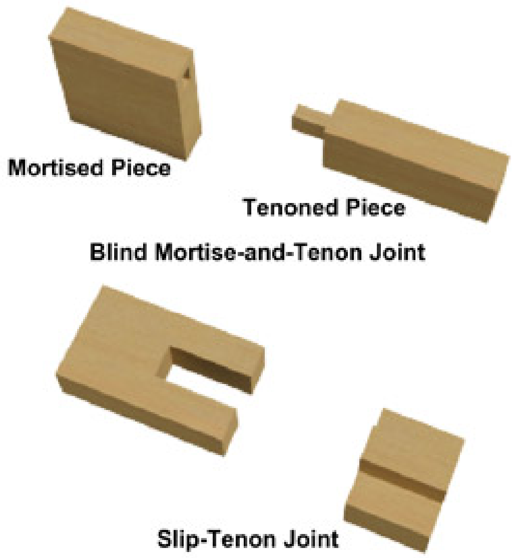


Figure 30 – Tenon joints.

2.2.5 Mortise and Tenon Joints

The mortise and tenon joint is most frequently used in furniture and cabinet work. In the blind mortise and tenon joint, the tenon does not penetrate all the way through the mortised member. This type of joint is shown in *Figure 30*.

A joint in which the tenon does penetrate all the way through is a through mortise and tenon joint, shown in *Figure 31*.

Besides the ordinary stub joint seen in *Figure 31 view A*, there are haunched joints, as seen in *view B*, and table haunched joints, as seen in *view C*. Haunching and table haunching increase the strength and rigidity of the joint.

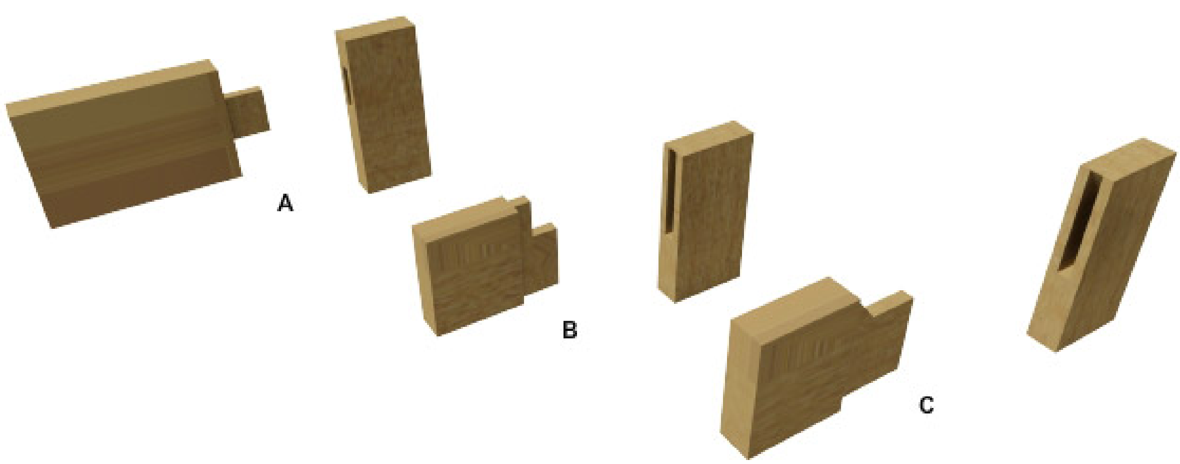


Figure 31 – Stub (view A), haunched (view B), and table haunched (view C) mortise and tenon joints.

The layout procedure for an ordinary stub mortise and tenon joint is shown in *Figure 32*.

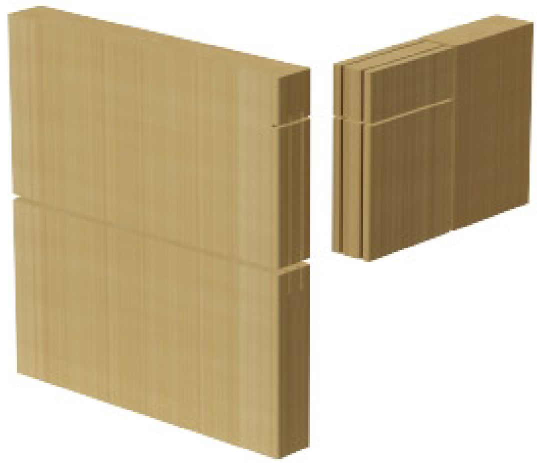


Figure 32 – Layout of stub mortise and tenon joint.

The shoulder and cheek cuts of the tenon are shown in *Figures 33* and *34*. Please note that the saw guard does not appear in these figures to better show the relationship of the blade to the stock.

To maintain the stock upright while making the cheek cuts, use a push board similar to the one shown in *Figure 34*. Tenons can also be cut with a dado head by the same method previously described for cutting end half lap joints.

Figure 33 – Making tenon shoulder cut on a table saw.

Figure 34 – Making tenon cheek cut on a table saw using a push board.

Mortises are cut mechanically on a hollow chisel mortising machine like the one shown in *Figure 35*. The cutting mechanism on this machine consists of a boring bit encased in a square, hollow, steel chisel. As the mechanism is pressed into the wood, the bit takes out most of the waste while the chisel pares the sides of the mortise square. Chisels come in various sizes, with corresponding sizes of bits to match.

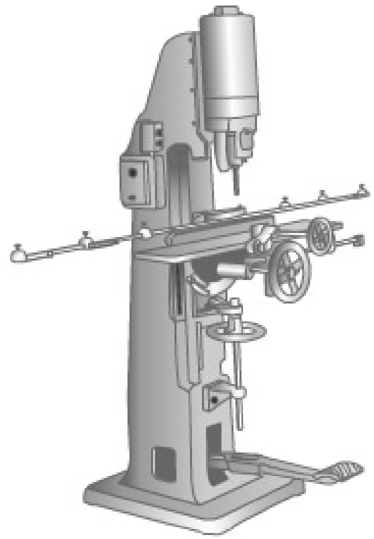


Figure 35 – Hollow chisel mortising machine.

If a mortising machine is not available, the same results can be attained by using a simple drill press to take out most of the waste and a hand chisel, for paring the sides square.

In some mortise and tenon joints, such as those between rails and legs in tables, the tenon member is much thinner than the mortise member. Sometimes a member of this kind is too thin to shape with shoulder cuts on both faces in the customary reamer. When this is the case, use a barefaced mortise and tenon joint. For a barefaced joint, cut the tenon member on one side only. The cheek on the opposite side is simply a continuation of the face of the member.

Mortise and tenon joints are fastened with glue and with additional fasteners, as required.

2.2.6 Dovetail Joints

The dovetail joint, shown in *Figure 36*, is the strongest of all the woodworking joints. It is used principally for joining the sides and ends of drawers in fine grades of furniture and cabinets. In a Seabee unit, you will seldom use dovetail joints since they are laborious and time consuming to make.

A through dovetail joint is a joint in which the pins pass all the way through the tail member. Where the pins pass only part way through, the member is known as a blind dovetail joint.

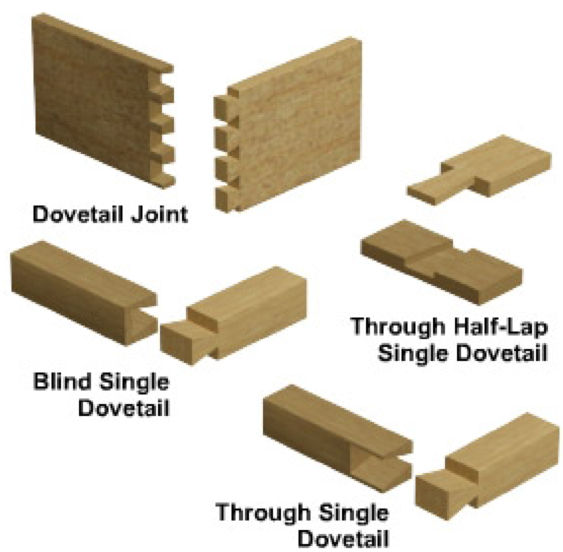


Figure 36 – Dovetail joints.

The simplest of the dovetail joints is the dovetail half lap joint, shown in *Figure 37.*

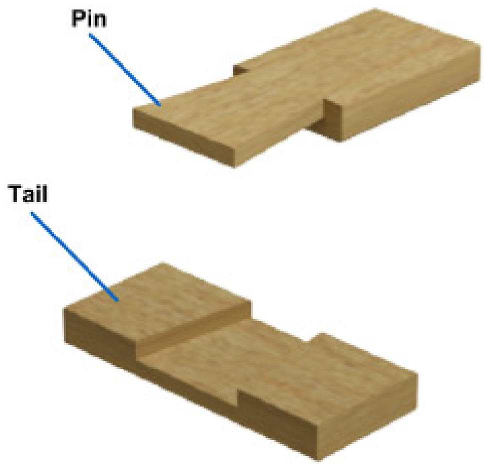


Figure 37 – Dovetail half lap joint.

Figure 38 shows how this type of joint is laid out, and *Figure 39* shows the completed joint.

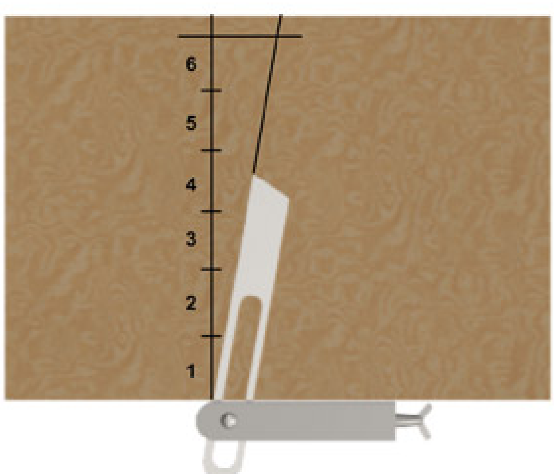


Figure 38 – Laying off 10° angle for dovetail joint.

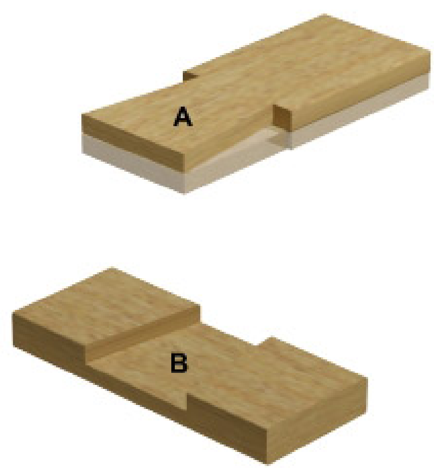


Figure 39 – Making a dovetail half lap joint.

A multiple dovetail joint is shown in *Figure 40*; *Figure 41* shows how the waste is chiseled from the multiple joint.

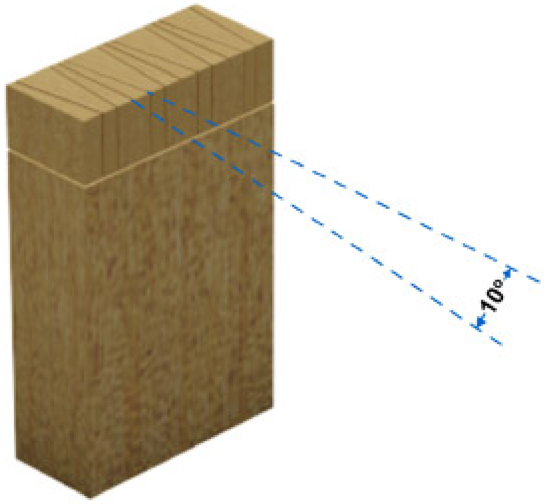


Figure 40 – Laying out a pin member for a through multiple dovetail joint.

Figure 41 – Chiseling out waste in a through multiple dovetail joint.

2.2.7 Box Corner Joint

With the exception of the obvious difference in the layout, the box corner joint shown in *Figure 42* is made in a manner similar to that of the through multiple dovetail joint.

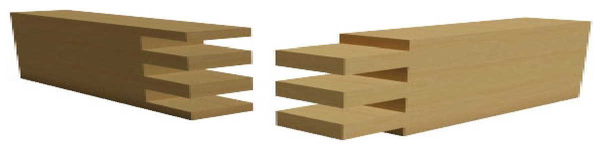


Figure 42 – Box corner joint.

2.2.8 Coping Joints

Inside corner joints between molding trim members are usually made by butting the end of one member against the face of the other. *Figure 43* shows the method of shaping the end of the abutting member to fit the face of the other member:

1. Saw off the end of the abutting member square, as you would for an ordinary butt joint between ordinary flat faced members.
2. Miter the end to 45°, as shown in the first and second views of *Figure 42*.
3. Set the coping saw at the top of the line of the miter cut, hold the saw at 90° to the lengthwise axis of the piece, and saw off the segment shown in the third view, following closely the face line left by the 45° miter cut. The end of the abutting member will then match the face of the other member, as shown in the third view. A joint made in this reamer is called a coping joint. You will have to cut coping joints on a large variety of moldings.

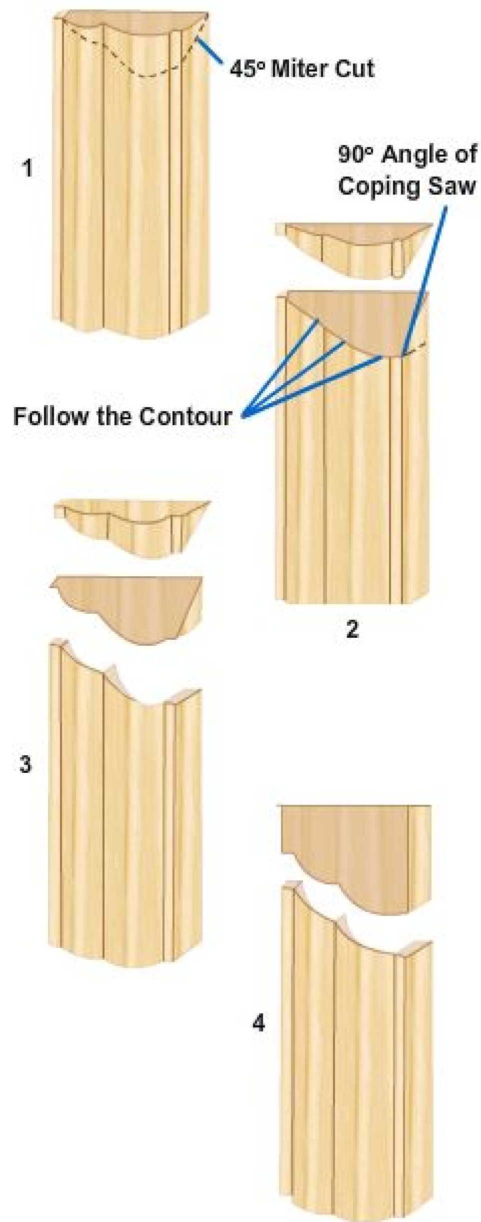


Figure 43 – Making a coping joint.

Figure 44 shows the simplest and most common moldings and trims used in woodworking.

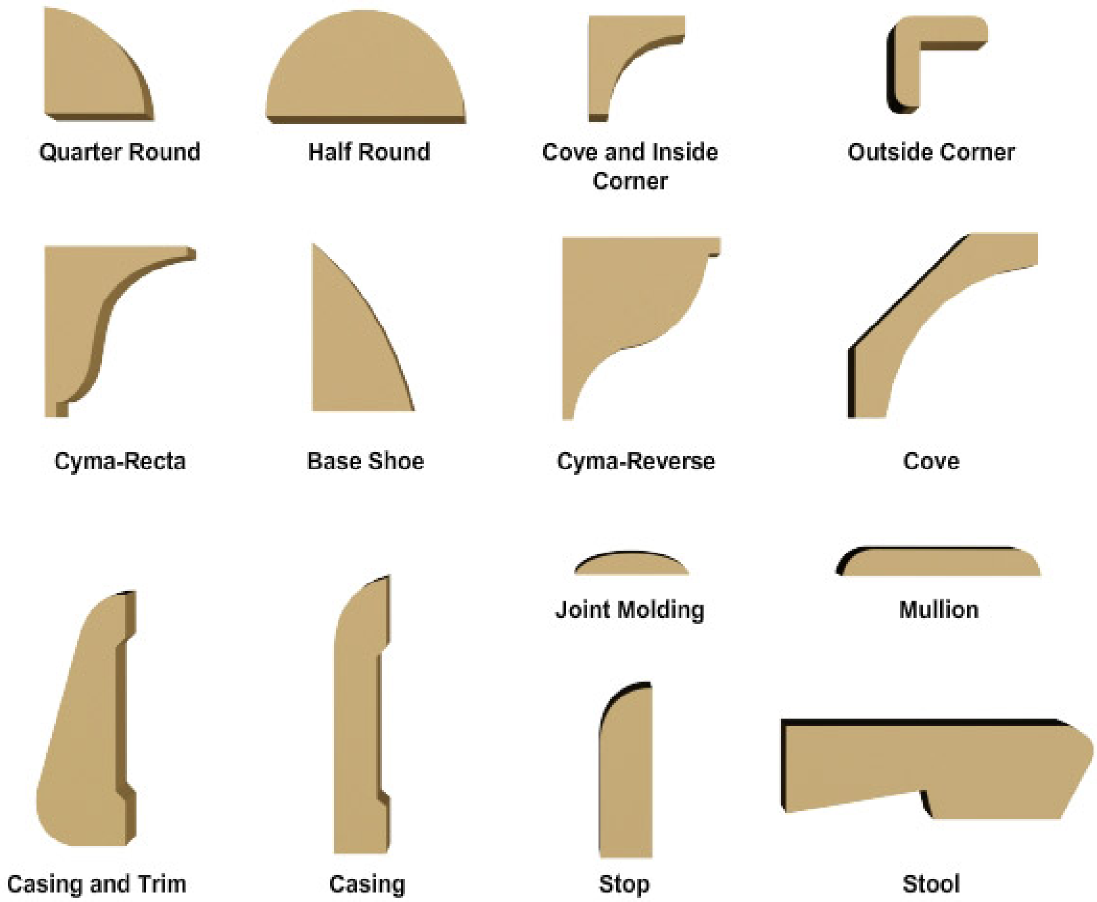


Figure 44 – Simple molding and trim shapes.

3.0.0 METHODS of FASTENING

A variety of metal fastening devices are used by Seabees in construction. Although nails are the most commonly used fastener, the use of staples to attach wood structural members is growing. For certain operations, screws and bolts are required. In addition, various metal devices exist for anchoring materials into concrete, masonry, and steel.

The increasing use of adhesives such as glues and **mastics** is an important development in the building industry. Adhesives are used in combination with, or in place of, nails and screws.

3.1.0 Nails

Nails, the most common type of metal fasteners, are available in a wide range of types and sizes.

3.1.1 Basic Nail Types

Some basic nail types are shown in *Figure 45*. The ***common nail*** is designed for rough framing. The *box* ***nail*** is used for toenailing and light work in frame construction. The ***casing nail*** is used in finished carpentry work to fasten doors and window casings and other wood trim. The ***finishing nail*** and ***brad*** are used for light wood trim material and are easy to drive below the surface of lumber with a nail set.

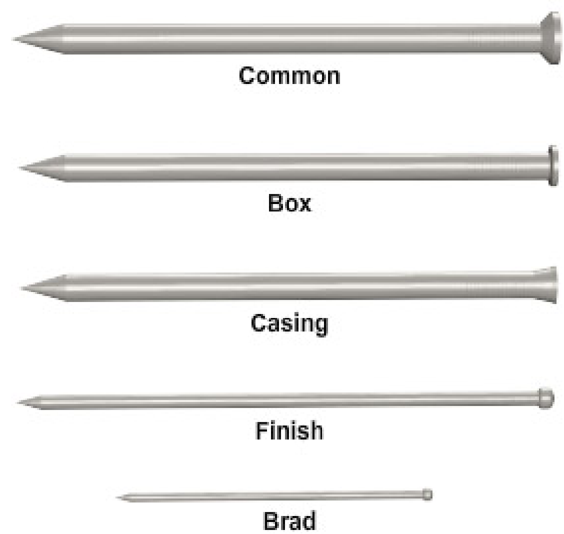
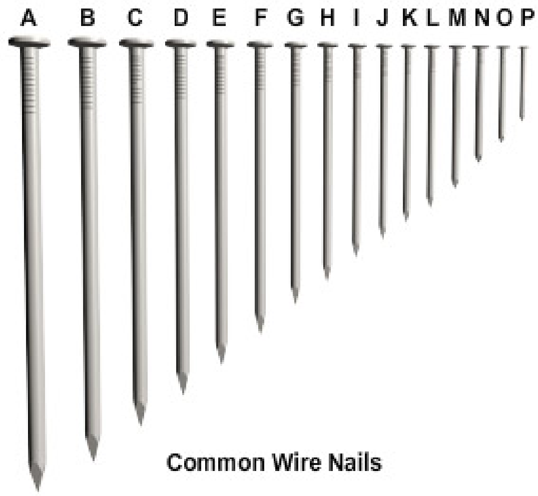


Figure 45 – Basic types of nails.

The size of a nail is measured in a unit known as a penny. Penny is abbreviated with the lowercase letter d. It indicates the length of the nail. A 6d (6 penny nail is 2 inches long. A 10d (10 penny nail is 3 inches long as shown in *Figure 46*. These measurements apply to common, box, casing, and finish nails only. Brads and small box nails are identified by their actual length and gauge number.



Length and Gauge

	Size		Inches	Number	Approximate Number to Pound
A	60	d	6	2	11
B	50	d	5 ½	3	14
C	40	d	5	4	18
D	30	d	4 ½	5	24
E	20	d	4	6	31
F	16	d	3 ½	7	49
G	12	d	3 ¼	8	63
H	10	d	3	9	69
I	9	d	2 ¾	10 ¼	96
J	8	d	2 ½	10 ¼	106
K	7	d	2 ¼	11 ½	161
L	6	d	2	11 ½	181
M	5	d	1 ¾	12 ½	271
N	4	d	1 ½	12 ½	316
O	3	d	1 ¼	14	568
P	2	d	1	15	876

Figure 46 – Nail sizes given in "penny" (d) units.

A nail, whatever the type, should be at least three times as long as the thickness of the wood it is intended to hold. Two thirds of the length of the nail is driven into the other piece of wood for proper anchorage. The other one third of the length provides the necessary anchorage of the piece being fastened. Bend over protruding nails to prevent damage to materials and injury to personnel.

There are a few general rules to follow using nails in building. Drive nails at an angle slightly toward each other to improve their holding power. Be careful in placing nails to provide the greatest holding power. Nails driven with the grain do not hold as well as nails driven across the grain. A few nails of proper type and size, properly placed and properly driven, will hold better than a great many driven close together. Nails are generally the cheapest and easiest fasteners.

3.1.2 Specialty Nails

Figure 47 shows a few of the many specialized nails. Some nails are specially coated with zinc, cement, or resin materials. Some have threading for increased holding power. Nails are made from many materials, including iron, steel, copper, bronze, aluminum, and stainless steel.

Figure 47 – Specialized nails.

Annular and spiral nails are threaded for greater holding power. They are good for fastening paneling or plywood flooring. The drywall nail is used for hanging drywall and has a special coating to prevent rust. Roofing nails are not specified by the penny system; they are referred to by length. They are available in lengths from 3/4 inch to 2 inches and have large heads. The double headed nail, or duplex head nail, is used for temporary construction, such as form work or scaffolding. The double head on this nail makes it easy to pull out when forms or scaffolding are torn down.

Nails for power nailing come in rolls or clips for easy loading into a nailer. They are coated for easier driving and greater holding power. *Table 10* gives the general size and type of nails prefered for specific applications.

Table 10 – Size, Type, and Use of Nails

Size	Length (inch)[1]	Diameter (inch)	Remarks	Where Used
2d	1	.072	Small head	Finish work, shop work
2d	1	.072	Large flat head	Small timber, wood shingles, lathes
3d	1 1/4	.08	Small head	Finish work, shop work
3d	1 1/4	.08	Large flat head	Small timber, wood shingles, lathes
4d	1 1/2	.098	Small head	Finish work, shop work
4d	1 1/2	.098	Large flat head	Small timber, lathes, shop work
5d	1 3/4	.098	Small head	Finish work, shop work
5d	1 3/4	.098	Large flat head	Small timber, lathes, shop work
6d	2	.113	Small head	Finish work, casing, stops, etc., shop work
6d	2	.113	Large flat head	Small timber, siding, sheathing, etc., shop work
7d	2 1/4	.113	Small head	Casing, base, ceiling, stops, etc.
7d	2 1/4	.113	Large flat head	Sheathing, siding, subflooring, light framing
8d	2 1/2	.131	Small head	Casing, base, ceiling, wainscot, etc. shop work
8d	2 1/2	.131	Large flat head	Sheathing, siding, subflooring, light framing, shop work
8d	1 1/4	.131	Extra-large flat head	Roll roofing, composition shingles
9d	2 3/4	.131	Small head	Casing, base, ceiling, etc.
9d	2 3/4	.131	Large flat head	Sheathing, siding, subflooring, framing, shop work
10d	3	.148	Small head	Casing, base, ceiling, etc., shop work
10d	3	.148	Large flat head	Sheathing, siding, subflooring, framing, shop work
12d	3 1/4	.148	Large flat head	Sheathing, subflooring, framing
16d	3 1/2	.162	Large flat head	Framing, bridges, etc.
20d	4	.192	Large flat head	Heavy framing, bridges, etc.
30d	4 1/2	.207	Large flat head	Heavy framing, bridges, etc.
40d	5	.225	Large flat head	Heavy framing, bridges, etc.
50d	5 1/2	.244	Large flat head	Extra-heavy framing, bridges, etc.
60d	6	.262	Large flat head	Extra-heavy framing, bridges, etc.

[1]This chart applies to wire nails, although it may be used to determine the length of cut nails.

3.2.0 Staples

Staples are available in a wide variety of shapes and sizes, some of which are shown in *Figure 48*. Heavy duty staples are used to fasten plywood sheeting and subflooring. Heavy duty staples are driven by electrically or pneumatically operated tools. Light duty and medium duty staples are used for attaching molding and other interior trim. Staples are sometimes driven in by hand operated tools.

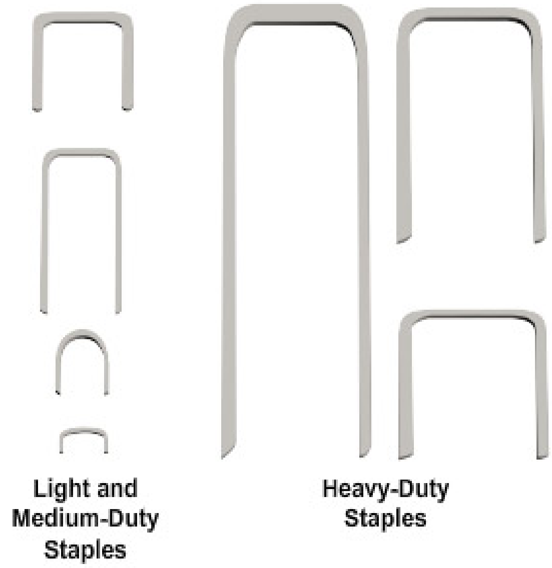


Figure 48 – Types of staples.

3.3.0 Screws

The use of screws, rather than nails, as fasteners may be dictated by a number of factors. These may include the type of material to be fastened, the requirement for greater holding power than can be obtained with nails, the finished appearance desired, and the fact that the number of fasteners that can be used is limited. Using screws, rather than nails, is more expensive in terms of time and money, but it is often necessary to meet requirements for superior results.

The main advantages of screws are that they provide more holding power, can be easily tightened to draw the items being fastened securely together, are neater in appearance if properly driven, and can be withdrawn without damaging the material. All screws can have slotted or Phillips heads, as shown in *Figure 49*.

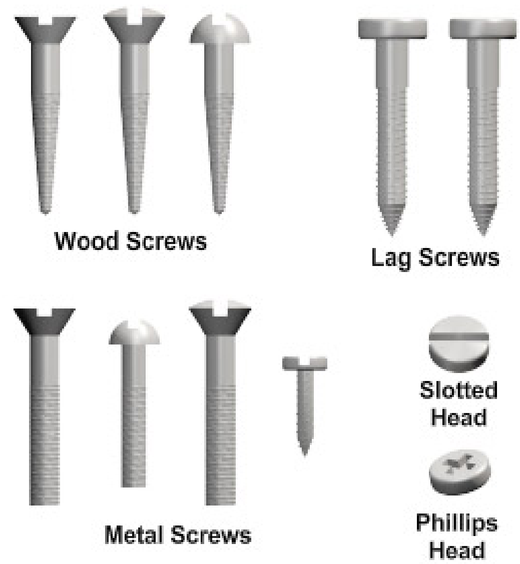


Figure 49 – Types of screws.

3.3.1 Metal Screws

For the assembly of metal parts, use sheet metal screws. These screws are made regularly in steel and brass with four types of heads: flat, round, oval, and fillister, shown in that order in *Figure 49*.

3.3.2 Lag Screws

The proper name for a ***lag screw*** shown in *Figure 49* is lag bolt. These screws are often required in constructing large projects, such as a building. They are longer and much heavier than the common wood screw and have coarser threads that extend from a cone, or gimlet point, slightly more than half the length of the screw. Square head and hexagonal head lag screws are always externally driven, usually by means of a wrench. They are used when ordinary wood screws would be too short or too light and spikes would not be strong enough. *Table 11* gives lengths and diameters of lag screws. Combined with expansion anchors, they are used to frame timbers to existing masonry.

Table 11 – Lag Screw Sizes

Length	**Diameter (Inches)**			
(Inches)	1/4	3/8, 7/16, 1/2	5/8, 3/4	7/8, 1
1	x	x		
1 1/2	x	x	x	
2, 2 1/2, 3, 3 1/2, etc., 7 1/2, 8 to 10	x	x	x	x
11 to 12		x	x	x
13 to 16			x	x

Expansion shields, or expansion anchors as they are sometimes called, are inserted in a predrilled hole, usually in masonry, to provide a gripping base or anchor for a screw, bolt, or nail intended to fasten an item to the surface in which the hole was bored. The shield can be obtained separately, or it may include the screw, bolt, or nail. After the expansion shield is inserted in the predrilled hole, the fastener is driven into the hole in the shield, expanding the shield and wedging it firmly against the surface of the hole.

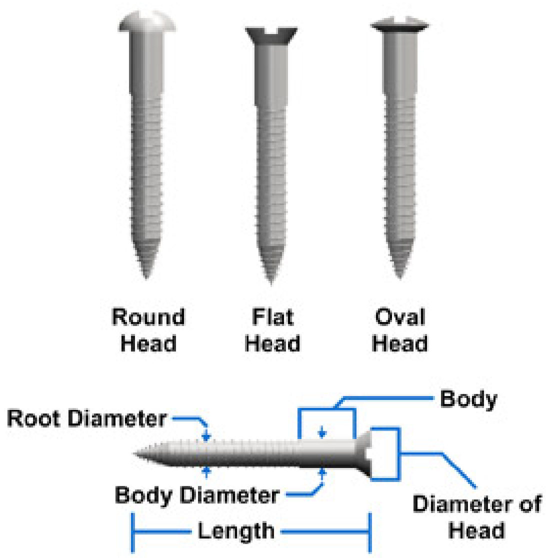


Figure 50 – Types and nomenclature of wood screws.

3.3.3 Wood Screws

The common wood screw is usually made of unhardened steel, stainless steel, aluminum, or brass. The steel may be bright finished or blued; or zinc, cadmium, or chrome plated. Wood screws are threaded from a gimlet point for approximately two-thirds of the length of the screw and provided with a slotted head designed to be driven by an inserted driver. Wood screws, as shown in *Figure 50*, are designated according to head style. The most common types are flathead, oval head, and roundhead, shown in that order. Proper nomenclature of a screw, shown in *Figure 50*, includes the type, material, finish, length, screw size number indicating the wire guage of the body, drill or bit size for the body hole, and drill or bit size for the starter hole.

To prepare wood for receiving the screws, bore a body hole the diameter of the screw to be used in the piece of wood to be fastened as shown in *Figure 51*.

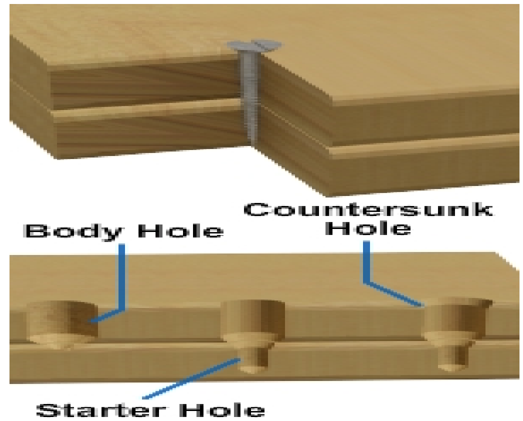


Figure 51 – Proper way to sink a screw.

Then bore a starter hole in the base wood with a diameter less than that of the screw threads and a depth of one-half or two-thirds the length of the threads to be anchored. The purpose of this careful preparation is to assure accuracy in the placement of the screws, to reduce the possibility of splitting the wood, and reduce the time and effort required to drive the screw. Properly set slotted and Phillips flathead and oval head screws are countersunk sufficiently to permit a covering material to cover the head. Slotted roundhead and Phillips roundhead screws are not countersunk, but they are driven so that the head is firmly flush with the surface of the wood. The slot of the roundhead screw is left parallel with the grain of the wood.

Wood screws come in sizes that vary from 1/4 inch to 6 inches. Screws up to 1 inch in length increase by eighths, screws from 1 to 3 inches increase by quarters, and screws from 3 to 6 inches increase by half inches. Screws vary in length and size of shaft. Each length is made in a number of shaft sizes specified by an arbitrary number that represents no particular measurement but indicates relative differences in the diameter of the screws. *Tables 12* and *13* provide size, length, gauge, and applicable drill and ***auger*** bit sizes for screws.

Table 12 – Screw Sizes and Dimensions

Length	Size Numbers																				
(Inch)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24
1/4	x	x	x	x																		
3/8	x	x	x	x	x	x	x	x	x	x												
1/2		x	x	x	x	x	x	x	x	x	x	x	x									
5/8		x	x	x	x	x	x	x	x	x	x	x	x		x							
3/4			x	x	x	x	x	x	x	x	x	x	x		x		x					
7/8			x	x	x	x	x	x	x	x	x	x	x		x		x					
1				x	x	x	x	x	x	x	x	x	x		x		x		x	x		
1 1/4					x	x	x	x	x	x	x	x	x		x		x		x	x		x
1 1/2					x	x	x	x	x	x	x	x	x		x		x		x	x		x
1 3/4						x	x	x	x	x	x	x	x		x		x		x	x		x
2						x	x	x	x	x	x	x	x		x		x		x	x		x
2 1/4						x	x	x	x	x	x	x	x		x		x		x	x		x
2 1/2						x	x	x	x	x	x	x	x		x		x		x	x		x
2 3/4							x	x	x	x	x	x	x		x		x		x	x		x
3							x	x	x	x	x	x	x		x		x		x	x		x
3 1/2									x	x	x	x	x		x		x		x	x		x
4									x	x	x	x	x		x		x		x	x		x
4 1/2													x		x		x		x	x		x
5													x		x		x		x	x		x
6															x		x		x	x		x
Threads Per Inch	**32**	**28**	**26**	**24**	**22**	**20**	**18**	**16**	**15**	**14**	**13**	**12**	**11**		**10**		**9**		**8**	**8**		**7**
Diameter Of Screw (Inch)	**.060**	**.073**	**.086**	**.099**	**.112**	**.125**	**.138**	**.151**	**.164**	**.177**	**.190**	**.203**	**.216**		**.242**		**.268**		**.294**	**.320**		**.372**

Table 13 – Drill and Auger Bit Sizes for Wood Screws

Screw Size No.		1	2	3	4	5	6	7	8	9	10	12	14	16	18
Nominal Screw		.073	.086	.099	.112	.125	.138	.151	.164	.177	.190	.216	.242	.268	.294
Body Diameter		5/64	3/32	3/32	7/64	1/8	9/64	5/32	11/64	11/64	3/16	7/32	15/64	17/64	19/64
Pilot Hole	**Drill size**	5/64	3/32	7/64	7/64	1/8	9/64	5/32	11/64	3/16	3/16	7/32	1/4	17/64	19/64
	Bit size	–	–	–	–	–	–	–	–	–		4	4	5	5
Starter Hole	**Drill size**	–	1/16	1/16	5/64	5/64	3/32	7/64	7/64	1/8	1/8	9/64	5/32	3/16	13/64
	Bit size	–	–	–	–	–	–	–	–	–	–	–	–		4

3.4.0 Bolts

Bolts are used in construction requiring great strength or when the work under construction must be frequently disassembled. Their use usually implies the use of nuts for fastening and sometimes the use of washers to protect the surface of the materials they fasten. Bolts are selected for application to specific requirements in terms of length, diameter, threads, style of head, and type. Proper selection of head style and type of bolt results in good appearance as well as good construction. The use of washers between the nut and a wood surface or between both the nut and the head and their opposing surfaces helps you avoid marring the surfaces and permits additional torque in tightening.

3.4.1 Carriage Bolts

Carriage bolts fall into three categories: square neck, finned neck, and ribbed neck. All three are shown in *Figure 52*.

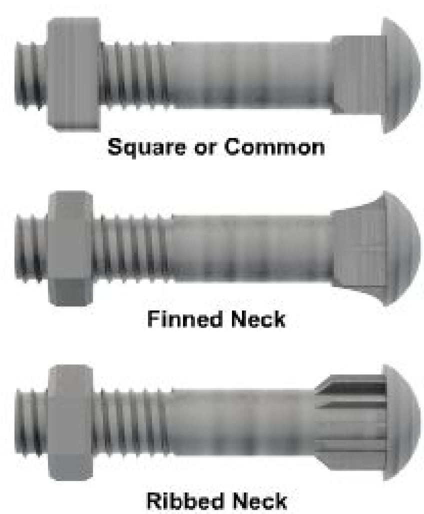


Figure 52 – Carriage bolts.

These bolts have round heads that are not designed to be driven. They are threaded only part of the way up the shaft. Usually, the threads are two to four times the diameter of the bolt in length. In each type of carriage bolt, the upper part of the shank, immediately below the head, is designed to grip the material in which the bolt is inserted and keep the bolt from turning when a nut is tightened down on it or removed. The finned type is designed with two or more fins extending from the head to the shank. The ribbed type is designed with longitudinal ribs, splines, or serrations on all or part of a shoulder located immediately beneath the head. Holes bored to receive carriage bolts are bored to be a tight fit for the body of the bolt and counterbored to permit the head of the bolt to fit flush with, or below the surface of, the material being fastened. The bolt is then driven through the hole with a hammer. Carriage bolts are chiefly for wood to wood application, but they can also be used for wood to metal applications. If used for wood to metal application, the head should be fitted to the wood item. Metal surfaces are sometimes predrilled and countersunk to permit the use of carriage bolts metal to metal. Carriage bolts can be obtained from 1/4 inch to 1 inch in diameter and from 3/4 inch to 20 inches long (*Table 14*). Use a common flat washer with carriage bolts between the nut and the surface.

Table 14 – Carriage Bolt Sizes

Length (Inches)	Diameter (Inches)			
	3/16, 1/4, 4/16, 3/8	7/16, 1/2	9/16, 5/8	3/4
3/4	x	–	–	–
1	x	x	–	–
1 1/4	x	x	x	–
1 1/2, 2, 2 1/2, etc. 9 1/2, 10 to 20	x	x	x	x

3.4.2 Machine Bolts

The ***machine bolts*** shown in *Figure 53* are made with cut national fine and national coarse threads extending in length from twice the diameter of the bolt plus 1/4 inch for bolts less than 6 inches in length to twice the diameter of the bolt plus 1/2 inch for bolts over 6 inches in length.

They are precision made and generally applied metal to metal where close tolerance is desirable. The head may be square, hexagonal, rounded, or flat countersunk. The nut usually corresponds in shape to the head of the bolt with which it is used. Machine bolts are externally driven only. Selection of the proper machine bolt is made on the basis of head style, length, diameter, number of threads per inch, and coarseness of thread. The hole through which the bolt is to pass is bored to the same diameter as the bolt. Machine bolts are made in diameters from 1/4 inch to 3 inches and may be obtained in any length desired, as shown in *Table 15*.

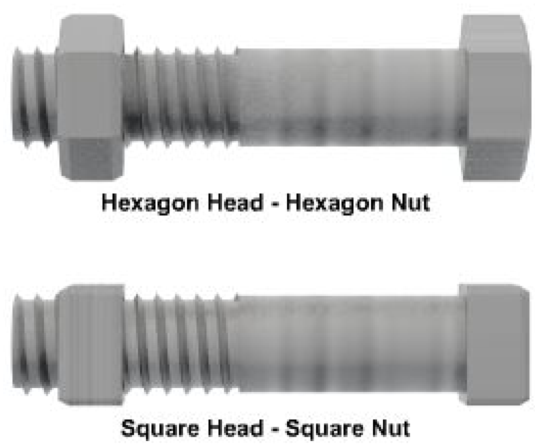


Figure 53 – Machine bolts.

Table 15 – Machine Bolt Sizes

Length (Inches)	Diameter (Inches)				
	1/4, 3/8	7/16	1/2, 9/16, 5/8	1/2, 7/8, 1	1 1/8, 1 1/4
3/4	x	–	–	–	–
1 1/4	x	x	x	–	–
1 1/2, 2, 2 1/2	x	x	x	x	–
3, 3 1/2, 4, 4 1/2, etc., 9 1/2, 10 to 20	x	x	x	x	x
21 to 25	–	–	x	x	x
26 to 39	–	–	–	x	x

3.4.3 Stove Bolts

The ***stove bolts*** shown in *Figure 54* are less precisely made than machine bolts.

They are made with either flat or round slotted heads and may have threads extending over the full length of the body, over part of the body, or over most of the body. They are generally used with square nuts and applied metal to metal, wood to wood, or wood to metal. If flatheaded, they are countersunk. If roundheaded, they are drawn flush to the surface.

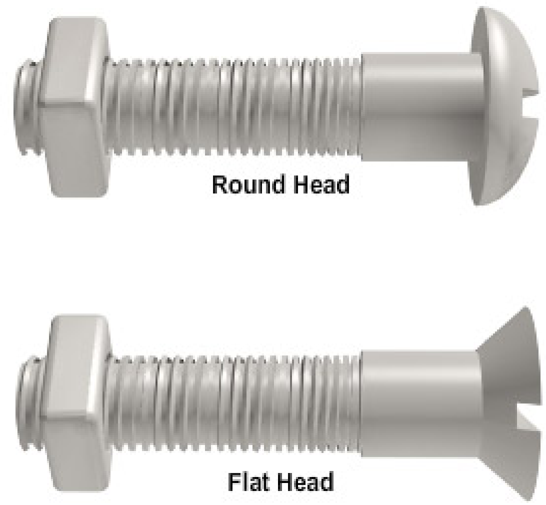


Figure 54 – Stove bolts.

3.4.4 Expansion Bolts

The ***expansion bolt***, shown in *Figure 55* is a bolt used in conjunction with an expansion shield to provide anchorage in substances in which a threaded fastener alone is useless. The shield, or expansion anchor, is inserted in a predrilled hole and expands when the bolt is driven into it. It becomes wedged firmly in the hole, providing a secure base for the grip of the fastener.

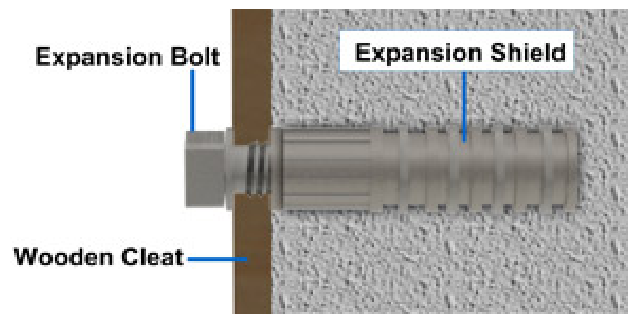


Figure 55 – Expansion bolt.

3.4.5 Toggle Bolts

The ***toggle bolt***, shown in *Figure 56*, is a machine screw with a spring action, wing head nut that folds back as the entire assembly is pushed through a prepared hole in a hollow wall. The wing head then springs open inside the wall cavity. As the screw is tightened, the wing head is drawn against the inside surface of the finished wall material. Spring action, wing head toggle bolts are available in a variety of machine screw combinations. Common sizes range from 1/8 inch to 3/8 inch in diameter and 2 inches to 6 inches in length. They are particularly useful with sheetrock wall surfaces.

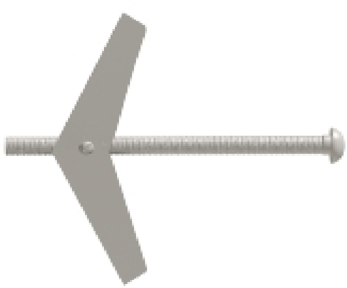


Figure 56 – Toggle bolt.

3.4.6 Molly Bolts

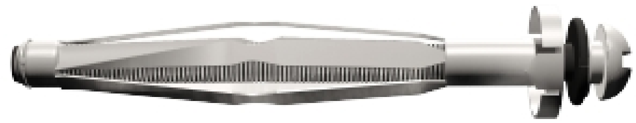


Figure 57 – Molly bolt.

The ***molly bolt*** or molly expansion anchor, shown in *Figure 57*, is used to fasten small cabinets, towel bars, drapery hangers, mirrors, electrical fixtures, and other lightweight items to hollow walls. It is inserted in a prepared hole. Prongs on the outside of the shield grip the wall surfaces to prevent the shield from turning as the anchor screw is being driven. As the screw is tightened, the shield spreads and flattens against the interior of the wall. Various sizes of screw anchors can be used in hollow walls 1/8 inch to 1 3/4 inches thick.

3.4.7 Driftpins

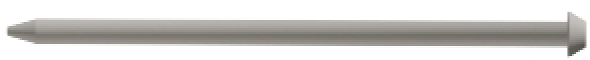


Figure 58 – Driftpin.

The driftpin, shown in *Figure 58*, is a long, heavy, threadless bolt used to hold heavy pieces of timber together. It has a head that varies in diameter from 1/2 to 1 inch and in length from 18 to 26 inches. The term driftpin is almost universally used in practice. For supply purposes, the correct designation is driftbolt.

To use the driftpin, make a hole slightly smaller than the diameter of the pin in the timber. Drive the pin into the hole. The compression action of the wood fibers holds the pin in place.

3.5.0 Corrugated Fasteners

The corrugated fastener is one of many means by which joints and splices are fastened in small timber and boards. It is used particularly in the miter joint. Corrugated fasteners are made of 18 to 22 gauge sheet metal with alternate ridges and grooves; the ridges vary from 3/16 to 5/ 16 inch, center to center. One end is cut square; the other end is sharpened with beveled edges. There are two types of corrugated fasteners: one with the ridges running parallel, as shown in *Figure 59, view A*, the other with ridges running at a slight angle to one another, as shown in *Figure 59, view B*.

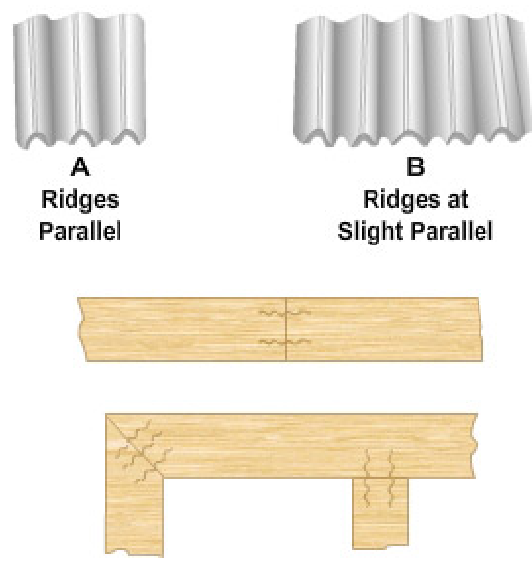


Figure 59 – Corrugated fasteners and their uses.

The latter type has a tendency to compress the material since the ridges and grooves are closer at the top than at the bottom. These fasteners are made in several different lengths and widths. The width varies from 5/8 to 1 1/8 inches; the length varies from 1/4 to 3/4 inch. The fasteners also are made with different numbers of ridges, ranging from three to six ridges per fastener. Corrugated fasteners are used in a number of ways: to fasten parallel boards together, as in fastening tabletops; to make any type of joint, and as a substitute for nails where nails may split the timber. In small timber, corrugated fasteners have greater holding power than nails. The proper method of using the fasteners is shown in *Figure 59*.

3.6.0 Adhesives

Seabees use many different types of adhesives in various phases of their construction projects. Glues (which have a plastic base) and mastics (which have an asphalt, rubber, or resin base) are the two major categories of adhesives.

The method of applying adhesives, their drying time, and their bonding characteristics vary. Some adhesives are more resistant to moisture and hot and cold temperatures than others.

CAUTION

Some adhesives are highly flammable; they should be used only in a well-ventilated work area. Others are highly irritating to the skin and eyes.

3.6.1 Glues

The primary function of glue is to hold together joints in mill and cabinet work. Most modern glues have a plastic base. Glues are sold as a powder to which water must be added or in liquid form. Many types of glue are available under brand names. A brief description of some of the more popular types of glue is listed below.

Polyvinyl resin, also known as white glue, is a liquid that comes in ready to use plastic squeeze bottles. It does a good job of bonding wood together and it sets up (dries) quickly after being applied. Because white glue is not waterproof, do not use it on work that will be subjected to constant moisture or high humidity.

Urea resin is plastic based glue sold in a powder form. The required amount is mixed with water when the glue is needed. Urea resin makes an excellent bond for wood and has fair water resistance.

Phenolic resin glue is highly resistant to temperature extremes and water. It is often used for bonding the veneer layers of exterior grade plywood.

Resorcinol glue has excellent water resistance and temperature resistance, and it makes a very strong bond. Resorcinol resin is often used for bonding the wood layers of laminated timbers.

Contact cement is used to bond plastic laminates to wood surfaces. This glue has a neoprene rubber base. Because contact cement bonds very rapidly, it is useful for joining parts that cannot be clamped together.

3.6.2 Mastics

Mastics are widely used throughout the construction industry. They are generally used to apply floor coverings, roofing materials, ceramic tiles, and wall paneling. The asphalt, rubber, or resin base of mastics gives them a thick consistency. Mastics are sold in cans, tubes, or canisters that fit into hand-operated or air-operated caulking guns. These adhesives can be used to bond materials directly to masonry or concrete walls. If furring strips are required on a wavy concrete wall, the strips can be applied with mastic rather than by the more difficult procedure of driving in concrete nails. You can also fasten insulation materials to masonry and concrete walls, bond drywall (gypsum board) directly to wall studs, and bond gypsum board to furring strips or directly to concrete or masonry walls with a mastic adhesive. Because you don’t use nails, there are no nail indentations to fill. By using mastic adhesives, you can apply paneling with very few or no nails at all. Wall panels can be bonded to studs, furring strips, or directly against concrete or masonry walls. Mastic adhesives can be used with nails or staples to fasten plywood panels to floor joists. The mastic adhesive helps eliminate squeaks, bounce, and nail popping. It also increases the stiffness and strength of the floor unit.

Common Trade Terms

Auger	A carpenter's hand tool used for boring holes in wood.
Box nail	Lightweight nails with large heads.
Brad	A slender nail with a small head.
Carriage bolt	A threaded bolt with a round, smooth head. The bolt is prevented from rotating in its hole by a square neck directly under the head.
Casing nail	Twopenny (2d) to fortypenny (40d) nails with flaring heads.
Circular saw	A thin steel-toothed disk that rotates on a power-driven spindle. Can be used either as a hand tool or mounted on a table.
Common nail	Twopenny (2d) to sixtypenny (60d) strong nails.
Corrugated fasteners	A small, wavy steel fastener with one edge sharpened. The fastener is driven into two pieces of wood, bridging the joint in order to hold them together.
Dado joint	A joint created by fitting the end of one piece of wood at a right angle into a groove cut across the width of another, to a depth of half its thickness.
Dovetail joints	In finish carpentry, an interlocking joint that is wider at its end than at its base.
Expansion bolt	An anchoring or fastening device used in masonry, which expands within a predrilled hole as a bolt is tightened.
Finishing nail	Twopenny (2d) to twentypenny (20d) sizes with small barrel shaped heads.
Gain joints	The mortise or notch in a piece of wood into which a piece of wood, hinge, or other hardware fits.
Hardwoods	A general term referring to any of a variety of broad-leaved, deciduous trees, and the wood from those trees. The term does not designate the physical hardness of wood, as some hardwoods are actually softer than some softwood (coniferous) species.
Jointer	A power driven woodworking tool or long, hand operated bench plane. Used to square the edges of lumber or panels.
Knotholes	The holes left when knots fall out of lumber.
Lag screw	A screw with a wrench head and wood screw threads.
Laminated	Any material formed by bonding together several layers or sheets with adhesive under pressure and sometimes with nails or bolts.

Laminated lumber Any of several products formed by built up layers (plies) of wood. Thin veneers may be laminated to a wood subsurface, several plies may be laminated together to form plywood, or thicker pieces may be used to form structural members such as beams or arches.

Lap joints A type of joint in which two building elements are not butted up against each other, but are overlapped, with part of one covering part of the other. Typical examples include roof and wall shingles, clapboard siding, welded metal sheets or plates, and concrete reinforcing bars lapped together at their ends.

Machine bolts A threaded straight bolt usually specified by gauge, thread, and head type.

Mitering Cutting at an angle.

Miter joints A joint, usually 90°, formed by joining two surfaces beveled at angles, usually 45° each.

Molly bolt A threaded insert for plaster, sheetrock, or concrete walls for receiving a bolt, screw, or nail.

Mortise and tenon joints A joint between two members, usually wood, which incorporates one or more tenons on one member fitting into mortises in the other member. Used on joints such as door sills, door rails, window sashes, and cabinetry.

Nominal The common size by which lumber is known, such as 2 x 4. The nominal size is larger than the dressed size of lumber.

Plywood A flat panel made up of a number of thin sheets (veneers) of wood. The grain direction of each ply, or layer, is at right angles to the one adjacent to it. The veneer sheets are united under pressure by a bonding agent.

Rabbet joints A longitudinal edge joint formed by fitting together rabbeted boards.

Softwood (1) A general term referring to any of a variety of trees having narrow, needle-like or scale-like leaves, usually coniferous. (2) The wood from such trees. The term has nothing to do with the softness of the wood; some softwoods are harder than certain of the hardwood species.

Stove bolts A common bolt with a round or flat head and a slot for a screwdriver.

Toenailed Nail driven at an angle for improved stability.

Toggle bolt A bolt and nut assembly used to fasten objects to a hollow wall or a wall accessible from only one side. The nut has pivoted wings that close against a spring when the nut end of the assembly is pushed through a hole and is open on the other side.

1. **What is the hard fibrous substance that forms the major part of the trunk and branches of a tree?**
   - Wood
   - Timber
   - Lumber
   - Root

2. **What does seasoning lumber mean?**
   - Removing moisture from the wood
   - Drying the wood in the open air or in a shed
   - Drying the wood using heat
   - All of the above

3. **True or False. A Blue Stain (mold fungus) may weaken the wood.**
   - True
   - False

4. **True or False. Trees are classified as either softwood or hardwood, therefore all lumber is classified the same way.**
   - True
   - False

5. **True or False. The quality of softwoods are classified according to their intended use.**
   - True
   - False

6. **A grade of wood is based on what?**
   - Strength
   - Stiffness
   - Appearance
   - All of the above

7. **Lumber is graded for quality in accordance with American Lumber Standards set by the National Bureau of Standards for the U.S. Department of Commerce. According to table 9-5, what is Grade A lumber?**
   - Lumber that is practically free of blemishes and defects
   - Lumber that may contain a few minor blemishes
   - Lumber that contains numerous defects and blemishes
   - None of the above

8. **True or False. Grades of hardwood lumber are established by the National Hardwood Lumber Association.**
   - True
   - False
9. **According to table 9-9, plywood uses exterior, where would grade A-A be used?**
   - Outdoor where the appearance of both sides of the wood is important
   - Outdoor where the appearance of one side of the wood is important
   - Utility uses such as farm buildings or fences
   - Used as backing
10. **True or False. Hardwood plywood panels are primarily used for door skins, cabinets, and wall paneling.**
    - True
    - False
11. **What is the primary advantage of laminated lumber?**
    - Light weight
    - Low cost
    - Increased load carrying capacity
    - Increased resistance to decay
12. **As a builder you should be able to judge the moisture content of lumber by which of the following characteristics?**
    - Taste, color and weight
    - Color, weight, smell, and feel
    - Color, grain, and smell only
    - Taste, color, grain, and smell
13. **A twist or curve caused by shrinkage appearing in a flat board is what kind of defect?**
    - Shake
    - Wane
    - Check
    - Warp
14. **What is the essential difference between exterior and interior plywood?**
    - The grain
    - The thickness
    - The glue
    - The piles

15. A circular saw can be used to cut a stopped groove or stopped dado using which of the following attachments?

- ○ A stop block
- ○ A rabbet ledge
- ○ A haunch board
- ○ A carriage block